Empirical Essays on Risk Taking by Banks and Households

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Abstract

This thesis consists of three empirical chapters that explore contemporary topics related to risk. Specifically, this thesis aims to contribute to the literature relating to the risk-taking channel of monetary policy and the literature relating to the household sector's risk profile by examining three distinct but related topics.

The initial empirical chapter examines the link between monetary policy and banks' appetite for risk in the U.S.. Specifically, the risk-taking channel of monetary policy is examined by scrutinizing the response of banks' nonperforming loans to total loans ratios to an identified monetary policy shock. The chapter also investigates if there is any type of systematic heterogeneity in the way banks react to monetary policy shocks. Furthermore, the chapter examines the presence of spillover effects as a result of a shock originating from a specific bank. The results show that in the medium run, banks' nonperforming loans ratios increase, providing evidence in support of the presence of an active risk-taking channel in the U.S. banking system. A bank's characteristics play an important role in the way they react to a policy rate shock. The results also indicate that shocks originating from larger and riskier banks have lasting effects on the whole system, while shocks from smaller and less risky banks do not.

The subsequent chapter presents empirical analysis of the determinants of risky asset holdings by Japanese households. Four different econometric methodologies are used to assess whether the methodological approach employed affects the estimated parameter coefficients. Furthermore, key explanatory variables that capture household trust in the stock market; household trust in the government; and household perception of risk are used to provide further insight into the determinants of risky asset holdings in Japan. The results indicate significant impacts from these

key explanatory variables, revealing new channels which influence Japanese households' financial decisions. Moreover, the four alternative methodological approaches employed in the analysis reinforce the robustness of the impact of the variables considered in this chapter and also reveal considerable heterogeneity in the effects of some variables.

The final chapter provides an empirical comparison of the determinants of risk attitudes in Japan and the U.S.. This chapter also tests if the risk attitudes measures used in the analysis explain individuals' actual choices in a variety of contexts to ensure that these measures are valid proxies for actual risk taking behaviours. Furthermore, it is crucial to examine the stability of individuals' attitudes towards risk, since exogenous shocks, such as experiencing natural disasters, can cause a permanent change in an individual's risk attitudes. Therefore, the final chapter also assesses the impact of experiencing natural disasters on individuals' attitudes towards risk. The results indicate that a number of variables have a statistically significant impact on individuals' risk attitudes and the impact of some of these variables differ across Japan and the U.S.. The exposure to natural disasters influences the risk attitudes of Japanese male individuals and this impact is robust to the use of a number of different measures of the risk of natural disasters.

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Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Aims and motivation

Policy makers and regulatory authorities assign a central role to the level of risk in the economy when conducting and setting out their policies. Different agents in the economy have different attitudes towards risk. For example, some agents tend to have excessive risk taking behaviours, while others tend to overprotect their financial portfolios from exposure to any risk. The two agents whom attitudes towards risk are of a particular concern to policy makers are households and financial institutions, especially banks. The observed level of risky assets held in a household's financial portfolio is lower than the predictions of the classical theory and it is sub-optimal from policy makers' prospective (Badarinza, Campbell, & Ramadorai, 2016). On the other hand, the level of risk in the banking system in general is high and was excessively high in the years preceding the 2008 financial crisis. This level of risk prompted various regulatory authorities, in most developed countries, to implement and continuously improve a number of prudential policies to make the banking system more resilient and to prevent banking crises from occurring (Diamond & Rajan, 2009).

Empirical examination of the risk taking behaviours of banks has gained significant interest since the 2008 financial crisis. This is not surprising given that the social and the economic costs of systemic banking crises are large and have far reaching implications.[1] Financial institutions, and especially banks, operate in a high-risk environment and the widespread impact of a banking crisis is related to the fact that banks' systemic risk comes from two sources. The first source comes from outside the financial system, as each bank faces exposure to the real economy and these exposures are correlated. Also banks have financial exposure to each other as a result of the interdependencies among banks. These interdependencies have no geographic limits, which was evident in the 2008 financial crisis that originated in the

[1] See Besar, Booth, Chan, Milne, and Pickles (2011) for an overview of a number of financial crises.

U.S. but quickly spread through the U.S. and around the world causing a dramatic collapse to the banking sector of most developed countries. Furthermore, the crisis permeated through to the real sector of the economies of these countries and triggered an economic crisis.[2] The consequences of the excessive risk taking behaviours of banks has led the financial regulators and supervisory authorities to strengthen their macroprudential framework to prevent the occurrence of another crisis. The U.S. "Volcker Rule", effective from 1 of April 2014, and the UK "Ring-fencing", implemented as of 1 of January 2019, are examples of legislation developed by the U.S. and the UK governments to improve the resilience of banks and to protect the core retail banking services from risks associated with banks' investment and international activities. Under these legislations, banks are required to separate their investment and international banking activities from the provision of retail banking functions.

A number of studies have examined the fundamental cause of the 2008 financial crisis (see, for example, Diamond & Rajan, 2009; Taylor, 2009; Allen & Carletti, 2010). There is wide agreement among these studies that expansionary monetary policies and the increase in debt instruments available were two important factors responsible for the onset of the 2008 financial crisis. Persistently low real interest rates caused a reduction in risk aversion of banks and other investors, implying an increase in their appetites for risk, see Maddaloni and Peydró (2011). Banks softened their lending standards over and above the improvement of borrowers' creditworthiness, which in turn fuelled a boom in asset prices and securitized credit inducing global financial imbalances between savings and investment in major countries.

The 2008 financial crisis intensified the debate about whether the responsibilities of monetary policy have to be extended beyond price stability and aggregate demand, to encompass financial stability and mainly the risk-taking propensity of economic agents. Financial stability has long been an important consideration of

[2] See Adrian and Shin (2010) for an overview of the events preceding the 2008 financial crisis.

central banks, but has never been set out as an objective to achieve (Goodhart & Schoenmaker, 1995; Bernanke & Gertler, 2001). Angeloni, Faia, and Lo Duca (2015) argue that there are three fundamental elements that establish the paradigm within which central banks were operating until 2007. The first one is the single focus, which states that central banks' only objective is maintaining price stability. The second element is the independence of central banks from other agents in the economy, such as the government and trade unions. The final element is the assignment principle, which states that other agents in the economy should not share the responsibility of price stability with the central bank, nor should the central bank be distracted by the objectives of other agents. The existence of a link between changes in the interest rate and banks' appetite for risk suggests that the single focus principle of central banks may have to be revisited. The assignment principle has also been put into question given that the 2008 financial crisis has caused another "Great Recession" with its effect still weighing heavily on economic growth in many countries.

Before the 2008 financial crisis, the literature on the transmission mechanism of monetary policy has extensively examined the channels through which monetary policy impacts the quantity of credit in the banking system. However, the 2008 financial crisis highlighted that analysing the quality of credit in the economy as well as the quantity is important for the stability of the financial system. The quantity of credit could be used as an indicator of the level of economic activities, whereas analysing the quality of credit could help in identifying the sustainability of the banking system when faced with shocks from these activities, see De Nicolò, Dell'Ariccia, Laeven, and Valencia (2010). The link between low interest rates and banks' appetite for risk, identified by the 2008 financial crisis, has extended the channels through which monetary policy impacts financial institutions. The new channel of the monetary transmission mechanism is referred to by Borio and Zhu (2012) as the risk-taking channel and examines the impact of changes in monetary policy rates on either risk perceptions or risk-tolerance of banks. Based on the underpinnings of the theoretical research on the risk-taking channel, a number of researchers have provided evidence that in an environment with low interest rates, banks exhibit risk taking behaviour (see, for example, Jiménez, Ongena, Peydró, & Saurina, 2014; Ioannidou, Ongena, & Peydró, 2015; Altunbas, Gambacorta, & Marques-Ibanez, 2014; Angeloni et al., 2015; Buch, Eickmeier, & Prieto, 2014b, 2014a).

The household sector is another sector that can influence a variety of macroeconomic and microeconomic outcomes given its size and its significant exposure to the financial sector. The financial behaviours of households relating to saving, spending and the levels of debt have a significant impact on the level of aggregate demand in the economy and on individuals' levels of well-being. At the macro level, the impact on aggregate demand will influence market prices, which will in turn have an impact on monetary and financial stability. The level of household debt in the economy has serious implications for the stability of the financial system if the increased level of debt is not sustainable. Greater household debt will make households more sensitive to movements in interest rates and to changes in income. At the micro level, the way in which households allocate their funds is of interest to economists and policy makers given the current ageing population as a result of high life expectancy and a low fertility rate.

Households can allocate their financial wealth to safe assets, such as bank deposits and government bonds, or/and invest in risky assets such as shares and securities. Understanding how individuals allocate their wealth is an important factor in promoting growth and financial stability. Specifically, capital markets are now more attractive for firms and small businesses for raising funds than using the traditional banks' loans. Therefore, for an efficient capital allocation this increase in the supply of equity and securities should be met by changes in the demand side, that is increasing the share of risky assets in household financial portfolios. Furthermore, the recent adaptation of the defined contribution pension scheme in many countries, such as Japan and the U.S., means that individuals will be indirectly exposed to movement in stock markets. Therefore, understanding individuals' perceptions of the stock market functioning is valuable from a policy formation perspective.

Promoting participation in the stock market among households is crucial given the changing population demographics. This change means that individuals in the future will be faced with the choice of smaller pensions or later retirement as the support ratio is decreasing and expected to decrease more in the future.[3] This indicates that households should find stock market participation attractive as they will have a greater incentive for wealth accumulation. However, the observed composition of households financial portfolios across developed economies indicates that households on average hold a low proportion of their wealth in risky assets. This is of concern to governments and policy makers, specifically in countries with a rapidly ageing population and a shrinking workforce, such as Japan. Furthermore, the level of risky asset holdings by households does not accord with the predictions of the classical theory of household financial portfolios.[4] This disparity between the suggested optimal level of risky asset holdings, by policy makers and theory, and the observed holdings is referred to in the literature as the "participation puzzle".[5]

The conservative investment approach by households is not specific to one country, the low level of risky asset holdings is observed in many countries. For example, in the U.S. the share of equity held by households is on average 36.0% of total financial portfolio, while it is 18.0% in the EU, see Bank of Japan (2017b). However, risky assets in Japan make up only 10.0% of households portfolios, which is much lower than that observed in the U.S. and the EU. This poses a real challenge to the Japanese government given that Japan is one of the world's oldest societies, with

[3]The support ratio is defined as the ratio of the number of people working compared to people beyond retirement age and describes the burden placed on the working population.

[4]The classical theory suggests that rational investors will participate in the stock market as long as the stock market return is higher than the return on risk free assets.

[5]See Badarinza et al. (2016) and Guiso and Sodini (2013) for an excellent review of the literature.

the UN expecting that, by 2040, more than one in three people in Japan will be over 65 years old. Given the low level of risky asset holdings and the ageing feature of Japanese society, it is surprising that only a limited number of empirical studies have analysed the composition of Japanese households' financial portfolios (see, for example, Iwaisako, Ono, Saito, & Tokuda, 2016; Aoki, Michaelides, & Nikolov, 2016; Ito, Takizuka, Fujiwara, et al., 2017). Ascertaining the determinants that influence the composition of a household's financial portfolio is crucial given the efforts of governments in many developed countries to encourage households to participate in the stock market.

Governments in developed countries, such as Japan, the U.S. and the UK, regularly make significant financial reforms which aim to reduce barriers faced by individuals to stock market entry and develop initiatives, which aim to enhance individuals' understanding of the different financial products available in the market. An example of how governments are trying to encourage stock market participation is the UK Individual Savings Account (ISA) scheme, which is a tax incentive investments and/or savings vehicle. Under this scheme individuals can put an annual allowance of £20,000 into a Stocks and Shares ISA (or a Cash ISA) which allows the individual to invest in a range of different asset classes and instruments and the returns from these investments are not subject to income tax or capital gains tax.

The literature suggests that individuals' attitudes towards risk are an important characteristic which influences investment decisions. These decisions are not limited to financial decisions, attitudes towards risk will have an impact on employment choice, health outcomes, political and migration decisions. Therefore, understanding the determinants of individuals' preferences towards risk and the stability of these preferences are conceptually at the heart of microeconomics. Systematic changes in individual risk preferences will have important implications for macroeconomic performance. For example, experiencing an external negative shock, such as the 2008 financial and economic crises, will make individuals less willing to take risk.

This will subsequently amplify an economic crisis since the systematic increase in individuals' aversion towards risk will possibly divert investors from high growth but risky investments to safer but lower growth investments. Furthermore, a systematic increase in individuals' aversion towards risk will increase individuals' required risk premium, which will then increase the cost of capital. For a country such as Japan, with its ageing population and the high frequency of natural disasters, an increase in the proportion of individuals who are less willing to take risk will potentially have even worse consequences on economic growth. Therefore, identifying the determinants of individuals' risk attitudes and examining if risk attitudes vary when individuals are faced with high risk of exposure to natural disasters is of great interest to policy makers and academics. For example, policy makers should anticipate a systematic change in individuals' attitudes towards risk after a shock if the exposure to this shock is likely to alter individuals' risk attitudes.

In summary, the focus of this thesis lies on topics related to financial institutions' risk appetite and the household sector's risk profile. The first empirical chapter examines the link between monetary policy and banks' appetite for risk in the U.S.. This chapter contributes to the empirical literature on the risk-taking channel of monetary policy by implementing the Global Vector Autoregression (GVAR) methodology, developed by Pesaran, Schuermann, and Weiner (2004). This flexible econometric framework accounts for the heterogeneity of banks' risk taking behaviours in response to monetary policy shocks and for the transmission of shocks across banks (spillover effects) with differing characteristics.

The aim of the second empirical chapter is to provide further insight into the determinants of risky asset holdings in Japan. The contribution of this chapter to the existing literature is threefold. This chapter is the first study that uses the Keio Household Panel Survey (KHPS) dataset to analyse household financial portfolios. The chapter examines key explanatory variables that capture: household trust in the stock market; trust in the government; and household perception of risk. Finally, this chapter analyses whether the methodological approach employed affects the estimated parameter coefficients by applying four different econometric methodologies.

The final empirical chapter provides an empirical comparison of the determinants of risk attitudes in Japan and the U.S.. The contributions of this chapter are as follows: this chapter is the only empirical study, to my knowledge, that compares the determinants of risk attitudes between Japan and the U.S.. This chapter uses a set of natural disaster risk of exposure measures to explore the robustness of the impact of experiencing a natural disaster on risk attitudes. Finally, this chapter examines the validity of the "Preference Parameters Study" measures of risk attitudes by assessing whether these measures reflect actual risk taking behaviours of individuals.

1.2 Structure and content of the thesis

Chapters 2, 3 and 4 present the empirical analysis of this thesis and each chapter is a standalone self-contained study. Chapter 2 examines the link between monetary policy and banks' appetite for risk in the U.S.. Chapter 3 presents empirical analysis of the determinants of risky asset holdings of Japanese households. The final empirical chapter, Chapter 4, provides an empirical comparison of the determinants of risk attitudes and how these relate to risky behaviours in Japan and the U.S.. Finally, Chapter 5 provides a conclusion to the whole thesis and discusses key policy implications. A brief overview of each of the empirical chapters is given below.

1.2.1 Chapter 2

Existing literature related to the risk taking behaviours of financial institutions argues that in periods of low interest rates, financial intermediaries soften their lending standards and take on excessive risk. This chapter empirically examines the link between monetary policy and banks' appetite for risk; a link that has been explicitly named the "risk-taking channel of monetary policy" by Borio and Zhu (2012). To do so, bank level data relating to 30 banks from the largest 100 banks in the U.S., in terms of assets' size, is examined over the period of 1985Q1-2007Q4. The data is extracted from the Consolidated Report of Condition and Income ("Call Reports"); all insured commercial banks in the U.S. have to submit this report to the Federal Reserve in each quarter. The causal effect of a monetary policy shock on banks' risk taking behaviours can only be identified if the impact of expected defaults in the banking system is isolated from changes in monetary policy. Therefore this chapter uses an exogenous measure of the policy rate constructed by Caglayan, Kocaaslan, and Mouratidis (2017) that captures changes in monetary policy and accounts for the time-variation and structural breaks in the data generating process. Furthermore, the chapter uses the Romer and Romer (2004) measure as an alternative proxy for a monetary policy shock. Banks' risk taking activities are captured by the ratio of nonperforming loans to total loans. The Z-score measure is also used as an alternative proxy for bank's risk in the robustness check.

The contribution of this chapter to the empirical literature is the use of the GVAR methodology. By using this econometric methodology, this chapter aims to provide further insight into the risk-taking channel as the GVAR approach accounts both for the heterogeneity of banks' risk taking behaviours in response to monetary policy shocks and for the transmission of shocks across banks (spillover effects) with differing characteristics. These two issues have not been addressed simultaneously in the previous literature and the approach reveals interesting dynamics in the banking sector.

The empirical results provide further evidence in support of the presence of an active risk-taking channel in the U.S. banking system. Specifically, the results show that in the short-run, banks' nonperforming loans ratios moderately decline in response to an expansionary monetary policy shock, while in the medium-run, these ratios tend to increase for most of the banks implying an increase in risk taking activities. Furthermore, the investigation shows that in the medium- and the long-run, the magnitude and the duration of banks' reactions to the shock vary depending on their capital structure. The response to a monetary expansion is more pronounced for large, well capitalized banks. Furthermore, the size of the bank plays an important role in the transmission of shocks (spillover effects). Shocks originating from larger and riskier banks have lasting effects on the whole system, while no such effect is observed when the adverse shock emanates from a smaller bank. The composition of a bank's loan portfolio also plays an important role in the behaviour of the bank's total loans to assets ratio after a monetary policy shock. Specifically, only banks with commercial loans being the largest component of their loan portfolio do increase their ratio of total loans to assets, whereas the opposite is observed in banks where consumers and real estate loans are the largest share of their total loans. These results are robust to the use of the Z-score as an alternative measure for bank's risk and to the use of the Romer and Romer (2004) measure as an alternative proxy of monetary policy shock.

1.2.2 Chapter 3

This chapter provides an empirical analysis of the determinants of risky asset holdings by Japanese households by analysing data drawn from the Keio Household Panel Survey (KHPS). Initially, all waves of the KHPS data set (2004 to 2015) are used to examine the determinants of risky asset holdings. Subsequently, the focus is on wave 10 since in this wave respondents were asked detailed questions regarding their perceived risk of selected assets and respondents' opinions about the functioning of the stock market. The aim of this chapter is to provide further insight into the determinants of risky asset holdings in Japan by analysing potentially important explanatory variables that have not been explored for Japanese households before in this context. These variables capture: household trust in the stock market; trust in the government; and household perception of risk. In addition, this chapter aims to assess whether the methodological approach employed affects the estimated parameter coefficients by applying four different econometric methodologies. These are: the tobit model; the Censored Quantile Regression (CQR); and the one-part and the two-part of the Fractional Regression Model (FRM). The last two approaches are rarely used in household finance literature.

The results of the tobit model are used to verify the findings obtained in the existing literature and serve as a benchmark to compare the results of the alternative econometric models used. Each of the approaches employed in this chapter has unique features which help in exploring and fully understanding the determinants of Japanese households attitudes' towards risky investments. The two-part FRM model jointly models the incidence and extent of risky asset holdings, which is important as factors that explain the former decision may not be the same as those that affect the latter decision or their magnitudes may be different. The CQR accounts for the full characterization of the conditional distribution of the dependent variable. In contract, estimators which are based on the mean conditional distribution of the dependent variable provide only a partial view of the relationship between a set of regressors and the outcome variable. The results of the alternative methodological approaches reinforced the robustness of the impact of the variables considered in this chapter but also revealed considerable heterogeneity in the effect of some variables. This confirms that each model unmasks an important aspect of the financial behaviours of Japanese households.

The analysis relating to the key explanatory variables reveals some interesting results. The variable related to trust in the current government indicates that those who cannot decide on whether to support the current government hold, on average, a 8.2% lower proportion of risky assets than those who do support the government. This is an important result given the fact that the Japanese government announced in January 2013 its "three-arrows" strategy (also known as "Abenomics") to achieve an early end to deflation and overcome economic stagnation.

The variables related to the household's impression of the overall reliability of the stock market are statistically and economically significant. For example, individuals who agree that in the stock market "profit cannot be made with certainty" hold a lower proportion of risky assets. Moreover, the variables that reflect individuals' perceived trustworthiness of different dimensions of the stock market operations, namely; fairness, efficiency and prudential supervision, are also important predictors of risky asset holdings by Japanese households. Finally, the results of the variables related to the individual's perception of risk associated with selected assets suggest that the individual's risk perception is an important predictor of their financial decisions in Japan.

The findings of the chapter have important policy implications related to Japanese households' financial decisions. For example, the findings of the two-part FRM will inform policy makers about which variables will have the greatest impact if the aim is to promote a culture of participation in the stock market in Japan and which variables to target if increasing the level of holdings is the concern.

1.2.3 Chapter 4

In the existing literature, major developments have been made in examining the determinants of an individual's attitudes towards risk. However, with the exception of Dohmen, Lehmann, and Pignatti (2016) and Vieider et al. (2015), comparisons of the determinants of risk attitudes across countries are scarce in the literature. Furthermore, it is important to understand how individuals' risk attitudes vary when they face a high risk of exposure to natural disasters. The final empirical chapter aims to examine the determinants of risk attitudes in two countries, namely Japan and the U.S.. This chapter also tests if the risk attitudes measures used in the analysis explain individuals' actual choices in a variety of contexts to ensure that these measures are valid proxies for actual risk taking behaviours. Moreover, the final empirical chapter examines if Japanese individuals change their attitudes towards risk differently to U.S. individuals if faced by a higher risk of exposure to natural disasters. To do so, the final empirical chapter uses panel data from the "Preference Parameters Study of Osaka University" which is conducted in Japan and the U.S. covering the period from 2005 to 2010. Direct comparisons between Japan and the U.S., which is one of this chapter's contributions, can be made using this survey since it asks identical questions in each country. To ascertain the impact of natural disasters, an exogenous shock, on risk attitudes this chapter uses a range of measures of natural disaster risk.

The results indicate that a number of variables have a statistically significant impact on an individual's risk attitudes in both countries. However, the magnitude and the statistical significance of some variables differ across Japan and the U.S.. For example, the magnitudes of some variables are larger for Japanese individuals, such as: age; being exposed to the risk of unemployment in the near future; and the risk of facing borrowing constraints. Whereas the magnitudes of other variables have a larger impact on U.S. respondents, such as: being self-employed; level of education; income; and self-reported health status.

An important concern in the literature is whether the measures of risk attitudes used reveal actual attitudes towards risk of individuals. The validity of the risk attitude measures used in the final chapter are confirmed as they have considerable predictive power in explaining individuals' decisions in a variety of contexts such as; smoking, drinking, gambling and a number of financial choices outcomes. Furthermore, the issue that there could be unobserved factors that affect both the determinants of attitudes towards risk and the holdings of risky financial assets or engaging in risky activities is addressed. Specifically, the validity of these measures is further confirmed using a system of two equations to account for possible endogeneity between risky choices and attitudes towards risk.

The risk of exposure to natural disasters is found to only influence Japanese male individuals. Specifically, as the earthquake intensity increases Japanese male individuals become less willing to take risk, and this impact is robust to the use of different earthquake risk measures.

An interesting finding of this chapter is that the determinants, stability and susceptibility to change of attitudes towards risk are different depending on the gender and the country of the individual. For example, the height of the individual and the risk of experiencing an earthquake are found to influence the risk attitudes of Japanese male individuals only. The state of the economy has a statistically significant impact on risk attitudes of U.S. male individuals, and U.S. male individuals who live in cities are more willing to take risk than those who live in rural areas. Based on these findings, it is possible that policy makers may locate and predict where policies, which aim to influence an individual's risk profile, will have the greatest impact. Furthermore, the findings related to experiencing earthquakes mean that policy makers should expect a systematic change in the attitudes towards risk of Japanese male individuals after earthquakes with large intensities.

Chapter 2

The Risk-taking Channel of Monetary Policy: A GVAR Approach

2.1 Introduction

The 2008 global financial crisis has brought the relationship between monetary policy and financial institutions' appetite for risk to the forefront of the economic stability debate. The low level of interest rates in the years preceding the global financial crisis, stretching from 2001 to 2005, made financial intermediaries soften their lending standards and take on excessive risk. In an earlier paper Lowe and Borio (2002) have shown that financial imbalances may develop in high growth, low inflation, low interest rate economies. This environment will eventually require a monetary response to preserve both financial and monetary stability in response to developments in credit and asset markets.

The required monetary response is not clear as the paradigm within which central banks previously operated is now questionable. Before the financial crisis in 2007-2008, the literature was questioning the balance between central banks' price stability objective and its financial stability role as the lender of last resort (see, for example, Goodhart & Schoenmaker, 1995; Bernanke & Gertler, 2001).[1] However, the 2008 global financial crisis raised the question that central banks' responsibilities may have to be extended beyond price stability and aggregate demand, to encompass financial stability (other than the lender of last resort) and mainly the risk taking propensity of economic agents. In particular, Angeloni et al. (2015) argue that if monetary policy contributes to the formation of risk in the financial sector, and if the latter in turn feeds back on macroeconomic variables with unknown lags, then monetary policy has to take into account the impact of financial stability on real economic activity. Therefore, it is critical to have a comprehensive understanding of the linkages between monetary policy, assets prices and risk in the financial sector.

A body of literature has emerged exploring the link between monetary policy, and the perception and pricing of risk by economic agents (see, for example, Altunbas

[1] For example, Goodhart, Ito, and Payne (1994) argue that central banks should not be distracted by the assignment of targets other than that of price stability.

et al., 2014; De Nicolò et al., 2010; Maddaloni & Peydró, 2011; Borio & Zhu, 2012; Jiménez et al., 2014). This link has been explicitly named by Borio and Zhu (2012) as the "risk-taking channel" and has been added to the existing channels of the transmission mechanism of monetary policy.[2] Since then few theoretical models have been developed to build a conceptual framework for the risk-taking channel.[3] These models suggest that the risk-taking channel will take effect through the impact of the policy rate on asset valuation, or from the link it has with the market rate.

Overall, the empirical literature presents mixed evidence in relation to banks' risk-taking channel as the association between bank risk and monetary policy varies across types of banks (size and ownership), banking systems, and time. Specifically, Dell'Ariccia, Laeven, and Suarez (2017) have argued that when banks are allowed to adjust their capital structures, lower interest rates lead to greater leverage and higher risk. However, if the capital structure is fixed, the impact of a reduction in interest rates on bank risk depends on the degree of bank capitalization: well-capitalized banks increase risk, while highly leveraged banks may decrease it if loan demand is linear or concave. It should also be noted that the financial accelerator model developed by Bernanke, Gertler, and Gilchrist (1996) implies that lower interest rates may have countervailing effects on bank risk. In particular, while low interest rates would reduce bank risk by decreasing the interest burden of firms, it would also increase the collateral value and borrowing capability of high-risk firms.[4]

This chapter contributes to the empirical literature on risk-taking channel by implementing a flexible econometric framework, which accounts both for the heterogeneity of banks' risk taking behaviours in response to monetary policy shocks and for the transmission of shocks across banks (spillover effects) with differing charac-

[2]These channels are: interest rate channel, credit channel, asset price channel, exchange rate channel and expectations channel. See Mishkin (2016) for more details.

[3] See, for example, De Nicolò et al. (2010) and Buch et al. (2014a).

[4]Furthermore, recent DSGE models have different implications about the role of monetary policy on bank risk. Angeloni and Faia (2013) show that monetary expansion and a positive productivity shock increase bank leverage and risk while Zhang (2009) argue that the reverse is true.

teristics. In this context, the Global Vector Autoregression (GVAR) methodology, developed by Pesaran et al. (2004), is most suitable as it is capable of estimating possible interactions among a large set of variables by decomposing the underlying large VARs into smaller conditional models that are linked together through their cross-sectional averages while no restrictions are imposed on the dynamics of the individual sub-models.[5] The GVAR model provides a flexible means to compute the interlinkages between the variables of interest in comparison to its alternatives. For example, the Factor Augmented Vector Autoregressive (FAVAR) model, which is used the most in the literature, can summarizes the information of a large data set of variables in few factors augmented, but the economic interpretation of the extracted factors is a difficult task. Therefore, this chapter distinct itself from the existing literature by adopting a coherent global model which can address issues that have not been examined in the previous literature such as the spillover effects or heterogeneity of banks' responses to monetary policy shocks.

The chapter examines the presence of a risk-taking channel by scrutinizing the response of the ratio of banks' nonperforming loans to total loans as monetary policy changes. More formally, this chapter uses quarterly U.S. data that covers the period 1985Q1 to 2007Q4 to examine whether monetary policy influence banks' risk taking. Furthermore, this chapter investigates if there is any type of systematic heterogeneity in the way banks react to monetary policy shocks. Finally, the chapter shows how the response of one bank to an expansionary monetary policy shock is transferred among other banks in the system.

The empirical results of this chapter provide evidence that in the short-run, banks' nonperforming loans ratios moderately decline in response to an expansionary monetary policy shock. However, in the medium run, nonperforming loans ratios

[5] A fundamental problem of global models is the curse of dimensionality, which arises when the number of variables is large compared to the time dimension. To overcome the curse of dimensionality, Pesaran et al. (2004) developed a global VAR for the analysis of global interdependencies and the propagation of shocks across countries.

tend to increase for most of the banks, suggesting the prevalence of a risk-taking channel. Furthermore, the investigation shows that although in the short-run the reaction of banks to an expansionary policy shock is rather homogeneous, in the medium- and the long-run, the magnitude and the duration of banks' reactions to the shock vary. In relation to these observations, it turns out that banks' heterogeneous risk taking responses to monetary policy shocks relate to their capital structure. Furthermore, the impulse response functions results provide evidence that bank size plays an important role in the transmission of shocks (spillover effects): an adverse shock to nonperforming loans ratio of a large bank would lead to an immediate and long lasting impact on the remaining banks within the system, while no such effect is observed when the adverse shock emanates from a smaller bank.

The results present a strong co-movement amongst banks' nonperforming loan ratios and stress the importance of a healthy banking system as whole as well as at individual level. Moreover, the composition of banks' loan portfolio has a significant impact on the reaction of banks' loans to assets ratio to a monetary policy shock. The results are robust to the use of banks' Z-score as an alternative measure for banks' risk and to the use of an alternative measure of monetary policy shock.

The rest of this chapter is structured as follows. The theoretical framework and the literature review of the risk-taking channel are provided in Section 2.2 and Section 2.3 respectively. An analytical description of the methodology is presented in Section 2.4. Section 2.5 presents the data and Section 2.6 presents the model estimation. A discussion of the empirical results is given in Section 2.7. Section 2.8 concludes the chapter and suggests areas for further research.

2.2 The operative framework of risk-taking channel

The designation of the "risk-taking channel" of monetary policy first appeared in Borio and Zhu (2012) who shed light explicitly on this transmission mechanism defined as *"the impact of changes in policy rates on either risk perceptions or risk-tolerance and hence on the degree of risk in the portfolios, on the pricing of assets, and on the price and non-price terms of the extension of funding."* Borio and Zhu (2012, p. 242). Subsequently, researchers begun to establish theoretical frameworks to link monetary policy to risk taking activities by financial institutions.

Borio and Zhu (2012) suggest that there are at least three ways through which the risk-taking channel may operate when interest rates are kept low or has been declining for a long period. The first channel, which is referred to as 'search for yield' by Rajan (2006), relates to the linkages between bank manager's target return and the market rate of return. Financial institutions manage their assets with reference to their liabilities; therefore, the incentive to switch to riskier assets in a period of declining interest rates will increase. This behaviour might reflect the contractual nature of some institutions, such as, pension fund and insurance companies. These institutions are obliged to set a minimum rate of return linked to their liabilities, and in some countries, such as Switzerland, this minimum rate of return is reinforced by regulation. Financial institutions will start engaging in risky investments in order to reduce the gap between the yield on highly rated government bonds and the minimum guaranteed rate of return linked to their liabilities.

The second channel through which the risk-taking channel operates is through the impact of the interest rate on valuation, income and cash flows. This mechanism is similar but broader in spirit to the financial accelerator mechanism, by which debtors' borrowing constraints will be reduced as a result of an increase in collateral values, (see, for example, Bernanke et al., 1996; Bernanke & Gertler, 1995; N. Chen, 2001). A reduction in interest rate will lead to an increase in collateral and asset values, which in turn influences either banks' risk perceptions or risk tolerance. Risk perceptions are reduced as the increase in collateral and asset values will alter the way banks estimate risk indicators such as probabilities of default, loss-given defaults and volatilities. This is a risk taking indication as lending is driven by the behaviour of banks rather than the improvement in the debtors' collateral and repayment capacity. The fact that these risk indicators have procyclical behaviour amplifies the change in banks' risk perceptions. Risk tolerance is simply influenced by the fact that an increase in banks' wealth, as the cost of the liabilities side decreases with monetary easing, is associated with an increase in risk tolerance.

The third channel operates through the leverage affect, which is a complementary view to the search for the yield channel, as it will reinforce the initial increase in asset prices. The leverage affect view addresses the link between asset price volatility and corporate leverage, see Buch et al. (2014a). In this context, a low interest rate will boost assets prices, which will in turn reduce assets prices volatility. This reduction in volatility will cause a fall in leverage as equity prices will increase; hence banks will have more incentive to take on more risks to fill this gap. Adrian and Shin (2010, p. 419) argue that *"financial intermediaries adjusting their balance sheets actively, and doing so in such a way that leverage is high during booms and low during busts. That is, leverage is procyclical."* The overall result from the leverage and search of yield channels is a fragile banking system, which is highly sensitive to negative changes in assets values.

All three channels indicate that monetary policy easing will induce greater risk taking. However, these channels will not operate in a similar way across different banks, different banking systems, and time. Specifically, Dell'Ariccia et al. (2017) provided an analytical model which predicts that the strength of the relationship between the policy rate and bank risk taking is a function of bank's capital structure, borrowers' collateral and monitoring cost. To elaborate more on this, part of

Dell'Ariccia et al. (2017) and Buch et al. (2014a) theoretical model is used. In this model the probability of loan repayment is increasing in the intensity of monitoring. Banks' will choose an optimal level of monitoring by assessing the gains and losses from monitoring efforts. Therefore, the degree of banks' risk is linked to banks' optimal monitoring intensity q^*:

$$q^* = \frac{1}{c}[i_L - i_D(1-k) - w + ak], \tag{2.1}$$

where k is the portion of bank's assets financed by equity capital, $(1-k)$ is the deposit portion of asset, i_L is bank's revenue from loans and $i_D(1-k)$ is the share paid to depositors.[6] w is the collateral value which is exogenously given. ak is the cost of equity capital. According to Equation 2.1, q^* decreases (risk increases) in the costs of monitoring c, in the deposit rate i_D (which is fixed at the policy rate) and in collateral values w.[7] It increases in lending rates i_L and in the degree of capitalization k. In this set up the model predicts that the effect of monetary policy on banks' risk will depends on two countervailing forces, the interest rate pass through effect which increases the incentives to monitor and the risk shifting effect which decreases monitoring incentives.

The interest rate pass-through is related to the intermediation margin $(i_L - i_D)$ which will increase after a policy cut as this will lower the deposit rate. The overall effect will be an increase in bank expected return and hence reducing investments in risky assets and reducing monitoring cost. However, the pass-through effect magnitude depends on the structure of the banking system and how fast the lending rate reflects policy rate. Therefore, the pass-through effect on banks' risk will be minimal in the case of full competition, and maximal in a monopolist environment,

[6]Note that k and $(1-k)$ represent banks' only liabilities.

[7]The reason for including collateral vale in the model is because real estate market development has an impact on risk taking behaviour of banks. In this model, lending is backed up by real estate, hence and increase in the values of these collaterals as a result of monetary policy actions, will reduce the benefit from monitoring. Therefore, banks' will reduce their efforts in monitoring.

when the pass-through to the lending rate is zero.

The risk shifting force is related to the liability side of a bank's balance sheet and the degree of limited liability protection offered to the bank. If deposits are the highest portion of a bank's capital (high leverage), the bank will benefit from a reduction in policy rate, and this will increase its incentive to monitor (and hence reduce risk). However, in the case of low leverage (banks with high portion of equity capital) the gain from a higher intermediation margin is relatively modest and hence the incentive to monitor decreases (increase in risk).

Furthermore, Drechsler, Savov, and Schnabl (2018) argue that funding conditions play an important role in banks' risk taking activities. This is because the cost of taking leverage decreases (risk taking increases) when the cost of holding liquid securities is low (the liquidity premium). Therefore, risk taking activities by banks will increase in a low interest rate environment since the liquidity premium decreases when nominal interest rate is low, see Drechsler et al. (2018). The relationship between liquidity premium and risk taking is amplified by the existence of institutional friction as discussed in Acharya and Naqvi (2019). They argue that, since managerial compensation is based on lending volume, *"managers have an incentive to reach for yield by over investing in risky assets and under investing in safer assets as long as the bank has access to sufficient liquidity"*, Acharya and Naqvi (2019, p. 2).

Therefore, as the capital structure is crucial in the risk-taking channel, it is important to take into account the time by which banks are able to adjust their capital structure after a monetary policy change. In the short-run, as banks are unable to adjust capital structure, well-capitalized banks will increase risks and poorly capitalised ones will reduce risk. In the medium to the long-run banks can adjust capital easily, which will then determine banks' risk attitudes.

2.3 Empirical evidence on the risk-taking channel

The literature on the risk-taking channel is limited, due to the challenges concerning the identification strategy of the link between monetary policy stance and risk taking by banks. One of these challenges is identifying the exogenous changes in monetary policy. This is because, monetary stance is endogenous in banks' risk equation, and therefore it is difficult to identify an orthogonal shock for monetary policy. Another challenge is related to the availability of data. Assessing the link between banks' risk taking and monetary policy requires examining the supply side of credit, as this is what reflects the appetite for more risk by banks, not the change in demand for credit and the quality of borrowers in periods of low interest rate. However, only detailed bank level data can disentangle the effect of low interest rate on credit supply from its effect on credit demand. Even if this data is available, in general it will be limited to a certain types of banks' activities. For example, the Survey of Terms of Business Lending in the U.S. gives detailed information only of new commercial and industrial loans.

Empirical literature examines the risk-taking channel by looking either directly at how banks, during low interest rate periods, extend their supply of loans to riskier borrowers, or by linking the risk taking behaviour of banks to the loan rate charged to the risky borrowers compared to the rate charged to the less risky ones. Both approaches are conditional on banks' specific characteristics and the state of the economy. In particular, Jiménez et al. (2014) identify four hypotheses by which the link between monetary policy and risk taking can/should be addressed.

The first one is by identifying if banks change their lending standards when monetary policy changes. For example, engaging with borrowers who are in the past considered to be risky but now worth engaging with as their net worth has increased in a low interest rate period. A second method is to assess if banks will change the way by which they price new loans in a low interest rate period; this will make ex-post risky borrowers also worth engaging with. The third method looks at the collateral values of the borrowers. Since, after a period of low interest rates, a contractionary monetary policy will devalue the net worth of the outstanding risky borrowers. Finally, the link between monetary policy and risk taking by banks can be examined by assessing the quality of loans in banks' loan portfolios. Heterogeneity is an important factor in the analysis, as the risk-taking channel will not operate in a similar way across different banks, different banking systems, and time. The empirical examination of the first two hypotheses require access to confidential data, whereas the assessment of the last two hypothesis can be carried out using bank level data which are publicly available in most countries.

To test the first hypothesis, Jiménez et al. (2014) use confidential loan-level data from the Spanish Credit Register covering the period from 1988 to 2006. They examined the risk-taking channel by measuring banks' credit supply expansion in Spain in response to a change in monetary policy stance. Their results show that lower overnight interest rates induces less capitalized banks to grant more loan applications to ex-ante risky firms. The results indicate that these banks also commit to larger loan volumes with fewer collateral requirements to firms which have a higher ex-post likelihood of default. Jiménez et al. (2014) argue that the values of collateral and the search for yield will be higher in the medium run than in the short-run. Furthermore, in the short-run the reduction of interest rates will reduce the burden on existing borrowers, and generally in the short-run the volume of existing loans is larger than the volume of new loans. Jiménez et al. (2014) also indicate that the impact of monetary policy on banks' risk taking is not symmetric amongst all banks. Small, liquid and weakly capitalised banks take on more risk when the interest rate is low, as liquid assets hold a high cost with low return.[8]

To control for endogeneity of monetary policy and to address the first two hy-

[8]In Jiménez et al. (2014) paper, the problem of identifying the exogenous changes in monetary policy didn't arise as monetary policies in Spain were set in Frankfurt up until 1999 and within the Euro-system afterwards.

potheses discussed above, Ioannidou et al. (2015) examined the impact of the federal funds rate on the riskiness (banks' credit supply expansion) and pricing (the change in interest rate charges) of new loans granted in Bolivia between 1999 and 2003. The U.S. monetary policy will affect the Bolivian economy as the Bolivian peso during that period was pegged to the U.S. dollar, and hence a good indicator of an exogenous monetary policy will be the U.S. federal fund rate. Ioannidou et al. (2015) reported evidence that initiating loans with a sub-prime credit rating or loans to riskier borrowers with current or past non-performance become more likely when the federal funds rate is low. What is more, the results confirm that banks' risk perception also changes when the interest rate decreases, as Bolivian banks reduce the loans rate charged to risky borrowers compared to less risky ones. In the context of banks' characteristics, the results were similar to Jiménez et al. (2014) regarding liquidity, size and capital. However, Ioannidou et al. (2015) have added that banks with low funding from foreign financial institutions take on more risk due to the lack of external monitoring.

Unlike the previous two papers, Altunbas et al. (2014) used a market based risk measure to examine the link between bank risk taking and monetary policy on a sample of 643 banks in Europe and U.S. from 1998 to 2008. Banks' risk is estimated by the Expected Default Frequency (EDF) which is supplied by Moody's KMV. Their results confirm the existence of the risk-taking channel, and their findings are in line with Jiménez et al. (2014), in the sense that banks tend to grant more risky loans only in the medium run. However, in the context of banks' characteristics, their findings are contradictory to those of Jiménez et al. (2014) and Ioannidou et al. (2015). They find that liquid and well-capitalized banks are less tolerant towards new risk than illiquid and less capitalised banks. These contradictory results could be due to country specific characteristics.

The Federal Reserves Survey of Terms of Business Lending questionnaire asks banks to rate the risk of new loans to businesses based on a number of borrowers' related factors.[9] Buch et al. (2014a) used these factors to classify new loans into different risk categories and assess the riskiness of banks' loan portfolios by examining shifts across risk categories. They examine how shocks to commercial property prices and monetary policy affect the riskiness of new loans using a FAVAR model.[10] Their results indicate that there is no evidence of increased risk taking at the aggregate level of the banking system after an expansionary monetary policy shocks or an unexpected increase in housing prices. However, they argue that there are important differences across banking groups at the bank level. In particular, they show that bank risk increases for small domestic banks while it declines for foreign banks and remains unchanged for large domestic banks.

Similar to the approach used by Buch et al. (2014a), Maddaloni and Peydró (2011) also rely on answers from banks to the Bank Lending Survey for Europe and the Senior Loan Officer Survey for the U.S.. Both of these surveys request banks to provide qualitative answers (no figures are required) on the lending standards they apply to customers (supply of credit) and on the loan demand they receive (demand of credit). Maddaloni and Peydró (2011) use these information alongside securitisation activity and banking supervision standards to assess the impact of changes in the short-term and long-term interest rates on lending standards for both businesses and households. They find that banks' risk tolerance increases when the short term interest rate is low, and this increase is amplified in high securitisation activity and a weak supervision environment. However, these findings do not hold for long-term interest rate.

Buch et al. (2014b) examine the link between banks and the macro-economy for the U.S. using bank level data from the Call Reports. Data for more than 1500 commercial banks and major macroeconomics variables are used in a FAVAR

[9]These factors are: customer's credit history; the health of the customer's cash flow; credit rating; access to alternative sources of finance at favourable terms; management quality; collateral's value and liquidity; and quality of the guarantor.

[10]They include commercial property prices to capture changes in collateral values.

to analyse the dynamic impact of an identified orthogonal macroeconomic shocks (supply; demand; monetary policy; and house price) on bank's variables. They measured banks' level of risk using two different measures. The first one is the share of nonperforming loans which is a backward-looking measure and gives an overall indication of the quality of credit stock. The share of non-interest income in bank's total income is used as a forward-looking measure of risk since it gives an indication on how volatile the income of the bank is. They find that the backward-looking measure of risk tends to decline after expansionary macroeconomic (including monetary) shocks, which is contradictory to the results found in the papers discussed above. However, the forward-looking measure of bank risk increases after expansionary monetary policy shocks. Moreover, Buch et al. (2014b) findings indicate that a number of factors explains heterogeneity in individual bank's responses to macroeconomic shocks. Specifically Buch et al. (2014b, p. 716) argue that *"Bank size, capitalization, liquidity, risk, and the exposure to real estate and consumer loans matter for risk and lending responses of individual banks to monetary policy and house price shocks"*.

De Graeve, Kick, and Koetter (2008) use a combination of micro and macro data in a hazard model for bank stress and VAR model to examine the relation between monetary and financial stability. Examining the largest European economy, Germany, and data from 1995 to 2004, they find similar results to Buch et al. (2014a). In particular, they show that the average probability of bank stress increases after one year of an unexpected tightening of monetary policy. This response is not the same across all banks, as the response of small and not well capitalised banks is stronger than publicly owned banks.

The literature on the risk-taking channel of monetary policy is large and is not limited to the banking sector. For example, Hau and Lai (2016) examine the impact of a decrease in the real short-term interest rate, in eight European countries, relative to the European Central Bank (ECB) monetary policy on the investor asset allocation process in the mutual fund industry. They found that loose monetary policy encourage investors to shift their portfolio investments out of money market funds and into the riskier equity market funds.[11]

Di Maggio and Kacperczyk (2017) also study the impact of low interest rates on the reach for yield behaviour in the mutual funds industry. Specifically, they examine the response of money market funds to the low interest rate environment using weekly data on the universe of U.S. prime funds and found that these funds take on greater risk by investing in longer-maturity and riskier asset classes, even though they are designed to hold only safe, short-term assets.

Pension funds responses to changes in monetary policy are also examined in the risk-taking channel literature. Pension funds managers have the temptation to take on higher risk to reach for yield in order to avoid making larger contribution. Chodorow-Reich (2014) finds that pension funds with worse funding status or shorter liability reached for higher returns during the period 2009 to 2011, but not after that period. This increase in risk taking is necessary since funds with shorter liability have less time to make up any funding short. Similarly, Joyce, Liu, and Tonks (2017) examined the impact of quantitative easing (QE) policies on the portfolio allocation decisions of large institutional investors, specifically UK insurance companies and pension funds. They found that these institutions shift their portfolios away from government bonds towards corporate bonds, increase in risk taking, in response to the Bank of England asset purchases.

The empirical studies, related to the banking sector, discussed above have applied various models to investigate the risk-taking channel without simultaneously considering how the increase in risk in the financial system will spread. Moreover, the increase in banks' risk might be associated with many channels, not only the

[11] Money market funds are mutual funds that considered relatively safe as this type of funds invest only in short-term debt securities like U.S. Government Treasury products. Whereas equity funds are also a mutual fund, but one that primarily invests in stocks.

channel of monetary policy. In particular, the increase in risk might be due to a change in the level of activities of the economy or, more importantly, this increase might be as a result of a sector shock or a shock in a bank or a group of banks. Analysing all these points simultaneously require an advanced and comprehensive model with the possibility of including a large set of variables of different institutions. While the FAVAR can consider the empirical content of a large set of variables by means of principal components analysis, the economic interpretation and the identification of the factors is problematic. Furthermore, even though the FAVAR can accommodate a large set of variables for a single institution or country, its ability to link these institutions or countries in a global setting is not clear.

Moreover, the empirical studies discussed in the previous section have not considered how the increase in risk in the financial system will spread. The risk of contagion within the financial system became more pronounced in recent years as a result of the increased financial integration and inter-linkages.

Therefore, to provide a detailed analysis to the risk-taking channel, and to address the impact of monetary policy and macroeconomic shocks on bank's risk while accounting for possible spillover and feedback effects, a coherent global model that includes a large set of variables from many institutions is required. This chapter aims to model a number of bank specific variables over a period of time and across a number of banks, by applying the Global Vector Auto-regression (GVAR) modelling approach. This modelling approach is first proposed by Pesaran et al. (2004) and further developed by Dees, Mauro, Pesaran, and Smith (2007).

2.4 Econometric model

2.4.1 The GVAR model

The GVAR model is particularly suitable for the analysis of the transmission of real and financial shocks across countries and regions.[12] The GVAR model considered in this chapter analyses the transmission of shocks across 30 U.S. banks.[13] In this GVAR approach, i indicates a bank rather than a country or a region. More specifically, the GVAR model is built on a set of VARX* models.[14] Each model will include a vector of bank specific variables $\mathbf{x}_{it}$ (treated as endogenous), a vector of bank specific foreign variables $\mathbf{x}^*_{it}$ (treated as weakly exogenous) and a vector of observed common variables $\mathbf{d}_t$ (treated as exogenous).

Formally, considering a world of N banks indexed by i=1, 2, ...N, a typical bank specific VARX*(p_i, q_i) has the following representation:[15]

$$\Phi_i(L, p_i)\mathbf{x}_{it} = \mathbf{a}_{i0} + \mathbf{a}_{i1}t + \mathbf{\Psi}_i(L, q_i)\mathbf{d}_t + \mathbf{\Lambda}_i(L, q_i)\mathbf{x}^*_{it} + \mathbf{u}_{it} \ , \tag{2.2}$$

where L is the lag operator, $\mathbf{a}_{i0}$ is a vector of fixed intercepts and $\mathbf{a}_{i1}t$ is a vector of coefficients of the deterministic time trend, both of these vectors are of a $k_i \times 1$ dimension.[16] The vector of bank-specific idiosyncratic shocks is denoted by $\mathbf{u}_{it}$, which are assumed to be serially uncorrelated with zero mean and a non-singular covariance matrix, namely $\mathbf{u}_{it} \sim i.i.d.(0, \Sigma_{ii})$.

The matrix lag polynomial of the coefficients associated with the domestic, for-

[12] The GVAR model was initially developed as a tool for analysing credit risk in the 1997 East Asian financial crisis; many other applications of the GVAR have been adopted soon after that.
[13] di Mauro and Pesaran (2013) collect a number of empirical applications of the GVAR in one handbook.
[14] VARX*(p_i, q_i) models with weakly exogenous non-stationary variables have been introduced by Harbo, Johansen, Nielsen, and Rahbek (1998) and Pesaran, Shin, and Smith (2000).
[15] This section draws heavily from Pesaran et al. (2004) and Dees et al. (2007)
[16] The lag order of the domestic and foreign variables are selected on a bank-by-bank basis.

eign, and common variables are $\Phi_i(L, p_i) = \mathbf{I}_{k_i} - \sum_{l=1}^{p_i} \Phi_l L^l$, $\mathbf{\Lambda}_i(L, q_i) = \sum_{l=0}^{q_i} \Lambda_l L^l$ and $\mathbf{\Psi}_i(L, q_i) = \sum_{l=0}^{q_i} \Psi_l L^l$ respectively. The dimensions of these matrices $\Phi_i, \mathbf{\Lambda}_i$, $\mathbf{\Psi}_i$ are $k_i \times k_i$, $k_i \times k_i^*$ and $k_i \times g$, respectively.

The vector of bank specific foreign variables, $\mathbf{x}_{it}^*$, is specific to each bank, and represents the importance of bank i to bank j. This captures interdependence among banks, which is calculated as weighted averages of the corresponding variables for that bank. Specifically, this vector is constructed as $\mathbf{x}_{it}^* = \Sigma_{j=1}^N w_{ij} x_{jt}$, where $w_{ij} \geq 0$ is a sequence of bank specific weights with $\Sigma_{j=i}^N w_{ij} = 1$ and $w_{ii} = 0$.

The associated weights are constructed using the bilateral interbank exposure of banks. However, only aggregate data for each bank's interbank total assets and total liabilities can be observed from the Call Reports. Therefore, imposing further restrictions is needed to compute bilateral exposures as complete data on the bilateral exposure are not available. The literature suggests the use of a distribution that maximises the uncertainty of the distribution of these exposures (see, for example, Upper & Worms, 2004; Wells, 2004). In particular, banks are assumed to spread their borrowing and lending as widely as possible across all banks. This assumption implies that the exposure of bank i to bank j is increasing both with the total interbank lending of bank i and total interbank borrowing of bank j. In that sense, these exposures reflect the relative importance of each institution in the interbank market.[17]

Equation (2.2) indicates that spillover effects across banks can occur through three distinct but interrelated channels: a) direct and lagged impact of x_{it}^* on x_{it}; b) dependence of bank specific variables on common global exogenous variables (i.e. $\mathbf{d}_t$); and c) non-zero contemporaneous dependence of shocks via cross-bank covariances Σ_{ij}.

[17] The approach discussed here has been used by Upper and Worms (2004) and Wells (2004). See Section 6.1.2 in the appendix for details.

Reordering equation (2.2) yields:

$$\mathbf{A}_i(L,p_i,q_i)\mathbf{z}_{it} = \mathbf{a}_{i0} + \mathbf{a}_{i1}t + \mathbf{\Psi}_i(L,q_i)\mathbf{d}_t + \mathbf{u}_{it}, \tag{2.3}$$

where

$$\mathbf{z}_{it} = [\mathbf{x}_{it}, \mathbf{x}^*_{it}]'$$

$$\mathbf{A}_i(L,p_i,q_i) = [\Phi_i(L,p_i) - \mathbf{\Lambda}_i(L,q_i)].$$

Let $p = \max(p_i, q_i)$ and construct $\mathbf{A}_i(L,p) = \sum_{l=0}^{p} \mathbf{A}_{il}L^l$ then (2.3) can be written as

$$\mathbf{A}_{i0}\mathbf{z}_{it} = \mathbf{a}_{i0} + \mathbf{a}_{i1}t + \sum_{l=1}^{p} \mathbf{A}_{il}\mathbf{z}_{it-l} + \sum_{l=0}^{p} \Psi_{il}\mathbf{d}_{t-l} + \mathbf{u}_{it}, \tag{2.4}$$

where $\mathbf{A}_{i0} = (\mathbf{I}_{k_i} - \mathbf{\Lambda}_{i0})$, $\mathbf{A}_{il} = (\Phi_{il}, \mathbf{\Lambda}_{il})$ for $l = 1, 2, ...p$, $\Phi_{il} = 0$ for $l > p_i$ and $\mathbf{\Lambda}_{il} = 0$ for $l > q_i$. Estimation of (2.4) is the first step of the GVAR approach. The second step of the GVAR approach consists of stacking N bank specific models in one large global VAR. In particular, let $\mathbf{x}_t = [\mathbf{x}'_{1t}, \mathbf{x}'_{2t}, ...\mathbf{x}'_{Nt}]'$ and using the $(k_i + k^*_i) \times k$ link matrices $\mathbf{W}_i = [\mathbf{E}'_i, \widetilde{\mathbf{W}}_i']$, where $\mathbf{E}$ is $k \times k_i$ dimensional selection matrix so that $\mathbf{x}_{it} = \mathbf{E}'_i\ \mathbf{x}_t$ and $\widetilde{\mathbf{W}}_i$ is $k \times k^*_i$ such as $\mathbf{x}^*_{it} = \widetilde{\mathbf{W}}'_i\mathbf{x}_t$, we have[18]:

$$\mathbf{z}_{it} = \begin{pmatrix} \mathbf{x}_{it} \\ \\ \mathbf{x}^*_{it} \end{pmatrix} = \mathbf{W}_i\mathbf{x}_t. \tag{2.5}$$

Substituting (2.5) into (2.4) yields

$$\mathbf{A}_{i0}\mathbf{W}_i\mathbf{x}_t = \mathbf{a_{i0}} + \mathbf{a}_{i1}t + \sum_{l=1}^{p} \mathbf{A}_{il}\mathbf{W}_i\mathbf{x}_{t-l} + \sum_{l=0}^{p} \Psi_{il}\mathbf{d}_{t-l} + \mathbf{u}_{it} \tag{2.6}$$

[18] where $\mathbf{x}^*_{it} = \widetilde{\mathbf{W}}'_i\mathbf{x}_t, = [w_{i1}\mathbf{I}_{k1}\ w_{i2}\mathbf{I}_{k2} \cdots w_{iN}\mathbf{I}_{kN}]\,[\mathbf{x}_{1t}\ \mathbf{x}_{2t} \cdots \mathbf{x}_{Nt}]'$

and stacking these models for $i = 1, 2, ...N$, we obtain

$$\mathbf{G}_0\mathbf{x}_t = \mathbf{a_0}+\mathbf{a}_1\mathbf{t} + \sum_{l=1}^{p} \mathbf{G}_l\mathbf{x}_{t-l}+ \sum_{l=0}^{p} \mathbf{\Psi}_l\mathbf{d}_{t-l} + \mathbf{u}_t \ , \tag{2.7}$$

where $\mathbf{u}_t = (\mathbf{u}'_{1t}, \mathbf{u}'_{2t}, ..., \mathbf{u}'_{Nt})'$, and

$$\mathbf{a_0} = \begin{pmatrix} \mathbf{a}_{10} \\ \mathbf{a}_{20} \\ . \\ . \\ . \\ \mathbf{a}_{N0} \end{pmatrix}, \ \mathbf{a_1} = \begin{pmatrix} \mathbf{a}_{11} \\ \mathbf{a}_{21} \\ . \\ . \\ . \\ \mathbf{a}_{N1} \end{pmatrix}, \ \mathbf{G}_l = \begin{pmatrix} \mathbf{A}_{1l}\mathbf{W}_1 \\ \mathbf{A}_{2l}\mathbf{W}_2 \\ . \\ . \\ . \\ \mathbf{A}_{Nl}\mathbf{W}_N \end{pmatrix}, \ \mathbf{\Psi}_l = \begin{pmatrix} \mathbf{\Psi}_{1l} \\ \mathbf{\Psi}_{2l} \\ . \\ . \\ . \\ \mathbf{\Psi}_{Nl} \end{pmatrix}$$

for $l = 1, 2, ...p$. If the matrix $\mathbf{G}_0$ is invertible, then (2.7) can be written as:

$$\mathbf{x}_t = \sum_{l=0}^{p} \mathbf{F}_l\mathbf{x}_{t-l}+\mathbf{G}_\mathbf{0}^{-\mathbf{1}}\mathbf{u}_t \tag{2.8}$$

where $\mathbf{F}_l = \mathbf{G}_\mathbf{0}^{-\mathbf{1}}\mathbf{G}_l$. The GVAR model (2.8) is solved and used for the Generalized Impulse Response Functions (GIRFs) and the Generalized Forecast Error Variance Decompositions (GFEVD) analysis. The results of the GVAR model are derived using the routines, which are based on MATLAB, included in the GVAR toolbox provided by Smith and Galesi (2014).

2.5 Data

The analysis in this chapter is carried out using both macroeconomic and bank level data on a quarterly basis covering the period from 1985Q1 to 2007Q4. The data used are only up to 2007 because agency problems between the borrowers and lenders would be larger in crisis periods in comparison to normal times. Furthermore, as the framework of monetary policy has changed substantially following the global financial crisis, it is preferable to examine the presence of a risk-taking channel of monetary policy in normal conditions to capture the true relation, see Buch et al. (2014b).

The GVAR framework adopted in this chapter utilizes several bank level variables extracted from the Consolidated Report of Condition and Income. All insured commercial banks in the U.S. have to submit to the Federal Reserve in each quarter the Consolidated Report of Condition and Income, which is referred to as the "Call Reports". Bank's total loans to assets ratio (tl_{it}) is constructed, using the Call Report codes, as (rcfd1400/rcfd2170), where the numerator measures total loans and lease financing receivables net of unearned income, and the denominator is total assets.[19] Bank's return on assets (q_{it}) is used as a performance measure, which is calculated as (riad4340/rcfd2170). The ratio of nonperforming loans to total loans is the main proxy for bank risk (br_{it}), which is calculated as (rcfd1403/rcfd1407).

This chapter also uses quarterly macroeconomic variables comprised of the log of GDP (y_t) and real house prices (hp_t^r). Real house prices were measured as a ratio of the Freddie Mac Mortgage price to the GDP deflator. Data on house prices were extracted from FreeLunch.com. Data on GDP deflator were obtained from Federal Reserve Bank of St. Louis.

2.5.1 Constructing bank's level data

To carry out the investigation, bank level data is extracted from the largest 100 banks in the U.S. banking system based on bank's total assets value at the end of 2007. This chapter follows Buch et al. (2014b) in the selection criteria of the banks

[19] All codes that start with ***rcfd*** refer to consolidated (domestic and foreign offices) balance sheet items. Codes that starts with ***riad*** are related to all income statement items. See Table A1 for a full definition of the codes used in this chapter.

used in the analysis. Specifically, the analysis focuses on those banks which fully contribute to the dataset for the entire period under examination. Banks whose loan to assets ratio was greater than 1 are also removed from the dataset.[20] Furthermore, banks whose nonperforming loans to total loans ratio or return to asset ratio were in the bottom or top percentile at any point in time are eliminated.[21]

Given the screening above, the investigation focuses on 30 banks which commanded 46.0% of the total assets in the U.S. banking system in 2007 and account for 60.0% of the assets of the top 100 banks in the U.S.. Figure 2.1 shows the ranking of the banks in the sample based on bank's total assets, where the largest bank is Bank2 and the smallest bank is Bank61.[22] Table 2.2 provides further details on the 30 banks used in this chapter. The table shows that the total assets of the top two banks are around 46.0% of the sample assets, of which around 45.0% in foreign branches. Bank17 and Bank26 also hold a high percentages of their assets in foreign branches (61.0% and 64.0% respectively). The rest of banks in the sample hold almost 100% of the their assets in domestic branches. Table 2.1 shows a summary statistics for selected variables for both the sample used in this chapter and a sample that includes all of the top 100 banks. These statistics indicate that the distribution of the data do not change significantly after implementing the selection criteria discussed above.

Figure 2.2 presents the average total loans of these banks. The volumes of total loans depicted in this figure indicate that some banks have a large proportion of their assets in non-traditional bank activities. This means that our sample is quite heterogeneous as visualized by Figure 2.3, which shows the composition of loan portfolio of each bank. In fact, the theoretical model explained in Section 2.2

[20] 28 banks were not present over the entirety of our sample while three banks were found to have loan to assets ratio greater than 1.

[21] 39 banks failed to satisfy both criteria.

[22] Note that the number which follows the word "Bank" refers to the ranking of the bank among the top 100 banks according to assets values at the end of 2007. This means that Bank2 is the second largest bank in the U.S. in 2007

suggests that individual bank characteristics would play a role on the response of risk variables to monetary as well as other shocks. For instance, Dell'Ariccia et al. (2017) have provided an analytical model to show that there is a negative association between bank's risk taking behaviour and monetary policy shocks for well capitalized banks, while no such relation is observed for less capitalized banks.

2.5.2 Measuring bank risk

The literature suggests two different ways to measure banks' risk taking activities. Forward-looking measures (ex-ante measures) and backward-looking measures (ex-post measures). The expected default frequency (EDF) (see, for example, Altunbas et al., 2014; Aspachs, Goodhart, Tsomocos, & Zicchino, 2007; Castrén, Dees, & Zaher, 2008) and internal loan rating (see, for example, Jiménez et al., 2014; Buch et al., 2014a; Dell'Ariccia et al., 2017) are among the forward-looking measures that are used the most in the literature.

The EDF, which is the probability that a bank will default within a given time horizon, has the advantage of allowing for a direct assessment of how the markets perceive the effects of a transfer of credit risk impact on bank risk. The internal loan rating approach uses information on the risk rating assigned to loans by banks to measure changes in the strictness of lending criteria on new loans. This forward-looking measure of bank's risk have the advantage of distinguishing between realized risk (on existing loans) and new risk (on new loans).

A disadvantage of the forward-looking measures is the availability of the information needed to construct these measures. The EDF, which is computed by Moody's KMV using financial markets data and Moody's proprietary bankruptcy database, is only available since 1999 and only for large banks. The internal loan rating measure is based on lending surveys, such as the ECB's Bank Lending Survey (BLS) or the Federal Reserve's Senior Loan Officer Opinion Survey on Bank Lending Practices (SLOOS). These surveys are usually not available for public users. Even if such data is available, in general it will be limited to certain types of banks' activities. For example, the Survey of Terms of Business Lending in the U.S. gives detailed information only of new commercial and industrial loans. Furthermore, Dell'Ariccia et al. (2017, p. 617) argue that lending survey data *"generally indicate only whether lending standards have changed relative to the recent past, not their absolute level."*

Unlike the forward-looking measures, the backward-looking measures, such as nonperforming loans and Z-score, have the advantages of being widely available, not affected by the changes in the accounting standards and they can be constructed over a long time period, see Buch et al. (2014b). However, these types of measure are unable to distinguished new loans from outstanding loans at the time of a monetary policy shock.

Therefore, similar to Buch et al. (2014b), the share of nonperforming loans to total loans is used in this chapter as the main proxy for bank's risk (br_{it}). Total nonperforming loans equals the sum of "Total Loans and Lease Finance Receivables, Nonaccrual" (item rcfd1403) and "Total Loans and Lease Finance Receivables, Past Due 90 Days and More and Still Accruing" (item rcfd1407). This proxy indicates any changes in the overall quality of the stock of credit and allows the exploration of the relationship between monetary policy and the stability of the financial intermediaries.

Banks' Z-score is used in this chapter as an alternative proxy of bank risk. This measure, too, has been widely used in the literature (see, for example, Laeven & Levine, 2009; Foos, Norden, & Weber, 2010; Altunbas, Marqués-Ibáñez, & Manganelli, 2011). The Z-score is calculated using the ratio of banks' return on assets and its standard deviation, as well as the equity to assets ratio. This measure can be interpreted as the distance (number of standard deviations) that bank's profit has to fall for the bank to become insolvent. Therefore, it is inversely related to the probability of insolvency: the higher the Z-score is, the more stable the bank is.

The Z-score is calculated as follows:

$$Z = \frac{ROA_{it} + CAR_{it}}{Sd(ROA_{it})},$$

where ROA is the return on assets of bank i in year t (riad4340/rcfd2170), CAR is total equity over total assets of bank i in year t (rcfd3210/rcfd2170) and $Sd(ROA)$ is the standard deviation of return on assets, which is computed over a four quarter rolling window. Figure 2.4 and Figure 2.5 show the ranking of banks in the sample according to their nonperforming loans ratio and the Z-score, respectively. Even though the focus of each measure presented in these figures is different, it is worth noting that both measures yield a very similar ranking of banks.

2.5.3 Measuring monetary policy shock

One of the challenges in examining the link between monetary policy shocks and banks' risk taking behaviour is the identification of exogenous changes in monetary policy. The causal effect of monetary policy shock on banks' risk taking can only be identified if the impact of expected defaults in the banking system is isolated from changes in monetary policy. This condition will only hold if financial stability is not included in central banks' loss function.[23] However, current monetary policy and the expected default rates in the banking system are indirectly associated since the latter will be related to future economic conditions. Ioannidou et al. (2015) argue that during periods of financial uncertainty central banks tend to reduce the interest rate. Therefore, the presence of endogeneity between the proxy for monetary policy and credit risk should be controlled for in the assessment of monetary policy effects on banks' appetite towards risk.

The conventional way of measuring monetary policy shocks is by capturing the actual changes of the Federal Funds Rate (FFR). However, this approach has been

[23] After the 2008 financial crisis, the debate in the literature focuses on the balance between central banks' price stability objective and its financial stability role (see, for example, Smets, 2014; Goodhart, 2011; Cukierman, 2013)

criticized in the literature. For example, Romer and Romer (2004) argue that the actual changes of the FFR will be contaminated by the endogenous movements of the interest rate and expected actions of the Federal Reserve System (the Fed). Therefore, this measure will underestimate the impact of monetary policy on output growth, which is in turn associated with future defaults in the banking system. To overcome this problem, Romer and Romer (2004) suggest regressing the intended policy rates, the one set by the Federal Open Market Committee (FOMC), on the Fed's internal forecast of real economic activity and of inflation. These internal forecasts are taken from the Greenbook of the Fed's Board of Governors in which they produce projections of various economic indicators for the U.S. economy before each meeting of the FOMC. In Romer and Romer (2004) model, the impact of these projections are assumed to remain constant across time in the central bank's reaction function.[24]

However, Caglayan et al. (2017) and Barakchian and Crowe (2013) argue that the Romer and Romer (2004) approach will lead to biased information regarding the impact of monetary policy shocks on the target variables as it does not capture time-variation and structural breaks in the data generating process. Specifically, Barakchian and Crowe (2013) argue that policy makers have become more forward-looking over the years and that Romer and Romer (2004) measure of monetary policy shock is subject to structural breaks and time-variation. Caglayan et al. (2017) modify the approach of Romer and Romer (2004) by allowing all parameters of the eighteen variables in the Romer and Romer (2004) model to be time-variant with regime switching. Therefore, the Caglayan et al. (2017) measure will capture the exogenous changes in the FFR since it will only include the unexpected component of FFR changes as well as accounting for the forward-looking expectations of the Fed.

[24] Romer and Romer (2004) model has eighteen parameters: the desired Federal funds target prior to the FOMC meeting, the current quarter of unemployment, eight forecasts for the real GDP growth and eight forecasts for the GDP deflater.

This chapter uses the monetary policy shock constructed by Caglayan et al. (2017) since this modification is the most recent approach in measuring monetary policy shock. However, in the sensitivity analysis section, the Romer and Romer (2004) measure is used as a robustness check.

2.6 Preliminary tests of GVAR conditions

The uniqueness of the GVAR model is not just its rich results and substantial forecast power, its large cross-section and time dimensions make the GVAR model preferable to the traditional VAR model. However, Pesaran et al. (2004) stated that the GVAR model is only valid if specific conditions are satisfied. Therefore, as a prerequisite, the investigation starts by testing the order of integration of the endogenous and exogenous variables. This will be followed by an examination of the endogeity of bank specific foreign variables ($\mathbf{x}_{it}^{*}$). Furthermore, the validity of the GVAR model requires that the cross-dependence of the idiosyncratic shocks are weakly correlated. This means testing if the inclusion of the foreign variables ($\mathbf{x}_{it}^{*}$) in each bank model is successful in reducing the common correlation among all the variables in the system. Finally, the stability of the GVAR model is tested.[25]

2.6.1 Unit root test

The GVAR methodology can be applied to stationary and/or integrated variables. However, Pesaran et al. (2004) argue that to be able to distinguish between short-run and long-run relations, the variables included in the GVAR model should be all integrated of order one, $I(1)$ for short. Furthermore, $I(1)$ variables will allow to interpret the long-run relations as cointegrating. Therefore, the order of integration of all domestic, foreign and global variables series used in this chapter are examined by means of formal unit root tests. Sgherri and Galesi (2009) argue that

[25]Another condition of the GVAR validity is that the weights (w_{ij}) used to link bank's models to each other and reflect interdependence among banks are relatively small. Table A10 shows that the vast majority of the weights are not too close to one.

the traditional Augmented Dickey-Fuller (ADF) test is a powerful test only in small samples. Therefore, and for the sake of brevity, only the weighted-Symmetric Augmented Dickey-fuller (WS-ADF) test introduced by Park and Fuller (1995) is used to test all the domestic and foreign variables on levels, levels with trend, first and second differences. Whereas, both tests, (ADF) and (WS-ADF), are used for the global variables.[26]

The lag length employed in the WS-ADF and ADF unit root tests are selected by the Akaike Information Criterion (AIC) based on standard ADF regressions. The results of the WS-ADF test of the domestic and foreign variables in levels and time trend, level without time trend, first differences and second differences are shown in Table A2 and Table A3 respectively. Both tables indicate that the hypothesis of a unit root for most of the variables cannot be rejected.

Furthermore, Table A4 shows the output for panel unit root test. The test which is implemented in Table A4 is the Levin–Lin–Chu test Levin, Lin, and Chu (2002), where the null hypothesis is that panels contain unit roots, and the alternative is that *all* panels are stationary.[27] The table shows that we can not reject the null hypothesis for the levels with trend and levels without trend of the variables. However, the null hypothesis is rejected for the first difference of the data meaning that there are no unit roots in the panels once the first difference is considered ensuring that the variables included in the GVAR model are all integrated of order one, $I(1)$.

2.6.2 Exogeneity test

A vital assumption in the estimation of individual bank VARX$^*(p_i, q_i)$ model is the weak exogeneity of bank specific foreign variables ($\mathbf{x}^*_{it} = [br^*_{it}, q^*_{it}, tl^*_{it}]$). The weak

[26]Note that Leybourne, Kim, and Newbold (2005) and Pantula, Gonzalez-Farias, and Fuller (1994) also show that the WS ADF test outperforms both the traditional ADF and the GLS-ADF test proposed by Elliorr, Rothenberg, and Stock (1996).

[27]Levin et al. (2002) recommend using their procedure for moderate-sized panels (between 10 and 250 unit and 25 to 250 observations per unit).

exogeneity assumption implies that there is no long-run feedback from bank-specific domestic variables ($\mathbf{x}_{it}$) to the bank-specific foreign ($\mathbf{x}^*_{it}$), without ruling out any lagged short-run feedback between these variables, see Hiebert and Vansteenkiste (2010). If the weak exogeneity assumption is not rejected then $\mathbf{x}^*_{it}$ is said to be a "long-run forcing" for $\mathbf{x}_{it}$, which implies that the disequilibrium error does not have any information about the marginal distribution of $\mathbf{x}^*_{it}$. A formal test for the weak exogeneity of bank-specific foreign variables is implemented by testing the joint significance of the estimated error correction terms in the marginal models of the foreign variables. In particular, for each variable ℓ of $\mathbf{x}^*_{it}$ the following regression is carried out:

$$\begin{aligned}\Delta x^*_{it,\ell} = c_{i0,\ell} + \sum_{j=1}^{r_i} \delta_{ij,\ell} ECM^j_{i,t-1} + \sum_{s=1}^{p^*_i} \phi'_{is,\ell} \Delta \mathbf{x}_{it-s} + \sum_{s=1}^{q^*_i} \theta'_{is,\ell} \Delta \mathbf{x}^*_{it-s} + \\ \sum_{j=0}^{j=1} \psi_{ij,\ell} \Delta \mathbf{d}_{t-j} + u_{it,\ell},\end{aligned} \tag{2.9}$$

where $ECM_{ij,t-1}$, $j = 1, 2, ...r_i$, are the estimated error correction terms associated with the r_i cointegrating vectors found for bank i. In Equation 2.9 p^*_i and q^*_i are the orders of lagged changes of domestic and foreign variables; ($\mathbf{x}_{it}$) and ($\mathbf{x}^*_{it}$), respectively.[28] The test for weak exogeneity is an F-test of the joint hypothesis that $\delta_{ij,\ell} = 0$, for $j = 1, 2, ..., r_i$ in Equation 2.9.

Table A5 reports the 5% critical values and test statistics for all foreign variables ($\mathbf{x}^*_{it}$).[29] The F-test results show that the weak exogeneity assumption is not rejected for most of the foreign and global variables at the 5% significant level. Most of the studies that use the GVAR approach find that some variables fail to satisfy the

[28] Note the specification of marginal model in Equation 2.9 is independent of the conditional VARX* model in (2.2). Therefore, the lagged orders p^*_i and q^*_i are not necessarily the same as the p_i and q_i of bank specific VARX*(p_i, q_i).

[29] The table also includes the results of the global variables $\mathbf{d}_t = [rr_t, y_t, hp^r_t]$

weak exogeneity assumption (see, for example, Sgherri & Galesi, 2009; Hiebert & Vansteenkiste, 2010; Cashin, Mohaddes, Raissi, & Raissi, 2014). Similar to these studies, Table A5 also shows that the weak exogeneity assumption cannot be rejected for the overwhelming majority of the variables considered in this chapter. Specifically, only 21 out of 180 exogeneity tests reported to be statistically significant at the 5% level.

2.6.3 Average pair-wise cross-sectional correlations

Another assumption of GVAR modelling is that idiosyncratic shocks of the individual banks models are cross-sectionally weakly correlated. Such as the covariance between the weakly exogenous foreign specific variables and the idiosyncratic error term should converge to zero, $Cov(u_{it,\ell}, \mathbf{x}^*_{it}) \rightarrow 0$, as the number of banks approaches infinity $N \rightarrow \infty$.

The average pair-wise cross-sectional correlations are computed to see whether foreign variables are effective in reducing the cross-sectional correlation of idiosyncratic shocks across all variables in the GVAR. Specifically, the average pairwise cross-sectional correlation for the level and the first differences of the endogenous variables in the model and the associated residuals are computed.[30] This approach relates to the cross-sectional dependence test proposed in Pesaran (2004). In particular, conditioning the bank specific models on foreign variables, the remaining correlation across banks is expected to be small. Specifically, Sgherri and Galesi (2009, p. 9) argue that *"Our purpose is thus to obtain simultaneously weakly correlated residuals in the system, such that, in the context of the dynamical analysis of the model, our simulated shocks would be potentially idiosyncratic."*

[30]In particular, the computations, both in levels and in first differences, are the average pair-wise correlation of bank-specific variables. For example, the average pair-wise correlation of the risk of bank i is given by: $\overline{br}_i = \frac{1}{N}\sum_{j=1}^{N} \rho_{ij}(br)$ where $\rho_{ij}(br)$ is the correlation of the risk of bank i with the risk of bank j, N is the number of banks included in the sample. The residuals are obtained after estimating all bank-specific VARX$^*(p_i, q_i)$ models.

Table A6 presents the average pair-wise cross sectional correlations for the level and the first difference of the endogenous variables in the model, as well as the associated model's residuals. Results show that the average cross sectional correlation is generally high for the level of endogenous variables and declines for the first difference and the estimated VARX* residuals. In particular, the highest cross-sectional correlation is observed for the level of nonperforming loan ratios of large banks. This observation is consistent with the view that nonperforming loans ratio reflects changes in the underlying macroeconomic environment. Whereas the return on assets and loans to assets ratios show a lower correlation.[31] This finding suggests that changes in return on assets and loan to assets ratio reflect changes in bank behaviour concerning managerial and policy preferences.

However, when the first difference of the variables are considered, the degree of correlation for all the variables under study fall. Furthermore, the cross-sectional correlations for the residuals for all VARX* models are near zero, indicating that the model is successful in capturing the common effects among the variables. Moreover, these results show the importance and usefulness of modelling the bank specific foreign variables, as confirmed by the size of the bank residual correlations.

2.6.4 Stability of the GVAR model

Another condition stated by Pesaran et al. (2004) is that the GVAR model has to be dynamically stable, and this can be checked by analysing the eigenvalues of the system. In particular, the theorem developed by Pesaran et al. (2004) states that the rank of the cointegrated matrix in the GVAR model should not exceed the number of cointegrating relations in all the individual banks' models. In principle, if there are k variables and the cointegration test suggest r cointegrating relations, then there should be $k-r$ unit eigenvalues and the remaining eigenvalues should have modulus strictly less than one. The GVAR model in this chapter has 93 endogenous variables

[31] Similar results are found by Sgherri and Galesi (2009) who analysed credit growth using data from several countries.

in total and the total number of cointegrated relations is 60. Table A7 shows that indeed there are 33 eigenvalue on the unit circle and the remaining eigenvalues have moduli less than unity and we can conclude that the model is stable.

2.7 Empirical findings

Given that all the requirements of the GVAR model are met and that most of the variables have a unit root, each bank-VARX* model is estimated individually in its vector error-correcting form VECMX*. The results of the GVAR model are discussed in the following steps.

Firstly, the findings from the dynamic analysis of the GVAR model are presented using the Generalized Impulse Response Functions (GIRFs) to several shocks. This will start by analysing the impact of an expansionary monetary policy shock on a number of variables. Subsequently, the spillover effects that may emerge due to global shocks or due to shocks emanating from specific banks will be analysed. In particular, the GIRFs analysis presents details on spillover effects arising from a shock from the largest and the smallest banks. These findings are further confirmed using banks' Z-score, as an alternative measure of bank's risk and the Romer and Romer (2004) measure as an alternative monetary policy shock measure.

Secondly, the coefficient estimates of the contemporaneous foreign variables ($\mathbf{x}_{it}^*$) on their bank specific counterparts are obtained using the estimation of each bank-VECMX* model. These estimates measure by how much a domestic variable changes as a result of a one percentage change in the foreign-specific counterpart. Results of the Generalized Forecast Error Variance Decompositions (GFEVD) which capture the linkages among the banks are discussed last.

2.7.1 Generalized impulse response functions analysis

To analyse the dynamics and interdependencies, both on impact and over time, among different banks and across different variables, this chapter relies on the results of the GIRFs. The GIRFs are first proposed by Koop, Pesaran, and Potter (1996) and further developed by Pesaran and Shin (1998) as an alternative to the Orthogonalised Impulse Responses (OIR) of Sims (1980). The main advantage of the GIRFs over the OIR is that the former are invariant to the ordering of the variables and of the banks in the GVAR model. This is very important consideration given that one could argue for a specific ordering of the variables included in each bank model, but it would be difficult to justify how banks are ordered in the GVAR based on economic intuition.

Another advantage of the GIRFs is that it follows the idea of nonlinear impulse response function and computes the mean impulse response function by integrating out all other shocks. Specifically, Vansteenkiste (2007, p. 17) argue that *"The OIR approach requires the impulse responses to be computed with respect to a set of orthogonalised shocks, whilst the GIR approach considers shocks to individual errors and integrates out the effects of the other shocks using the observed distribution of all the shocks without any orthogonalisation."*

Therefore, the GIRFs are used to present the time profile of the impact of shocks to exogenous variables and the spillover effects. In particular, the following innovations are simulated: 1) the impact of an expansionary monetary policy shock on banks' nonperforming loans ratios, return on assets and loan to assets ratio.[32] 2) The impact of a positive global shock on banks' nonperforming loans ratios.[33] 3) The impact of a positive shock that emanates from a large and a small bank on the rest of the banks' in the system.

[32] An expansionary monetary policy shock implies a negative change (i.e. a decrease) of the interest rate.
[33] A positive shock to nonperforming loans ratio implies an increase in nonperforming loans.

Impulse response to an expansionary monetary policy shock

The focus of this section is on the effect of a negative interest rate shock (expansionary monetary policy) on banks' risk taking behaviour. The behaviour of bank's nonperforming loans ratio is examined in reference to a downward movement in policy rate rather than an upward movement because the risk variables are more sensitive to downward movement, see Lopez, Tenjo, and Zarate (2011).

Response of nonperforming loans ratio

In line with the theoretical model explained in Section 2.2, an expansionary monetary policy shock has a significant impact on the main risk indicator, nonperforming loans ratio. Figure 2.7 shows that, in the short-run, nonperforming loans ratio of all banks generally decline in response to a downward one standard deviation shock to monetary policy. However, this initial response reverses in the medium run as nonperforming loans begin to increase for most banks. In particular, Figure 2.7 indicates that banks' nonperforming loans, i.e. bank risk, increase after the fourth quarter following the expansionary monetary policy shock. This reversal is considered as evidence in favour of the bank risk-taking channel (see, for example, Altunbas et al., 2011; Lopez et al., 2011; Castrén, Dées, & Zaher, 2010; Jiménez et al., 2014).

The dynamics of nonperforming loans ratio can be explained as follows. As the collateral and assets values of potential borrowers increase following an expansionary monetary policy shock, banks extend credit to credit worthy as well as risky borrowers. In the short-run, all new borrowers are expected to pay the interest charge on the loans given the low rates. As a result, a drop in nonperforming loans ratio is expected when the interest rate declines due to the reduction of the interest burden on existing borrowers. However, in the long-run, as interest rates increase, coupled with the competitive nature of the business environment, it is expected that a fair number of riskier borrowers would fail to comply with their commitments rendering an increase in nonperforming loans ratio.

It should be noted that the reaction of nonperforming loans ratio to the monetary policy shock varies across banks. The heterogeneity of bank response to a monetary policy shock is consistent with the theoretical predictions explained in Section 2.2. To that end, Dell'Ariccia et al. (2017) argue that in the medium to the long-run, the response of bank risk to a monetary policy shock is driven by two countervailing forces, which are related to the capital structure of the bank. In particular, due to limited liability there is the risk-shifting effect, which increases the probability of monitoring after a decrease of the policy rate. Alternatively, there is the pass-through effect, which decreases the incentive to monitor due to declining profits following a decrease in the lending rate. The relative strength of these two forces depend on the extent of bank capitalization. For low level of capitalisation the former will dominate the latter effect and lead to a lower level of nonperforming loans. This is because low policy rates will increase the intermediation margin. Thus banks with high levels of leverage have an incentive to increase monitoring to realize expected returns from higher margin. However, for banks with high levels of capital, the pass-through effect will dominate leading to an increase in the level of nonperforming loans.

In the light of this discussion, banks with higher deposits in their capital structure would exhibit low risk (for instance Bank2, Bank13, Bank26, Bank33 and Bank61), whereas, banks with high equity capital ratio (for instance Bank5 and Bank7) would show stronger and higher increase in nonperforming loans ratio. Figure 2.6 plots banks' average equity capital ratios.

It is not possible with the data set used in this chapter to make a firm conclusion that the increase in risk is driven by the change of banks' behaviour towards risk taking (supply side). However, the heterogeneity across the banks in the sample in the response to a monetary policy shock, can be interpreted as a supportive point to the supply driven argument (see, for example, Kashyap & Stein, 1995; Angeloni et al., 2015).

Response of return on assets

Figure 2.8 depicts the response of return on assets to an *expansionary* monetary policy shock. Theoretical predictions suggest that return on assets would increase in the short-run but fall in the medium horizon, see Buch et al. (2014b). This is consistent with the results observed in Figure 2.7 where nonperforming loans ratios decrease in the short-run but increase in the medium run. As a consequence, return on assets increases initially, as nonperforming loans ratios decline. However, in the medium run, as the level of nonperforming loans increase, return on assets declines.

It is useful to recall that, through a negative change of the policy rate, the aim of policy makers is to achieve higher economic growth and lower unemployment by inducing businesses to increase their fixed investment expenditures. However, bank's level data that are examined in this chapter indicates that expansionary monetary policy shocks can introduce a certain fragility into the financial system evidenced by declining return on assets and increasing nonperforming loans in the medium to long-run. This observation is in contrast with the initial objectives of the policy makers and suggestive for the prevalence of the risk-taking channel.

Response of loans to assets ratio

The response of loans to assets ratio to monetary policy shock is well documented in the literature theoretically and empirically (see, for example, Altunbas et al., 2011; Angeloni et al., 2015; Buch et al., 2014b). In line with the credit channel of monetary policy, loans are expected to increase immediately after an expansionary monetary shock before they start to decrease in the long-run Buch et al. (2014b). Moreover, the long-run real neutrality of monetary policy suggests that expansionary monetary policy shocks lead to a rise in economic activity which will in turn increase the demand and supply of loans.

However, Figure 2.9 shows that not all banks react in the way theory predicts, in fact some banks decrease loans immediately after the shock (Bank7, Bank30, Bank38 and Bank58). On the other hand, other banks increase loans immediately after the shock and decrease them in the medium run (for example, see Bank11, Bank13, Bank 21 and Bank51). However, when looking at the impulse response functions with reference to bank's loan portfolio composition shown in Figure 2.3, an interesting pattern can be observed. The immediate increase and then decrease in loans is mostly observed in banks with commercial loans being relatively a large component of their loan portfolio (Bank13, Bank21, Bank26, Bank54 and Bank59). However, the opposite is observed in banks where consumers and real estate loans are the largest share of their total loans (Bank7, Bank30, Bank38 and Bank58). These results contradict Den Haan, Sumner, and Yamashiro (2007) findings that commercial and industrial loans increase after a monetary tightening while consumer loan increase.[34]

A possible explanation to the increase in commercial loans is related to the change in the supply from banks' side. Commercial loans are considered to be short term loans, so banks alter the volume of these loans to adjust the structure of the risk weighted assets or to optimize the credit portfolio return. Hence banks meet the capital regulation; specifically if one considered the adverse effect of change in monetary policy on banks' interest revenue. Moreover, banks also change their supply of consumer and real estate loans as a result of changes in monetary policy. The reason for this change is related to the stickiness of the rate of consumer loans. This means that the spread banks can charge on consumer loans cannot be altered quickly after a monetary policy shock, making other loans more attractive for banks. Therefore, it is expected to observe a decrease in these types of loans after a negative monetary policy shock as a results of banks' substituting out these loans with more attractive loans, such as commercial loans.

It is difficult to form a concrete conclusion regarding the interaction between monetary policy and loan components with the results observed in Figure 2.9. This is

[34]This might be related to the measure of monetary policy shock used, as Den Haan et al. (2007) measure is based on the innovations in the federal funds rate.

because this chapter examines the impact of monetary policy on loans to assets ratio (an aggregate measure) and uses portfolio composition to aide the interpretations. In Den Haan et al. (2007), the authors used individual series for each component of the loans portfolio composition (commercial, consumers and real estate loans). However, the discussion above shows how informative it is to study the behaviour of loan components as they might have different laws of motion. According to Den Haan et al. (2007, p. 905), *"if the micro components of a variable have different laws of motion, then the impulse response function of the aggregate variable may hide useful information about the role that these micro components play in the monetary transmission mechanism"*.

2.7.2 Spillover effects: Global *versus* bank specific shocks

An important question that policymakers would seek an answer to is whether there is evidence of spillover effects of credit risk within the banking system. To examine the possibility of spillover effects this chapter follows two routes. Initially, following Dees et al. (2007), a global bank risk shock is generated, which is defined as the weighted average of specific shocks across all banks, to examine its impact on nonperforming loans ratio of individual banks. Results, which are shown in Figure 2.10, do not provide clear evidence of spillover effects due to global shocks. For some banks (Bank13, Bank17 and Bank53), following the global shock, there is evidence that the risk is increasing but for some others there are no such effects.

Another way of examining spillover effects is to investigate the impact of an adverse shock emanating from an individual bank to the rest of the system. The results of these shocks show evidence that risk could spillover through the financial system. To that end, this chapter provides details for the case of a shock that emanated from a large bank, Bank3, and that from a small bank, Bank61. It should be noted that in terms of assets, Bank3 is on average ten times larger than Bank61. Furthermore, based on the Z-score and nonperforming loans ratio, it turns out that

Bank3 is one of the riskiest bank whereas Bank61 can be considered as one of the least risky banks in this sample.

Figure 2.11 and Figure 2.12 portray the response of banks to a positive shock to the nonperforming loans ratios of Bank3 and Bank61 (i.e. large and small banks), respectively. Figure 2.11 shows that the nonperforming loans ratio of banks increase significantly when an adverse shock emanates from Bank3. The magnitude of the response is not homogeneous across all banks, some banks show a strong and significant response (Bank13, Bank17 and Bank42) while others show a mild but long lasting response (Bank2, Bank3, Bank6 and Bank59). In some cases nonperforming loans ratio decrease after about a year (Bank38, Bank54 and Bank56). In contrast, Figure 2.12 provides evidence that the remaining banks in the system are not affected significantly when a similar type of shock emanates from Bank61.

The presence of spillover effects from a large and risky bank to the rest of the banks in the system should be of concern to the policy makers. Given these findings, there is a firm basis for regulators and policy makers to closely monitor large banks, as managers' of larger banks have the tendency to approve loans to riskier borrowers. This mechanism is amplified by the fact that risky borrowers are charged a higher rate, see Buch et al. (2014b). Were the interest rates to increase unexpectedly, these banks may end up with substantial amounts of nonperforming loans, affecting the whole of the banking system. Furthermore, if these banks are considered to be *too big to fail*, their managers would not refrain from lending to riskier borrowers in search for higher yield when they believe that the bank would be rescued by the Fed. As a consequence, risk taking behaviour of large risky banks could ultimately yield a financial system which is open to systemic failures.

2.7.3 Sensitivity analysis

To check the robustness of the findings, the analysis is repeated replacing nonperforming loans ratios with banks' Z-score as a measure of risk. Overall, this alternative risk proxy provides similar findings. In particular, Figure 2.13 plots the response of the Z-score to an *expansionary* monetary policy shock.[35] The figure shows an immediate and significant decline of the Z-score of several banks (Bank2, Bank19, Bank53, Bank54 among others) following the monetary policy shock. The decline in banks' Z-score is considered as an evidence in favour of the risk-taking channel. Interestingly, the Z-score is found to be increasing for four of the banks in the sample (Bank13, Bank25, Bank30 and Bank58), suggesting that bank risk for these institutions reduces when the monetary policy is relaxed. Among these four banks, only Bank13 is relatively large.

When banks' Z-score is used as an alternative measure of bank risk to examine the spillover effects, the results remain similar to the findings of nonperforming loans. In particular, Figure 2.14 plots the impulse responses of banks' Z-score to a shock emanating from Bank3 (large bank). The figure indicates that bank risk increases for a large fraction of banks in the system (the Z-score declines). However, an inspection of Figure 2.15, which displays the results of the same experiment using Bank61 (the smallest bank) as the source of the shock, do not indicate to any significant response from the rest of the banks that are included in the sample of this chapter.

Note that an investigation of the spillover effects from Bank13, whose Z-score increased (declining risk) in response to an expansionary monetary policy shock (see Figure 2.13) is also considered in this chapter. Figure 2.16 shows that an adverse shock to the Z-score emanating from this bank does not have any impact on the rest of the banks in the sample. This is in line with prior expectations, as Bank13 has a low risk structure. Overall, this is a useful exercise because it shows that being large is not the real reason why a bank would affect the health of the financial system but its capital structure and riskiness.

[35] The Z-score is inversely related to the probability of insolvency: the higher the Z-score is, the more stable the bank is. See Section 2.5.2

The results found in this chapter are also robust to the use of an alternative measure of monetary policy shock. Specifically, the Romer and Romer (2004) measure of monetary policy shock is used to repeat the results found in Figure 2.7. In particular, Figure 2.17 plots the response of nonperforming loans ratio to an *expansionary* monetary policy shock using the Romer and Romer (2004). The figure clearly shows that banks' nonperforming loans rations behave in the same way that found in Figure 2.7. One notable observation from comparing the two figures is that the response of banks' nonperforming loans ratios is more pronounced in the short-run when using the main measure of policy rate shock (see Figure 2.7), whereas it is the medium run reaction that is more pronounced when the Romer and Romer (2004) measure is used.

2.7.4 Impact elasticity

Table 2.3 provides the contemporaneous effect of the foreign (starred) variables on their domestic (bank level) counterparts, which can be interpreted as the impact elasticity of the starred variables on the domestic variables. The information presented in this table is particularly informative in describing the co-movements among variables across different banks which are examined in this chapter. Most of these elasticities are significant and high in magnitude. In particular, the elasticity of bank risk captured through nonperforming loans ratio (br_{it}) is found to be significant in more than 60.0% of the sample and mainly for larger banks. This is an indication to the presence of relatively strong co-movements across banks' nonperforming loans ratios. Using Bank2 as an example, a 1% increase in nonperforming loans ratio of foreign banks (br^*_{2t}), weighted by the importance of these banks in Bank2's nonperforming loans ratio, will lead to a 2.7% increase in nonperforming loans of Bank2 (br_{2t}). According to Sgherri and Galesi (2009, p. 11) *"impact elasticities greater than one indicate that the domestic variable overreacts to a variation in real equity prices of its financial partners, while the opposite holds when impact elasticities are lower than one"*. Therefore, this finding, can be considered as *prima* *facie* evidence of spillover effects across banks in the sample of this chapter.

Table 2.3 also shows that for a considerable fraction of banks there is high elasticity of bank's return on assets (q_{it} and q^*_{it}) implying strong co-movements between bank specific and foreign measures of return on assets. Moreover, when total loan to assets ratio are examined, the results indicate to a mild and negative elasticity (tl_{it} and tl^*_{it}), which are significant only for a few banks.

In general, the statistical significance and magnitudes of these impact elasticities provide further confirmation of the findings of the (GIRFs) found in the previous section. Specifically, the strong co-movements among nonperforming loans ration variables across different banks further confirms the synchronization of the GIRFs associated with changes in nonperforming loans rations.

2.7.5 GFEVD

This chapter further examines the linkages among the banks under study by means of GFEVD. In doing so, the forecast error variance of the simulated historical shock is allocated into its respective variables and banks. The importance of the innovation of a given bank's variable to the rest of the banks' variables is measured by the relative contributions of each bank to the explanation of the forecast error variance of the historical shock. The sum of these contributions does not add up to unity, due to the existence of contemporaneous correlations among innovations (non-zero covariance), see Pesaran and Shin (1998). Although the contributions of each bank to the forecast error variance of the historical shock cannot be considered as proportions, GFEVD remain a useful device to study the transmission channels through which banks' shocks are systematically propagated.

Results of the GFEVD are reported in Section 6.1.1. Specifically, a one unit positive standard error shock to Bank2 (a large bank) and Bank61 (a small bank) nonperforming are shown in Table A8 and Table A9, respectively. Following the historical shock to the global nonperforming loans ratio of Bank2, most of the forecast error variance in the short-run is explained by Bank2 variables; however, the share decreases over time. Large banks' nonperforming loans are also an important determinant of the forecast error variance of Bank2 nonperforming loans, suggesting that there are strong financial linkages within large banks in the sample. For example, on impact, Bank3 contributes for 11.7 percent of the variance of the historical shock. However, the relative contribution of nonperforming loans decreases over time. In contract, the contribution of total loans to assets ratio in explaining the forecast error variance increases overtime. For example, after four quarters, Bank2 total loans to assets ratio contributes 9.7 percent to the explanation of the forecast error variance. The influence of the global variables (GDP, monetary policy shock and house prices) also increase over time. For example, the contribution of interest rate is stronger after four quarters, explaining about 6.5 percent of the forecast error variance, while the GDP and house prices explain 2.5 and 2.8, respectively.

Table A9 presents the results relating to Bank61, a smaller bank. The results reveal that the linkages with other banks are less pronounced but there is greater influence from global variables. The forecast error variance of Bank61 is mainly explained by its own nonperforming loans and by those of the top two banks. Unlike the case of Bank2, monetary policy shock seems to have greater influence on smaller banks and this influence increases over time. For example, the contribution of monetary policy shock after one quarter is about 21.3 percent of the forecast error variance, while the GDP and house prices explain 2.6 and 2.1, respectively.

In general, these results suggest that larger banks are more linked to each other and to the rest of the banks, while smaller banks being independent and not largely influence by the other banks. However, the results show that the contribution of monetary policy shock to the smaller bank's nonperforming loans variance is much larger than its contribution to the variance of nonperforming loans of larger banks, which might suggest that large banks hold greater market power and funding advantages than smaller banks.

2.8 Conclusion

The 2008 financial crisis has led us to see that an integrated macroprudential regulation requires that the monetary authority's responsibilities may have to be extended beyond price stability and aggregate demand to encompass financial stability. Yet the previous literature on the link between policy rate and risk taking by banks is limited.

This chapter exploited information on the view that expansionary monetary policy shock increases the incentive of banks to take on more risk through using a GVAR model. Specifically, the chapter used the GVAR framework to investigate three interrelated questions concerning the risk-taking channel of the monetary transmission mechanism. The first one was to test the impact of a downward exogenous change of policy rate on banks' risk taking activities, profitability and lending behaviours. The second question was related to the heterogeneity of banks' risk taking response to exogenous monetary policy shocks. The final question was related to whether there are spillover effects following global and bank specific shocks to the measure of bank's risk. These issues are relevant and important to both monetary policy authorities and academic circles as the findings showed that central banks can inadvertently destabilize the functioning of the financial markets.

The findings of this chapter provided further evidence in support for the presence of an active risk-taking channel in the U.S.. In particular, the results showed that banks' risk taking behaviours, in response to a monetary expansion, was more pronounced for large, well capitalized banks. This observation is consistent with Dell'Ariccia et al. (2017) who discussed the role of capital structure in relation to banks' risk taking behaviour.

The impulse response function presented clear evidence of spillover effect of risk, as shocks originating from larger and riskier banks had lasting effects on the whole system. Larger banks that tend to have more nonperforming loans will persist in lending to risky borrowers, and this mechanism is amplified by the fact that risky borrowers are charged a higher rate, Buch et al. (2014b). The results presented a strong co-movement amongst banks' nonperforming loan in the sample and stress the importance of a healthy banking system as whole as well as at individual level.

Regarding the behaviours of the banks' loans to assets ratio after a monetary policy shock, the empirical results of this chapter shed light on some important characteristics. Generally, loans are expected to increase immediately after an expansionary monetary shock before they start to decrease. However, the results indicated that mostly banks with commercial loans being the largest component of their loan portfolio increased their total loans to assets ratio initially but decreased it in the medium to the long-run. The opposite was observed in banks where consumers and real estate loans were the largest share of their total loans portfolio.

The results relating to the reaction of the ratio of the return on assets to expansionary monetary policy shocks showed that these shocks can introduce a certain fragility into the financial system as the return on assets declined in the medium to the long-run. This is an important observation since policy makers aim from lowering interest rate is to achieve higher economic growth and lower unemployment.

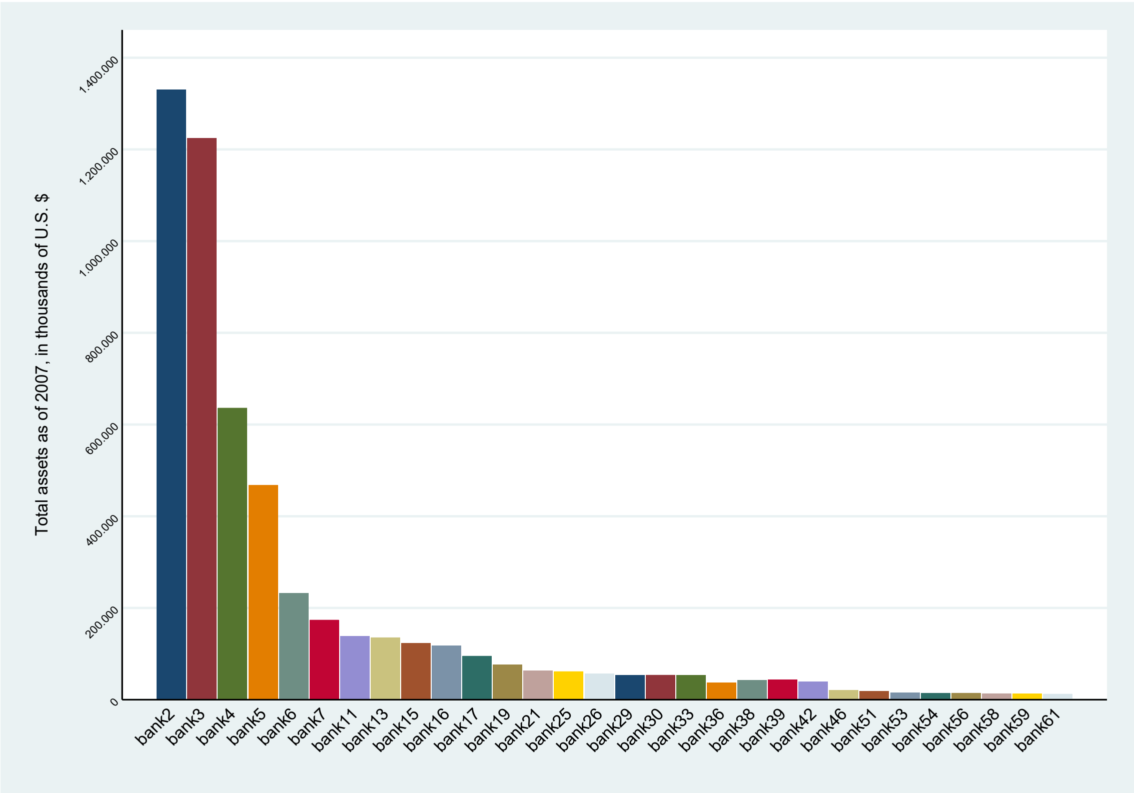
The statistical significance and magnitudes of the impact elasticities of the foreign (starred) variables on their domestic (bank level) counterparts provided a further confirmation to the presence of relatively strong co-movements across banks' nonperforming loans ratios. These co-movements were also confirmed in the results of the variance decompositions of the nonperforming loans ratio. The GFEVD results suggested that larger banks were more linked to each other and to the rest of the banks in our sample, while the smaller banks being independent and not largely influence by the other banks. The contribution of monetary policy shock to smaller banks' nonperforming loans variance was much larger than its contribution to the variance of nonperforming loans of larger banks.

These results were robust to the use of two alternative bank risk measures; nonperforming loans and the Z-score. Moreover, the results were also robust to the use of Romer and Romer (2004) measure as an alternative proxy of the monetary policy shock provided by Caglayan et al. (2017).

The evidence presented in this chapter supports the view that monetary policy affects the risk taking behaviours of financial intermediaries. In particular, while large banks' managers feel safe due to being *too big to fail*, their search for high yield could sow the seeds of the next financial crisis. In this respect, given that standard monetary policy rules ultimately affect the financial markets through several drivers such as credit, liquidity and risk taking, policymakers should not ignore but monitor the stability of the financial intermediaries. In fact, as the debate goes on, many countries which were effected by the global financial crisis have already begun to implement macroprudential policies to prevent the build up of financial imbalances and to ensure that the financial system is resilient to shocks. More research along these lines is needed.

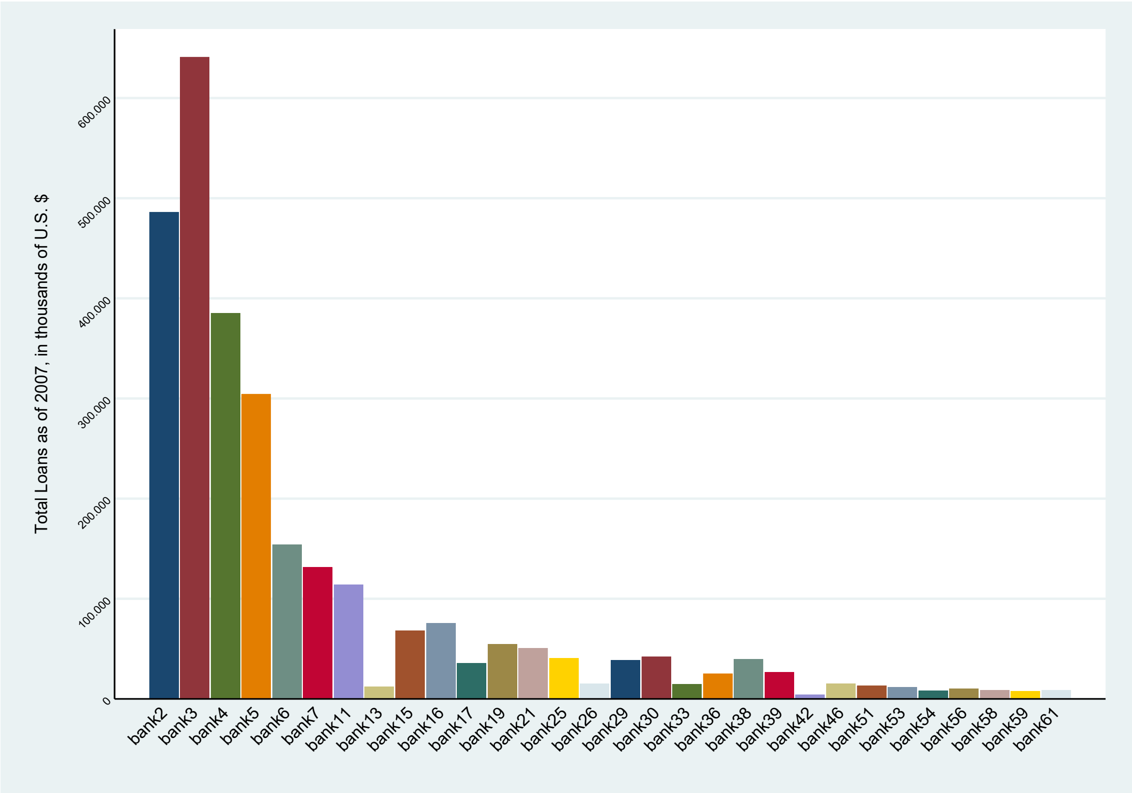
2.9 Figures

Figure 2.1: Banks' ranking according to assets size



Notes: The above figure shows the ranking of the 30 banks used in this chapter according to assets size as of 2007. The information used to construct the figure is based on the "rcfd2170" call report item code.

Figure 2.2: Banks' average total loans

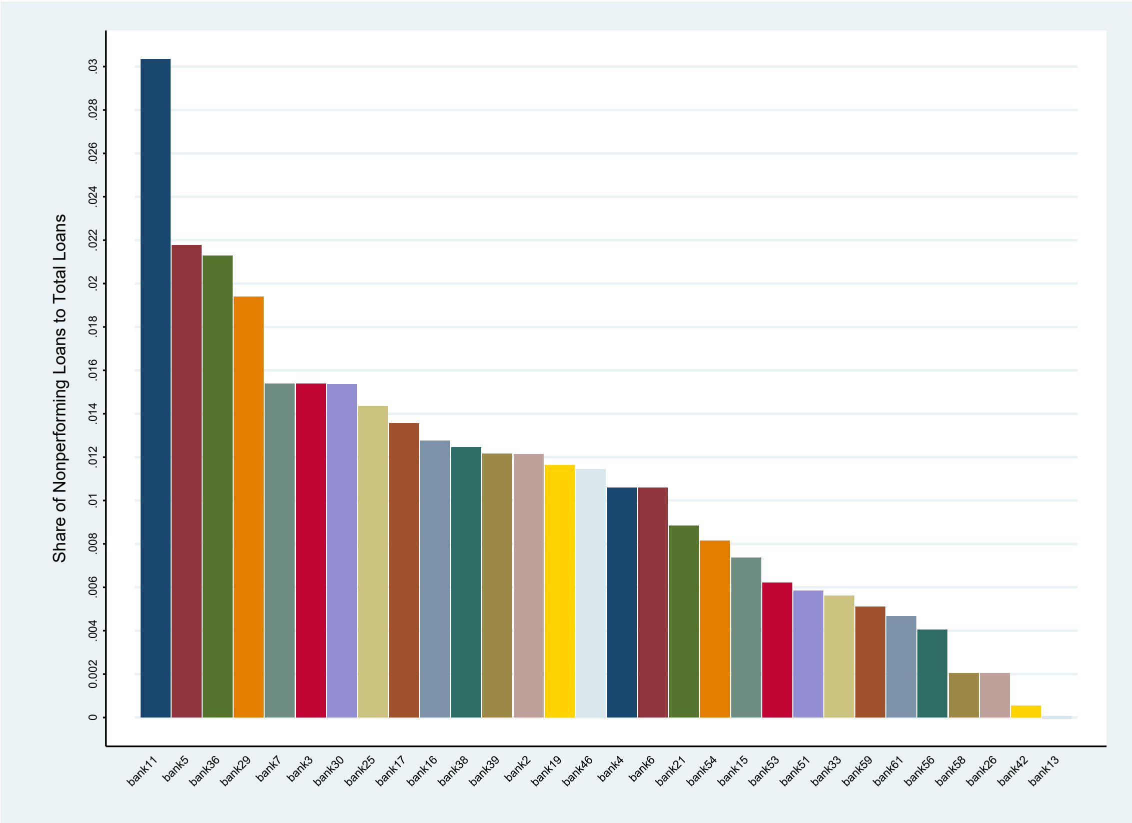


Notes: The above figure shows the average total loans of the 30 banks used in this chapter over the sample period, 1985Q1 to 2007Q4. The information used to construct the figure is based on the "rcfd1400" call report item code.

Figure 2.3: Banks' total loan composition

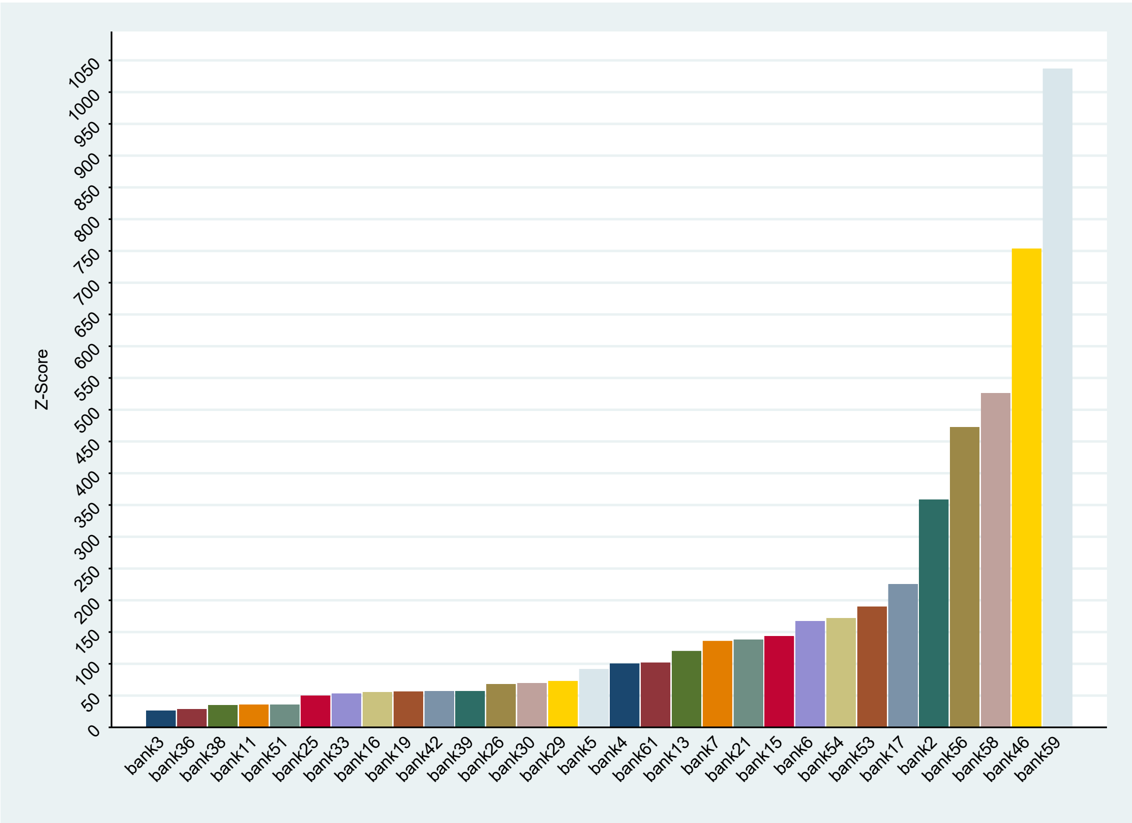
Notes: The above figure shows the composition of the loan portfolios of the 30 banks used in this chapter. The figure represents the average of each component over the sample period, 1985Q1 to 2007Q4. The information used to construct the figure is based on the following codes: "rcfd1975" to capture loans to individuals, "rcfd1600" to capture commercial and industrial loans and "rcfd1410" to capture loans secured by real estate.

Figure 2.4: Banks' average nonperforming loans ratio



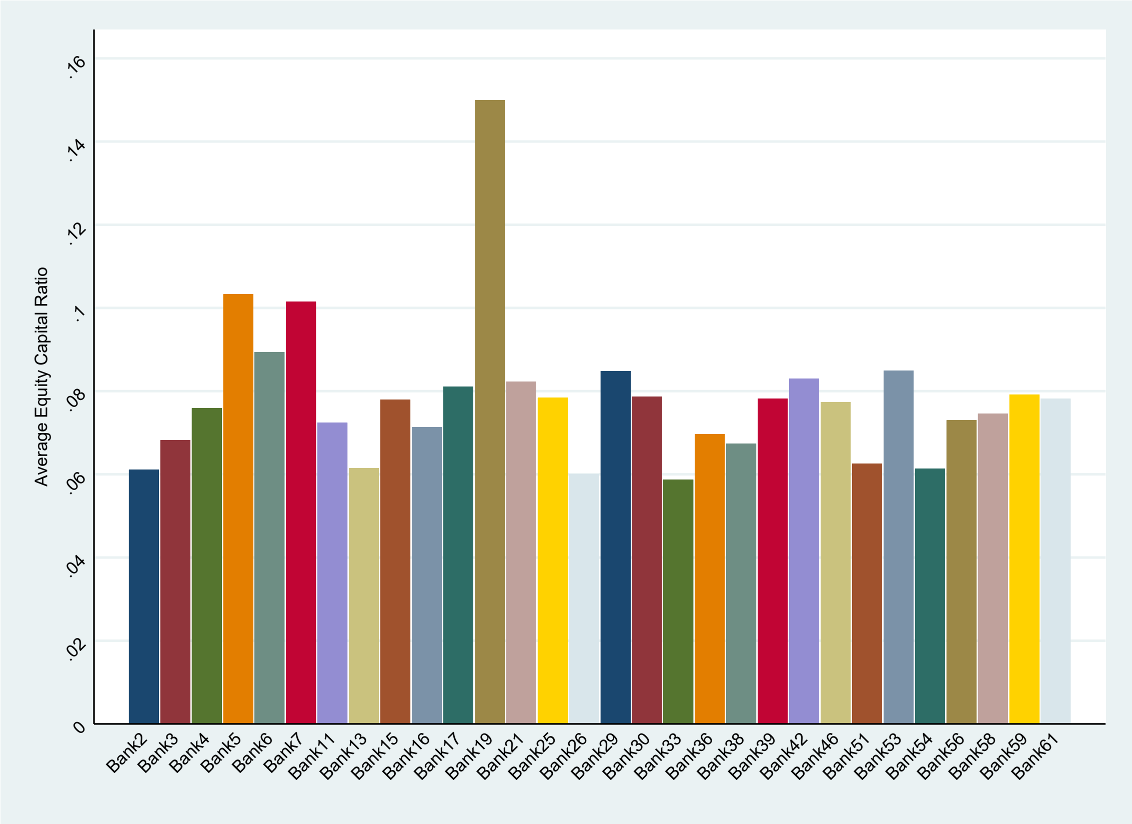
Notes: The above figure shows the ranking of the average nonperforming loans ratio of the 30 banks used in this chapter over the sample period, 1985Q1 to 2007Q4. The information used to construct the figure is based on the following codes: "rcfd1400" to capture total loans and "rcfd1407+rcfd1403" to capture total nonperforming loans.

Figure 2.5: Banks' average Z-score



Notes: The above figure shows the average Z-score of the 30 banks used in this chapter over the sample period, 1985Q1 to 2007Q4. The information used to construct the figure is based on the following codes: "riad4340" to capture net income, "rsfd2170" to capture total assets and "rcfd3210" to capture total equity capital. See Section 2.5.2 for more details.

Figure 2.6: Average equity capital ratio



Notes: The above figure shows the average equity capital ratio of the 30 banks used in this chapter over the sample period, 1985Q1 to 2007Q4. The information used to construct the figure is based on the following codes: "rcfd1400" to capture total loans and "rcfd1407+rcfd1403" to capture total nonperforming loans.

Figure 2.7: Response of nonperforming loans ratio to a negative shock in monetary policy

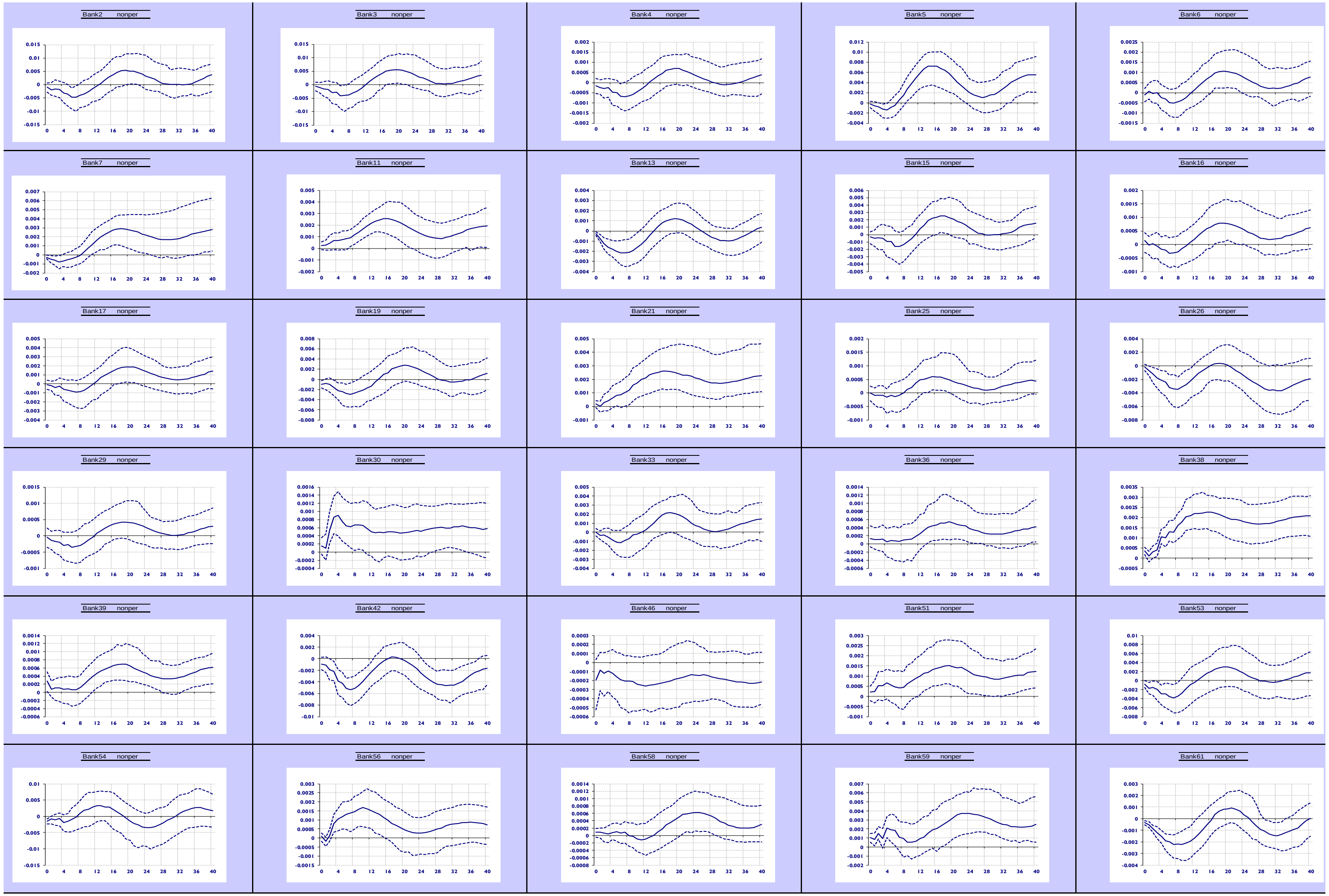


Figure 2.8: Response of return on assets to a negative shock in monetary policy

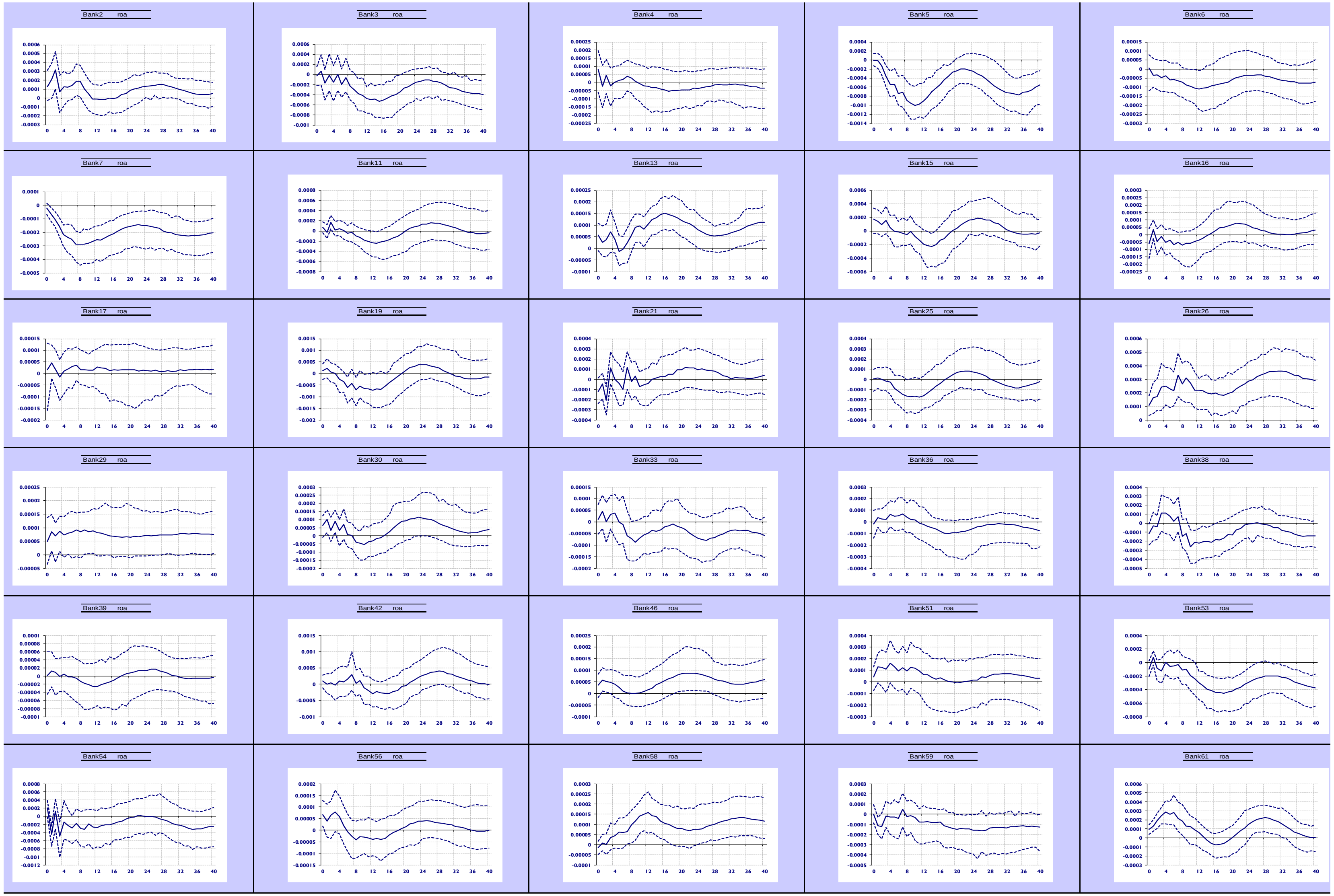


Figure 2.9: Response of loans to assets ratio to a negative shock in monetary policy

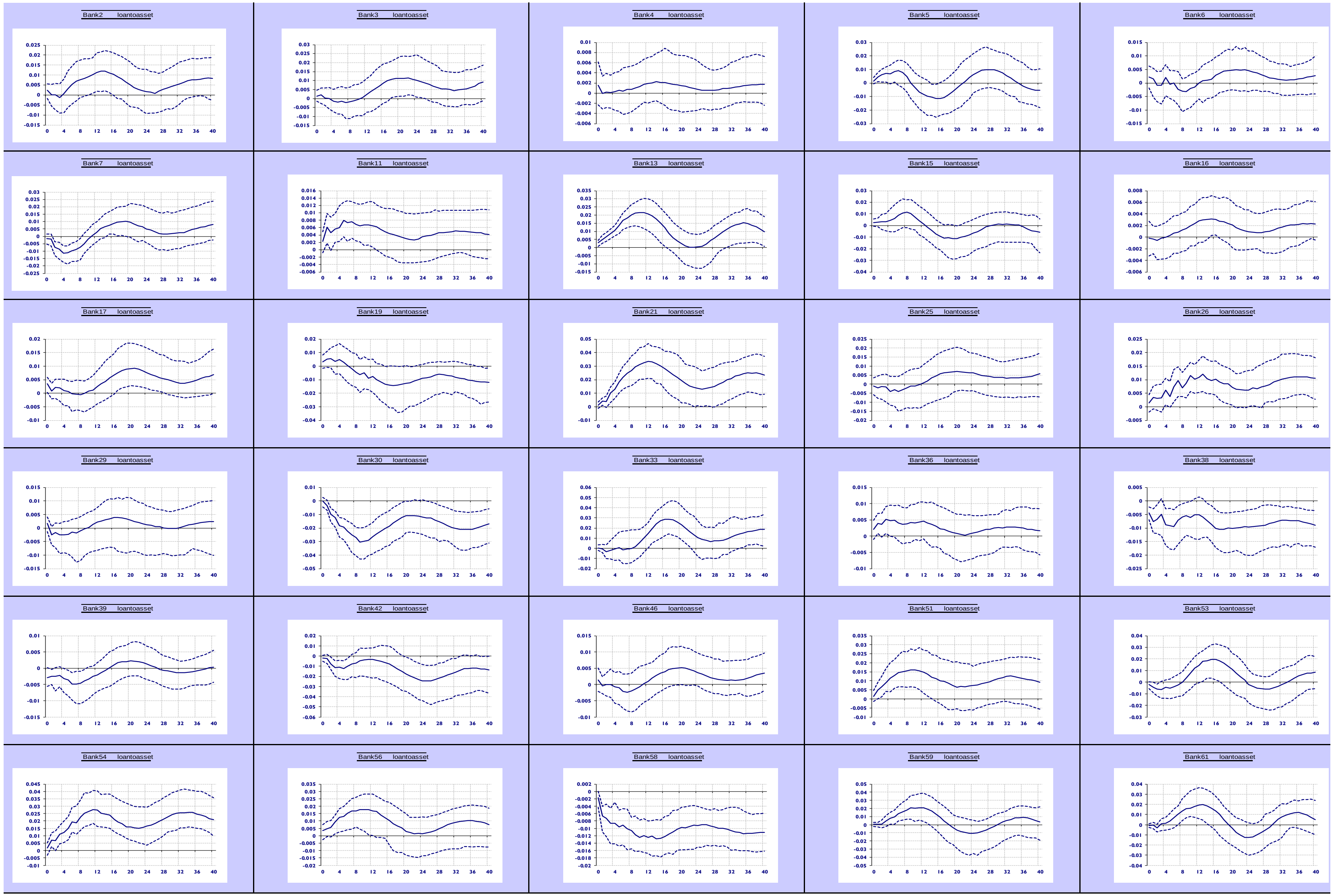


Figure 2.10: Response of nonperforming loans ratio to a positive global shock in nonperforming loans

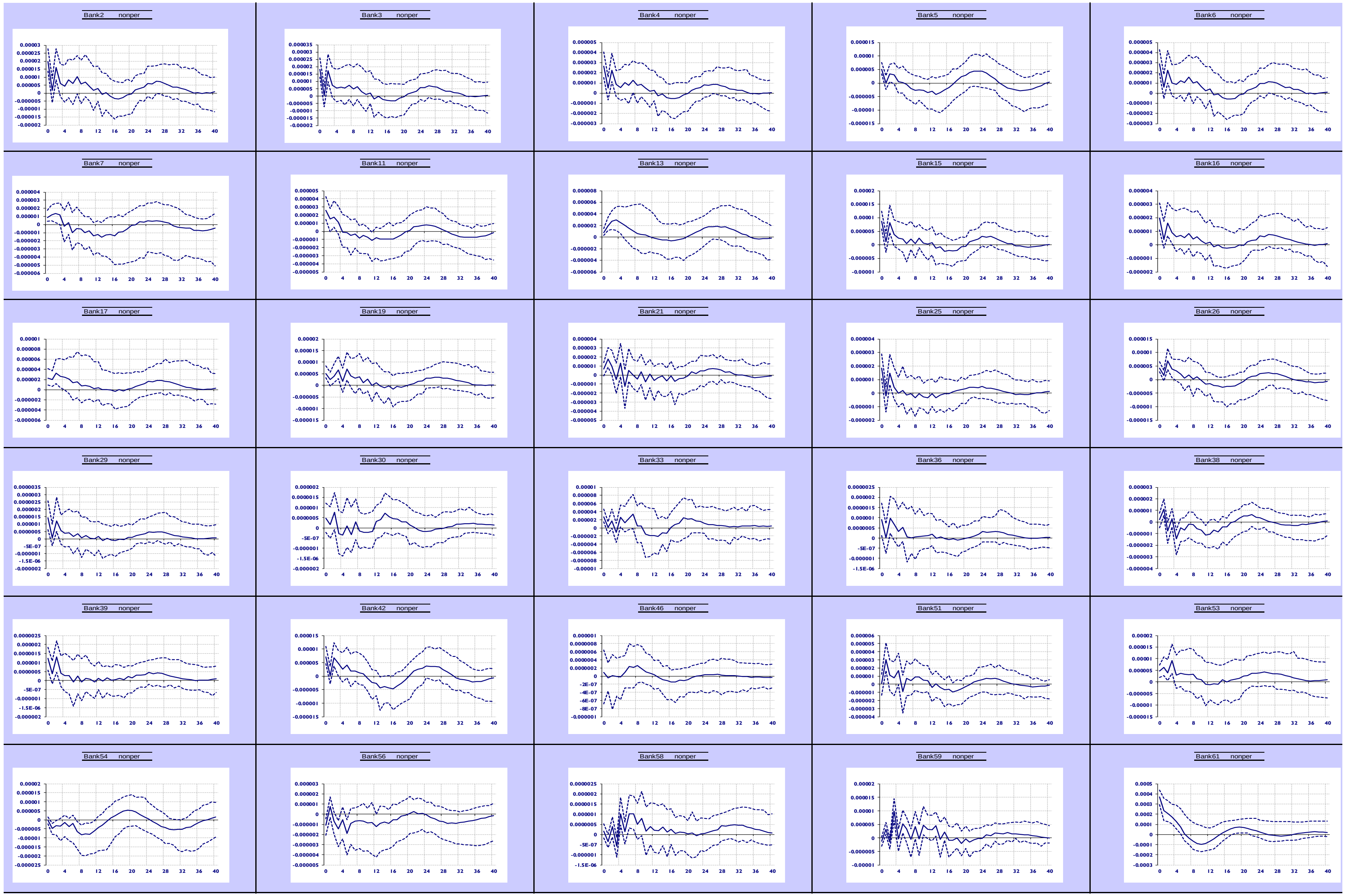


Figure 2.11: Response of nonperforming loans ratio to a positive shock in Bank3 nonperforming loans

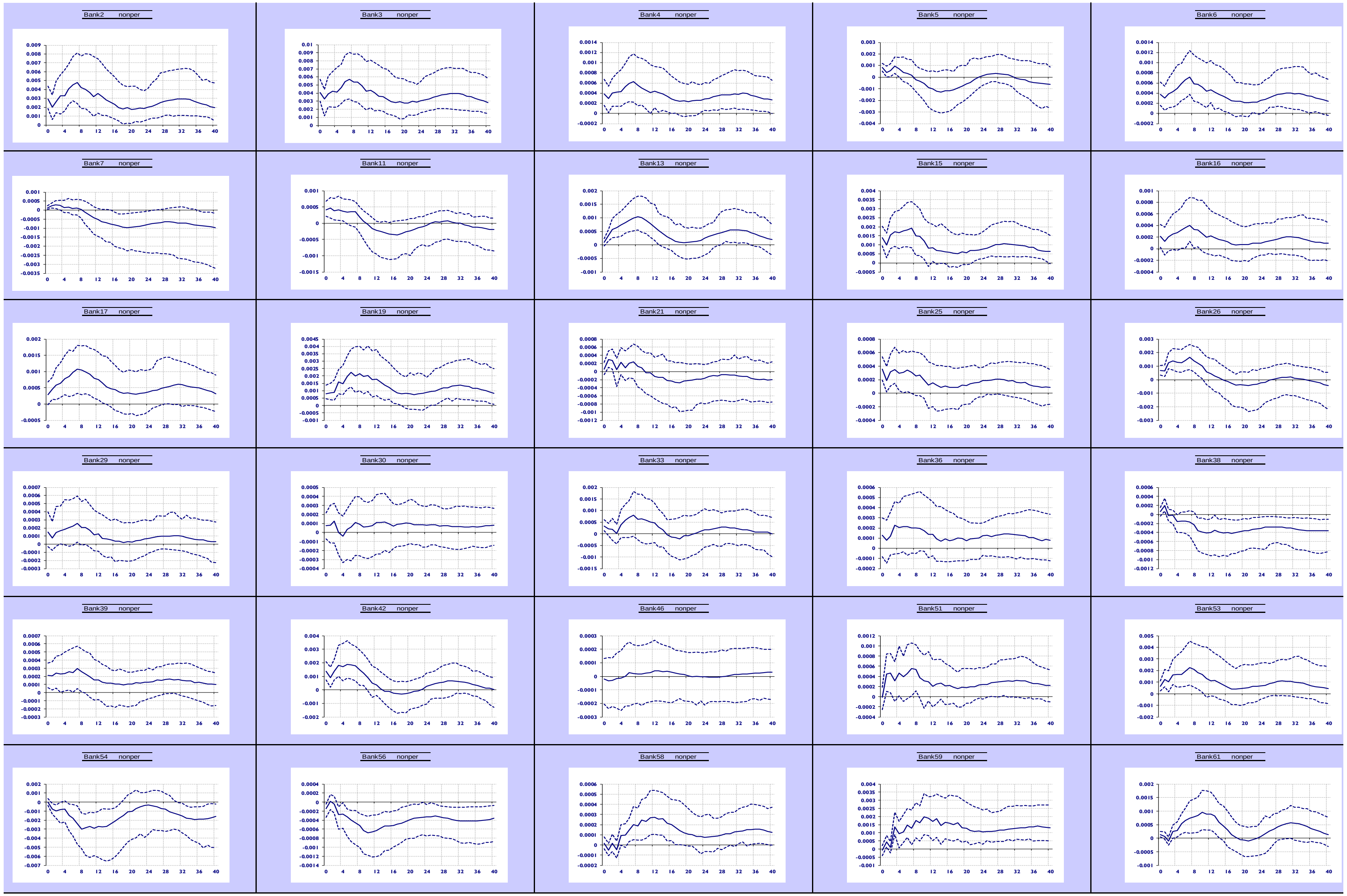


Figure 2.12: Response of nonperforming loans ratio to a positive shock in Bank61 nonperforming loans

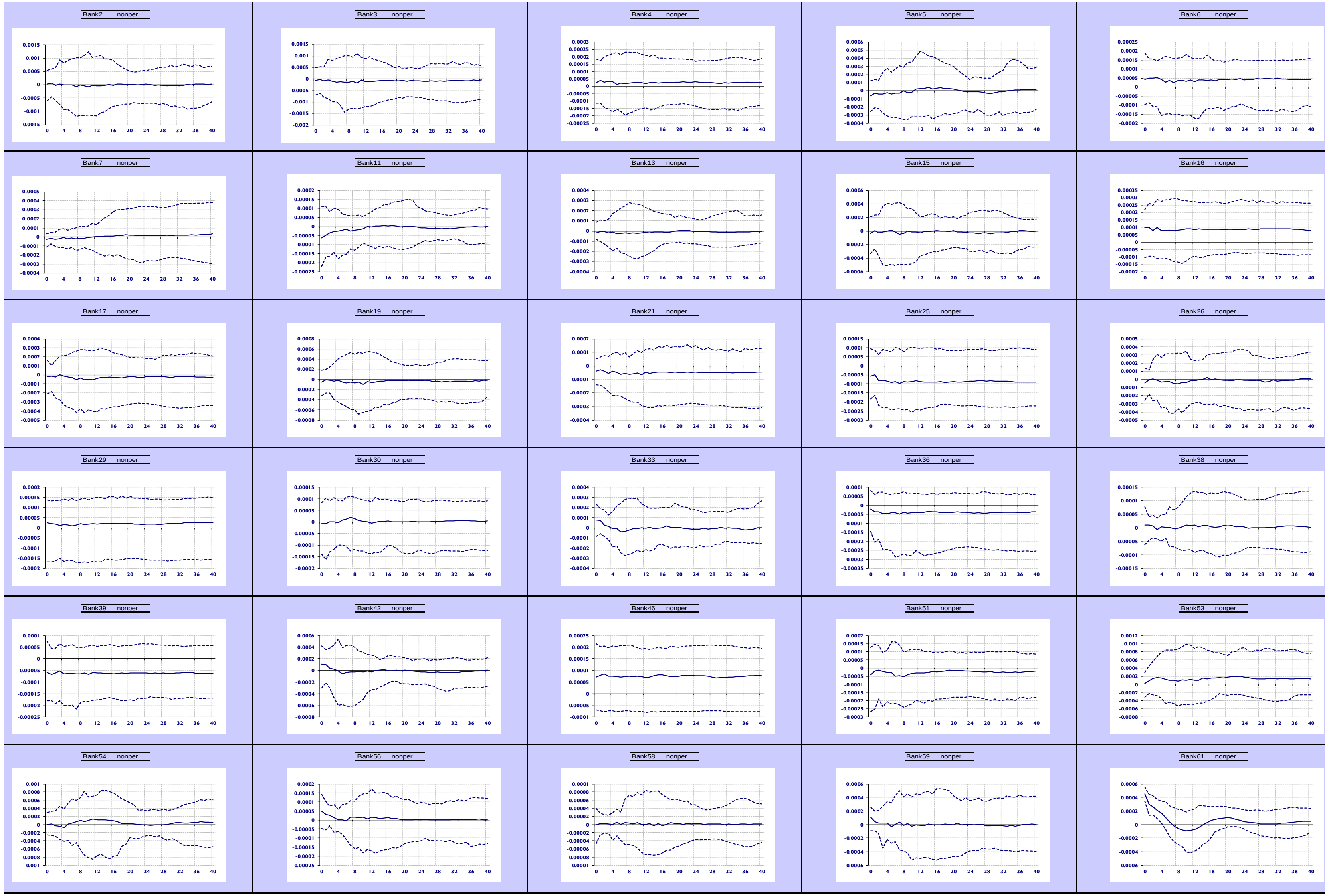


Figure 2.13: Response of banks' Z-score to a negative shock in monetary policy

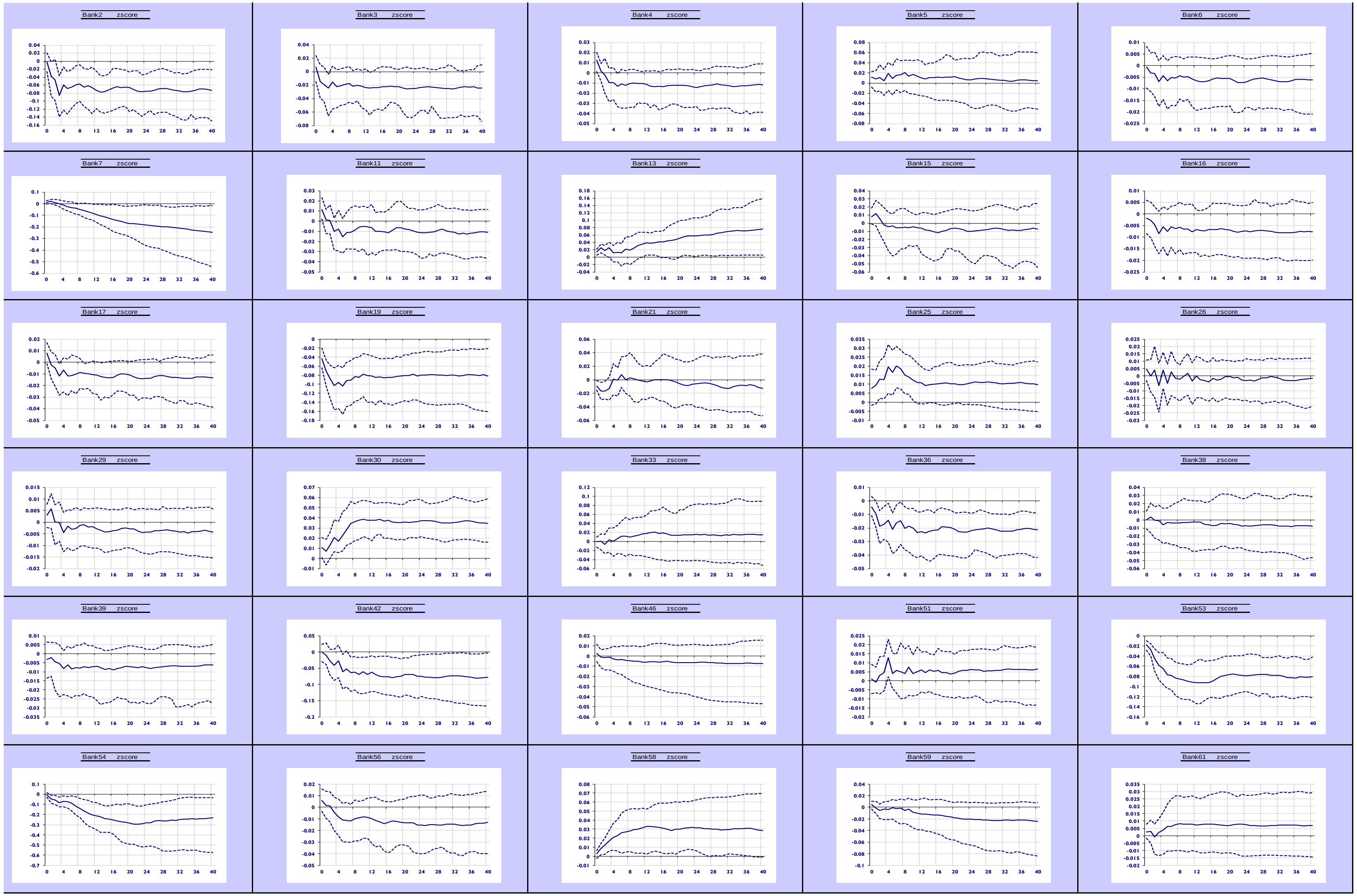


Figure 2.14: Response of banks' Z-score to a negative shock in Bank3 Z-score

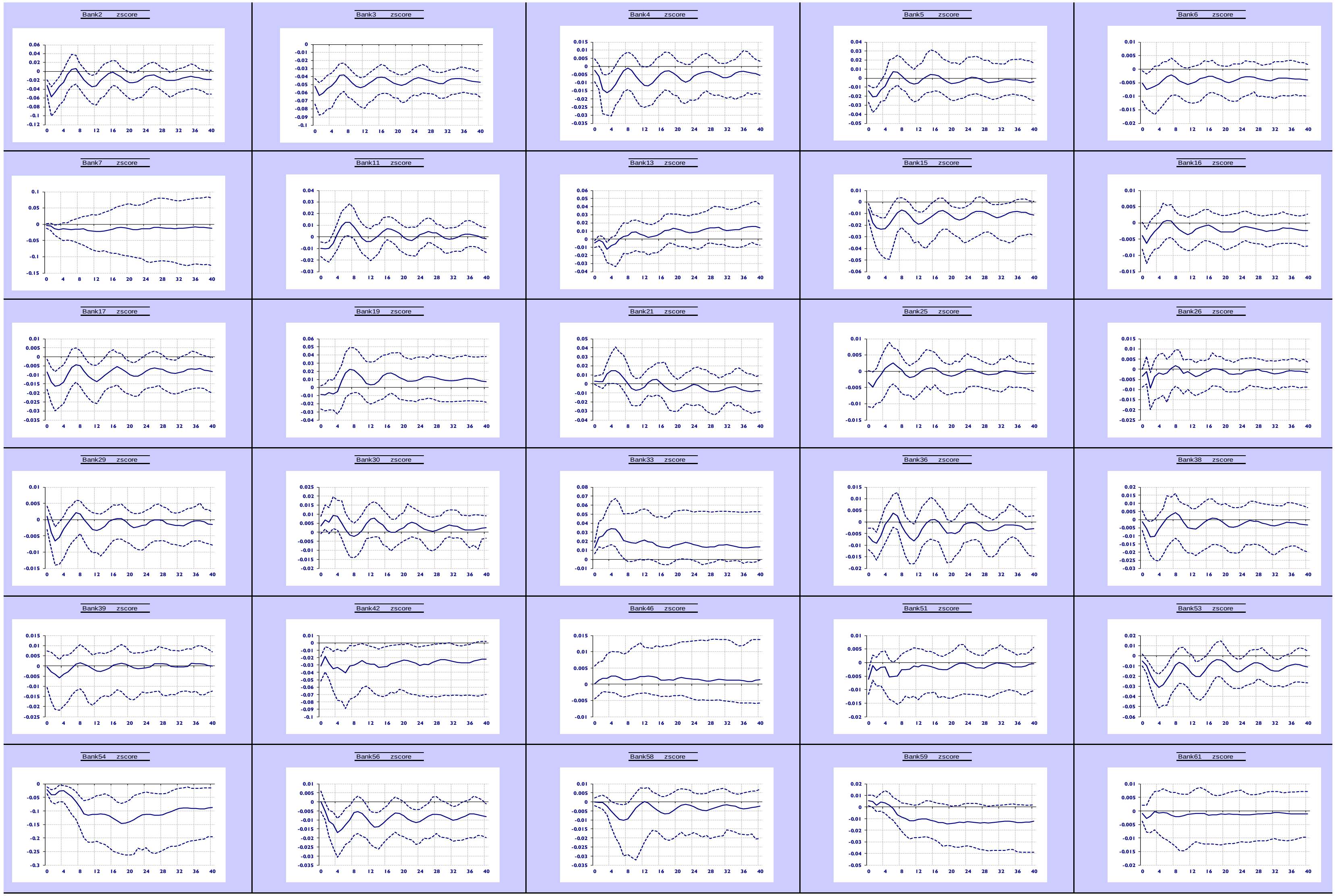


Figure 2.15: Response of banks' Z-score to a negative shock in Bank61 Z-score

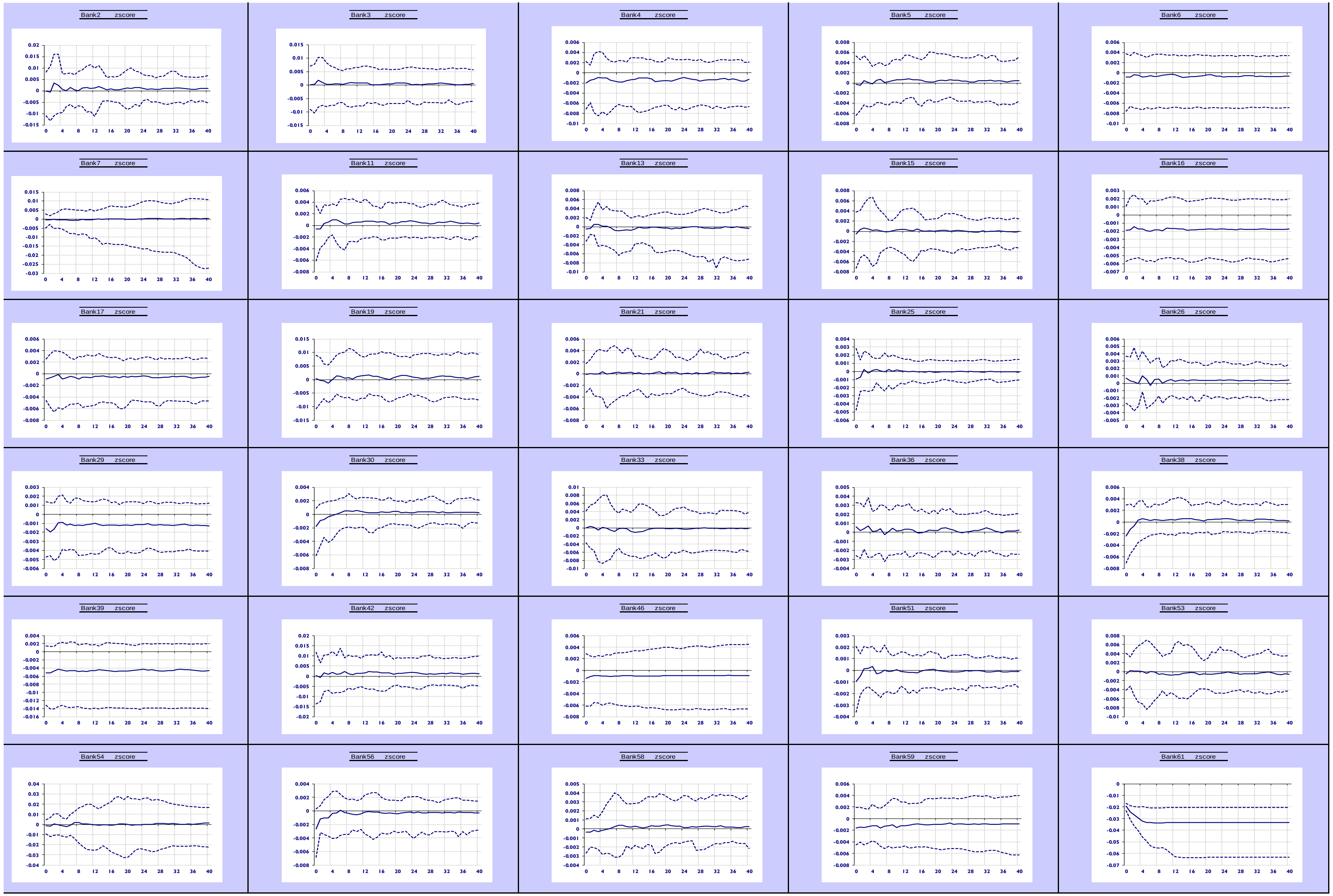


Figure 2.16: Response of Banks' Z-score to a negative shock in Bank13 Z-score

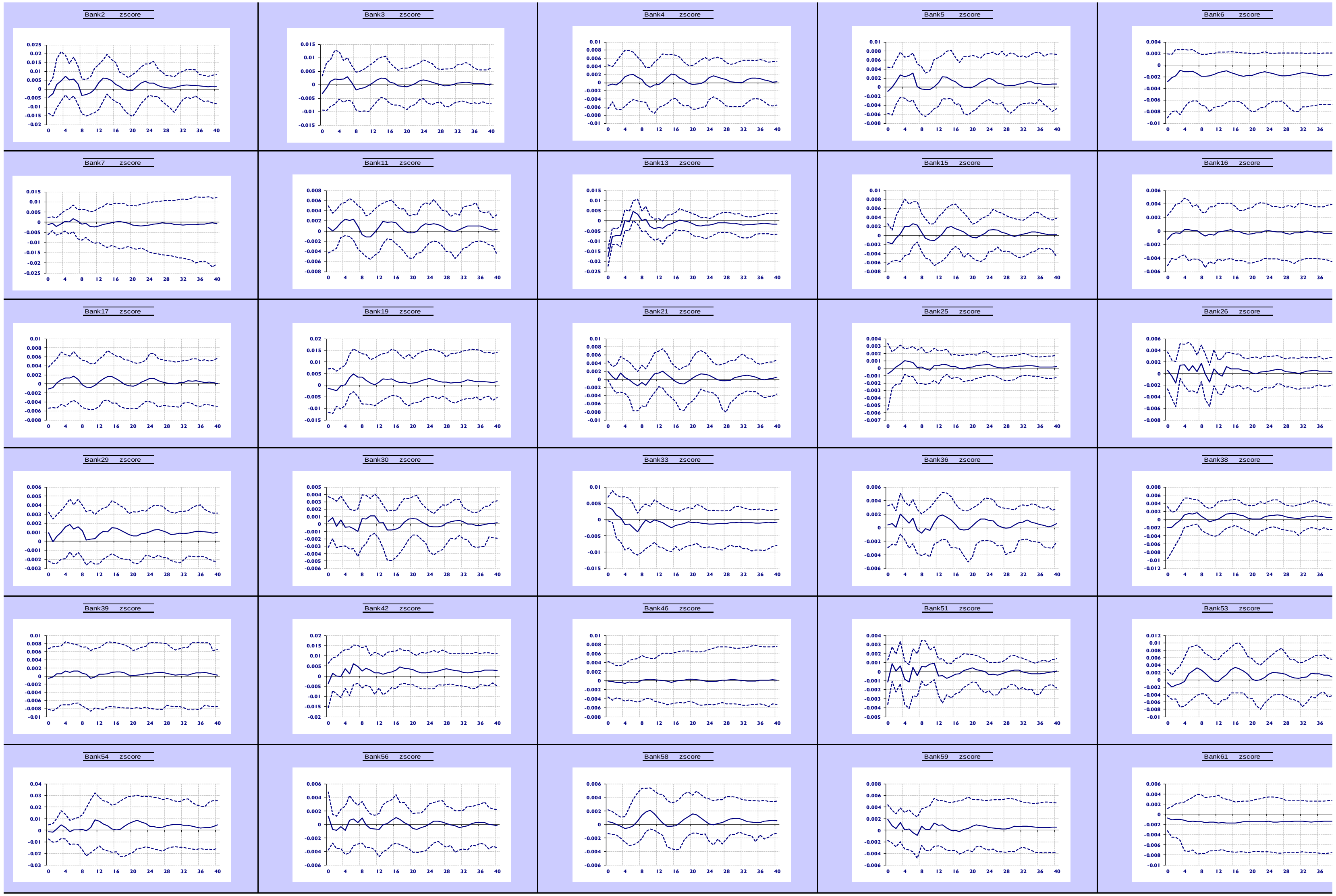
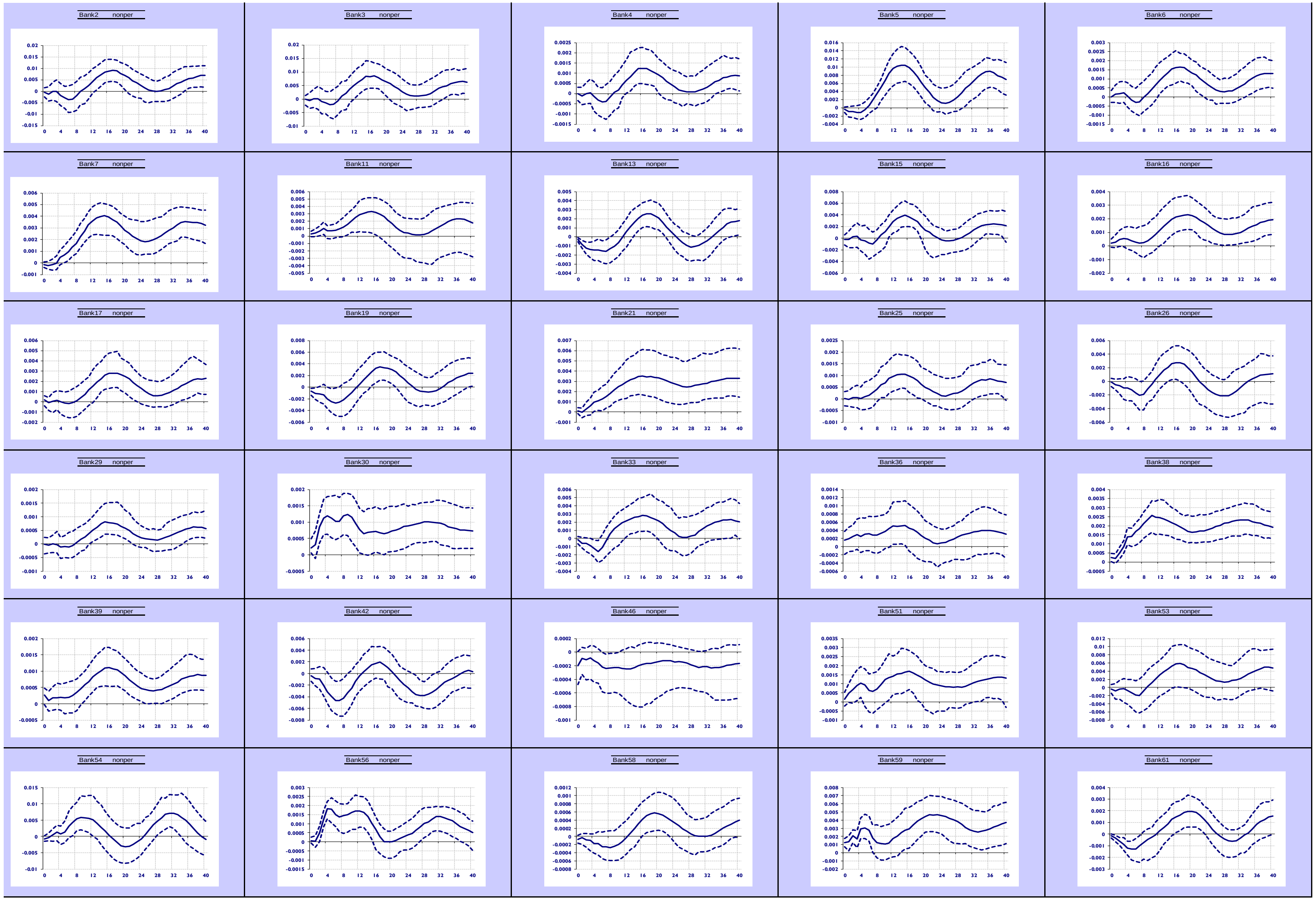


Figure 2.17: Response of nonperforming loans ratio to a negative shock in the Romer and Romer measure of policy rate shock



2.10 Tables

Table 2.1: Summary statistics: Top 100 banks vs. the 30 banks used

Top 100 Banks	**Mean**	**Std. Dev.**	**Min**	**Max**
Total assets	23152	85017	2	1318888
Total loans	13417	44205	0.158	688334
Loans to assets ratio	0.6009	0.1522	0.0012	1.0192
Nonperforming loans ratio	0.0145	0.0180	0.0010	0.6528
The Z-score	327	1196	-0.31	108985
Equity capital ratio	0.0819	0.0480	0.0230	0.9518
Return on assets	0.0029	0.0029	-0.0931	0.0293
Return on equity	0.0365	0.0397	-1.1629	0.3726
The 30 banks used	**Mean**	**Std. Dev.**	**Min**	**Max**
Total assets	40160	112475	21	1318888
Total loans	22920	56651	12	688334
Loans to assets ratio	0.5804	0.1403	0.0855	0.9937
Nonperforming loans ratio	0.0145	0.0148	0.0010	0.1181
The Z-score	309.17	388.09	1.21	9944
Equity capital ratio	0.0702	0.0241	0.0244	0.5236
Return on assets	0.0029	0.0023	-0.0374	0.0293
Return on equity	0.0403	0.0328	-0.6452	0.3726

Notes: Total assets and total loans are in thousands of U.S. \$. Figures represent the means of the variables over the sample period.

Table 2.2: Details of the 30 banks used

Name of the bank	Bank's ID	Rank	Consolidated Assets	Domestic Assets	Percentage of Domestic	Domestic Branches	Foreign Branches
JPMORGAN CHASE BK NA	852218	2	1,179,390	652,824	55	2852	46
CITIBANK NA	476810	3	1,019,497	537,861	53	1005	375
WACHOVIA BK NA	484422	4	518,123	487,894	94	3159	11
WELLS FARGO BK NA	451965	5	398,671	398,546	100	4052	2
U S BK NA	504713	6	217,802	216,581	99	2822	1
SUNTRUST BK	675332	7	182,628	182,628	100	1942	0
NATIONAL CITY BK	259518	11	134,345	133,894	100	1468	2
STATE STREET B & TC	35301	13	96,296	82,651	86	2	10
PNC BK NA	817824	15	90,142	88,357	98	953	0
KEYBANK NA	280110	16	88,081	85,863	97	1158	1
BANK OF NY	541101	17	85,952	52,731	61	8	9
CITIBANK SD NA	486752	19	79,761	79,761	100	0	0
COMERICA BK	60143	21	58,543	57,252	98	382	1
FIFTH THIRD BK	723112	25	52,672	52,672	100	415	1
NORTHERN TC	210434	26	52,313	33,358	64	17	3
FIFTH THIRD BK	913940	29	48,441	48,441	100	718	0
M & I MARSHALL	983448	30	48,017	48,017	100	309	0
COMMERCE BK NA	363415	33	41,170	41,170	100	343	0
FIRST HORIZON NAT CORP	485559	36	37,608	37,608	100	222	0
HUNTINGTON NB	12311	38	34,914	34,914	100	491	0
COMPASS BK	697633	39	34,181	34,181	100	444	0
MELLON BK NA	934329	42	26,226	22,713	87	26	1
ASSOCIATED BK NA	917742	46	20,532	20,532	100	351	0
ZIONS FIRST NB	276579	51	14,849	14,848	100	169	0
CITY NB	63069	53	14,665	14,665	100	72	0
BANK OF OK NA	339858	54	14,366	13,766	96	79	0
COMMERCE BK NA	601050	56	13,891	13,891	100	169	0
FIRST-CITIZENS B & TC	491224	58	13,327	13,327	100	334	0
FROST NB/CULLEN	682563	59	13,307	13,307	100	123	0
VALLEY NB/VALLEY NBC	229801	61	12,364	12,364	100	161	0

Notes: The table shows information about the 30 banks used in this chapter as of 2007. The ranking is based on total assets. Assets are in thousands of U.S. $. Data are from The Federal Reserve System, see https://www.federalreserve.gov/releases/lbr/

Table 2.3: Contemporaneous effect of foreign variables on domestic variables

	Nonperforming loans	Return on assets	Loan to assets		Nonperforming loans	Return on assets	Loan to assets
Bank2	2.716***	0.886**	0.448	**Bank29**	0.109*	0.001	0.463**
	(11.087)	(3.223)	(1.154)		(1.652)	(0.003)	(3.062)
Bank3	1.374***	0.809***	0.181	**Bank30**	0.03	0.109*	0.068
	(10.035)	(4.535)	(1.268)		(0.485)	(1.569)	(0.452)
Bank4	0.152**	0.227*	0.058	**Bank33**	0.157*	0.011	0.114
	(2.6)	(1.907)	(0.278)		(1.994)	(0.186)	(1.114)
Bank5	0.353***	0.244*	0.145	**Bank36**	0.052	0.064	-0.128
	(4.574)	(1.522)	(1.139)		(0.807)	(0.563)	(-1.031)
Bank6	0.194***	0.064	-0.017	**Bank38**	0.006	0.276**	-0.267**
	(3.832)	(0.714)	(-0.084)		(0.106)	(2.047)	(-2.221)
Bank7	0.056	0.02	0.362**	**Bank39**	0.07*	0.037	-0.236*
	(1.324)	(0.434)	(2.197)		(1.589)	(0.753)	(-1.486)
Bank11	0.178**	0.286**	-0.361	**Bank42**	0.513**	-0.075	0.262
	(2.832)	(2.133)	(-2.06)		(3.195)	(-0.305)	(1.278)
Bank13	0.034	-0.144**	0.236**	**Bank46**	0.005	0.047	-0.053
	(0.782)	(-2.096)	(2.14)		(0.086)	(1.134)	(-0.254)
Bank15	0.605***	0.19**	0.172	**Bank51**	0.02	0.147	0.139
	(9.366)	(1.199)	(0.722)		(0.175)	(1.049)	(0.762)
Bank16	0.129*	0.167*	0.388**	**Bank53**	0.358*	0.171	-0.152
	(1.812)	(1.565)	(2.695)		(1.75)	(1.345)	(-0.838)
Bank17	0.145	0.33**	-0.087	**Bank54**	-0.02	0.34	0.362**
	(1.245)	(2.252)	(-0.401)		(-0.088)	(1.242)	(2.367)
Bank19	0.336**	0.86*	-0.038	**Bank56**	-0.072	0.073	-0.045
	(2.157)	(1.791)	(-0.144)		(-1.395)	(1.279)	(-0.202)
Bank21	0.037	0.509**	0.463***	**Bank58**	0.021	0.055	0.096
	(0.508)	(3.17)	(4.184)		(0.74)	(1.238)	(0.92)
Bank25	0.123**	0.203**	0.701**	**Bank59**	-0.087	0.018	-0.082
	(2.435)	(2.161)	(3.006)		(-0.527)	(0.195)	(-0.577)
Bank26	0.276**	0.263**	0.103	**Bank61**	0.075*	0.017	0.167
	(3.445)	(3.559)	(0.447)		(1.962)	(0.317)	(1.156)

Notes: The table shows the contemporaneous effect of the foreign (starred) variables on their domestic (bank level) counterparts. These effects describe the co-movements among variables across the 30 banks examined in this chapter. * denotes significance at the 10% level ** denotes significance at the 5% level and *** denotes significance at the 1% level. t-statistics are shown in parentheses.

Chapter 3

Risky Asset Holdings by Japanese Households: The Role of Attitudes, Trust and Risk Perception

3.1 Introduction

A distinct feature of Japan is its ageing population as a result of high life expectancy and a low fertility rate. This demographic structure would suggest that Japanese households should find stock market participation more attractive as they will have a higher incentive for wealth accumulation. In contrast, households financial portfolios in Japan have a very low share of risky financial assets, defined as the fraction of financial wealth invested in risky assets, in comparison to the U.S. and Europe. The Bank of Japan (2017b) shows that the share of equity held by Japanese households was on average 10.0% in 2017 in comparison to 18.0% in the EU and 36.0% in the U.S.. Safe assets in the form of cash and deposits, however, make up the vast majority of Japanese household financial portfolios, which have been on average above 50.0% since 1990. The rest of the portfolio consists, on average, of 5.0% investment trust, 30.0% insurance and pension and 5.0% others, the Bank of Japan (2017b).[1]

This conservative investment approach by Japanese households is not recent, it has been observed for many years and it has been of concern to the Japanese government for decades. The Bank of Japan (2017a) shows that the share of risky assets in Japanese household financial portfolios has been hovering around 10.0% since 2004. The share was even lower (around 7.0%) at the end of 1990s as a result of the collapse of the stock market capitalisation in the early 1990s, which was a serious crisis that hit investors and the market lost more than 50.0% of its capital. The literature argues that this cautious investment behaviour of Japanese households is a typical characteristic of their risk averse nature. A feature that has been documented by the World Value Survey, where 73.0% of individuals interviewed in Japan between 2010 and 2014 described themselves as risk averse individuals compared to only 39.0% of individuals in the U.S..

[1] "Others" is defined by Bank of Japan (2017b) as the residual which is the remaining after deducting these categories from total financial assets.

Although Japanese households, on average, hold a lower proportion of their wealth in risky assets compared to the U.S. and Europe, the share of risky assets in Japan and these countries is also of a concern to governments and policy makers. This is because the observed level of risky asset holdings is not the level that the classical theory of household financial portfolios predicts and it is not the optimal level of holdings from the policy maker prospective. The classical theory suggests that rational investors will participate in the stock market as long as the stock market return is higher than the return on risk free assets. On the other hand, the optimal level of holdings from the policy maker prospective should be higher than the observed rate as a higher level of stock market participation by households will help accelerate economic growth, see Guiso and Sodini (2013). This disparity between the predicted optimal level of risky asset holdings and the observed holdings is referred to as the "participation puzzle" in the literature.

This puzzle has motivated a growing number of studies which aim to investigate the determinants of holding stocks and shares, see Badarinza et al. (2016) and Guiso and Sodini (2013) for an excellent review of the literature. These studies are driven by the increasing availability of high quality microeconomic data which are crucial in analysing households' financial decisions. Understanding how individuals allocate their wealth is an important factor in promoting growth and financial stability. Specifically, firms and small businesses are moving away from the traditional bank loans to the capital markets to raise funds. Therefore, changes in the supply side of financial assets should be met by a change in the demand side, that is increasing the share of risky assets in household financial portfolios.

Furthermore, understanding how individuals allocate their funds is informative from a policy formation perspective given the recent adaptation of the defined contribution pension scheme in Japan and many other countries and the debate surrounding its success. Having an understanding of the factors that have an impact on the level of risky asset holdings and how policies can influence this level, will provide an important perspective to the debate on the recent structural reforms of the Japanese economy brought by the government's "three-arrows" strategy (also known as "Abenomics").[2] Despite the importance of understanding households' financial portfolio decisions, only a small number of papers empirically analyse these decisions for Japanese households. Attempts have been made by a few studies, (see, for example, Iwaisako et al., 2016; Iwaisako, 2009; Aoki et al., 2016; Kinari, 2007; Nakagawa & Shimizu, 2000; Ito et al., 2017), to explain Japanese households' cautious investment behaviour, but no conclusions have been reached with regards to the main factors influencing the low risky asset share in the financial portfolios of Japanese households. This chapter analyses data drawn from the Keio Household Panel Survey (KHPS) available from the Panel Data Research Centre at Keio University to provide further insight to the determinants of risky asset holdings in Japan.

In the existing literature, papers that examine risky assets holdings of Japanese households are limited in terms of the variables and the econometric models that are considered in the analysis. Moreover, only a handful of papers examine aspects of households' trust in the functioning of the stock market and general trust in the government and these papers focus on data from the U.S. or Europe.[3,4] However, most of these studies use a generalised measure of trust.[5] Therefore, this chapter will fill these gaps in the existing literature by incorporating the effects of individuals' opinions of stock market performance and different dimensions of individual trust,

[2]1st Arrow: Dramatic monetary easing to achieve an early end to deflation and overcome economic stagnation. 2nd Arrow: A robust fiscal policy to stimulate short-term growth. 3rd Arrow: Introducing a reform of various regulations to encourage private investment and to make Japanese industries more competitive.

[3]See, for example, Guiso, Sapienza, and Zingales (2008), Delis and Mylonidis (2015), Georgarakos and Pasini (2011), Balloch, Nicolae, and Philip (2015) and Bucciol, Cavasso, and Zarri (2016).

[4]Individuals' trust in the stock market has been recently identified in the literature to be an important factor in explaining stock market participation, but there are no studies that explore the role of this factor in Japan.

[5]With the exception of Balloch et al. (2015) who used a measure of trust which is specific to household trust in the stock market and Guiso et al. (2008) who proxy trust in the stock market with individuals' trust in bank officials and advisers.

using measures of trust that reflect individuals' perceived trustworthiness, into a number of modelling approaches.[6]

More specifically, the contribution of this chapter to the existing literature is threefold. Firstly, I am aware of no other empirical study for Japan that has analysed the effects of household trust in the stock market and household perception of risk on risky asset holdings. Secondly, this chapter is the first study that uses the KHPS dataset to analyse household financial portfolios. The KHPS provides detailed information about respondents' social and demographic characteristics, and also information regarding their financial asset holdings. Furthermore, in wave 10 (2013) respondents were asked detailed questions regarding their perceived risk of selected assets and their opinions about the functioning of the stock market. Therefore, this chapter will use all waves of the KHPS data set (2004 to 2015) in the first part of the analysis but the focus will be mainly on wave 10 to further explore household holdings of risky assets. Finally, the chapter uses four alternative methodological approaches to explore the robustness of the findings. The tobit model is used as a reference case against which the findings of the literature and the alternative models adopted here are compared to. This chapter also uses the Censored Quantile Regression (CQR) and the one-part and the two-part of the Fractional Regression Model (FRM). The CQR and the two-part FRM approaches are rarely used in household finance literature.

Each of the approaches employed in this chapter has unique features which help in exploring and fully understanding the determinants of Japanese households attitudes' towards risky investments. The FRM can handle proportions and the two-part model jointly models the decision to hold risky asset and the level of risky asset holdings. This is crucial as factors that explain the former decision may not be the same as those that affect the latter decision or their magnitude may be different. The CQR allows an examination of the complete distribution and handles censor-

[6]Measures of the trust in the institutions that facilitate holdings of risky assets is arguably far more important than relying on a generalized measure of trust for this area of analysis.

ing at zero without the assumptions of normality and homoscedasticity that are necessary in the tobit model. Estimators which are based on the mean conditional distribution of the dependent variable provide only a partial view of the relationship between a set of regressors and the outcome variable. However, it is interesting and informative to identify which characteristics influence risky asset ownership at different points of the conditional distribution, which is provided by the quantile regression.

The results are broadly consistent qualitatively across the tobit model, the one-part FRM and the binary part of the two-part FRM. However, there are significant differences in terms of the magnitude of the marginal effects among these four models. Furthermore, the analysis shows that, when examining risky asset holdings conditional on participation, the coefficients differ not only in terms of magnitude but also in terms of sign and the level of significance. Finally, the CQR model reveals that considering only the effects of the regressors on the mean holdings of risky asset masks considerable heterogeneity in the effects of some variables.

This chapter is structured as follows; Section 3.2 will explain the classical theory of household financial portfolios. A review of the literature relating to household portfolio allocation is presented in Section 3.3 with a specific focus on Japan. Section 3.4 provides a discussion of the data, dependent variable and the independent variables. Section 3.5 presents the alternative methodologies employed in this chapter, whilst Section 3.6 discusses the results. Finally, Section 3.7 concludes the chapter.

3.2 The classical theory of household financial portfolios

The composition of household financial portfolios has been analysed extensively in the literature both theoretically and empirically. One of the most important theories of households' financial behaviour is the classical theory of household financial portfolios developed and first formalized by Markowitz (1952). This theory links the optimal portfolio composition to the return on an asset and the variance of this return in an extremely parsimonious model. Tobin (1958b) expanded on Markowitz's work, building on the same assumptions and structure of the classical theory, and further illustrates that an investor's degree of risk aversion will determine the convexity of their utility function. Hence, investors will maximise their utility function based on the risk-return pattern of available assets, the level of their total wealth and their degree of risk aversion. Theories which are built on the standard expected utility framework consider risk preferences as central and a key ingredient in modelling financial decisions. For example, the classical Merton (1969) and Samuelson (1969) models of consumption and portfolio choice directly link the fraction of financial wealth invested in risky assets to the individual's degree of risk aversion and the distribution of the return on assets. In particular, the investor's optimal proportion of risky assets under the assumptions of these models can be defined as:

$$\lambda_i = \frac{E(R_r) - R_f}{\gamma_i \sigma_r^2} \quad , \tag{3.1}$$

where λ_i is the proportion of financial wealth invested in risky assets, $(E(R_r) - R_f)$ is the expected risk premium, σ_r is the return volatility of risky assets, and γ_i is the degree of relative risk aversion.[7]

The models described above are based on strong assumptions such as: no partici-

[7] Where R_r is the expected return of the risky assets and R_f is the return of the risk-free assets.

pation or transaction costs; markets are complete; no labour income; risk-free assets generate a constant return; and wealth is held in a liquid form. Based on these unrealistic assumptions, two important implications can be observed from Equation 3.1: the first one is that rational investors will participate in the stock market given that $(R_r - R_f) > 0$, no matter how risk averse an investor is. The second implication is that the risk aversion parameter γ_i will ascertain that all heterogeneity in the observed portfolio shares is related to differences in the risk preference of investors. This implies that the observed portfolio shares are independent of, for example, investor's age and wealth under the assumption of constant absolute risk aversion. However, the observed risky asset holdings across countries contradict these two implications, despite the historical positive risk premium observed in most countries. For example, recent data used by Badarinza et al. (2016) shows that there is a high percentage of household that do not hold any risky assets and also the proportions of risky assets held by households are much lower than what the classical theory predicts. Moreover, the data shows that stock market participation rates differ across countries and change over time. The implication that age and wealth are independent of risky asset holdings is also contradicted by the documented inverse-U shape of age effect on an individual's risky asset allocation. For example, Ameriks and Zeldes (2004) analysed household asset allocation behaviour in the U.S. and found that risky asset shares have a hump-shaped relationship to age. Guiso, Haliassos, and Jappelli (2002) found similar patterns for the European countries.

The strong assumptions of the classical theory are behind its limitation in accounting for the observed stock holding heterogeneity. For example, the fact that in reality investors face participation costs might explain the high percentage of zero risky asset holdings, which is referred to as the "participation puzzle" in the literature. These costs are associated with the information needed for an investor to be able to form a portfolio close to the market portfolio and are also associated with the cost of trading needed to form a diversified portfolio.[8] Hence, even small

[8]The market portfolio is the portfolio of all available securities in the market with each security

participation costs are sufficient to keep many households out of the stock market as the benefit from holding risky assets is too small to offset this fixed cost, see Haliassos (2003). The other unrealistic assumption of the classical theory is that wealth is held in a liquid and tradeable form. A large component of household wealth is allocated to housing, which is an illiquid non-financial asset, or in the form of the non-tradeable human capital, as households cannot sell claims to this capital. Finally, assuming that investors have no labour income is another unrealistic assumption as labour income and the risk associated with its uncertainty are important determinants of risky asset holdings as the literature suggests.

3.3 Literature review

Given the limitations of the classical theory in capturing the significant discrepancy between the observed heterogeneity and the predicted homogeneity of household holdings of risky assets from the theory, a rich literature has focused on explaining the "participation puzzle" over the past decade. Many alternative suggestions to this puzzle have been put forward and empirically tested. Early studies have focused on the basic demographic factors in explaining the limited stock market participation by households. Bertaut (1998), used the U.S. Survey of Consumer Finance (SCF) data to analyse U.S. household stock holding behaviour.[9] Bertaut (1998) finds, like other subsequent studies, that education, financial wealth, non-financial wealth all have statistically significant positive effects on the probability of holding risky assets.

The positive correlation between risky asset holdings and wealth has been found in many other empirical studies (see, for example, Campbell & Cochrane, 1999; Guiso & Paiella, 2008; Calvet & Sodini, 2014). These studies argue that a plausible

weighted in proportion to its market capitalisations.

[9] This survey contains rich information on socio-economic characteristics and financial variables and has been widely used in the household finance literature.

explanation for this positive correlation could be that the degree of risk aversion declines with wealth. For example, Calvet and Sodini (2014) confirmed this correlation using high quality Swedish data on identical twins that can clearly identify the wealth effect as the twins will have the same genetic determinants of risk aversion. Heaton and Lucas (1997) argue that the strong correlation between risky asset holdings and wealth can also be explained by participation costs. This claim cannot be empirically tested as participation costs are not observable, however, observing its implication can help in indirectly testing this.[10] In particular, the observed high rate of non-participation among households at the bottom distribution of wealth can be justified given that the fixed costs of participation will outweigh the benefit of investing in risky assets. Participation costs are not limited to brokerage fees and trading costs, they also include information costs and can vary cross-sectionally depending on the education level of individuals. This is because educated individuals might have an advantage in acquiring information related to financial markets and might find it easier to learn about various financial products, hence the positive correlation between education and risky asset holdings. However, this does not imply that all low-wealth and/or uneducated households do not participate in the stock market, similarly it does not justify the low participation rate for wealthy and/or educated households.

Participation costs, risk aversion and demographic variables alone find it hard to reconcile the observed heterogeneity of risky asset holdings. For example, Guiso and Sodini (2013) argue that countries with the same level of financial market sophistication will have different levels of risky asset holdings among households. Also, as mentioned above, participation costs alone cannot justify the low participation rate for wealthy and/or educated households. Therefore, recent studies have started to focus on specific attributes of households to explain the "participation puzzle",

[10] Guiso and Sodini (2013, p. 1454) argue that "*the increase in stock market participation that has taken place over the past two decades is also consistent with a decline in participation costs. The availability of financial information on the Internet, and the expansion of the mutual fund industry have effectively made access to the equity market cheaper.*"

after controlling for these basic demographic factors. This line of research has also been helped by the recent availability of high quality data on household's assets and liabilities; detailed financial and non-financial assets information and subjective questions related to preferences and experiences.

The most widely discussed factor in explaining the "participation puzzle" relates to background risks. Background risks are the idiosyncratic risks which are not easily avoided or diversified by households and they arise from sources such as labour and entrepreneurial income or real estate holdings. When households face undiversified background risks, they are less willing to invest in risky assets. This is because households will react to the increase in the overall exposure to risk by following a conservative investment strategy, hence avoiding or reducing their exposure to tradeable risky investments, such as risky asset holdings. Background risks are not included in the analysis of the theoretical models discussed above, as the assumption of complete markets will insure that such risks are correctly priced and capitalised into households' wealth (see, Heaton & Lucas, 2000).

The most obvious source of background risks is income uncertainty, as it is difficult to insure or diversify and income forms a large proportion of household wealth. Guiso, Jappelli, and Terlizzese (1996) empirically analysed the impact income risk and borrowing constraints have on the composition of the household's financial portfolio using a cross-section of Italian households. Income risk is estimated subjectively by asking individuals about their opinions of the expected inflation and expected income growth. Borrowing constraints are estimated based on the probability that a household was denied credit or discouraged from borrowing. Using a tobit model, the results of Guiso et al. (1996) support the proposition that income risk and credit constraints reduce households' willingness to invest in risky assets. Their results also indicate that there is a positive relationship between the proportion of risky assets held and the household's head age, income, wealth and education in line with the previous discussions.

A comprehensive empirical and theoretical discussion about the role of background risks in household portfolio choices is provided by Heaton and Lucas (2000). Their results confirm that there is considerable heterogeneity in exposure to background risks which can reconcile the significant differences in households' holdings of risky assets. Heaton and Lucas (2000) claim that heterogeneity in background risks exposure can be explained by variation in factors such as labour income, proprietary business risk, and in ownership of employer's stock. Heaton and Lucas (2000) argue that the correlation between the return on market portfolios and different household income sources is another important factor that influences households' risky asset holdings. Using the 1979-1990 Panel of Individual Tax Return Data from the U.S., Heaton and Lucas (2000) measure the correlation of the return on market portfolio with the standard deviation of individual's labour and business income. They find that business income risk is more important than labour income risk in terms of the impact on portfolio choice.

The importance of background risks in explaining the limited stock market participation puzzle and the observed variation in risky asset holdings is further confirmed by Palia, Qi, and Wu (2014) using the U.S. Panel Study of Income Dynamics (PSID). They estimated standard deviations of the growth rates of labour income, home equity and business income to proxy for the three main background risks; human capital, housing and private business, respectively. For the empirical analysis they use Logit model to assess the impact of background risk variables on the decision to participate, and a tobit regression to study the impact on the level of risky asset holdings. The findings suggest that a one standard deviation increase in all background risk variables will decrease stock market participation by 10.8% and cause a drop in the proportion of stock holdings to wealth by 3.6%. They argue that background risks influence the participation decision more than the amount of stock holdings. Furthermore, they also calculated the covariance of the three background risk variables with stock returns and the returns on the risk-free asset. They found that when labour income is highly correlated with stock market returns, both participation and the level of stock holding are negatively affected. On the other hand, a high correlation between the return on risk-free assets and labour income will increase the probability of participation and households will allocate a higher proportion of their wealth in stock investments. Another contribution of Palia et al. (2014) is that, in-line with the empirical and theoretical literature, education has a significant positive impact on household portfolios as it is considered to be a proxy for transaction costs. However, they also found that the effect of an increase in background risks is more pronounced in highly educated households. Unlike findings of Heaton and Lucas (2000), Palia et al. (2014) found that labour income is the most important factor followed by housing then business income. They argue that this discrepancy in the results could be due to the fact that Heaton and Lucas (2000) use a sample of individuals with significant amounts of financial wealth and income from sources other than labour income, whereas their sample is of general households.

The association between background risks and the composition of the household's financial portfolio is also confirmed using data from Australia. Cardak and Wilkins (2009) provide comprehensive analysis of households' portfolio decisions based on the Household, Income and Labour Dynamics in Australia (HILDA) survey. This dataset contains detailed information about Australian households' assets and liabilities, which allows the exploration of many hypothesised explanations of households' financial behaviour. Cardak and Wilkins (2009) include alternative background risks along with other basic factors in a tobit regression and use two sub-samples, one of employed individuals and the other is for those who are retired and above the age of 55. The main contribution of this paper is the inclusion of several variables such as: observed preferences; liquidity and credit constraints; investment substitutes; labour income risk; business income; health risk and committed expenditures. Furthermore, the richness of the data makes it possible to construct different measures of the same variable. For example, credit constraints are measured in three different ways; the possibility of raising 2000 dollars; having a credit card; paying the credit card's balance monthly. Labour income risk is also measured by realised variability of household labour income relative to age and a time trend to ensure that the measure is not driven by variability from life cycle ageing and economy-wide time trends. The paper found that demographic factors for the employed sample have the same effects as that found in the full sample, which are in turn in-line with other papers. However, within the retired sample, age is statistically insignificant. Labour income uncertainty and health risk negatively impact on the proportion of risky assets as expected with the exception that health risk is only important for the employed sample. Background risk associated with committed expenditure (mortgage and rent expenditures) has an unexpected positive impact on the risky assets ratio. Cardak and Wilkins (2009) argue that perhaps home-owners use their property as collateral to raise cheap credit to fund their investments. Cardak and Wilkins (2009) also suggest that the positive impacts of educational attainment and not being an immigrant are associated with the importance of financial awareness and literacy for risky asset holdings.

Financial literacy has become the main focus of recent and growing literature as household surveys start to explicitly provide measures of the individual's financial awareness. Van Rooij, Lusardi, and Alessie (2011) designed questions related to the interest rate, inflation and financial market instruments to measure the level of an individual's financial numeracy and literacy in Netherlands. They found that financial literacy is an important determinant of risky asset holdings as their empirical model shows that financially illiterate households are significantly less likely to invest in the stock market. Van Rooij et al. (2011) also found that a household's understanding of the concepts of inflation and the interest rate are much better than concepts related to financial market instruments (stocks, bonds and mutual funds). This might be due to the fact that the complexity of financial products has increased considerably over the years.

As mentioned before, participation costs go beyond the monetary costs, as investors need the time and ability to understand the risk-return trade-off and other information related to stock market operations. The education attainment variable is used in the literature to account for the fact that some individuals are better able to gather and understand such information. However, Christiansen, Joensen, and Rangvid (2007) argue that the type of education and information the individual receives is also important. They used Danish data to show that the probability of participating in the stock market increases if the investor completes economics education or if an economist moves into the household. Badarinza et al. (2016, p. 13) argue that *"A difficulty in interpreting these studies is that financial literacy is endogenous; wealthier people, and people with greater risk tolerance and hence greater interest in risky asset markets, may choose to become financially literate."*

Another factor that has been recently highlighted in the literature to influence an individual's financial decisions is the individual's general trust in formal financial institutions (see, for example, Guiso et al., 2008; Delis & Mylonidis, 2015; Georgarakos & Pasini, 2011; Balloch et al., 2015; Bucciol et al., 2016). Guiso et al. (2008) investigate the impact of trust on an individual's willingness to participate in the stock market. Theoretically, they argued that an individual's view of the stock market can be compared to that of the three-card game. They argue that even after observing the game many rounds, an individual may not trust the fairness of the game nor the person playing it. Using data on Dutch households, the empirical models show that the probability of direct participation in the stock market increases by 6.5 percentage points for individuals who do trust others and those who do participate will on average have a 3.4 percentage points higher share in stocks.[11] Moreover, Guiso et al. (2008) use the Italian Bank customers survey to construct a measure of trust in the institutions that facilitate stock market participation rather than the generalized measure of trust. The findings also show that trust has a positive impact on the participation rate and the level of participation. The cross country analysis of Guiso

[11] General trust is measured by the response to "Generally speaking, would you say that most people can be trusted or that you have to be very careful in dealing with people?"

et al. (2008) also shows that stock market participation is low in countries where trust levels are low. Guiso et al. (2008, p. 2560) argue that *"cultural differences in trust appear to be a new additional explanation for cross-country differences in stock market development"*. Guiso and Sodini (2013) also indicate that the lack of trust can explain the low participation in stock market among the wealthy, as trust is a relatively stable individual trait and does not vary across wealth levels. The findings of Guiso et al. (2008) stress the fact that negative events or prolonged exposure to low returns in the stock market will not only change an individual's subjective probabilities about stock market returns, but also the fundamental trust in the system that facilitates those returns. Georgarakos and Pasini (2011) also analysed the joint importance of trust and sociability on households' financial decisions using data from the Survey on Health, Ageing and Retirement in Europe. They found that both mistrust and sociability affect stock market participation through distinct channels. Mistrust will affect participation negatively as it dissolves the perceived risk premium, whereas sociability will enhance participation since it lowers the costs associated with it through cheaper information sharing.

To examine the importance of stock market literacy, sociability and trust for households' financial decisions Balloch et al. (2015) use the American Life Panel (ALP) surveys. Their measure of trust is based on the average of the responses to three questions about households' level of trust in the stock market, trust in stockbrokers and trust in investment advisers. Similar to Guiso et al. (2008) they also find that trust is associated with the probability of participation and the share of investment in stocks. Their results also indicate that stock market literate households are more likely to participate in stocks and invest a higher proportion of their wealth in the stock market. Furthermore, they argue that sociability does not play an important role for participation once stock market literacy is accounted for.

Household future expectations have also been documented in the literature to influence stock market participation. Using data from the Health and Retirement

Study in the U.S., Kézdi and Willis (2009) show that there is substantial heterogeneity in stock market expectations, heterogeneity that is a strong predictor of the heterogeneity in the fraction of households' wealth invested in risky assets. Kézdi and Willis (2009) argue that the reason for the systematic differences in expectations across different demographic groups, despite exposure to common and publicly available stock prices, is the fact that gathering information to form expectations requires effort, intelligence and motivation.[12] Hurd, Van Rooij, and Winter (2011) also found considerable heterogeneity in expected rates of return among Dutch households and those who perceive more risk in the rates of return are less likely to hold stocks. Malmendier and Nagel (2011) focus on the relation between past experiences and participation in the stock market. They found, using the Survey of Consumer Finances data from the U.S., that households tend to overweight events they have experienced in the past especially negative events. Their findings show that risky asset returns experienced during an individual's lifetime have a significant effect on the willingness to participate in the stock market and to take financial risk.

Japanese household portfolios

A distinct feature of Japanese households' financial portfolios is the high percentage of safe assets, such as cash and deposits. A number of studies have made an attempt to explain and identify factors influencing the low share of risky assets in the financial portfolios of Japanese households. This section will first describe Japanese household financial portfolios in terms of the classical theory described previously. In particular, Equation 3.1 suggests that the share of risky assets is determined by the following factors: the expected risk premium $(R_r - R_f)$; the volatility of the risky asset return σ; and the degree of the investor's relative risk aversion γ_i. Therefore, this section will first analyse each of these factors and see if they can explain the observed differences in risky asset holdings between Japan, the U.S. and Europe.

[12] They argue that the low stock holding levels found in single women, single men, African Americans, the less educated and those with lower cognitive capacity is related to their low expectations about stock market returns.

The literature argues that the conservative investment behaviour of Japanese households is a typical characteristic of their risk averse nature. Investing in risky assets is not the only indicator of aversion to risk in Japan. Figures from OECD (2014) show that Japan's market share in the total gross insurance premium is second at 10.0% after the U.S. at 49.0%. The World Value Survey conducted in 60 countries assesses individuals' general risk attitudes by asking the following question: "Adventure and taking risks are important to this person; to have an exciting life". Between 2010 and 2014, 2443 individuals were interviewed in Japan of which 73.0% described themselves as risk averse individuals by answering either "not like me" or "not like me at all" to the above question. This figure is the highest among eight developed countries as shown in Figure 3.1. For example, in the U.S. only 39.0% described themselves as risk averse individuals and in Cyprus this figure is even lower (20.0%), see Figure 3.1.

Starting up a business is considered to be a risky step to take in life and a country's aggregate measure of the number of adults starting own business is a good indicator of the risk attitude of the country's individuals. According to the Global Entrepreneurship Monitor (GEM), Japan's position among the 29 innovation-driven economies is last in the number of adults who are either a nascent entrepreneur or owner-manager of a new business, see Table 3.1.[13] Only 3.8% of adults engage in starting up a new business compared to 13.8% in the U.S. and an average of 8.0% of the 29 countries. 55.0% of adults who perceive starting up a business as a good opportunities, indicate that fear of failure would prevent them from taking up such a step, this compared to only 30.0% in the U.S. and an average of 38.0%.

These numbers might have been amplified by how the economy has been performing as only 7.0% see good opportunities to start a firm where they live compared to 51.0% in the U.S. and an average of 39.0%, see Table 3.1. Indeed, looking at the historical performance of the Japanese economy it is possible that Japanese people have

[13]Innovation-driven economies are the most developed economies with technology and knowledge-intensive business are the dominant source of competitive advantage.

good reasons to be cautious about starting up businesses given the events that have damaged their economy. Figures in the "Statistical handbook of Japan", Statistics Bureau, Japan (2017) show that Japan's economy enjoyed 10.0% per annum growth up until the first oil crisis in 1973 and the second oil crisis in 1978. After changing Japan's industrial structure from "energy-dependent" to "energy-saving" and some administrative and financial reforms, Japan's economy showed some improvement at the beginning of the 1980s. However, the sharp decline in land prices after the fall in stock prices has marked the start of a major economic recession, the so called collapse of the bubble economy.

Figures reported in the Statistics Bureau, Japan (2017) depicting total stock market capitalization and the stock price index of Japan over time, show the severity of the collapse of the stock market capitalisation at the end of 1992. According to the Statistics Bureau, Japan (2017), total market capitalization was 591 trillion yen at the end of 1989, it then dropped to 281 trillion yen by the end of 1992. As a consequences of falling land prices, bad debts started to build up in the loan portfolio of Japan's financial institutions, this in turn triggered Japan's banking crisis in 1997. Furthermore, Japan was not insulated from the impact of the 2008 financial crisis, despite the fact that the financial sector was not deeply exposed to sub-prime mortgages or other derivative instruments. The crisis impacted the Japanese economy through the decline in business investments and exports as a result of the economic contraction in the U.S. and Europe coupled with the rise in the yen.

The conservative investment behaviour of Japanese households is even more pronounced when one consider the monetary policy environment faced by Japanese households since the collapse of the house price boom and the asset price bubble of the late 1980s. During this period, the so-called lost two decades, the Central Bank of Japan has adopted a highly expansionary monetary policy. This action will effectively drives down the risk-free rate to very low levels depressing the returns from low risk assets. Lian, Ma, and Wang (2019) argue that individuals demonstrate a stronger preference for risky assets when the risk-free rate is low. This behaviour is also confirmed by Brown, Kontonikas, and Montagnoli (2020) who show that expansionary monetary policy is associated with higher household portfolio allocation to high risk assets and lower allocation to low risk assets. This observation makes the puzzle of low stock market participation in Japan even more puzzling.

Given the discussion above it might be the case that the difference in risky asset holdings between Japan and the rest of the world is due to the fundamental risk averse nature of Japanese people, which has been effected by the performance of the Japanese economy and the stock market in particular.

The other two determinants of the risky asset share in Equation 3.1, the expected risk premium $(R_r - R_f)$ and the return volatility of risky assets σ, might also explain the low participation in the stock market in Japan. As mentioned previously, the Japanese stock market is characterised by a very poor history of realised stock returns as compared to the U.S. and Europe. Over the period 1995-2016 Japanese stock market index (TPOIX) has underperformed the U.S. S&P 500, see Nakajo, Shino, and Imakubo (2017). Specifically, Nakajo et al. (2017) show that the prices of stocks in the S&P 500 have a higher probability to rise than fall, while stocks in the TPOIX were more likely to fall than to rise. Given this poor performance of the Japanese stock market, it seems natural to see a low level of stock holdings among Japanese households. However, stock markets around the world have also experienced severe losses a multitude of times, but yet the stock market participation in general has not been as low as the rate observed in Japan.

Having reviewed the performance of the Japanese economy and the stock market and how this might influence households' risky asset holdings according to the classical theory described in Equation 3.1, the rest of this section reviews the small number of empirical studies that analyse Japanese households' financial portfolios.

Kinari (2007) empirically tested the power of the classical theory and found that the classical theory cannot fully explain differences in risky asset shares between Japan and the U.S..[14] In particular, Kinari (2007) argues that individuals' degree of risk aversion and the distribution of the return on assets discussed in the classical theory are not sufficient to explain the observed differences in risky asset holdings between Japan and the U.S.. To highlight the limitations of the classical theory, Kinari (2007) compared the means and standard deviation values of the risky asset shares which are predicted by the classical theory with the actual observed values in Japan and the U.S.. The results confirm that the theoretically predicted values do not coincide with the observed values. To overcome the limitations of the classical theory, Kinari (2007) included the commonly used demographic factors in a tobit model to test if they can explain the differences in the risky assets participation rate and the level of holdings between Japanese and U.S. households.[15] The results suggest that in general there are common features across the two countries as several variables are significant and have the same sign. However, the main difference is that the marginal effects of these variables are larger in the U.S.. Moreover, unemployment risk and housing are only significant for the U.S., whereas financial business and health indicators are only significant for Japan. Kinari (2007) concluded that the differential in the risky asset shares between Japan and the U.S. comes from other factors that are not considered explicitly in the tobit regression, such as; cohort effect; loss aversion and/or factors related to differences in financial institutions.

One of the early studies which investigated the reasons Japanese households are reluctant to invest in risky assets is Nakagawa and Shimizu (2000). Using tobit and probit models and data from the Family Savings Survey for 1991 and 1999, they find that the decline in the rate of return on stocks and the high volatility attached

[14] The paper uses the "Preferences and Life Satisfaction Survey" in Japan and the U.S. conducted by Osaka University.

[15] Unemployment risk, borrowing constraints, self-employed, financial business, university, housing, health, investment horizon, age dummies, income, wealth, and child dummies.

to this return explain the decline in a household's risky asset holdings. Moreover, the deteriorating income environment in the Japanese economy at the time of the survey has increased precautionary demand for safe assets, "the precautionary savings motive". The paper identifies a number of structural factors that make current risky financial assets unattractive, such as the taxation system, the lack of asset related information and the high cost of such investment. Furthermore, Nakagawa and Shimizu (2000) found that Japanese households are two or three times as risk averse as their U.S. counterparts based on the estimated risk aversion coefficient of the CAPM and the survey results which indicate that more than 70.0% of households put great importance on the "safety" and the "liquidity" of assets. However, in this context the level of risk aversion should be estimated independently of the level of risky asset holdings, perhaps using subjective questions such as the hypothetical lottery questions or insurance cover, in order to correctly identify the causality of the effect.

Since the analysis of Nakagawa and Shimizu (2000) was restricted to two years, both occurring after the bubble, Iwaisako, Mitchell, and Piggott (2004) argue that the observed fall in the share of risky assets in the data of Nakagawa and Shimizu (2000) could be an adjustment back towards the status quo, as stock holdings by Japanese households increased rapidly in the late 1980s. Iwaisako et al. (2004) evaluated the patterns in the level and composition of financial and non-financial assets across different types of Japanese households using the Nikkei Radar data for the year 2000 and employing probit and tobit models. The paper contributes to the limited literature on Japanese households' portfolios by considering households' claims on social security and pensions. The findings confirm that a household's holdings of risky assets, housing assets and total wealth increases with income. However, households tend to invest a higher proportion of their wealth in real estate than in equity when they are older. This finding suggests that households still see housing as a more attractive form of saving than the stock market despite the price depreciation of houses in Japan. This pattern is further confirmed as income positively affects equity holdings, but at a decreasing rate, while in the housing equations it has a positive and growing impact on housing wealth. The findings relating to the other variables, such as education, gender and material status all have the usual effects on equity holdings and housing wealth. However, being employed is negative and statistically significant in the equity regression, suggesting that if the head is not working, equity holding will be higher. Iwaisako et al. (2004) argue that the employment status variable might be reflecting that the head of the household is retired rather than not working.

To provide a detailed description of the interaction between risky asset holdings and real estate holdings over the life cycle, Iwaisako (2009) uses the Nikkei Radar data from 1987 to 1999.[16] Iwaisako (2009) emphasises the importance of including real estate holdings in the analysis of the Japanese financial portfolio due to the unique structure of the housing market in Japan. The relationship between age and risky asset holdings has been documented to increase with age, reaching a peak at middle age before declining, see Ameriks and Zeldes (2004) for the U.S. and Guiso, Haliassos, and Jappelli (2002) for Europe. Iwaisako (2009) found that the Japanese behave similarly with one exception that the peak comes at a much later stage of life, in their 50s, and remains fairly constant thereafter. Moreover, this relationship between age and risky asset holdings is found only conditional on holding real estate, this relationship disappears for households that do not own real estate. Iwaisako (2009) argues that the high land prices in Japan and the higher average down payments compared to the U.S. leave Japanese households in a highly leveraged position. This will lead to a higher share of real estate in total wealth, explaining why Japanese households hold less risky assets and the peak of their holdings comes at a much later stage of life.

To link household choices to the state of the macro economy, Aoki et al. (2016)

[16] There is an early version of this paper in (2003) which also compares the Nikie data with other data sets in Japan.

analyse Japanese households' financial portfolios based on a life-cycle model.[17] They argue that their counter factual experiments confirm that the persistently low level of inflation in Japan, which has averaged close to zero for almost 15 years, can discourage stock market participation. In particular, if the inflation rate in Japan was similar to the world wide agreed target of 2.0%, stock market participation would increase from 15.3% in their baseline simulation to around 20.0%. Low expected stock returns is another factor the paper claims that has an important impact on household financial behaviour. Aoki et al. (2016) argue that if they increase the mean equity premium in the baseline calibration model for Japan from 1.8% to 4.0%, stock market participation rate will increase to 50.0%, a ratio which has been experienced in the U.S.. The participation cost of the stock market in Japan is estimated by their calibrated structural model to be relatively high at 9.0%, this cost is estimated in the literature for the U.S. to be around only 5.0%. Aoki et al. (2016) argue that the stock market participation rate in Japan would increase from 15.3% to 43.0% if the participation cost is set at 5.0%. The paper concludes that "*persistently poor macroeconomic performance with low interest rates, low stock returns and low inflation can have a very far reaching impact on household behaviour*" Aoki et al. (2016, p. 43).

Recently, Ito et al. (2017) analyse the mechanisms that influence household portfolio selection in Japan and the U.S.. The paper used the "Preferences and Life Satisfaction Survey" to carry out comparison between Japan and the U.S. as this survey asks the same questions in both countries. Ito et al. (2017) argue that the determinants of the level of risky investments (the conditional share) will differ from those affecting the decision to participate in the stock market (participation rate), hence they analysed the two issues separately using dynamic panel data models. The paper assumes that the conditional share of risky assets depends on: the expected return on risky assets; the return on safe assets; market volatility; relative risk aversion; liquidity constraints and precautionary saving motives. The paper

[17] They used data from the Japanese Survey of Household Finance (SHF) from 1981 to 2014.

also argues that the participation rate, which is estimated by a random effects panel probit model, will depend on entry costs as well as the variables in the conditional share. The findings of the GMM model, used for the level equation, indicate that the classical theory factors explained in Equation 3.1 and factors related to liquidity constraints, all have a significant important influence on the level of risky assets held at the household level in both countries. However, precautionary saving motives and concern about the future have no significant effects on the level of risky assets in both countries. In contrast, the results from the probit model indicate that all the factors included in the model have significant impacts on the participation rate, especially the financial literacy factors. Ito et al. (2017) argue that the differences in the conditional share between Japan and the U.S. are mainly explained by the classical theory factors and other unobserved factors captured by the constant term. However, the major difference in the participation rate between the two countries is explained by financial literacy and the constant term along with the other factors included in the model. Ito et al. (2017) argue that based on these results, to improve the participation rate and the conditional share in Japan, the following should be improved: the market distribution of the return on risky assets; structural factors related to financial institutions and the financial education of Japanese households.[18] A limitation of Ito et al. (2017) is that it does not include the impact of real asset holdings and the life cycle of the households in the analysis. These two factors have been identified to have a strong impact on the financial behaviour of households.

Summary

The discussion of the papers above shows that the literature have provided a greater insight into a multitude of topics surrounding risky asset holdings by households. However, a number of gaps can still be identified in the literature related

[18] An initiative in the field of financial education which has been operating in Japan since 1983 is the Central Council for Financial Services Information, www.shiruporuto.jp/e. The main purpose of the council is to educate the public regarding the importance of basic financial and economic knowledge.

to the analysis of risky asset holdings of Japanese households, which is what this chapter will try to address.

Although there is a number of studies that explain and identify factors influencing the low share of risky assets in the financial portfolios of Japanese households, the types of statistical models used can be seen as a limiting factor. Most of the papers which examine the determinants of risky asset holdings in Japan use a tobit specifications. However, using a tobit model for modelling variables that are proportional in nature is conceptually flawed, as argued by Cook, Kieschnick, and McCullough (2008), as it violates the assumption of linearity between the dependent and independent variables. To overcome this issue, the literature suggests the use of the FRM as an alternative modelling approach to the tobit model, which can handle proportions where both zeros and ones may appear. Therefore, the empirical analysis presented in this chapter make use of four alternative methodological approaches to explore the robustness of the findings. Two of these approaches, CQR and the FRM models, have not been applied to Japanese data in this context. Moreover, aspects of households' trust in the functioning of the stock market and general trust in the government have not been analysed before in the literature that focus on Japanese households.[19] Therefore, this chapter will contribute to the existing literature on the determinants of risky asset holdings by analysing the effects of household trust in the stock market, trust in the government and household perception of risk on risky asset holdings for Japanese households. Finally, this chapter will use the KHPS dataset, a dataset that has never been used before to examine Japanese households' financial portfolios.

[19] Balloch et al. (2015) use the American Life Panel (ALP) surveys to examine the importance of households' level of trust in the stock market for households' financial decisions. Guiso et al. (2008) examined the role of trust using data from the Dutch National Bank (DNB) Household Survey and data from the Italian Bank customers survey.

3.4 Data

This chapter uses the KHPS available from the Panel Data Research Centre at Keio University. The KHPS is one of the most comprehensive panel surveys of households in Japan and it has been conducted annually by Keio University since 2004 using the drop-off pick-up (DOPU) method. Respondents were selected by stratified two-stage random sampling of people aged between 20 and 69, male and female.[20] The KHPS provides detailed information about respondents' social and demographic characteristics, and also basic information regarding their financial asset holdings. In wave 10 (2013) respondents were also asked detailed questions regarding their perceived risk of selected assets and respondents' opinions about the functioning of the stock market. Therefore, this chapter will focus on wave 10 to further explore household holdings of risky assets.[21] This wave contains information on 3,568 households of which 2,945 provide complete information on the variables that are the focus of this chapter. Information is collected for the respondent and his/her spouse in the case of married couples. However, as the analysis in this chapter is of household asset holdings, the household is the unit of analysis rather than individual respondents. Following Cardak and Wilkins (2009), household characteristics are derived from the head of the household, who is explicitly identified in the survey questionnaire.

3.4.1 Dependent variable

The KHPS asks respondents to report the values of the household's financial portfolio in two categories, deposits and securities. The KHPS lists the items which are included in each category as follows: "(1) Deposits: Postal savings certificates, time deposits, instalment savings and ordinary deposits. Bank, shinkin bank, etc.

[20] Generally, responses by other family members are not permitted.

[21] In the first part of the chapter, all waves of the KHPS data set (2004 to 2015) are used to examine the determinants of risky asset holdings. However, only variables included in the baseline model are analysed to allow for comparison with other studies.

Time deposits, instalment savings and ordinary deposits. Company deposits, gold investment accounts, gold savings accounts, medium-term government bond funds, etc; (2) Securities: Shares (market value), bonds (par value), stock investment trusts (market value), corporate and public bond investment trusts (market value), loans in trust and money in trust (par value), etc".

This chapter follows the literature and defines risky assets category to be total value of securities (category (2)) and safe assets to be total values of deposits (category (1)). The chapter also defines total financial wealth as the total value of deposits and securities (category (1)+(2)). Hence, the dependant variable is the fraction of financial wealth invested in risky assets.

Table 3.3 provides summary statistics for the risky assets ratio and how this variable varies by age, education level, gender, employment status, marital status and health status. The average holdings of risky assets in our sample is 6.4%, which is much lower than U.S. and European household, see Bank of Japan (2017b). Table 3.3 also shows that holdings of risky assets increase with age, which is at odds with the humped shaped relationship observed in the U.S. and Europe. In line with prior expectations, more educated household heads hold a higher share of risky assets. Similarly, households with male heads allocate a higher proportion of their financial assets in risky assets than households with female heads. The summary statistics in Table 3.3 suggest that household heads who are in part-time employment or in the "other" category (student, housewife and retired) hold a higher share of risky assets than those who are in full time employment. Finally, variations of risky asset holding among the four health status categories, and between being married and being single are limited. Figure 3.2 shows the distribution of the proportion of risky assets which display a high percentage of zero holdings in our sample. Figure 3.3 shows the distribution conditional on holding the risky assets, which also shows that those who do hold risky assets hold small proportions.

Wealth distribution

To gain an in depth understanding of the wealth distribution in Japan, Table 3.2 reports the summary statistics of the six main asset and liability classes. These statistics confirm that Japanese households are much more risk averse than their European and U.S. counterparts, as they hold a lower proportion of securities and a much larger proportion of safe assets. The statistics in Table 3.2 are also in line with the data of Bank of Japan (2017b), confirming that the KHPS dataset is a representative sample of Japanese households. The average value of safe assets in the sample is ¥8,430,000, whereas the median is ¥3,120,000.[22] The mean holding of securities among all households is ¥1,480,000 (around £9,800) and the median is zero. Similarly, the means of the other four measures are much less than the median values, which is due to the fact that only a small proportion of households hold a large amount in each asset/liability class. Further insight into the distribution of these measures can be obtained by looking at the distribution by percentiles. We observe from Table 3.2 that the lower 50 percent of our sample have ¥3,120,000 or less in safe assets whereas the top 10 percentile have at least ¥20,770,000 in safe assets. When the distribution of securities is compared to that of savings, we observe that the former is much more heavily skewed. Only the top 10 percentile of our sample hold some investment in securities, which reinforces the fact noted earlier that in our sample the participation rate in risky assets is very low for Japanese households. In fact, the percentage of households in our sample that hold zero securities is 78.0%, which is crucial to account for when deciding on the appropriate empirical methodology as discussed in the next section. When looking at total assets, defined as, financial wealth plus the market values of the residential property and the associated plot, it is still clear that the distribution of wealth is heavily skewed. Households who are in the bottom 25 percentile have only ¥4,570,000 in total assets, whereas the top 10 percentile have almost 12 times that amount at ¥58,150,000. Total debt and non-mortgage debt display similar trend to the other

[22] This is around £56,000 for the mean and £21,000 for the median, assuming £1=¥149.

measures. However, it is surprising to see that only the top 10 percentile have non-mortgage debt. To summarise, Table 3.2 shows that in our sample there are a large variations across households' allocation of assets and that the distribution of main assets classes is significantly skewed.

3.4.2 Independent variables

The KHPS dataset contains detailed information on the demographic and socio-economic characteristics of household heads. The baseline specification discussed next will first define the commonly used determinants of risky asset holding in the literature. However, one of the main contributions of this chapter is the analysis of new variables that might be important in explaining the low stock market participation rate and be crucial in understanding Japanese household investment decisions. These variables and the baseline variables are defined in Table 3.4, whilst summary statistics are presented in Table 3.5.

Baseline variables

The literature has identified a number of demographic and socio-economic characteristics which influence stock market participation decision of households (see, for example, Haliassos & Bertaut, 1995; Campbell, 2006; Guiso & Sodini, 2013). These papers suggest that important predictors of risky asset holdings are income and wealth. In line with Cardak and Wilkins (2009) this chapter adjusts households' income for household composition using the OECD-modified equivalence scale.[23] Finally, the natural logarithm is taken for the adjusted income. Similarly, the natural logarithm is taken for the net wealth, which is defined as total financial and non-financial assets minus total debt. For both variables the natural logarithm is set to zero when the values of these variables are zero. In the case of negative net wealth, as a result of total debt being larger than assets, an inverse hyperbolic sine

[23]Specifically, household total pre-tax income is divided by 1.5 for each adult other that the household's head and by 0.3 for each child.

transformation is applied using “asinh” routine in STATA, Oldham, Myland, and Spanier (2010). The literature suggests that in addition to income and wealth, the level of education of the household head is a key determinant of risky asset holdings. This might be due to the fact that educated individual are better able to understand sophisticated financial products. Table 3.5 shows that there are considerable numbers of educated Japanese households in our sample. Table 3.5 shows that 30.0% of household heads have a university or higher level of education and 46.0% have a high school level of education. To control for the household head’s current employment we construct a set of dummies derived from the question: “Last month (January), did you perform any paid work (including paid work at family businesses)?” The binary variables are, working (omitted category), unemployed, part-time work and other (housewife, students and other).

A growing body of literature incorporates background risks in the analysis of household financial portfolios. Exposure to unfavourable background risks will have a significant impact on the optimal level of risky asset holdings. The first background risk to be considered is labour income risk, which is measured at the household level. The literature suggests different methods of measuring labour income risk, see for example Cardak and Wilkins (2009). In this chapter we adopt two of these methods, the first is the classical measure of risk, which measures labour income risk by simply the variance of household income. However, in the second method individuals derive their expectations about future income from a prediction based upon their observable characteristics, for more details see Cardak and Wilkins (2009). This process can be expressed as:

$$y_{it} = a_t + X_{it}\beta_t + \mu_{it}\,, \tag{3.2}$$

where a_t is a calendar year effect included to reflect the macroeconomic environment. Whilst X includes all observable and demographic characteristics of the household head which have an impact on labour earning. These characteristics include: gender, age, region, family size and education.[24] Then labour income risk is simply the variance of μ_{it}, which is the idiosyncratic and unpredictable part of household total labour income y_{it}.[25]

Health risk is also one of the variables included as a background risk in the analysis of risky asset holdings. Risk associated with health status cannot be diversified and can be seen as a source of income and expenditure risk. Japanese households will face costs associated with healthcare despite the fact that Japan provides access to public health care. Japanese households are required to pay a fraction of the medical treatment cost, which is 20.0% or 30.0% depending on the insurance scheme the household enrolled in. This fraction is paid on the day but capped to a monthly limit to ensure affordability. Hence, the health status of the household head will potentially influence household portfolio composition. The health variable included in the KHPS is based on a self-reported question which asks the head of the household whether his/her health is good, pretty good, normal or poor. Around 15 percent reported poor health, 44 percent of individuals in our sample reported a normal health status, 12 percent reported good health and 29 percent reported pretty good health. These self-reported measures of health are commonly used in the assessment of household portfolios (see, for example, Love & Smith, 2010; Mariotti, Mumford, & Pena-Boquete, 2015; Cardak & Wilkins, 2009).

Mortgage payments and rent expenses are two types of committed expenditure identified in the literature as risky liabilities that might have an impact on household's portfolio composition (see, for example, Fratantoni, 1998; Cardak & Wilkins, 2009). Generally, committed expenditure risk is measured as the ratio of primary residence expenditures to household labour income. For those with rented proper-

[24]The homogeneity of labour income risk with respect to risky asset ownership is unlikely to be an issue as suggested by Cardak and Wilkins (2009). They argued that it is much easier to control exposure from holding risky assets than controlling labour income risk, hence it is unlikely that holdings of risky assets will influence labour market activities.

[25]However, both of these measures yield similar results, hence we only report the results based on the simple classical method.

ties, expenditures include annual rent, while for home owners housing expenditures include annual mortgage payments. Home ownership is also an important variable to control for. The literature suggests that home ownership can be considered as an investment substitute, Cardak and Wilkins (2009). However, other studies argue that home ownership can be used as collateral to facilitate borrowing and generate liquidity which is important in household finance decision, see Mariotti et al. (2015).

In addition to the determinants discussed above, this chapter controls for demographic characteristics which are likely to influence the stock market participation decision of households. For example, Age has attracted considerable discussion in the literature as individuals face different financial constraints and saving goals in different phases of their life. Also, head of household gender is important as men and women exhibit different behaviour towards financial decisions. It will also matter whether there are children present in the household, the number of adults and whether the household's head is married. Therefore, we control for these variables alongside two geographical controls, region and city size. Considering the demographic characteristics mentioned above in more detail, the average age of the household head in the sample is 51 years old, 87 percent are male, and 82 per cent are married. The average number of adults in our sample is three adults and 35 percent of households have one or more dependent child present.

The variables discussed above are commonly analysed in the literature. However, this chapter contributes to the current literature by including key explanatory variables, each of which captures an aspect of Japanese household behaviour when taking financial decisions. In each wave the KHPS explores specific aspect of household's behaviour. In wave 10 (2013) respondents were asked detailed questions regarding their perceived risk of selected assets and their opinions about the functioning of the stock market. These variables have not been analysed for Japanese households before, therefore, they might help to explain the low participation rate of Japanese households in the stock market. Table 3.4 provides the specific questions asked in the survey for each variable.

Attitudinal variables

A recent trend in the current literature is the focus on non traditional factors, mainly behavioural factors, to fully explain the low stock market participation rate of households, see for example, Guiso et al. (2008).

The set of general attitudinal variables aims to capture some of the behavioural factors which may influence risky asset holdings such as, individual risk attitudes. An indicator of individual financial risk aversion is usually included in the analysis of household risky asset holdings, however, the KHPS has a question regarding risk aversion in general. Specifically, respondents are asked: *"When you have to go out somewhere in your town all day, what is the chance of rain that makes you take an umbrella with you? 0%-100%"*. Therefore, we use this variable to proxy for the risk aversion level of household heads in our sample, see Jung and Treibich (2015). In particular, those who answered that they always carry an umbrella will be considered as risk averse, whereas those who answered that only 100 percent chance of rain makes them carry one are regarded as risk loving. In our sample, 13 percent of household heads always carry an umbrella, whereas only 2 percent will carry an umbrella only if there is 100 percent chance of rain.

The second variable in this set is related to savings' preferences. The question is: *"Around how much is the total savings goal you are now considering for every month?"* However, as we are interested in household's preferences, this variable is changed from a continuous one to a binary variable that indicates if the household has a saving goal or not rather than the actual amount of savings the household aims for. This variable captures those who have a saving goal and as a result can be considered as being financially organised and hence are more likely to engage in other financial products. However, it is also possible that having the need to save might be a reflection of greater background risk and hence might have a negative impact on the proportion of risky asset holdings. 61 percent of the sample have a saving goal.

Household's future financial and political expectations have been documented in the literature to influence various aspects of household finances (see, for example, Brown, Garino, Taylor, & Wheatley Price, 2005; Malmendier & Nagel, 2011; Kézdi & Willis, 2009; Lunt & Livingstone, 1991). Expectations will be reflected in individual risk preferences as these preferences are also based on exposure to risky environments in the future, not only the riskiness of the environment in which a decision is currently being made. The two variables included to capture individuals' future expectations are related to future retirement income and the Japanese government. Specifically, respondents are asked: *"Do you think that you have income and assets that are enough to lead a retirement life without problems?"*; and *"Do you support the present government?"*. The two indicators capture different subjective aspects which could influence the investment decision and cannot be covered by objective variables. While the question relating to expected future retirement income captures how comfortable individuals are about future income, the government question reflects the trust an individual has in government policies in general. The latter variable is of particular importance as the Japanese government announced in January 2013 (at the same time wave 10 was taking place) its "three-arrows" strategy to achieve an early end to deflation and overcome economic stagnation. Only 10 percent in our sample think that they have enough retirement income, 20 percent do not know and 70 percent they think that their retirement income is not enough. Turning to the government support variable, 49 percent do support the current government, 26 percent they do not and 25 percent they cannot decide.

Table 3.6 shows pairwise correlations between the share of risky assets and the variables in this set. The table shows that most of the variables in this set correlate with the expected sign with the dependent variable. For example, those who do support the current government policy and those who do have a saving goal hold more risky assets. Whereas those who think that retirement income is not enough will limit their exposure to financial risk as they feel uncomfortable with future income. However, the sign of the risk attitude measure is at odd with expectation.

Impression about stock markets

The main feature of the stock market that attracts investors is the belief that the stock market will yield a higher return than risk free investments. Without this belief, investors will choose not to participate in the stock market even in the absence of any participation costs. However, this belief is built on different dimensions of trust in the stock market, such as, trust in the profitability, fairness, efficiency and prudential supervision of the stock market. Therefore, trust in the stock market is another important factor that has been recently highlighted in the literature to influence the decision of households to invest in risky financial assets (see, for example, Guiso et al., 2008; Delis & Mylonidis, 2015; Georgarakos & Pasini, 2011; Bucciol et al., 2016). The measure of trust which has been used in these studies is a measure of generalized trust, with the exception of Guiso et al. (2008) who used customers' confidence toward the bank as a broker.[26] However, measures of the trust in the institutions that facilitate stock market participation is arguably far more important than relying on a generalized measure of trust for this area of analysis. Therefore, this paper contributes to the literature by using detailed measures of individual's trust in the stock market, which collectively can be seen as an indicator of households' impressions of the overall reliability of the stock market. The statements are:

"Please circle the answer that best applies to you for each of the following statements regarding your impression about the stock market.(0) Disagree (1) Somewhat disagree (2) can't say either way (3) Somewhat agree (4) Agree:
1- Profits cannot be made with certainty.

[26]General trust is measured by the answers to "Generally speaking, would you say that most people can be trusted or that you have to be very careful in dealing with people?".

2- Significant losses are possible.

3- Illegal activities such as insider trading are widespread.

4- No much progress has been made in terms of disclosure of information on corporate performance.

5- Market interventions by the central bank and the government are not thoroughly conducted."

The first two statements of this set focus on the profitability and riskiness of the stock market whereas the other three statements focus on stock market fairness, efficiency and prudential supervision. The risk and return trade-off is crucial for household in deciding whether to participate in the stock market or not. Profitability and riskiness of the stock market as perceived by households are captured by the first two variables. The variable related to trust in the government discussed in the previous section can be extended further to analyse individual trust in the stock market specifically. Guiso et al. (2008) investigate the impact of trust on influencing individuals' willingness to participate in the stock market.[27] Their findings suggest that negative events or prolonged exposure to low returns in the stock market will not only change an individual's subjective probabilities about stock market returns, but also the fundamental trust in the system that facilitates those returns. The last three variables of this set capture different dimensions of households' trust in the stock market.[28] In particular, the "illegal activities" statement captures the fairness and the quality of investor protection whereas the information disclosure statement captures stock market efficiency. Finally, the statement regarding market interventions by the central bank and the government captures stock market prudential supervision. Table 3.7 shows the distribution of these variables, where it is clear that the majority of respondents agree with the statements concerning the

[27] They compared individuals' views of the stock market to that of the three-card game. They argue that even after observing the game many rounds, an individual may not trust the fairness of the game nor the person playing it.

[28] The order of the response has been reversed to be in line with set three. As a consequence, a higher value in each of these variables denotes a higher agreement with the statement.

profitability and riskiness of the stock market. However, most of the respondents could not decide about the statements related to the three trust dimensions.

Table 3.6 shows pairwise correlations between the share of risky assets and the variables in this set. Similar to the variable in the "attitudinal variables" set, the table shows that all of the variables in this set correlate negatively with the dependent variable which is in line with prior expectations. For example, those who do not trust the fairness and the quality of investor protection of the stock market will limit their holdings of risky assets.

Risk ranking of selected assets

The variables in this set focus on the household's personal interpretation of the riskiness of selected assets. Each respondent is asked to rank the riskiness of six different types of saving and investment vehicles. Specifically, respondents are asked: *"If we assume stashing cash has a risk value of 0 and purchasing a betting slip or lottery ticket has a risk value of 10, what do you think are the risk values of the following types of saving and investment? on a scale of 0 to 10.*
1- Putting money in a conventional bank savings account.
2- Putting money in a foreign currency deposit.
3- Putting money in a postal savings account.
4- Buying stocks.
5- Buying a stock investment trust.
6- Investing in land and property."

These variables reflect individual perception of the risk attached to an asset given the current state of the economy. Distinguishing between the effect of risk preferences and risk perception is important to fully capture the underlying process which form the individual's optimal portfolio. E. Weber and Milliman (1997, p. 124) argued that *"differences in risky choice should not automatically be interpreted as the result of changes in people's preference for risk, but may also, at least partially, be* *the result of changes in their perception of the risks."*. Therefore, it should be noted that the profitability measure in set two is different from the riskiness of stock and investment trust variables in this set. While the former measures the uncertainty of stock market return and individual risk tolerance, the latter focuses on the riskiness of stock market returns as measured by the perceived return volatility.

M. Weber, Weber, and Nosić (2012) analysed brokerage customers' willingness to take risk during the period of the (2007, 2009) financial turmoil. Risk attitudes measures are used along with investors' expectations of the market return and volatility, which were measured in two different ways. One using numeric judgements of returns and volatility in returns and the other using subjective rating scales of the return and volatility ('extremely bad' to 'extremely good' for returns, and from 'not at all risky' to 'extremely risky' for risk), which is similar to the measure of risk of the selected assets used in this chapter. They analysed how these different measures changed over this period and which characteristics are associated with changes in risk taking. M. Weber et al. (2012) found that subjective expectations of market risk and return are a strong predictors of changes in risk taking. Whereas investors' numeric estimates of market returns and volatility, which are closer to the traditional model discussed in Equation 3.1, fail to predict observed changes in risk taking, suggesting that "*the more emotion-based components of these judgements that drive changes in risk taking*", M. Weber et al. (2012, p. 31). Hoffmann, Post, and Pennings (2013) also found similar results using brokerage records of 1510 clients of the Netherlands. In particular, they found that the main driving force for portfolio allocation is the fluctuation in investors' risk perceptions, while investors risk preferences did not change substantially during that period.

These studies show the importance of including risk perception in a household level risk taking equation. They also suggest that examining the evolution of investors risk perceptions and risk preferences may shed a light on the psychological factors influencing household financial portfolio decisions.[29] However, data on the set of variables discussed in this section for Japan is not available in a panel structure, hence this chapter only focus on the 2013 wave of the KHPS.

Table 3.6 shows pairwise correlations between the share of risky assets and the variables in this set. All of the variables in this set correlate negatively with the dependent variable, however, only individual perceptions of the risk attached to saving and postal saving are statistically significant.

3.5 Methodology

As discussed above, an important feature of the dependant variable is that a significant proportion of households hold no risky assets and that the dependant variable is proportional in nature. This requires particular econometric techniques to account for the fact that the dependant variable is defined on the interval $[0, 1]$. The chapter uses four alternative methodological approaches to explore the robustness of the findings to different modelling approaches, two of these approaches have not been applied to Japanese data in this context. The tobit model, developed by Tobin (1958a), is the most commonly used approach in the literature to assess the determinants of risky asset ownership, (see, for example, Cardak & Wilkins, 2009; Guiso et al., 1996), amongst many others. Therefore, the tobit model is used as a reference case against which the findings of the existing literature and the alternative models adopted here are compared to.

The tobit results are important to allow for a comparison with two alternative models used in this chapter which are, the Censored Quantile Regression (CQR) and the Fractional Response Model (FRM). Each of these approaches has a unique feature which helps in exploring the nature of the dataset and furthering understanding

[29] Barberis (2013) argue that psychological factors have an important role in the the creation of the 2008-2009 financial crisis.

of Japanese households' attitudes towards risky investments. The FRM consists of two models; the one-part model and two-part model. Each model of the FRM can handle proportions where both zeros and ones may appear and the two-part model jointly models the incidence and extent of risky asset holdings. This is crucial as factors that explain the former decision may not be the same as those that affect the latter decision or their effects may be different. The CQR allows an examination of the complete distribution and handles censoring at zero without the assumptions of normality and homoscedasticity that are necessary in the tobit model. Estimators which are based on the mean conditional distribution of the dependent variable provide only a partial view of the relationship between a set of regressors and the outcome variable. However, it is interesting and informative to explore whether the effects of determinants vary over the distribution, which is provided by the CQR.

3.5.1 Tobit Model

As mentioned above, the tobit model is commonly used to address the clustering at zero and one of the proportion of risky assets in household portfolios. Applying a simple Ordinary Least Squares (OLS) regression will lead to downward-biased estimates, because the sub-sample used is limited to households who have at least some risky asset holdings. Technically, an OLS on the sub-sample of households with positive risky asset holdings can be applied, but only when it is reasonable to assume that the decision to hold risky assets is uncorrelated with the level of risky asset holdings. Tobin (1958a) examined the relationship between household income and expenditure on luxury goods. He argued that the large concentration of households who spend exactly zero dollars on luxury goods should be taken into account. This is because an explanatory variable is expected to influence both the probability of a household buying luxury items and how much they actually spent, given that they have spent.

The tobit model is usually interpreted in terms of an underlying latent variable,

y_i^*, of which y_i is the realised observation, where the subscript i denotes the household index.[30] In this chapter y_i^* will be the propensity of households to hold risky assets but this is only realised as actual holding, y_i, if that propensity exceeds zero. Hence, although many observations may have zero holdings on the realised variable y_i, they can be considered as having differing holdings on the latent variable y_i^*. This latent variable is defined to be left censored at α (the lower limit, which is zero) and right censored at η (the upper limit, which is one). Therefore, the realised variable y_i is defined as follows:

$$y_i = \begin{cases} \eta & \text{if } y_i^* \geq \eta \\ y_i^* & \text{if } \alpha < y_i < \eta \\ \alpha & \text{if } y_i^* \leq \alpha \end{cases} . \tag{3.3}$$

The tobit model can be written in terms of the underlying or latent variable as:

$$y_i^* = \boldsymbol{\beta}' X_i + \varepsilon_i, \tag{3.4}$$

where X_i is the vector of independent variables discussed above, $\boldsymbol{\beta}$ is the corresponding vector of parameters. The error term ε_i is assumed to be normally, independently, and identically distributed, $\varepsilon_i \sim N(0, \sigma^2)$. The above model is estimated using the Maximum Likelihood Estimation (ML). The $\boldsymbol{\beta}$ vector of parameters that are typically produced by tobit ML estimation relate directly to the unobserved latent variable, y_i^*. Hence, each coefficient shows the effect of a change in an explanatory variable on the expected value of the latent variable, holding all other variables constant,that is:

$$\frac{\partial E(y_i^*|X_i)}{\partial X_i} = \boldsymbol{\beta}_i. \tag{3.5}$$

Therefore, to obtain a meaningful results one should relate the coefficients to the realised variable y_i instead. This can be achieved by finding the partial derivative

[30] The chapter will also use the random effect tobit model in the first part of the analysis. Full formulation of the random effect tobit model can be found in Greene (2012).

of the expected, unconditional value of the realized variable y_i:

$$\frac{\partial E(y_i|X_i)}{\partial X_i} = \boldsymbol{\beta}_i \times Pr[\alpha < y_i^* < \eta]. \tag{3.6}$$

In the above partial derivative, the coefficient is weighted by the probability that an observation, with a given set of x_i values, is uncensored. The impact of a change in one explanatory variable on y_i will depend on this probability. It is common in the literature to approximate this probability by the following scaling factor:

$$\frac{\text{The number of censored observations}}{\text{Total number of observations}}. \tag{3.7}$$

Therefore, each coefficient produced by the tobit model is multiplied by this scaling factor to obtain the marginal effects of changes in x_i, see Greene (2012).

3.5.2 Fractional Response Model (FRM)

The preferred estimation technique is largely determined by the nature of the dependent variable; that is, the proportion of risky assets held in the household financial portfolio. As mentioned before, the main feature of this variable is that it is a proportion that ranges continuously from 0 to 1, inclusively. An alternative modelling approach to the tobit model is the FRM, which can handle proportions where both zeros and ones may appear. Moreover, the two-part FRM allows the signs and sizes of the variables' coefficients for the participation decision equation to vary from the signs and sizes of the coefficients in the level of holdings equation. The FRM was developed by Papke and Wooldridge (1996) to deal with dependent variables defined on the closed interval $y_i \in [0, 1]$. The FRM requires a functional form for y_i that ensures the desired constraints are adhered to as follows:

$$E(y_i|X_i) = G(X_i\boldsymbol{\theta}). \tag{3.8}$$

Papke and Wooldridge (1996) suggest any cumulative distribution function as possible specifications for $G(.)$,

$$G(z) = \frac{e^z}{1 + e^z}. \tag{3.9}$$

Therefore, the logistic function in Equation 3.9 is a possible choice for $G(.)$, which maps z onto the (0,1) interval. Papke and Wooldridge (1996) propose estimating FRMs by quasi-maximum likelihood (QML) based on the Bernoulli log-likelihood function, which is given by

$$l_i(\boldsymbol{\theta}) = y_i \; log[G(X_i\boldsymbol{\theta})] + (1 - y_i) \; log[1 - G(X_i\boldsymbol{\theta})]. \tag{3.10}$$

The FRM model described above is an efficient model to explain the behaviour of a dependent variable characterised by a large number of zero values and of a fractional nature. However, it may be preferable to construct models which allow separate treatment of participation (to hold or not to hold risky assets) and allocation decisions (how much to hold in risky assets). This is crucial as factors that explain the former decision may not be the same as those that affect the latter decision or their effect may be different. In the framework of a "standard tobit" model, the incidence and extent of holding risky assets are determined by the same explanatory variables. Furthermore, the coefficients of these variables are restricted to having the same sign and magnitude in both underlying processes. Therefore, a two-part model is used in this chapter to allow separate treatments for the participation and allocation decisions for risky asset ownership by Japanese households. To achieve identification, we follow Spaenjers and Spira (2015) and Guiso, Haliassos, and Jappelli (2003) and include income and wealth quartiles in the equation of the stock market participation decision. Spaenjers and Spira (2015) argue that the relationship between the decision to participate in the stock market and wealth is non-linear. This is because changes in wealth at very low or very high wealth quantiles will not have a pronounced impact on the probability of participating in the stock market. Spaenjers and Spira (2015) argue that the level of holding risky assets conditional on participation does not show such non-linearity.

The two-part FRM was introduced by J. Ramalho and Silva (2009) as an extension of the original Papke and Wooldridge (1996) FRM model. The first part models the probability of a household participating in risky asset holding using a binary choice framework defined as:

$$Pr(y_i^* = 1|X_i) = Pr(y_i \in (0,1]|X_i) = G(X_i\boldsymbol{\theta}), \tag{3.11}$$

where y_i^* is defined as:

$$y_i^* = \begin{cases} 0 & \text{for } y_i = 0 \\ 1 & \text{for } y_i \in (0,1], \end{cases} \tag{3.12}$$

where $G(.)$ is as defined in (4). The second part of the two-part FRM relates to positive participation, i.e. the magnitude of risky asset holding in the portfolio. In this case, the specification for this part is:

$$E(y_i|Z_i, y_i \in (0,1]) = F(Z_i\boldsymbol{\gamma}). \tag{3.13}$$

$F(Z_i\boldsymbol{\gamma})$ can be estimated by QML and the logistic function is the specification used to estimate $\boldsymbol{\theta}$ as in the one-part FRM discussed above.[31] Therefore, equations (3.8) and (3.9) in the simple one-part FRM will be extended here to:

$$E(y_i|X_i, Z_i) = G(X_i\boldsymbol{\theta}).F(Z_i\boldsymbol{\gamma}); \tag{3.14}$$

$$E(y_i|X_i, Z_i) = \frac{e^{X_i\boldsymbol{\theta}+\boldsymbol{\gamma}}}{(1+e^{X_i\boldsymbol{\theta}})(1+e^{Z_i\boldsymbol{\gamma}})}. \tag{3.15}$$

Similar to the discussion related to the tobit model above, marginal effects should be obtained to assess the effect of a change in the explanatory variables on the probability of owning risky assets and the amount of risky assets owned, which are

[31] Note that the explanatory variables in the first part X_i and second part Z_i of the model are not required to be the same.

given by the equations (3.16) and (3.17), respectively.[32]

$$\frac{\partial Pr(y_i^* = 1|X_i)}{\partial X_{ij}} = \boldsymbol{\theta}_i \frac{e^{X_i \boldsymbol{\theta}}}{(1 + e^{X_i \boldsymbol{\theta}})^2}; \tag{3.16}$$

$$\frac{\partial E(y_i|Z_i, y_i \in (0,1])}{\partial Z_{ij}} = \boldsymbol{\gamma}_i \frac{e^{Z_i \boldsymbol{\gamma}}}{(1 + e^{Z_i \boldsymbol{\gamma}})^2}. \tag{3.17}$$

Allowing separate treatment of participation decision (to hold or not to hold risky assets) and allocation decision (how much to hold in risky assets) is informative for policy maker. The use of the two-part FRM allows authorities and financial institutions to target specific variables if their aim is to promote culture of participation in the stock market. However, if the concern is enhancing the level of holding of risky assets, then authorities and financial institutions can focus on the variables that have an impact on the level of allocation decision.

3.5.3 Censored Quantile Regression (CQR)

This chapter expands the analysis of the risky asset holdings by implementing a censored quantile regression (CQR), which allows an examination of the complete distribution and handles censoring at zero without any strict assumptions, see Powell (1986) and Chernozhukov, Fernández-Val, and Kowalski (2015).

In general, quantile regression has the advantage that it accounts for the full characterization of the conditional distribution of the dependent variable. Estimators which are based on the mean conditional distribution of the dependent variable provide only a partial view of the relationship between a set of regressors and the outcome variable. However, it is interesting and informative to identify how variables' effects on risky asset ownership vary over the distribution, which is provided by quantile regression. Moreover, estimators of the conditional mean are very sensitive to values in the tail of the distribution. Whereas, conditional quantile estimators

[32] Full formulations of the one-part FRM and two-part FRM can be found in J. Ramalho and Silva (2009).

are more robust to extreme values, which is important given the distribution of household risky asset holdings, see Figure 3.2. Hence, quantile regression is able to consider the potential impacts of covariates on the shape of the distribution rather than assuming that covariates will only shift the scale of the conditional distribution, Brown and Taylor (2008).

Turning to the efficiency of the CQR estimator, the CQR will produce consistent estimates in the presence of hetroscedastic errors as it is not based on the assumption of constant variance. Moreover, the CQR estimator is independent of the distribution of the error terms hence it is efficient when the error terms are not normally distributed. The formulation of the general QR as introduced by Powell (1986) is written as:

$$Q_\theta(Y_i|\mathbf{X_i}) = \boldsymbol{\beta}_\theta^{'}\boldsymbol{X}_i, \tag{3.18}$$

where $Q_\theta(Y_i|\boldsymbol{X}_i)$ denotes the θ conditional quantile of Y_i. The QR estimator of $\boldsymbol{\beta}_\theta$ is found by solving the following minimisation problem:

$$\min_{\boldsymbol{\beta}_\theta}\frac{1}{N}\left\{\sum_{Y_i \geq \boldsymbol{\beta}_\theta^{'}\boldsymbol{X}_i}\theta|Y_i - \boldsymbol{\beta}_\theta^{'}\boldsymbol{X}_i + \sum_{Y_i < \boldsymbol{\beta}_\theta^{'}\boldsymbol{X}_i}(1-\theta)|Y_i - \boldsymbol{\beta}_\theta^{'}\boldsymbol{X}_i\}\right\}. \tag{3.19}$$

Equation 3.19 shows that the QR estimator is an extension of the Least Absolute Deviation (LAD) estimation method as the problem is reduced to minimizing the sum of the absolute deviations of the error terms when $\theta = 0.5$. Equation 3.18 and Equation 3.19 can be extended to account for censoring at zero of the dependent variable and written as:

$$Q_\theta(Y_i|\mathbf{X_i}) = max\left\{\ 0, Q_\theta(\boldsymbol{\beta}_\theta^{'}\boldsymbol{X}_i + \boldsymbol{\varepsilon}_{\theta i}|\mathbf{X_i})\ \right\} = max\left\{\ 0, \boldsymbol{\beta}_\theta^{'}\boldsymbol{X}_i\ \right\}. \tag{3.20}$$

The CQR estimator of $\boldsymbol{\beta}_\theta$ is found by solving the following minimisation problem:

$$\min_{\boldsymbol{\beta}_\theta} \frac{1}{N} \sum_{i=1}^{N} [\{\theta - I(Y_i < max\{0, \boldsymbol{\beta}_\theta' \boldsymbol{X}_i\})\}(Y_i - max\{0, \boldsymbol{\beta}_\theta' \boldsymbol{X}_i\})], \tag{3.21}$$

where I is an indicator function equal to unity when the expression holds and zero otherwise. Equation 3.21 is estimated in STATA using the CIQV routine, see Chernozhukov, Fernandez-Val, Han, and Kowalski (2016).

3.6 Results

3.6.1 Baseline specifications

This section outlines the main results found for the baseline specifications. The baseline specifications only include factors that are commonly identified in the literature as determinants of risky asset holdings. One of the contributions of this chapter is the use of the KHPS data which has not been used before in the analysis of Japanese household financial portfolios. Therefore, before analysing the results of wave 10 (2013), it is important that the data panel structure is exploited and the results are compared to existing literature. This is to make sure that the data is of a high quality and that the results of the new variables explored in wave 10 (2013) found in this chapter are reliable and not driven by data issues. To do so, the panel structure of the data, from 2004 to 2015, is exploited using the random effects tobit model. The results of the random effects tobit model are compared to the findings of other papers on Japan and other countries. Therefore, the aim of this section is twofold: first, to compare the results found in the baseline model to those found in Japan and in other countries. This will help in identifying the causes of the differential in the risky asset holdings between Japan and other countries. Secondly, this section will compare the results of the four alternative econometric methodologies adopted in this chapter, the tobit model, the one-part and two-part

FRM and the CQR.

The results of the random effects tobit model are reported in Table 3.8 which includes only the baseline specification variables. The first two columns report the standard panel and cross-sectional tobit regressions results and the last three columns report the one-part and two-part FRM results.

The results of the tobit panel regression in the first column show that most of the variables have the expected sign. Wealth, equivalised income and being a home owner all have a positive impact on the proportion of risky asset holdings. Households in major cities hold higher proportions of risky assets than those living in rural areas. Similarly, education is found to have a positive impact on the proportion of risky asset holdings. However, the coefficients of age, employment status and health status are at odds with the findings of the U.S. and Europe for both the panel and the cross sectional analysis. The explanation of this will be discussed in the analysis of wave 10 (2013) regressions below. The results of the tobit panel regression are generally in line with existing literature. This suggest that the data is of a good quality and the subsequent analyses of wave 10 (2013) for the baseline specification and the key explanatory variables are reliable and can be regarded as a reflection of household's behaviour.

The rest of this section will discuss the results of wave 10 (2013) regressions reported in the last four columns of Table 3.8 and the marginal effects reported in Table 3.9. The results in Table 3.9 can be seen to be broadly consistent in terms of sign and statistical significance across the first three models, tobit, one-part FRM and the binary part of the two-part FRM. However, there are significant differences in terms of the magnitude of the marginal effects across these three models. Moreover, an important observation from Table 3.9 relates to the results of the fractional part of the two-part FRM in column four, which displays the marginal effects of the coefficients conditional on holding of risky assets. The analysis shows that, when examining risky asset holdings conditional on participation, the coefficients differ not only in terms of magnitude but also in terms of sign and the level of significance. This highlights the importance of separating modelling of the decision to hold risky assets and the level of holding.

Considering the results of the four models in Table 3.9 in more detail, richer households, both in terms of equivalised income and in terms of their net wealth, have a higher proportion of risky assets as the tobit model and the one-part FRM model suggest. The marginal effect of the natural logarithm of equivalised income in the tobit model is 5 times higher than that in the one-part FRM and it is four times higher for the natural logarithm of net wealth. Specifically, a 1% increase in equivalised income corresponds to a 12.7% increase in risky asset holdings for the tobit model, and 2.3% in the one-part FRM, *ceteris paribus*. Similarly, a 1% increase in net wealth will increase the proportion of risky assets by 1.9% in the tobit and 0.5% in the one-part FRM. On the other hand, the two-part FRM model yields results which suggest that separating the analysis of the decision to hold and the decision about the level of holding will dramatically change the results. Both equivalised income and net wealth are positively associated with a higher probability of holding of risky assets, which is in accordance with predictions of the finance theory. However, the results from the fractional continuous part show that net wealth is negativity associated with the level of risky assets held. The coefficient of equivalised income is also negative but statistically insignificant.

The effects of the age categories on risky asset holdings are in-line with the findings of studies on Japanese households but contradict the findings of the U.S. and European studies.[33] In general, risky asset holdings have been documented to have a humped shaped pattern with age, reaching a peak at middle age before declining, see Ameriks and Zeldes (2004) for the U.S. and Guiso, Haliassos, and Jappelli (2002) for Europe. The results of the tobit and the one-part FRM models in Table 3.9 show that the older the household head, the higher are his/her holdings

[33] Age-bracket dummies are included to allow for possible non-linearity in the effect of age on the proportion of risky assets.

of risky assets. The marginal effects of all age categories is negative and it is stronger for the young categories (20-30 and 30-40) compared to the omitted category (70+ years old). This suggest that younger people do not take greater investment risks as theory predicts, but the findings are consistent with the argument that financial knowledge and experience increase with age, see Bertaut (1998). The finding that older people reduce risky asset holdings in countries other than Japan is expected as older people tend to reduce their risk exposure as a response to the prospect of retirement and the dependence on other sources of income. In Japan, however, the story is different as argued by Iwaisako et al. (2016) and Iwaisako (2009). The unique housing market can provide a possible explanation to this relation as high land prices in Japan and the higher average down payments compared to the U.S., force Japanese households to postpone their risky investments until a later stage of life.

Comparing the results of the modelling approaches show that, similar to the wealth and income variables, the tobit model seems to overestimate the impact of the coefficients. The two-part FRM shows that the probability of participating in the stock market increases with age, however, the impact of age on the proportion of risky asset holdings is statistically insignificant, although the sign is in-line with the findings of the other models. Therefore, in contrast to the tobit and one-part models, the two-part model shows that age is only important for the participation decision and it is an insignificant determinant of the proportion of risky assets held by Japanese households.

Table 3.9 confirms the positive relationship between education and risky asset holdings. According to the tobit and one-part FRM models, education attainment is positively associated with the proportion of wealth invested in risky assets, this result is also found in many other studies (see, for example, Christiansen et al., 2007; Iwaisako et al., 2016; Cardak & Wilkins, 2009). For example, the tobit model shows that, compared to junior high school education, having a college degree is associated with a 21.5% higher proportion of risky assets, *ceteris paribus*. However, the level of education only influences the decision to participate in the stock market, not the proportion of risky assets held as the two-part FRM shows in Table 3.9, column 4. The positive relationship between education and risky asset holdings is expected given the fact that investors need the time and the ability to understand the risk-return trade-off and to understand sophisticated financial products.

As mentioned before, Japanese households face costs associated with healthcare despite the fact that Japan provides access to public health care. The results of the self-reported subjective health variable are at odds with the findings of other studies, such as Guiso et al. (1996) and Fratantoni (1998). Table 3.8 shows that household heads who reported normal health status will hold less risky assets compared to those who reported poor health status. In terms of the marginal effects reported in Table 3.9, those in normal health hold 6.5% less risky assets compared to those who are in poor health. Comparing the results across the three models, the tobit model and the one-part FRM model show the same impact, in terms of sign and significance, but only for those who reported normal health. The results of these two models for the other two categories are not the same. Moreover, in the two-part FRM, normal health status is only statistically significant for the proportion of risky assets held but not for the decision to participate in the stock market. These puzzling results found for the health status variable across the three models are difficult to justify. Cardak and Wilkins (2009) found insignificant coefficients for health status and argued that, in their setting, health risk is captured by the risk attitude and time preferences variables. In our baseline model, the risk preference variable is not included but a possible explanation of these puzzling results is that normal and poor health status are reported mainly by older people and in Japan, older people hold the highest share of risky assets, see Table 3.3.

Similar to the health and age, the results concerning employment status using the Japanese data also contradict the findings of studies for other countries. Table 3.8

shows that, in the tobit model, those who are in the category of "other work" (student, housewife or retired) hold more risky assets than those who are employed (the omitted category). Moreover, the one-part FRM model also shows that those who are in part-time employment also hold more risky assets than those in full employment. In both of these models, being unemployed has the expected negative sign but is statistically insignificant. The two-part FRM shows that unemployment has the expected negative and statistically significant effect on the probability of participating in the stock market. The other two categories, part-time work and other work, have the same effect as found in the tobit and one-part models but only on the proportion of risky assets held by the household and not on the decision to participate.

The marginal effects of the employment status categories reported in Table 3.9 are of considerable magnitude. For example, the two-part FRM model shows that, compared to being in full time employment, being in part-time or the "other work" category increases the proportion of risky assets held by 7.5% and 5.7% respectively, *ceteris paribus*. Iwaisako et al. (2004) also found the same puzzling result that if the household's head is not working, equity holdings will be higher. Iwaisako et al. (2004) argue that the employment status variable might be reflecting that the head of the household is retired rather than not working. In contrast, in this chapter, household heads who are students, a housewife or retired are grouped under the other category. Therefore, the positive and statistically significant effect of the "other" category compared to the "working" category arguably reflects the fact that the households who are working are saving up to buy a house and given the high price of houses in Japan this might only be achieved at the retirement age. Hence individuals will consider investing in risky assets only when they reach retirement. Moreover, retirement income received by retired households is certain and stable making them less risk averse than those who are in full-time employment.

Considering the effect of the other demographic factors, Table 3.8 shows that being male has a positive and statistically significant effect on the proportion of risky assets held as the tobit and the one-part FRM models suggest. However, gender only influences the decision to participate in the stock market but not the level of risky asset holdings as the two-part FRM model shows. This finding in consistent with most of the studies in this field, and the explanation of this finding is related to the argument that there are differences in risk preferences across genders (Guiso & Sodini, 2013). Indeed, Croson and Gneezy (2009) found that women are more risk averse than men in their review of the literature on gender differences in risk preferences in a number of different domains. Table 3.8 also shows that being married has a negative and statistically significant effect on the proportion of risky asset holdings across the three models. Findings from other studies on the effect of marital status on risky asset holdings show conflicting results. Some studies found, similar to our result, a negative effect of being married on the proportion of risky asset holdings and argue that married households are more conservative by nature, see for example Fratantoni (1998) who used the U.S. 1989 Survey of Consumer Finance. Whereas, other studies found that married or cohabiting households hold a higher level of risky assets compared to single people and argue that these households will potentially have more resources than single people, see for example Haliassos and Bertaut (1995) who also used the U.S. Survey of Consumer Finance but for 1983. The two-part FRM shows that marital status has the same effect, negative and statistically significant, for both the decision to hold and the level of of risky assets held. This result is similar to Bertaut and Starr-McCluer (2002), who found that being married increases the probability of holding risky assets but decreases the level of risky asset holdings. The number of children and the number of adults control for family composition and both of these variables have no effect on risky asset holdings.

Unlike the findings of other studies, variables related to housing such as home ownership, mortgage payments and rent expenses, have shown very little importance in the portfolio allocation of Japanese households.[34] Iwaisako (2009) emphasises the importance of including real estate holdings in the analysis of Japanese financial portfolios due to the unique structure of the housing market in Japan. However, Table 3.8 shows that only the tobit model indicates that households who own a house hold a higher proportion of risky assets, and Table 3.9 shows that owning a house increases the proportion of risky assets held by 6.2%, *ceteris paribus*. The one-part and two-part FRM models show that home ownership is not an important determinant of risky asset holdings. This finding is in line with Kinari (2007) who also found an insignificant effect of housing on the demand for risky assets in Japan. However, the results are at odds with the findings of Cardak and Wilkins (2009) that home ownership in Australia is associated with greater risky asset holdings and the findings of Fratantoni (1998) that home ownership in the U.S. is negatively related to risky asset demand.[35]

The other housing related variables are the mortgage ratio and the rent ratio that measure committed expenditure risks. Similar to the home ownership variable, the effect of the mortgage ratio is positive and significant but only in the one-part FRM model, whereas the rent ratio is statistically insignificant across the three modelling approaches. The mortgage ratio is expected to correlate negatively with the proportion of risky assets held by households as it is a source of background risk given that the household is committing to mortgage payments out of an uncertain stream of labour income. These counter-intuitive findings for home ownership and mortgage variables have also been documented in Cardak and Wilkins (2009). Cardak and Wilkins (2009) argue that these positive correlation might reflect greater access to cheap credit to finance investments in risky assets. The insignificant coefficient of the rent ratio is not surprising given the fact that rental agreements are short-term

[34] In unreported results, the same regression specification has been repeated by including each of these three variables separately and the results do not change.

[35] The literature suggests that home ownership can be considered as an investment substitute or a source of background risk as a result of house price volatility, Cardak and Wilkins (2009). However, other studies argue that home ownership can be used as collateral to facilitate borrowing and generate liquidity which is important in household financial decisions, Mariotti et al. (2015).

and they do not expose renters to huge costs in the case of defaulting as compared to mortgage agreements. Labour income risk is also found to have an insignificant effect on the proportion of risky assets held by Japanese households, which is at odds with the findings of other studies such as Guiso et al. (1996), Cardak and Wilkins (2009) and Heaton and Lucas (2000).[36]

In terms of geographic location, the results show that households who live in the regions listed in Table 3.8 hold less risky assets compared to the region of Kanto, the omitted region. However, only two regions are statistically significant across the tobit model and one-part FRM model, whereas the fractional part of the two-part model shows that five out of the seven regions are statistically significant. This is expected as Kanto is the largest region among the main eight regions in Japan and, with Tokyo located in it, the Kanto region is considered to be the main engine of Japan's economy. As for the other geographic variables, the size of the city where the household lives is statistically insignificant.

In summary, the results of the baseline specification are in line with a small number of studies that used Japanese data. However, the results can be seen to be only partially consistent with studies that use U.S. and European data. The tobit, one-part FRM and binary part of the FRM models show that income, gender, marital status, education, employment status, age and health status have an impact on the decision to hold risky assets. Whereas, in the continuous part of the FRM model only marital status, employment status, health status and wealth significantly influence the proportion of risky asset holdings. Variables related to housing have shown mixed results across the three modelling approaches.

[36]To the best of my knowledge, the effect of labour income uncertainty on portfolio allocation has not been analysed using Japanese data.

3.6.2 Key explanatory variables

Household participation in stock markets might be affected by individual characteristics other than those considered by the baseline model. As discussed earlier, traditional classical finance theory is unable to fully explain the low stock market participation rate of households. Therefore, this chapter contributes to the existing literature by analysing other factors which might influence households' financial decisions. These factors are grouped under three separate sets of variables which are: general attitudinal variables; impression about stock markets; and risk ranking of selected assets. The variables in each set have not been explored in the literature before. Therefore, each variable is modelled separately along with the baseline variables before including all of the variables in each set jointly. This is to make sure that each variable is capturing a unique characteristic of the respondent's behaviour and to examine the sensitivity of the findings of this chapter. If the sign, magnitude and the level of statistical significance of the coefficients do not change when all the variables are jointly estimated, then these variables are not correlated and each one captures a unique characteristic of the respondent's behaviour.

Table 3.10, Table 3.11 and Table 3.12 each has three panels showing the results of the key explanatory variables using the three modelling approaches. Specifically, Table 3.10 shows the results of the tobit model. In this table, each panel has a number of the models (models 1 to 7). Each model includes all of the baseline variables and one variable from each set before jointly include them in the regression which is reported in model (A). The last column of Table 3.10 shows the results related to model (B), which includes the baseline variables and all variables in all sets jointly. Comparing model A and model B with each individual model show that the sign and the level of statistical significance of the coefficients do not change, the magnitudes show very mild changes which is expected and can be ignored.[37]

[37]There are no significant changes to the results related to the baseline variables when the three sets are included.

Table 3.11 shows the results related to the one-part FRM regression and Table 3.12 shows the results related to the two-part FRM regression. Both of these tables show the same pattern found in Table 3.10 in terms of consistency of the results across the three sets and hence the same conclusion can be drawn.

Given the consistency of the results across the three sets in Table 3.10, Table 3.11 and Table 3.12, the discussion in the following sections will be based on the marginal effects of the variables in the three sets which are presented in Table 3.13. Specifically, Table 3.13 has two sections. Section A shows the marginal effects of the variables when each set is modelled separately using the three modelling approaches. Whereas section (B) shows the marginal effects when all the variables in all the three sets are jointly estimated using the three modelling approaches.

General attitudinal variables

The first variable in this set captures risk taking preferences. This chapter proxies an individual's financial risk aversion by a general measure of risk preferences. This measure is captured by the reported chance of rain that makes an individual carry an umbrella (probability of precipitation). Table 3.13 shows that there is a negative relationship between the level of risk aversion and the proportion of risky asset holdings, but only in the tobit model and at the 10% level of significance. The relationship between the risk aversion variable (higher probability of precipitation indicates lower risk aversion level) and risky asset holdings is expected to be positive as found in other studies (see, for example, Guiso et al., 1996; Cardak & Wilkins, 2009; Heaton & Lucas, 2000). On the other hand, the one-part FRM model does show that this relationship is indeed positive and significant at the 10% level of significance. However, the marginal effects on the risk attitude variable in both models are economically insignificant despite being statistically significant.

The second variable in this set is the savings behaviour of the household head, which is a binary variable taking the value of one if the household has a savings goal and zero otherwise. As discussed in the data section, the relationship between this variable and the proportion of risky asset holdings can be positive or negative. The tobit model in Table 3.13 shows that households with a savings goal hold on average a 4.4% higher proportion of risky assets than those which do not have a saving goal, *ceteris paribus*. Therefore, the result reflects the possibility that households with a saving goal are more financially organised and hence are more likely to engage in other financial products.[38] However, the results are not consistent across the modelling approaches. The one-part FRM shows that having a saving goal is not significant in the risky asset holdings equation, whereas the two-part model shows that having a saving goal is significant at the 1% level but only for the decision to hold stock but not the level of holdings.

Precautionary saving theory predicts that households will reduce their holdings of risky investments in response to a greater exposure to an unavoidable risk. A household's satisfaction with retirement income reflects how comfortable this individual is with income in later life. Therefore, this variable is expected to correlate negatively with the proportion of risky assets held by Japanese households. Indeed, the variable exerts a significant negative effect in all three models estimated at the 1% and 5% levels of significance. In particular, the proportion of risky asset holdings for those who think that their retirement income is not enough is 15.5% lower than those who think that their retirement income is enough at the 1% level of significance, *ceteris paribus*. The two-part FRM model shows that this variable is significant for the decision to hold risky assets but not for the level of holdings. This result has also been documented in Ito et al. (2017) who found that such concerns about income in later life have a substantial power in explaining the difference in the probability of holding risky assets between Japan and the U.S.. These findings might reflect households' concerns about the ageing population issue in Japan and its consequences of who is going to fund future retirement income. These concerns

[38]The precautionary motive of savings, which reflects greater risk exposure, is actually reflected in the household's satisfaction with retirement income variable.

may be reflected in an individual's risk preferences as these preferences are also based on exposure to risky environments in the future, not only the riskiness of the environment in which a decision is currently being made.

The last variable in this set captures an individual's trust in the current government's policies. Table 3.13 shows that those who cannot decide on whether to support the current government yet (grouped under the other category) hold, on average, a 8.2% lower proportion of risky assets than those who do support the government, using the tobit model. Comparing those who do not support the government with the omitted category, the tobit model also reveals that their proportion of risky assets is 3.5% lower at the 10% level of significance, *ceteris paribus*. However, when looking at the FRM models, only the binary part of the two-part FRM model shows that those who cannot decide differ significantly from the omitted category, suggesting that this variable is only important for the decision to hold stock but not the level of holdings.

Impression about stock markets

As mentioned in Section 3.4.2, this set is of variables argued to capture the household's impression of the overall reliability of the stock market. Recent literature highlights the influence of trust on the financial decisions of households and points out that less trusting households are less likely to participate in the stock market (see, for example, Guiso et al., 2008; Delis & Mylonidis, 2015; Georgarakos & Pasini, 2011; Balloch et al., 2015; Bucciol et al., 2016). Therefore, this chapter incorporates the effects of individuals' opinions of stock market performance and different dimensions of individual trust into the modelling approaches along with the baseline specifications, building a more realistic framework. This section will discuss the effect of individuals' opinions of the stock market performance first, captured by the profitability and riskiness variables, and will then discuss the trust dimension of this set, captured by fairness, efficiency and prudential supervision.

If stock returns are uncertain and an individual is averse to risk, it will be optimal for those individuals not to participate in the stock market. Table 3.10 shows that individuals who agree that in the stock market "profit cannot be made with certainty" hold a lower proportion of risky assets and the coefficient is statistically significant at the 1% level. Similarly, those who believe that significant losses are possible also hold a lower proportion of their wealth in risky assets but the coefficient is not statistically different from zero.

The expected effects of the profitability and riskiness variables cannot be explicitly discerned from the wording of each statement. The "profit cannot be made with certainty" statement could reflect the financial risk aversion of the individual, since the focus of this statement is on uncertainty. Therefore, those who agree with this statement are relatively risk averse individuals as they believe that the stock market will not provide compensation for risk via a risk premium. The "significant losses are possible" statement could be interpreted as an indicator of loss-aversion since the focus of this statement is on significant losses. However, interesting results emerge from Table 3.10 when looking at model A and model B, as the the effect of the statement of "significant losses are possible" becomes positive and significant at the 5% for model A and 1% for model B, which is at odds with the expected effect of the loss-aversion indicator. In particular, the results in Table 3.10, Table 3.11 and Table 3.12 show that those who agree that losses are possible hold a higher proportion of their wealth in risky assets, once all variables in this set are accounted for.

Another possible explanation for the positive impact of the riskiness variable is that this statement might reflect the household's experience in the stock market. Hence, households disagree with the statement that "losses are possible" if they have limited experience in the stock market, since recent events clearly support the statement, especially in the context of the 2008 financial crisis. Therefore, the positive effect of the riskiness variable can be justified given the historic performance of the Japanese stock market, hence those who agree with the statement are likely to be those who actually hold or have held stocks. This argument is supported by the results of the two-part FRM model as it shows that the riskiness statement is only important for the decision to participate but not the level of participation in the stock market.

The results of Table 3.13, which show the marginal effects when all variables are included, indicate that these two variables are also economically significant, compared to some of the key variables reported in Table 3.9. For example, the binary part of the two-part model shows that a one unit increase in the profitability variable decreases the probability of participating in the stock market by 2.7%, *ceteris paribus*.

Turning to the trust variables; fairness, efficiency and prudential supervision, Table 3.10 and Table 3.12 both show that these variables have significant and negative impacts on the financial decisions of Japanese households, when they are included separately. The two-part FRM model shows that these variables are only important for the probability of participation in the stock market. The one-part FRM model, see Table 3.11, shows that only the "high illegal activities" statement (fairness) has a strong, significant and negative impact on households' holdings of risky assets.

Examining the results in Table 3.10 and Table 3.12 in more detail show that before including all the variables in set two collectively, we obtain a significant and negative relationship for the "efficiency" and the "prudential supervision" variables as expected. However, once all variables in this set are included, these two variables no longer explain stock market participation. Hence in the tobit and two-part FRM models, it seems that the "high illegal activities" statement captures the association between these two variables and stock market participation. However, this variation in the results is not observed in the one-part FRM model, which shows that the signs and the statistical significance of these variables are consistent when included separately and jointly, see Table 3.11. The observed result of the high illegal activities variable across the three models reinforces the fact that this variable might be capturing the association between the "efficiency" and the "prudential supervision" variables and stock market participation. As mentioned before, these variables are expected to be correlated and hence in each of the modelling approaches each variable is included separately first, before jointly including them, to examine the robustness of the results.[39]

In general, these results are in line with the findings of Guiso et al. (2008), Delis and Mylonidis (2015), Georgarakos and Pasini (2011), Balloch et al. (2015) and Bucciol et al. (2016). However, most of these studies use a generalised measure of trust with the exception of Balloch et al. (2015) who used a measure of trust which is specific to household trust in the stock market and Guiso et al. (2008) who proxy trust in the stock market with individuals' trust in bank officials and advisers. This chapter uses trust measures which are similar to Balloch et al. (2015) as they reflect individuals' perceived trustworthiness of the stock market.[40]

Guiso et al. (2008) argue that the trust measure they have used is not a proxy of other indicators, such as optimism or expectations about stock market performance, as they control for these characteristics in their model specifications. Balloch et al. (2015) also argue that a measure of individual trust in the stock market might be a proxy of an individual's knowledge of stock market functions. In this chapter households' expectations are captured in some of the variables in set one, whereas set three (discussed next) can be argued to be a proxy of households' financial knowledge. The trust variables used in this chapter are a direct measure of trust in different dimensions of stock market operations and they reflect household confidence in the stock market's characteristics. In particular, the "illegal activities"

[39] In unreported results, factor analysis has been used to construct a factor that combines the profitability and riskiness variables and another factor that combines the effect of the trust variables. The results of these two factors when included in three modelling approaches are negative and significant as expected.

[40] Measures of the trust in the institutions that facilitate holdings of risky assets is arguably far more important than relying on a generalized measure of trust for this area of analysis.

statement captures the fairness and the quality of investor protection whereas the information disclosure one captures stock market efficiency. Market interventions by the central bank and the government statements capture stock market prudential supervision. Furthermore, the empirical results reported in model A and model B across Table 3.10, Table 3.11 and Table 3.12 show that the trust variables remain key determinants of stock market participation, even after the inclusion of the other two sets of variables along with the baseline specifications. Therefore, the results reported in this chapter confirm that trust is a significant determinant of households' holdings of risky assets, and the effect of trust does not diminish across the modelling approaches even after the inclusion of the other sets of variables.

Risk ranking of selected assets

As discussed in the data section, these variables are expected to reflect an individual's perception of risk associated with selected assets given the current state of the economy. The results in Table 3.10, Table 3.11 and Table 3.12 show that households invest in a manner which is consistent with their risk perceptions. In particular, Table 3.10 shows that, when each variable is included separately, only those who perceive that savings and postal savings accounts as possessing high risk will hold a lower proportion of their wealth in risky assets, the other four variables are statistically not different from zero. However, when including both the riskiness of saving accounts and riskiness of stocks together in the regression, both show a negative and significant correlation with risky asset holdings, see model 7 in Table 3.10. Whereas, when considering all the variables in set three together, only the riskiness of bank saving accounts and investment in stocks variables are significant. This result might be due to the fact that saving accounts and investing in stocks are the most common financial vehicles among households in this set.

The results in Table 3.11 are similar to those found using the tobit model. However, the ranking of stock investment risk perceived by households appears to be negative and significant when included alone (model 4) and when included with the full specification (model B). The effects of saving accounts and postal saving accounts are both negative and significant when considered alone but only the significance of the saving account variable holds for models A and B. The results in Table 3.12 are in line with the results of the tobit model regarding saving and postal saving accounts. The fractional part of the two-part model shows that households who perceive higher risk from investing in stocks hold a lower proportion of their wealth in risky assets, which is consistent with the risk perception theoretical expectation. Whereas the binary part shows that only the risk of saving accounts matters for the decision to participate in the stock market. In terms of magnitude, Table 3.13 shows that, for the tobit model, a one unit increase in the risk ranking of savings corresponds to 3.1% decrease in the proportion of risky assets held, *ceteris paribus*. The fractional part of the two-part FRM shows that a one unit increase in the ranking of investing in stocks will result in a 1.3% decrease in the proportion held of risky assets.

Variables related to saving vehicles could reflect a households' basic financial knowledge. Keeping money in saving accounts is considered to be a safe option in comparison to, for example, buying a lottery ticket and is not expected to be ranked as a high risk asset. For example, those who ranked saving accounts as a high risk asset did so as they might not fully understand concepts related to basic banking activities, such as deposit insurance and investor protection law.[41] Therefore, those individuals are not expected to participate in the stock market where it is important to understand complex products, concepts and conditions. This might explain the negative association between the perceived riskiness of savings and risky asset holdings found across the three modelling approaches.

Similar to the variables in set two, these variables are also expected to be correlated. The first three variables in this set focus on different savings vehicles. The other three variables are all related to investments, two variables are concerned with

[41] High level of inflation might make savings accounts a risky investment. However, for the period analysed in this chapter inflation rate in Japan was persistently at low levels.

investments in stocks and the other variable is related to investment in property. The results of the three modelling approaches show that the effects of saving and postal savings are significant and negative, but only when included separately. Similarly, the one-part FRM shows that the riskiness of stocks is also only significant when it is included separately. However, when all of the variables are jointly included only the riskiness of savings stays significant and negative. The effect of the riskiness of investing in stocks is not consistent as it is only significant for model B in the one-part FRM and the fractional part of the two-part FRM. These results show the importance of including some variables separately as some of them have not been examined before in the literature, hence there is no prior expectations about their power.[42]

These results, in general, support the findings of previous papers, such as, M. Weber et al. (2012) and Hoffmann et al. (2013). In particular, the results show that the individual's risk perception is an important predictor of their financial decisions in Japan. The effect of the risk perception of some assets does not diminish across the three modelling approaches even after the inclusion of risk preference measures. Therefore, distinguishing between the effect of risk preferences and risk perception is important to fully capture the underlying processes which form an individual's optimal portfolio.

3.6.3 Models' performance

The discussion in the previous section shows that the modelling approaches used in this chapter have significant differences in terms of the magnitude of the marginal effects. Therefore, it is important to discuss the performance of these models conceptually and formally support this discussing using rigorous statistical tests.

Panel A in Table 3.17 displays the Akaike (1998) Akaike information criterion

[42]In unreported results, factor analysis has been used to construct a factor that combines the first three and the last three variables in this set. The results of these two factors when included in the modelling approaches are negative and significant as expected.

(AIC) and Schwarz et al. (1978) Bayesian information criterion (BIC) for the tobit, one-part and two-part models. These statistics measure the goodness of fit of the models and the lowest value indicates the preferred model. Panel A in Table 3.17 suggests that the one-part FRM model captures the characteristics of the data better than the standard tobit model and the binary part of the two-part FRM model. This conclusion holds when the three additional sets of explanatory variables are included with the baseline specification, see Panel D in Table 3.17. Unfortunately, the AIC and BIC values of the two-part FRM model are reported for the binary part and fractional part separately. This is because these values cannot be calculated for the functional form assumed for the two-part model given in Equation 3.15. Hence, only the values of the binary part can be compared with the tobit or the one-part model. The fractional part of the two-part FRM model is based on a different number of observation as it shows the effects of the coefficients conditional on participating in the stock market.

However, Panel C in Table 3.17 reports the P test, which compares the performance of the two-part FRM model (binary and fractional parts jointly) with the one-part FRM model. The P test is proposed by Davidson and MacKinnon (1981) and it has been used by E. Ramalho, Ramalho, and Murteira (2011) for discriminating between alternative one-part and two-part FRMs (see E. Ramalho, Ramalho, and Henriques (2010) for full formulation). Specifically, the P test checks if the one-part FRM (two-part model) has the appropriate specifications to estimate the dependent variable given the information provided by the two-part model (one-part FRM). The first line of panel C in Table 3.17 shows that the null hypotheses (the two-part model) is rejected at the 5% level of significance in favour of the alternative (the one-part model), but only for the baseline specification. When the full specification is considered, panel F in Table 3.17, the null hypotheses is not rejected and the two-part model is the preferred model. This conclusion is also confirmed when looking at the second line of panel C and panel F. In this line the null hypotheses is the one-part model and it is clearly rejected at the 1% level of significance in favour of the alternative (the two-part model) for both the baseline specification and the full specification.

Finally, panel B in Table 3.17 reports the result of a link test, proposed by Pregibon (1980), for detecting general functional form misspecification. This test is based on the idea that no additional independent variables should be significant if a regression equation is properly specified. The link test adds the squared independent variable to the model and tests if it has any explanatory power. If the model is correctly specified, adding the squared independent variable to the model should not have any explanatory power. The coefficients of the predicted squared independent variable for each model are reported in in Table 3.17 panel B for the baseline specification and in panel E for full specification. It is apparent from the table that the squared independent variable is only significant in the tobit model.

The statistics in Table 3.17 show that the one-part FRM model is superior to the tobit model. On the other hand, Table 3.17 shows that the two-part FRM is superior to the one-part FRM. The underlying functional form of the FRM model could explain the superior performance of the FRM one-part and two-part. Specifically, the FRM model are based on a non-linear function form which is preferred as the dependent variable is proportional and implies a non-linear relationship with the independent variables.

Table 3.18 shows an alternative way of evaluating the goodness of fit of the modelling approaches used in this chapter. The table presents the predicted vs. the actual mean of the dependent variable for the baseline specification and the full specification. Table 3.18 reinforces the results found in Table 3.17 as the one-part model provides the closest prediction to the actual mean for both the baseline and full specification. Furthermore, the two-part model also provide a close prediction to the mean of risky assets share conditional on holding risky assets.

In conclusion, the two-part FRM and the CQR are conceptually and statistically (for the two-part) the preferred modelling approaches for the analysis of risky asset holdings.

3.6.4 Censored Quantile Regression (CQR) analysis

Censored Quantile Regression (CQR) analysis is employed in this section to provide further perspective on the determinants of risky asset holdings in Japan. CQR is an alternative estimator to the tobit model as it allows an examination of the complete distribution of the dependent variable and handles censoring at zero without the assumptions of normality and homoscedasticity that are necessary in the tobit model. It is interesting and informative to identify which characteristics influence risky asset holdings at different points of the conditional distribution, which is provided by the censored quantile regression.

Table 3.14 shows the marginal effects of the baseline specification from the CQR, in addition to the results of the tobit model discussed in Section 3.6.1 for means of comparison. The table reveals different behaviour across the quantiles, as some variables influence risky asset holdings differently for households with a low proportion of risky assets than for those with a high proportion of risky assets.[43] Broadly speaking, Table 3.14 indicates smaller and insignificant effects of some variables in the lower quantiles, while the effects are significantly larger as we move to higher quantiles. For example, Table 3.14 shows that the impact of being male increases significantly as we move to higher quantiles, with the effects at the bottom two quantiles being statistically insignificant. Similar results are found for the effect of being married, however, the impact is stronger at the top quantile than what is indicated by the tobit model. Regarding the number of children and the number of adults both of these variables have no effect on risky asset holdings, which is in line with the tobit model.

The impact of education is asymmetric according to the quantile examined.

[43] Coefficients below the 60th quantile are statistically and economically insignificant

Households with a head holding a high school or a college qualification hold a higher proportion of risky assets than those with no qualification but only at the 75th and 85th quantiles and the effect is much smaller than that reported by the tobit model. Whereas, at the top 95th quantile, only households with a head holding a university degree significantly hold higher proportions of risky assets than those with no education. This disparity was not revealed by the tobit model and is very informative from a policy formation perspective. For example, these findings suggest that if policy makers want to encourage individuals to invest a higher proportion of their wealth in risky assets, then they might have to target those with low education levels.

The results of the health status of the household head reported in Table 3.14 validate the explanation given to the puzzling results found in the tobit model and the FRM model. The results of the previous models show that household heads who reported normal or good health status will hold less risky assets compared to those who reported poor health status. In Table 3.14 the effect of the self-reported subjective health variable is only significant at the top 95th quantile and this effect is stronger than the one found in the tobit model. Table 3.3 shows that holdings of risky assets increase with age, those who are 70 years old or above hold 11.0% of their wealth in risky assets, whereas those who are 20 to 30 years old only hold 2.0% of their wealth in risky assets. Therefore, those who belong to the top 95th quantile will be mainly 70 or above years old and they will more likely report poor health condition, hence this contradicting results of health status to other papers, such as Guiso et al. (1996) and Fratantoni (1998).

The age effect reported in Table 3.14 has a significant differential impact according to which quantile under investigation. For example, at the 65th quantile only two age group categories display a significantly lower proportion of risky assets than those who are over 70, the omitted category. Considering the results at all the quantiles reveal interesting results. The 50 to 60 and the 60 to 70 year old groups are only significant at the 75th and 95th quantiles, whereas, the 20 to 30 years old group is significant only at the 85th and 95th quantiles. Again, this disparity was not revealed by the tobit model and is very informative from a policy formation perspective.

The impacts of equivalised income and net wealth also show a smaller and insignificant effects in the lower quantiles, while the effects are significantly larger as we move to higher quantiles. The equivalised income variable shows a weaker impact on risky asset holdings across the top four quantiles than as indicated by the tobit model.

As the CQR allows the effects of the regressors to differ at different quantiles of the conditional distribution of the dependent variable, some variables which were insignificant in the tobit model, are now identified to have a significant effect on risky asset holdings at certain parts of the distribution according to the CQR analysis. For example, the mortgage ratio has a positive and significant effect on risky asset holdings, but only for households who are at the top two quantiles of the proportion of risky assets. In contrast, the tobit model indicates that the effect of the mortgage ratio is insignificant. On the other hand, the effect of home ownership is positive and significant in the tobit model, whereas it is not significant at any quantile in the CQR analysis. The positive relationship between risky asset holdings and the mortgage ratio at the top two quantiles is consistent with Cardak and Wilkins (2009) and Heaton and Lucas (2000) but at odds with Fratantoni (1998), although these studies do not use quantile regression. Theoretically, home ownership can be used as collateral to facilitate borrowing and generate liquidity which is important in household finance decisions. Heaton and Lucas (2000, p. 1176) argue that *"a higher mortgage leads to higher stock holdings, suggesting that some stocks are indirectly financed via mortgage debt"*. Similar to home ownership, having a household head who is in part-time employment has a positive and significant effect for households in the top proportion of risky assets quantile, i.e. Q=0.95, with no significant effect found in the tobit model. Households who are in the "other" category of employment significantly hold higher proportions of risky assets than those who are in employment at the top two quantiles, with the effect being stronger than that found with the tobit model.

Table 3.15 reports the results of the CQR for the key explanatory variables analysed in this chapter. In particular, Table 3.15 has two sections. Section A shows the marginal effects of the variables when each set is modelled alone using the modelling approaches along the baseline variables in columns (2-7). Whereas section (B) shows the marginal effects when all the variables in all the key explanatory variables are jointly estimated using the different modelling approaches in columns (8-13).[44] Generally, the effects of the key explanatory variables on risky asset holdings follow the same pattern found in the baseline variables discussed in the previous section, except the variables which capture household head's impression about stock market.

In general, the general attitudinal variables show smaller and insignificant effects of some variables in the lower quantiles, while these effects are significantly larger as we move to higher quantiles. A notable exception is for having a saving goal variable, which has a significant positive impact on the proportion of risky asset holdings for the tobit model, but this impact is not observed in the CQR analysis. The household's satisfaction with retirement income, which reflects how comfortable this individual is with income in later life, correlates negatively with the proportion of risky assets held by Japanese households and the effect is insignificant only at the 65th quantile. However, the effect is significantly larger as we move to higher quantiles, with the effect being stronger than that found with the tobit model for those who are not sure about their retirement income. The last variable in this set, which captures an individual's trust in the current government's policies, has a significant differential impact according to which quantile we are investigating. The impact at the 85th quantile is similar to the one found in the tobit model but larger

[44]The results of the baseline variables are not reported in this table, but the coefficients are consistent with what is reported in Table 3.14.

in magnitude. However, only those who do not trust the government policy hold lower proportion of risky assets that those who do trust the government policies. The impacts at the top 95th quantile and the bottom 60th and 65th quantiles are statistically insignificant.

The impression about stock markets variables behave in the opposite direction to the pattern found in the baseline variables, that is, the impacts of these variables are statistically significant mostly for lower quantiles. Specifically, Table 3.15 shows that individuals who agree that in the stock market "profit cannot be made with certainty" hold lower proportions of risky assets but only for individuals at the 60th and 65th lower quantiles and the impact is smaller than that found with the tobit model. On the other hand, those who believe that significant losses are possible hold higher proportions of their wealth in risky assets but again the impact is significant only for the 60th and 85th quantiles. An explanation to these results is given in Section 3.6.2 as these two variables are expected to have a similar impact on risky asset holdings. The other three variables in this set focus on stock market fairness, efficiency and prudential supervision. Among these variables, only the "high illegal activities" is significant at all quantiles except the top 95th quantile. The CQR analysis show that the different dimensions of trust in the stock market have a significant impact mainly on those who are at the lower quantiles. This is an important and informative result that was not revealed by the tobit model. The results suggest that enhancing households' impressions of the overall reliability of the stock market is crucial in order to increase stock markets participation in Japan.

The variables in set three rank riskiness of selected assets and focus on the household's personal interpretation of the riskiness of selected assets. These variables reflect individual perception of risk given the current state of the economy. The results of the three modelling approaches discussed in the previous sections show that when all of the variables in this set are jointly included only the effect of the riskiness of savings stays significant and negative. However, according to the

CQR analysis three variables in this set are now identified to have a significant effect on risky asset holdings at certain parts of the distribution, these variables are insignificant in the tobit model. Specifically, the effect of the riskiness of postal saving account, investing in stocks and putting money in investments trust are now significant. However, according to section B of Table 3.15 postal saving impact diminishes when all the variables are considered.

The results of the CQR analysis indicate that considering only the effects of the regressors on the average holdings of risky asset mask considerable heterogeneity in the effects of many variables. According to the CQR analysis, some variables have smaller and insignificant effects in the lower quantiles, while the effects are significantly larger as we move to higher quantiles, see for example household's satisfaction with retirement income, equivalised income and net wealth variables. On the other hand, the CQR analysis show that some variables have a significant differential impact according to which quantile we are investigating, such as age effect, education and individual's trust in the current government's policies. The two variables in set two that are related to profitability and riskiness of the stock market influence risky asset holdings only for households with a low proportion of risky assets. Finally and most importantly, the CQR analysis reveals that some variables which were insignificant in the tobit model, are now identified to have a significant effect on risky asset holdings at certain parts of the distribution. These variables are: the mortgage ratio, part time employment and the riskiness of both postal saving account and investing in stocks.

3.7 Conclusion

This chapter has investigated the determinants of risky asset holdings by Japanese households using data from the KHPS. The contribution of this chapter to the existing literature was threefold. Firstly, this chapter is the first chapter to use the KHPS dataset to analyse holdings of risky assets by Japanese households. Secondly, to the best of my knowledge the effects of household trust in the stock market and household perception of risk on risky asset holdings have not been explored for Japanese households. Finally, the chapter used four alternative methodological approaches in the analysis to explore the robustness of the findings. Two of these approaches, the two-part FRM and CQR, have not been used before for Japan in this context.

The results of the baseline specification can be seen to be only partially consistent with the literature, which is expected as most of the literature is mainly focused on the U.S. and Europe. For example, compared to the findings for the U.S. and Europe, the peak of the positive impact of age on risky asset holdings came at a much later stage of life due to the structure of the housing market in Japan. However, the results of income and other demographic variables were in line with other studies. Variables related to housing have shown very little importance in the portfolio allocation of Japanese households, unlike the findings of other studies conducted in the U.S. and Europe.

The analysis of the additional key explanatory variables, which are an additional contribution in this chapter, revealed interesting results. For example, the variable related to household satisfaction with retirement income was found to have the most important impact on risky asset holdings in term of marginal effect amongst all the variables of the key explanatory variables. In line with expectations, the variables related to individuals' opinions of stock market performance were statistically and economically significant. The results reported in this chapter confirmed that trust in the legal aspects of the stock market is negatively correlated with households' holdings of risky asset, and this negative effect exists across all of the modelling approaches. The results of the variables related to individual's perception of risk associated with selected assets suggested that households invest in a manner which is consistent with their risk perceptions of saving accounts and investments in stocks.

The empirical analysis revealed that the methodological approaches adopted in this chapter can be seen to be broadly consistent in terms of sign and significance of the determinants of risky asset holdings across the first two models, the tobit and one-part FRM. However, there were significant differences in terms of the magnitude of the marginal effects among these models. These differences were apparent in the findings of the fractional part of the two-part FRM model. The analysis showed that, when examining risky asset holdings conditional on participation, the coefficients differed not only in terms of magnitude but also in terms of sign and the level of significance, advocating the separation of the analysis of the decision to hold risky assets and of the level of holdings.

Interesting results revealed from the use of the CQR approach, which indicated that considering only the effects of the regressors on the average holdings of risky asset mask considerable heterogeneity in the effects of many variables. According to the CQR analysis, some variables had smaller and insignificant effects in the lower quantiles, while the effects were significantly larger as we move to higher quantiles, see for example household's satisfaction with retirement income, equivalised income and net wealth variables. The CQR analysis also showed that some variables had a significant differential impact according to the quantile under investigating, such as: age, level of education and individual's trust in the current government's policies. The variables that were related to profitability and riskiness of the stock market influence risky asset holdings only for households with a low proportion of risky assets. Finally and most importantly, the CQR analysis revealed that some variables which were insignificant in the tobit model, are now identified to have a significant effect on risky asset holdings at certain parts of the distribution. These variables are: the mortgage ratio; part time employment; and the riskiness of both postal saving account and investing in stocks.

Important policy conclusions about Japanese households' financial decisions can be drawn from the findings of this chapter. For example, the motivation for using the two-part FRM was to understand which variables authorities and financial institutions need to target in order to promote a culture of participation in the stock market in Japan and which variables to target if the level of holdings was of concern. This information cannot be deduced from the tobit and one-part FRM models as in these models the differential impacts that the covariates have on the decision to participate in stock market and the level of participation is not accounted for. However, these two models were crucial in order to compare the findings of this chapter to the findings of other papers and to help identify the causes of the differentials in the risky asset holdings between Japan and other countries.

A limitation of this chapter is that the impacts of the key explanatory variables cannot be examined over time as only in wave 10 (2013) respondents were asked detailed questions regarding their perceived risk of selected assets and their opinions about the functioning of the stock market. However, examining the evolution of an investors' risk perceptions and risk preferences would shed light on the psychological factors influencing a household's financial portfolio decisions. Therefore, an interesting area for further research is to assess how Japanese individuals change their risk preferences and risk perceptions when financial or natural shocks occur.

3.8 Tables

Table 3.1: Selected indicators for the innovation-driven economies

Economy	Perceived opportunities	Perceived capabilities	Fear of failure rate	(TEA)	Good career choice
Japan	7.27	12.23	54.51	3.83	30.98
Italy	26.57	31.31	49.10	4.42	65.05
Germany	37.59	36.40	39.95	5.27	51.66
France	28.26	35.44	41.18	5.34	59.05
Belgium	35.93	30.40	49.35	5.40	52.41
Denmark	59.66	34.88	40.99	5.47	–
Spain	22.61	48.13	38.03	5.47	53.94
Finland	42.38	34.88	36.76	5.63	41.24
Norway	63.45	30.54	37.56	5.65	58.16
Slovenia	17.25	48.6	29.00	6.33	53.39
Ireland	33.36	47.24	39.33	6.53	49.39
Sweden	70.07	36.65	36.53	6.71	51.58
Switzerland	43.67	41.59	28.98	7.12	42.30
Luxembourg	42.54	37.56	42.01	7.14	40.66
Greece	19.91	45.54	61.58	7.85	58.42
Taiwan	33.47	29.00	37.39	8.49	75.22
Austria	44.4	48.67	34.92	8.71	–
Estonia	49.44	42.47	41.77	9.43	55.56
Netherlands	45.55	44.26	34.79	9.46	79.11
Portugal	22.87	46.59	38.38	9.97	62.23
Puerto Rico	25.08	48.84	24.01	10.04	18.51
United Kingdom	40.99	46.44	36.84	10.66	60.30
Slovakia	23.50	54.40	35.96	10.90	45.42
Singapore	16.71	21.35	39.40	10.96	51.73
Canada	55.52	48.98	36.52	13.04	57.25
Australia	45.72	46.80	39.21	13.14	53.35
United States	50.85	53.34	29.66	13.81	64.73
Trinidad and Tobago	58.62	75.23	16.79	14.62	79.47
Qatar	63.38	60.94	25.54	16.38	75.83
Average	38.85	42.02	37.79	8.54	55.07

Source: Global Entrepreneurship Monitor (GEM) Survey in 2014
Perceived opportunities: Percentage of 18-64 population who see good opportunities to start a firm in the area where they live.
Perceived capabilities: Percentage of 18-64 population who believe they have the required skills and knowledge to start a business.
Fear of failure rate: Percentage of 18-64 population perceiving good opportunities to start a business who indicate that fear of failure would prevent them from setting up a business.
Total early-stage Entrepreneurial Activity (TEA): Percentage of 18-64 population who are either a nascent entrepreneur or owner-manager of a new business.
Entrepreneurship as a Good Career Choice: Percentage of 18-64 population who agree with the statement that in their country, most people consider starting a business as a desirable career choice.

Table 3.2: Summary statistics and the distribution of main assets and debt classes

Asset class	Mean	Std.Dev	10%	25%	Median	75%	90%	% of zero
Safe assets	842.56	1400.51	0.00	31.15	311.53	1038.42	2076.84	21.81
Securities	147.65	615.46	0.00	0.00	0.00	0.00	311.53	78.29
Financial Assets	977.50	1667.95	0.00	31.15	311.53	1038.42	2803.74	22.74
Total Assets	2453.05	3023.73	0.00	456.91	1661.48	3219.11	5815.16	11.66
Total Debt	619.39	1653.56	0.00	0.00	0.00	778.82	2076.84	55.28
Non-mortgage Debt	103.50	1343.44	0.00	0.00	0.00	0.00	176.53	77.61
Observations					2945			

Figures are in tens of thousands and as of 2013.
Safe assets are the sum of: Postal savings certificates, time deposits, instalment savings and ordinary deposits. Bank, shinkin bank, etc. Time deposits, instalment savings and ordinary deposits. Company deposits, gold investment accounts, gold savings accounts, medium-term government bond funds, etc.
Securities are the sum of: Shares (market value), bonds (par value), stock investment trusts (market value), corporate and public bond investment trusts (market value), loans in trust and money in trust (par value), etc.
Financial assets equal to the sum of safe assets and securities.
Total assets equal to the sum of financial assets and the market values of the residential property and the associated plot.
Total debt is the sum of all borrowings including the outstanding balances of mortgage loans.
Non-mortgage debt is the sum of all borrowings excluding mortgage loans.

Table 3.3: The distribution of risky assets share in 2013

	Mean	Std.Dev	25%	Median	75%	90%
Risky assets ratio	0.064	0.168	0	0	0	0.25
Age groups						
20 to 30 Years old	0.018	0.076	0.000	0.000	0.000	0.000
30 to 40 Years old	0.035	0.142	0.000	0.000	0.000	0.032
40 to 50 Years old	0.047	0.152	0.000	0.000	0.000	0.118
50 to 60 Years old	0.057	0.147	0.000	0.000	0.000	0.231
60 to 70 Years old	0.073	0.180	0.000	0.000	0.000	0.286
70+ Years old	0.106	0.207	0.000	0.000	0.114	0.429
Education level						
Junior high sch.	0.032	0.139	0.000	0.000	0.000	0.010
High school	0.049	0.150	0.000	0.000	0.000	0.167
College	0.055	0.149	0.000	0.000	0.000	0.250
University+	0.102	0.201	0.000	0.000	0.111	0.400
Other	0.043	0.148	0.000	0.000	0.000	0.091
Gender						
Female	0.038	0.129	0.000	0.000	0.000	0.091
Male	0.068	0.173	0.000	0.000	0.000	0.273
Employment status						
Working	0.053	0.154	0.000	0.000	0.000	0.200
Part-time	0.086	0.193	0.000	0.000	0.005	0.417
Unemployed	0.030	0.105	0.000	0.000	0.000	0.333
Other work	0.104	0.210	0.000	0.000	0.114	0.411
Marital status						
Single	0.054	0.155	0.000	0.000	0.000	0.209
Married	0.066	0.170	0.000	0.000	0.000	0.254
Health status						
Good	0.065	0.166	0.000	0.000	0.000	0.255
Pretty good	0.071	0.177	0.000	0.000	0.000	0.308
Normal	0.056	0.154	0.000	0.000	0.000	0.213
Bad	0.072	0.188	0.000	0.000	0.000	0.286
Observations			2945			

Table 3.4: Independent variables: Definitions

Variable Name	Definition
Married	1 if the head of household is married or cohabiting, 0 otherwise.
Male	1 if head of household is male, 0 if female.
Number of adults	Number of adults present in the household.
Number of children	Number of children (under the age of 16) present in the household.
Employment status-(currently employed is the omitted category)	
Part-time	1 if head of household is in part-time employment, 0 otherwise.
Unemployed	1 if head of household is studying, 0 otherwise.
Other work	1 if head of household is unemployed or other, 0 otherwise.
Education level-(Below high school is the omitted category)	
High school	1 if head of household's highest level of education is high school level, 0 otherwise.
College	1 if head of household's highest level of education is college, 0 otherwise.
University+	1 if head of household's highest level of education is university or higher, 0 otherwise.
Other	1 if head of household's highest level of education is other, 0 otherwise.
Age -(Above 70 is the omitted category	
20 to 30 Years old	1 if head of household's age is between 20 to 30 years old, 0 otherwise.
30 to 40 Years old	1 if head of household's age is between 30 to 40 years old, 0 otherwise.
40 to 50 Years old	1 if head of household's age is between 40 to 50 years old, 0 otherwise.
50 to 60 Years old	1 if head of household's age is between 50 to 60 years old, 0 otherwise.
60 to 70 Years old	1 if head of household's age is between 60 to 70 years old, 0 otherwise.
Self-Reported Health Status - (Being of poor health is omitted category)	
Good	1 if the head of household reports being in good health, 0 otherwise
Pretty good	1 if the head of household reports being in pretty good health, 0 otherwise
Normal	1 if the head of household reports being in normal health, 0 otherwise
Region-(The largest region, Kanto, is the omitted category)	
Hokkaido	1 if head of household is in Hokkaido, 0 otherwise.
Tohoku	1 if head of household is in Tohoku, 0 otherwise.
Chubu	1 if head of household is in Chubu, 0 otherwise.
Kinki	1 if head of household is in Kinki, 0 otherwise.
Chugoku	1 if head of household is in Chugoku, 0 otherwise.
Shikoku	1 if head of household is in Shikoku, 0 otherwise.
Kyushu	1 if head of household is in Kyushu, 0 otherwise.
City size-(Town/village is the omitted category)	
Major city	1 if head of household is in a major city, 0 otherwise.
Other city	1 if head of household is in other cities, 0 otherwise.
Committed expenditure	
Rent ratio	Annual rent payments on main residence as a proportion of annual household disposable income.
Mortgage ratio	annual total mortgage repayments as a proportion of annual household disposable income.
Financial Measures	
Labour income risk	The variance of household income over the full sample period 2004-2015.
Equivalised income	Household disposable income adjusted for household composition using the OECD scale.
Net wealth	Total value of household financial and non-financial assets minus total debt.

Table 3.4: Independent variables: Definitions. *(Continued)*

Set one: General attitudinal variables	
Proxy of risk attitudes	When you have to go out somewhere in your town all day, what is the chance of rain that makes you take an umbrella with you? 0%-100%
Has a saving goal	Around how much is the total savings goal you are now considering? This has been changed to a binary variable. 0 No goal, 1 Has a saving goal.
Retirement income: Enough (omitted cat.)	Do you think that you have income and assets that are enough to lead a retirement life without problems? Yes
Retir. income, Not sure	Do you think that you have income and assets that are enough to lead a retirement life without problems? Neither
Retir. income, Not enough	Do you think that you have income and assets that are enough to lead a retirement life without problems? No
Support current Gov. (omitted cat.)	Do you support the present government? Yes
Don't support current Gov.	Do you support the present government? No
Support current Gov.: Other	Do you support the present government? No answer
Set two: Impression about the stock market	Please circle the answer that best applies to you for each of the following statements regarding your impression about the stock market.(0) Disagree (1) Somewhat disagree (2) can't say either way (3) Somewhat agree (4) Agree.
Profitability	Profits cannot be made with certainty.
Riskiness	Significant losses are possible.
Illegal	Illegal activities such as insider trading are widespread.
Disclosure	No much progress has been made in terms of disclosure of information on corporate performance.
Intervention	Market interventions by the central bank and the government are not thoroughly conducted.
Set three: Risk ranking of selected assets	If we assume stashing cash has a risk value of 0 and purchasing a betting slip or lottery ticket has a risk value of 10, what do you think are the risk values of the following types of saving and investment? 0-10 scale.
Saving risk	Putting money in a conventional bank savings account.
Currency risk	Putting money in a foreign currency deposit.
Postal risk	Putting money in a postal savings account.
Stock risk	Buying stocks.
Trust risk	Buying a stock investment trust.
Property risk	Investing in land and property.

Table 3.5: Summary statistics: Explanatory variables

Panel A: Baseline Specifications				
Continuous variables	Mean	Std. Dev.	Min.	Max.
Number of adults	3.0000	1.3039	1	10
Number of children	0.5799	0.9343	0	6
Committed expenditure				
Rent ratio	0.0424	0.1834	0	6.1091
Mortgage ratio	0.0640	0.1939	0	3.5040
Financial Measures				
Labour income risk	0.2741	0.2162	0.0022	2.1188
Equivalised income	5.5965	0.6066	0.6355	8.7483
Net wealth	4.9134	5.6447	-11.2993	11.3928
Binary variables		Percent		
Married		0.83		
Male		0.87		
Home owner		0.79		
Employment status				
Working (omitted cat.)		0.77		
Part-time		0.04		
Unemployed		0.01		
Other work		0.18		
Education level				
Junior high school (omitted cat.)		0.10		
High school		0.47		
College		0.08		
University+		0.30		
Other		0.05		
Age				
20 to 30 Years old		0.02		
30 to 40 Years old		0.12		
40 to 50 Years old		0.21		
50 to 60 Years old		0.24		
60 to 70 Years old		0.24		
70+ Years old (omitted cat.)		0.17		
Self-Reported Health Status				
Good		0.12		
Pretty good		0.29		
Normal		0.44		
Poor (omitted cat.)		0.15		

Table 3.5: Variables' summary statistics. *(Continued)*

Binary variables		Percent		
Region				
Hokkaido		0.05		
Tohoku		0.06		
Kanto (omitted cat.)		0.32		
Chubu		0.17		
Kinki		0.19		
Chugoku		0.06		
Shikoku		0.03		
Kyushu		0.12		
City size				
Major city		0.29		
Other city		0.61		
Town/village (omitted cat.)		0.10		
Panel B: Additional key variables				
I: General attitudinal variables		Percent		
Has a saving goal		0.61		
Retirement income: Enough (omitted cat.)		0.09		
Retirement income: Not sure		0.21		
Retirement income: Not enough		0.70		
Support current Gov. (omitted cat.)		0.48		
Don't support current Gov.		0.27		
Current Gov.: Other		0.25		
Continuous variables	Mean	Std. Dev.	Min.	Max.
General risk aversion	42.2725	23.3767	0	100
II: Impression about the stock market				
Profits are uncertain	2.9489	0.9630	0	4
Losses are possible	3.1608	0.8951	0	4
High illegal activities	2.5477	0.9412	0	4
No Info disclosure	2.4582	0.8636	0	4
CB & GOV. intervention	2.3975	0.8387	0	4
III: Risk ranking of selected assets				
Riskiness of savings	2.6968	2.5432	0	10
Riskiness of currency	5.6217	2.5726	0	10
Riskiness of postal	2.5206	2.6211	0	10
Riskiness of stocks	6.3512	2.5501	0	10
Riskiness of trusts	6.4167	2.5845	0	10
Riskiness of property	5.8090	2.5736	0	10
Observations for each variable		2945		

Table 3.6: Correlation between the share of risky assets and the key explanatory variables

I: General attitudinal variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)Risky assets share	1.00								
(2)Proxy of risk attitude	-0.06**	1.00							
(3)Has a saving goal	0.04*	0.01	1.00						
(4)Retirement income:Enough	0.17***	-0.05**	-0.01	1.00					
(5)Retirement income: Not sure	0.05**	-0.04	-0.01	-0.16***	1.00				
(6)Retirement income: Not enough	-0.15***	0.06***	0.02	-0.49***	-0.78***	1.00			
(7)Support current Gov.	0.06***	-0.01	0.07***	0.08***	0.06**	-0.11***	1.00		
(8)Don't support current Gov.	-0.04*	0.01	-0.04*	-0.04*	-0.02	0.04*	-0.59***	1.00	
(9)Current Gov.: Other	-0.04*	0.00	-0.04*	-0.06**	-0.05**	0.08***	-0.56***	-0.35***	1.00
II: Impression about the stock market	(1)	(2)	(3)	(4)	(5)	(6)			
(1)Risky assets share	1.00								
(2)Profitability	-0.07***	1.00							
(3)Riskiness	-0.02	0.64***	1.00						
(4)Illegal	-0.10***	0.39***	0.45***	1.00					
(5)Disclosure	-0.05**	0.35***	0.37***	0.62***	1.00				
(6)Intervention	-0.08***	0.35***	0.33***	0.56***	0.72***	1.00			
III: Risk ranking of selected assets	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
(1)Risky assets share	1.00								
(2)Riskiness of savings	-0.07***	1.00							
(3)Riskiness of currency	0.02	-0.03	1.00						
(4)Riskiness of postal	-0.07***	0.91***	-0.07***	1.00					
(5)Riskiness of stocks	-0.03	-0.28***	0.61***	-0.29***	1.00				
(6)Riskiness of trusts	-0.02	-0.28***	0.62***	-0.30***	0.89***	1.00			
(7)Riskiness of property	-0.03	-0.17***	0.42***	-0.17***	0.59***	0.60***	1.00		

(1) *denotes significance at the 10% level **denotes significance at the 5% level and ***denotes significance at the 1% level.

Table 3.7: Distribution of impression about the stock market variables as a percentage of total response

	Disagree	Somewhat disagree	Cannot say either way	Somewhat agree	Agree	Total
Profits are uncertain	1.75	3.47	27.95	31.7	35.13	100
Losses are possible	1.1	1.41	22.29	30.6	44.61	100
High illegal activities	1.75	7.49	44.06	27.68	19.02	100
No Info disclosure.	1.37	5.94	52.85	25.14	14.7	100
CB & GOV. intervention	1.44	5.6	57.8	22.05	13.12	100

Table 3.8: The determinants of risky assets share: Baseline specification

	Tobit Models		Fractional Regression Models[2]		
	Panel	Cross sect.[2]	One-part	Binary	Fractional
Married	-0.010	-0.122***	-0.498***	-0.216**	-0.202**
	(-0.64)	(-2.78)	(-3.17)	(-2.35)	(-2.14)
Male	0.011	0.167***	0.659***	0.305***	0.175
	(0.73)	(3.24)	(3.03)	(2.92)	(1.59)
Number of adults	-0.007**	0.009	0.033	0.002	0.005
	(-2.03)	(0.78)	(0.68)	(0.10)	(0.23)
Number of children	0.003	0.022	0.091	0.042	0.019
	(0.50)	(1.26)	(1.00)	(1.18)	(0.40)
Part-time	0.068***	0.101	0.506**	0.020	0.214*
	(4.09)	(1.51)	(2.25)	(0.14)	(1.65)
Unemployed	0.008	-0.239	-0.677	-0.522*	0.296
	(0.28)	(-1.58)	(-1.11)	(-1.75)	(1.49)
Other	0.060***	0.095**	0.386**	0.104	0.162*
	(5.33)	(2.38)	(2.38)	(1.14)	(1.86)
High school	0.142***	0.194***	0.620**	0.313***	-0.096
	(6.54)	(3.71)	(2.28)	(3.04)	(-0.59)
College	0.205***	0.275***	0.907***	0.388***	-0.024
	(6.98)	(4.01)	(2.85)	(2.80)	(-0.13)
University+	0.305***	0.385***	1.253***	0.644***	0.019
	(12.47)	(6.99)	(4.48)	(5.83)	(0.12)
Other	0.205***	0.112	0.352	0.196	-0.068
	(6.71)	(1.46)	(0.91)	(1.29)	(-0.31)
20 to 30 Years old	-0.095***	-0.399***	-1.772***	-0.442*	-0.374
	(-2.72)	(-2.88)	(-2.66)	(-1.77)	(-1.18)
30 to 40 Years old	-0.091***	-0.311***	-0.991***	-0.483***	-0.124
	(-4.55)	(-4.94)	(-3.42)	(-3.67)	(-0.78)
40 to 50 Years old	-0.050***	-0.279***	-0.881***	-0.427***	-0.075
	(-2.98)	(-5.17)	(-3.94)	(-3.65)	(-0.61)
50 to 60 Years old	-0.055***	-0.195***	-0.685***	-0.254**	-0.144
	(-3.82)	(-4.17)	(-3.59)	(-2.38)	(-1.49)
60 to 70 Years old	-0.010	-0.150***	-0.415***	-0.322***	0.002
	(-0.93)	(-3.78)	(-2.65)	(-3.48)	(0.02)
Good	0.019	-0.032	-0.248	-0.012	-0.173
	(1.52)	(-0.69)	(-1.27)	(-0.11)	(-1.62)
Pretty good	0.023**	-0.068*	-0.226	-0.111	-0.075
	(2.13)	(-1.75)	(-1.43)	(-1.32)	(-0.82)
Normal	0.015	-0.084**	-0.361**	-0.123	-0.158*
	(1.52)	(-2.29)	(-2.39)	(-1.58)	(-1.81)
Hokkaido	-0.317***	-0.496***	-2.192***	-0.841***	-0.459**
	(-7.51)	(-5.07)	(-4.31)	(-4.73)	(-2.27)
Tohoku	-0.242***	-0.077	-0.527**	0.021	-0.240*
	(-6.57)	(-1.34)	(-1.99)	(0.18)	(-1.91)
Chubu	-0.011	-0.016	-0.144	0.039	-0.138*
	(-0.48)	(-0.47)	(-1.06)	(0.50)	(-1.83)
Kinki	-0.009	-0.032	-0.266*	0.033	-0.229***
	(-0.40)	(-0.93)	(-1.96)	(0.44)	(-3.09)
Chugoku	-0.089**	-0.071	-0.344	-0.018	-0.102
	(-2.42)	(-1.27)	(-1.54)	(-0.15)	(-0.80)
Shikoku	-0.001	-0.030	-0.299	-0.009	-0.200
	(-0.03)	(-0.41)	(-1.04)	(-0.05)	(-1.46)
Kyushu	-0.153***	-0.137***	-0.654***	-0.167*	-0.214**
	(-5.42)	(-2.99)	(-3.19)	(-1.77)	(-2.05)

Table 3.8: The determinants of risky assets share: Baseline specification *(Continued)*

	Tobit Models		Fractional Regression Models[2]		
	Panel	Cross sect.[2]	One-part	Binary	Fractional
Major city	0.084***	-0.035	-0.192	-0.057	-0.056
	(3.84)	(-0.74)	(-1.02)	(-0.55)	(-0.52)
Other city	0.058***	-0.058	-0.205	-0.101	-0.043
	(3.07)	(-1.33)	(-1.19)	(-1.08)	(-0.42)
Rent ratio	0.016	0.010	0.079	-0.163	0.004
	(1.22)	(0.06)	(0.17)	(-0.45)	(0.01)
Mortgage ratio	-0.006	0.097	0.496**	0.087	0.408
	(-0.32)	(1.42)	(2.22)	(0.60)	(1.32)
Home owner	0.117***	0.079*	0.214	-0.059	0.004
	(8.21)	(1.67)	(1.01)	(-0.60)	(0.04)
Labour income risk	0.052	0.038	0.024	-0.029	-0.024
	(1.35)	(0.66)	(0.12)	(-0.22)	(-0.19)
Equivalised income	0.040***	0.162***	0.427***		-0.028
	(5.78)	(6.65)	(4.66)		(-0.50)
Net wealth	0.012***	0.025***	0.076***		-0.024***
	(14.40)	(8.20)	(3.88)		(-2.61)
II income quartile				0.121	
				(1.46)	
III income quartile				0.262***	
				(3.15)	
IV income quartile				0.497***	
				(5.72)	
II wealth quartile				0.187**	
				(2.33)	
III wealth quartile				0.578***	
				(7.18)	
IV wealth quartile				1.205***	
				(13.53)	
Year= 2005	0.080***				
	(6.00)				
Year= 2006	0.102***				
	(7.62)				
Year= 2007	0.091***				
	(7.04)				
Year= 2008	0.098***				
	(7.50)				
Year= 2009	0.047***				
	(3.48)				
Year= 2010	0.041***				
	(2.97)				
Year= 2011	0.046***				
	(3.26)				
Year= 2012	0.029**				
	(2.08)				
Year= 2013	0.032**				
	(2.22)				
Year= 2014	0.082***				
	(5.81)				
Year= 2015	0.097***				
	(6.84)				
Constant	-1.116***	-1.539***	-5.902***	-1.241***	0.421
	(-19.05)	(-8.59)	(-9.37)	(-5.43)	(0.99)
Observations	34315	2945	2945	2945	639

(1) *denotes significance at the 10% level **denotes significance at the 5% level and ***denotes significance at the 1% level. t-statistics are shown in parentheses. (2) Using 2013 wave only. (3) To achieve identification income and wealth quartiles are used in the one-part equation.

Table 3.9: The determinants of risky assets share: Marginal effects of the baseline specification

		Fractional Regression Models		
Independent variables	Tobit	One-Part	Binary	Fractional
Married	−0.096***	−0.030***	−0.053**	−0.071**
Male	0.130***	0.040***	0.075***	0.061
Number of adults	0.007	0.002	0.001	0.002
Number of children	0.0177	0.005	0.010	0.007
Home owner	0.062*	0.013	−0.014	0.002
Part-time	0.079	0.031**	0.005	0.075*
Unemployed	−0.187	−0.041	−0.129*	0.104
Other work	0.074**	0.023**	0.026	0.057*
High school	0.152***	0.037**	0.077***	−0.034
College	0.215***	0.055***	0.096***	−0.008
University+	0.301***	0.076***	0.159***	0.007
Other	0.088	0.021	0.049	−0.024
20 to 30 Years old	−0.313***	−0.107***	−0.109*	−0.132
30 to 40 Years old	−0.244***	−0.060***	−0.119***	−0.044
40 to 50 Years old	−0.219***	−0.053***	−0.106***	−0.027
50 to 60 Years old	−0.153***	−0.041***	−0.063**	−0.051
60 to 70 Years old	−0.118***	−0.025***	−0.080***	0.001
Good	−0.025	−0.015	−0.003	−0.061
Pretty good	−0.053*	−0.014	−0.027	−0.026
Normal	−0.065**	−0.022**	−0.031	−0.056*
Hokkaido	−0.388***	−0.132***	−0.208***	−0.161**
Tohoku	−0.060	−0.032**	0.005	−0.085*
Chubu	−0.013	−0.009	0.010	−0.049*
Kinki	−0.025	−0.016*	0.008	−0.080***
Chugoku	−0.055	−0.021	−0.004	−0.036
Shikoku	−0.024	−0.018	−0.002	−0.070
Kyushu	−0.107***	−0.039***	−0.041*	−0.075**
Major city	−0.028	−0.012	−0.014	−0.020
Other city	−0.046	−0.012	−0.025	−0.015
Rent ratio	0.008	0.005	−0.040	0.002
Mortgage ratio	0.076	0.030**	0.022	0.143
Labour income risk	0.030	0.001	−0.007	−0.008
Equivalised income	0.127***	0.026***		−0.010
Net wealth	0.019***	0.005***		−0.008***
II income quartile			0.030	
III income quartile			0.065***	
IV income quartile			0.123***	
II wealth quartile			0.046**	
III wealth quartile			0.143***	
IV wealth quartile			0.298***	
Constant	−1.205***			
Observations	2945	2945	2945	639

(1) *denotes significance at the 10% level **denotes significance at the 5% level and ***denotes significance at the 1% level. (2) t-statistics are shown in parentheses. (3) To achieve identification income and wealth quartiles are used in the one-part equation.

Table 3.10: The determinants of risky assets share: Tobit regressions of the key explanatory variables

I: General attitudinal variables	Model 1	Model 2	Model 3	Model 4				Model A	Model B
Proxy of risk attitude	-0.001							-0.001	-0.001
	(-0.91)							(-0.73)	(-0.99)
Has a saving goal		0.055**						0.057**	0.055**
		(2.16)						(2.26)	(2.19)
retir. income, Not sure			-0.116***					-0.119***	-0.103**
			(-2.85)					(-2.91)	(-2.56)
retir. income, Not enough			-0.206***					-0.205***	-0.185***
			(-5.46)					(-5.39)	(-4.92)
Don't support current Gov.				-0.061**				-0.049*	-0.045
				(-2.05)				(-1.66)	(-1.55)
Current Gov.: Other				-0.131***				-0.099**	-0.104**
				(-2.62)				(-1.95)	(-2.06)
II: Impression about stock markets	Model 1	Model 2	Model 3	Model 4	Model 5			Model A	
Profits are uncertain	-0.052***							-0.062***	-0.065***
	(-4.29)							(-4.16)	(-3.88)
Losses are possible		-0.008						0.055***	0.055***
		(-0.64)						(3.29)	(3.08)
High illegal activities			-0.050***					-0.050***	-0.063***
			(-4.24)					(-3.22)	(-3.77)
No Info disclosure				-0.031**				0.025	0.031
				(-2.45)				(1.28)	(1.46)
CB & GOV. intervention					-0.046***			-0.031*	-0.030
					(-3.51)			(-1.67)	(-1.42)
III: Risk ranking of selected assets	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model A	
Riskiness of savings	-0.022***						-0.025***	-0.041***	-0.039***
	(-4.34)						(-4.77)	(-3.20)	(-3.06)
Riskiness of currency		-0.001						0.009	0.011*
		(-0.26)						(1.42)	(1.80)
Riskiness of postal			-0.017***					0.016	0.016
			(-3.42)					(1.28)	(1.36)
Riskiness of stocks				-0.006			-0.012**	-0.011	-0.016
				(-1.12)			(-2.31)	(-1.10)	(-1.68)
Riskiness of trusts					-0.005			-0.006	-0.002
					(-1.03)			(-0.64)	(0.08)
Riskiness of property						-0.003		-0.001	0.001
						(-0.64)		(-0.19)	(0.16)
Observations				2945					

(1) *denotes significance at the 10% level **denotes significance at the 5% level and ***denotes significance at the 1% level. t-statistics are shown in parentheses. (2) Each model from 1 to 7 includes the baseline specifications and one variable from each set. Model A includes baseline specifications and all variables in each set. Model B includes baseline specifications and all variables in all sets.

Table 3.11: The determinants of risky assets share: One-part FRM regressions of the key explanatory variables

I: General attitudinal variables	Model 1	Model 2	Model 3	Model 4			Model A	Model B
Proxy of risk attitude	-0.003						-0.003	-0.001
	(-0.65)						(-0.30)	(-0.59)
Has a saving goal		0.161					0.166	0.156
		(1.59)					(1.64)	(1.54)
retir. income, Not sure			-0.285**				-0.304**	-0.284**
			(-2.08)				(-2.22)	(-2.03)
retir. income, Not enough			-0.576***				-0.581***	-0.529***
			(-4.52)				(-4.48)	(-4.01)
Don't support current Gov.				-0.243**			-0.214*	-0.199*
				(-2.06)			(-1.81)	(-1.67)
Current Gov.: Other				-0.314			-0.209	-0.232
				(-1.45)			(-0.97)	(-1.08)
II: Impression about stock markets	Model 1	Model 2	Model 3	Model 4	Model 5		Model A	
Profits are uncertain	-0.171***						-0.211***	-0.202***
	(-3.14)						(-3.44)	(-3.37)
Losses are possible		-0.017					0.162**	0.177**
		(-0.27)					(2.31)	(2.48)
High illegal activities			-0.148**				-0.167*	-0.281***
			(-1.97)				(-1.79)	(-3.64)
No Info disclosure				-0.073			0.085	0.082
				(-1.09)			(1.06)	(0.99)
CB & GOV. intervention					-0.102		-0.042	-0.012
					(-1.47)		(-0.54)	(-0.15)
III: Risk ranking of selected assets	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model A	
Riskiness of savings	-0.066***						-0.123**	-0.117**
	(-2.89)						(-2.44)	(-2.12)
Riskiness of currency		-0.009					0.030	0.043
		(-0.46)					(1.07)	(1.56)
Riskiness of postal			-0.049**				0.045	0.050
			(-2.29)				(0.95)	(0.95)
Riskiness of stocks				-0.031*			-0.071	-0.090*
				(-1.79)			(-1.45)	(-1.87)
Riskiness of trusts					-0.020		0.004	0.030
					(-1.22)		(0.08)	(0.64)
Riskiness of property						-0.010	0.003	0.009
						(-0.55)	(0.15)	(0.41)
Observations				2945				

(1) *denotes significance at the 10% level **denotes significance at the 5% level and ***denotes significance at the 1% level. t-statistics are shown in parentheses. (2) Each model from 1 to 7 includes the baseline specifications and one variable from each set. Model A includes baseline specifications and all variables in each set. Model B includes baseline specifications and all variable in all sets.

Table 3.12: The determinants of risky assets share: FRM two-part regressions of the key explanatory variables

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model A		Model B	
I: General attitudinal variables	Binary	Frac.	Binary	Frac.	Binary	Frac.	Binary	Frac.					Binary	Frac.	Binary	Frac.
Proxy of risk attitude	-0.002	-0.001											-0.001	-0.001	-0.002	-0.001
	(-0.54)	-0.20)											(-0.53)	(-0.55)	(-0.72)	(-0.59)
Has a saving goal			0.148***	-0.016									0.144***	-0.018	0.141***	-0.026
			(2.70)	(-0.29)									(2.59)	(-0.33)	(2.51)	(-0.46)
Retir. income, Not sure					-0.286***	-0.063							-0.294***	-0.050	-0.272**	-0.081
					(-2.71)	(-0.83)							(-2.72)	(-0.66)	(-2.49)	(-1.07)
Retir. income, Not enough					-0.362***	-0.030							-0.370***	-0.018	-0.355***	-0.041
					(-3.69)	(-0.39)							(-3.68)	(-0.23)	(-3.48)	(-0.54)
Don't support current Gov.							-0.104	-0.074					-0.092	-0.078	-0.085	-0.090
							(-1.64)	(-1.18)					(-1.44)	(-1.23)	(-1.31)	(-1.42)
Other, current Gov.							-0.258**	0.153					-0.222**	0.143	-0.241**	0.152
							(-2.48)	(1.09)					(-2.08)	(1.06)	(-2.24)	(1.10)
	Model 1		Model 2		Model 3		Model 4		Model 5				Model A			
II: Impression about the stock markets	Binary	Frac.	Binary	Frac.	Binary	Frac.	Binary	Frac.	Binary	Frac.			Binary	Frac.		.
Profits are uncertain	-0.096***	-0.032											-0.110***	-0.048	-0.123***	-0.047
	(-3.78)	(-0.98)											(-3.25)	(-1.35)	(-3.35)	(-1.33)
Losses are possible			-0.024	-0.002									0.107***	0.006	0.116***	0.011
			(-0.90)	(-0.04)									(2.80)	(0.16)	(2.81)	(0.30)
High illegal activities					-0.111***	0.012							-0.106***	0.001	-0.096**	-0.005
					(-4.39)	(0.40)							(-3.00)	(0.03)	(-2.46)	(-0.15)
No Info disclosure							-0.074***	0.025					0.044	0.010	0.062	0.021
							(-2.76)	(0.76)					(0.94)	(0.23)	(1.32)	(0.50)
CB & GOV. intervention									-0.098***	0.033			-0.067	0.037	-0.086*	0.034
									(-3.57)	(1.03)			(-1.51)	(0.98)	(-1.79)	(0.89)
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model A			
III: Risk ranking of selected assets	Binary	Frac.	Binary	Frac.	Binary	Frac.	Binary	Frac.	Binary	Frac.	Binary	Frac.	Binary	Frac.		
Riskiness of savings	-0.041***	0.001											-0.074***	0.004	-0.077***	0.004
	(-3.91)	(0.08)											(-2.93)	(0.11)	(-2.91)	(0.10)
Riskiness of currency			-0.005	-0.002									0.014	-0.000	0.016	0.000
			(-0.50)	(-0.19)									(1.00)	(-0.01)	(1.18)	(0.03)
Riskiness of postal					-0.032***	0.000							0.027	-0.006	0.029	-0.009
					(-3.16)	(0.04)							(1.10)	(-0.19)	(1.20)	(-0.27)
Riskiness of stocks							-0.009	-0.017					-0.006	-0.035*	-0.010	-0.038*
							(-0.90)	(-1.34)					(-0.24)	(-1.79)	(-0.43)	(-1.93)
Riskiness of trusts									-0.012	-0.002			-0.029	0.018	-0.023	0.017
									(-1.23)	(-0.14)			(-1.22)	(0.92)	(-1.00)	(0.89)
Riskiness of property											-0.004	0.004	0.002	0.011	0.005	0.012
											(-0.34)	(0.33)	(0.14)	(0.81)	(0.38)	(0.84)
Observations	2945	639	2945	639	2945	639	2945	639	2945	639	2945	639	2945	639	2945	639

(1)*denotes significance at the 10% level **denotes significance at the 5% level and ***denotes significance at the 1% level. t-statistics are shown in parentheses. (2) Each model from 1 to 6 includes the baseline specifications and one variable from each set. Model A includes baseline specifications and all variables in each set. Model B includes baseline specifications and all variable in all sets.

Table 3.13: The determinants of risky assets share: Marginal effects of Tobit and FRM of the key explanatory variables

	Section A[2]	Fractional Regression Models			Section B[3]	Fractional Regression Models		
I: General attitudinal variables	Tobit	One-Part	Binary	Fractional	Tobit	One-Part	Binary	Fractional
Proxy of risk attitude	−0.001*	0.000*	0.000	0.000	−0.001*	0.000*	0.000	0.000
Has a saving goal	0.044**	0.009	0.037***	−0.010	0.041**	0.008	0.035***	−0.009
Retir. income, Not sure	−0.085***	−0.016**	−0.066**	−0.021	−0.079**	−0.017**	−0.063**	−0.029
Retir. income, Not enough	−0.155***	−0.033***	−0.085***	−0.009	−0.147***	−0.031***	−0.084***	−0.015
Current Gov.: Don't support	−0.035*	−0.019	−0.026	−0.026	−0.031	−0.011	−0.016	−0.031
Current Gov.: Other	−0.082**	−0.013	−0.056**	0.056	−0.089**	−0.015	−0.061**	0.053
II: Impression about the stock markets								
Profits are uncertain	−0.048***	−0.013***	−0.027***	−0.017	−0.05***	−0.013***	−0.031***	−0.016
Losses are possible	0.043***	0.010**	0.026***	0.002	0.044***	0.010***	0.029***	0.004
High illegal activities	−0.039***	−0.010*	−0.026***	0.000	−0.035***	−0.009*	−0.021**	−0.002
No Info disclosure	0.020	0.005	0.011	0.003	0.024	0.006	0.015	0.008
CB & GOV. intervention	−0.024	−0.002	−0.016	0.013	−0.023	−0.002	−0.019*	0.012
III: Risk ranking of selected assets								
Riskiness of savings	−0.032***	−0.007**	−0.018***	0.001	−0.031***	−0.007**	−0.018***	0.001
Riskiness of currency	0.007	0.002	0.003	0.000	0.008	0.002	0.003	0.000
Riskiness of postal	0.013	0.003	0.007	−0.002	0.013	0.003	0.007	−0.003
Riskiness of stocks	−0.008	−0.004	−0.002	−0.012*	−0.011	−0.005*	−0.002	−0.013*
Riskiness of trusts	−0.005	0.000	−0.007	0.006	−0.002	0.001	−0.006	0.006
Riskiness of property	−0.001	0.000	0.000	0.004	0.001	0.001	0.001	0.004

(1)*denotes significance at the 10% level **denotes significance at the 5% level and ***denotes significance at the 1% level. t-statistics are shown in parentheses.(2) Models in this section include baseline specifications and all variables in each set separately.(3) Models in this section include baseline specifications and all variables in all sets.

Table 3.14: The determinants of risky assets share: CQR baseline specification

	Regression cut points					
Independent variables	Tobit	60	65	75	85	95
Married	−0.096***	−0.005	−0.011	−0.043**	−0.064**	−0.149**
Male	0.130***	0.011	0.02	0.066**	0.097**	0.131**
Number of adults	0.007	−0.001	0.001	0.005	−0.006	0.002
Number of children	0.0177	0.001	0.002	0.004	−0.005	0.024
Part-time	0.079	0.012	0.028	0.013	0.102	0.157*
Unemployed	−0.187	−0.001	−0.005	−0.07	−0.12	0.021
Other work	0.074**	0.006	0.017	0.03	0.077**	0.111*
High school	0.152***	0.004	0.005	0.073*	0.076*	0.105
College	0.215***	0.011	0.017	0.094**	0.101**	0.199
University+	0.301***	0.017	0.043	0.124***	0.187***	0.316***
Other	0.088	0.003	−0.033	0.026	0.012	0.071
20 to 30 Years old	−0.313***	−0.026	−0.063	−0.025	−0.147*	−0.386***
30 to 40 Years old	−0.244***	−0.015	−0.049**	−0.112***	−0.149***	−0.239***
40 to 50 Years old	−0.219***	−0.015	−0.036**	−0.1***	−0.124**	−0.245***
50 to 60 Years old	−0.153***	−0.01	−0.017	−0.071**	−0.07	−0.145**
60 to 70 Years old	−0.118***	−0.008	−0.007	−0.05**	−0.035	−0.105**
Good	−0.025	0.003	0.014	−0.002	0.014	−0.141
Pretty good	−0.053*	−0.001	0.005	−0.01	0.013	−0.147**
Normal	−0.065**	0.001	−0.002	−0.014	−0.013	−0.176***
Hokkaido	−0.388***	−0.012	−0.03	−0.122	−0.049	−0.325***
Tohoku	−0.06	−0.002	−0.011	−0.032	−0.042	−0.089
Chubu	−0.013	0.002	0.005	−0.003	−0.004	−0.045
Kinki	−0.025	−0.001	0.002	−0.007	−0.028	−0.1*
Chugoku	−0.055	−0.004	−0.009	−0.026	−0.038	−0.071
Shikoku	−0.024	0.001	0.001	0.003	−0.045	−0.144*
Kyushu	−0.107***	−0.002	−0.012	−0.069***	−0.074*	−0.151**
Major city	−0.028	0.002	0.001	−0.003	−0.021	−0.018
Other city	−0.046	0.001	−0.002	−0.005	−0.022	−0.021
Rent ratio	0.008	0.022	0.019	−0.105	0.044	0.044
Mortgage ratio	0.076	0.001	0.016	0.052	0.189***	0.156*
Home owner	0.062*	0.002	−0.005	−0.036	−0.028	0.022
Labour income risk	0.03	−0.001	0.003	0.012	−0.007	−0.014
Equivalised income	0.127***	0.005	0.014*	0.046***	0.059***	0.093**
Net wealth	0.019***	0.002	0.005	0.017**	0.025***	0.019***
Constant	−1.205***	−0.038	−0.092	−0.391***	−0.436***	−0.208

(1) *denotes significance at the 10% level **denotes significance at the 5% level and ***denotes significance at the 1% level. (2) Coefficients below the 60th quantile are statistically and economically insignificant

Table 3.15: The determinants of risky assets share: CQR regressions of the key explanatory variables

	Section A[2]	Regression cut points: Each set					Section B[3]	Regression cut points: All sets together				
	Tobit	60	65	75	85	95	Tobit	60	65	75	85	95
I: General attitudinal variables												
Proxy of risk attitude	−0.001*	0.000	0.000	0.000	0.000	−0.003**	−0.001*	0.000	0.00*	0.00*	0.000	0.000
Has a saving goal	0.044**	0.001	0.005	0.005	0.004	−0.004	0.041**	0.007	0.009	0.016	0.028	0.017
Retir. income, Not sure	−0.085***	−0.075	−0.095**	−0.077**	−0.111**	−0.144**	−0.079**	−0.02	−0.032	−0.029	−0.02	−0.073
Retir. income, Not enough	−0.155***	−0.075	−0.097**	−0.086***	−0.128***	−0.142**	−0.147***	−0.028	−0.039	−0.042	−0.063**	−0.131**
Current Gov.: Don't support	−0.035*	0.000	−0.004	−0.028**	−0.051**	−0.028	−0.031	0.000	0.000	−0.014	−0.022	−0.043
Current Gov.: Other	−0.082**	−0.001	−0.012	−0.041	−0.096**	−0.087	−0.089**	−0.014	−0.012	−0.043*	−0.08**	0.012
II: Impression about stock markets												
Profits are uncertain	−0.048***	−0.007*	−0.008*	−0.007	−0.015	−0.036	−0.05***	−0.004	−0.005	−0.011	−0.013	−0.062***
Losses are possible	0.043***	0.01**	0.007	0.007	0.022*	0.006	0.044***	0.012***	0.007	0.009	0.018	0.04
High illegal activities	−0.039***	−0.013**	−0.016**	−0.026***	−0.04***	−0.044	−0.035***	−0.008	−0.009	−0.017	−0.038***	−0.059**
No Info disclosure	0.02	0.003	0.003	0.002	0.011	0.022	0.024	0.000	0.000	0.003	0.003	0.042
CB & GOV. intervention	−0.024	0.000	−0.002	−0.005	−0.018	−0.041	−0.023	0.003	0.000	−0.003	−0.011	−0.031
III: Risk ranking of selected assets												
Riskiness of savings	−0.032***	−0.001	−0.005*	−0.011**	−0.022***	−0.043***	−0.031***	−0.006*	−0.006*	−0.010	−0.013	−0.028*
Riskiness of currency	0.007	0.000	0.000	−0.001	0.005	0.012	0.008	−0.002	−0.001	0.001	0.001	0.015*
Riskiness of postal	0.013	0.000	0.002	0.005	0.008	0.027**	0.013	0.004	0.003	0.007	0.004	0.013
Riskiness of stocks	−0.008	−0.001	0.002	0.000	−0.006	−0.031**	−0.011	0.002	0.000	−0.002	−0.011	−0.024*
Riskiness of trusts	−0.005	0.000	−0.006*	−0.005	0.002	0.014	−0.002	−0.005	−0.003	−0.002	0.008	0.01
Riskiness of property	−0.001	0.000	0.001	0.001	−0.003	−0.002	0.001	0.001	0.001	0.000	0.001	−0.001

(1)*denotes significance at the 10% level **denotes significance at the 5% level and ***denotes significance at the 1% level. t-statistics are shown in parentheses.(2) Models in this section include baseline specifications and all variables in each set separately.(3) Models in this section include baseline specifications and all variables in all sets.(4) Coefficients below the 60th quantile are statistically and economically insignificant.

Table 3.16: Household's employment status across age categories

Age groups	Working	Part-Time	Unemploye	Other	Total
20 to 30 Years old	40	2	0	0	42
30 to 40 Years old	346	4	1	6	357
40 to 50 Years old	601	10	4	3	618
50 to 60 Years old	663	16	7	13	699
60 to 70 Years old	474	49	16	167	706
70+ year old	117	34	7	332	490
Total	2241	115	35	521	2912

Table 3.17: Model performance of the three alternative methodological approaches

	Baseline specification			
Panel A: Information Criteria	Tobit	One part FRM	Binary part	Fractional part
AIC	2333.918	1136.683	2470.097	641.008
BIC	2549.076	1345.864	2703.185	796.7191
Panel B: Link test	0.205***	0.0404	-0.1692	-1.027
Panel C: P test				
H0: Two-part model. H1: One-part model	4.858**			
H0: One-part model. H1: Two-part model	43.468***			
	The key explanatory variables			
Panel D: Information Criteria	Tobit	One part FRM	Binary part	Fractional part
AIC	2253.775	1137.533	2425.045	671.0946
BIC	2570.535	1448.316	2759.734	902.4369
Panel E: Link test	0.2067***	-0.0186	-0.1828	-0.8658
Panel F: P test				
H0: Two-part model. H1: One-part model	0.011			
H0: One-part model. H1: Two-part model	33.336***			
Observations	2945	2945	2945	639

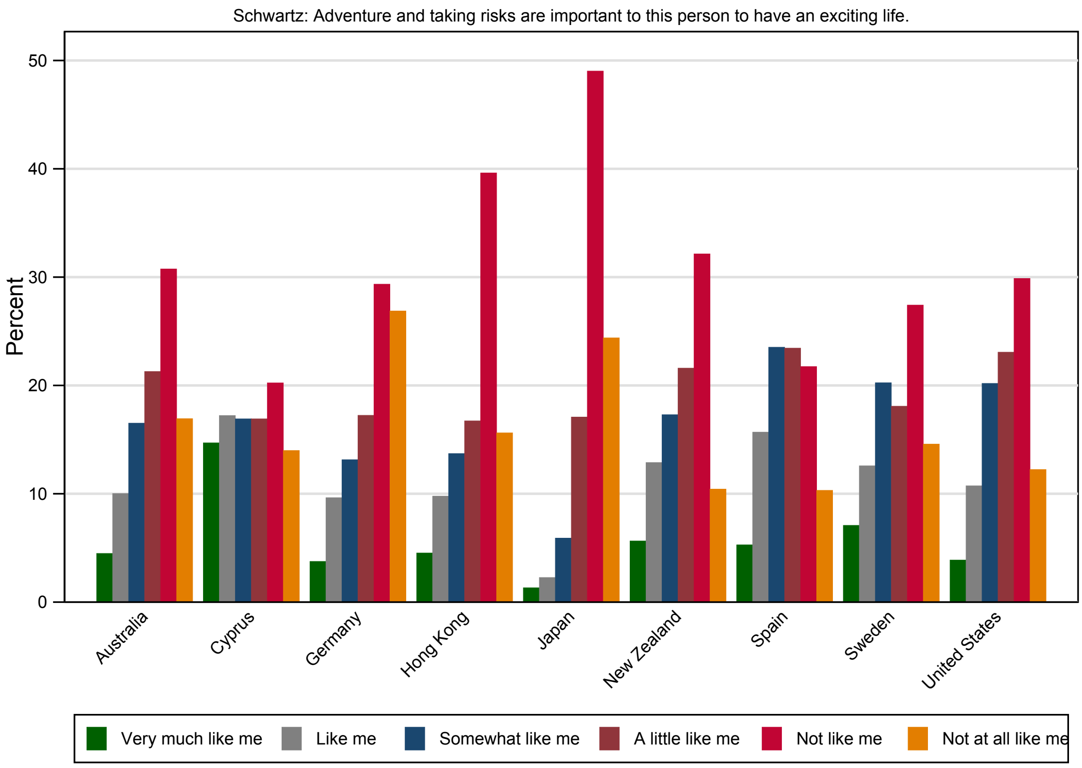
(1)*denotes significance at the 10% level **denotes significance at the 5% level and ***denotes significance at the 1% level.

Table 3.18: Mean of risky asset holdings: Sample and predicted

	Sample mean	Conditional on holding	Tobit	One-part FRM	Two-part (Binary)	Two-part (Fractional)
Baseline specification	0.06363	0.2932	0.06407	0.06363	0.21711	0.30024
Full specification	0.06363	0.2932	0.06411	0.06359	0.21722	0.2944

3.9 Figures

Figure 3.1: Adventure and taking risks



Source: Data are from the World Value Survey (Wave 6 2010-2014).

Figure 3.2: Proportion of risky assets

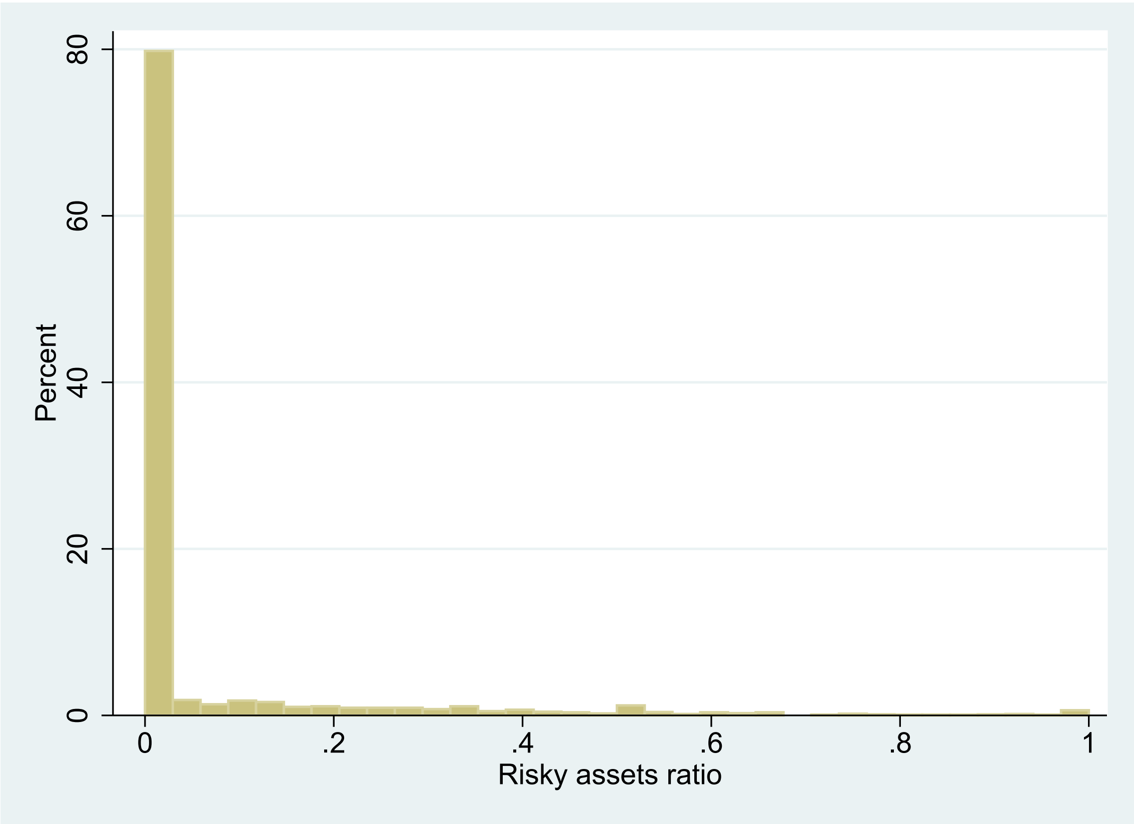
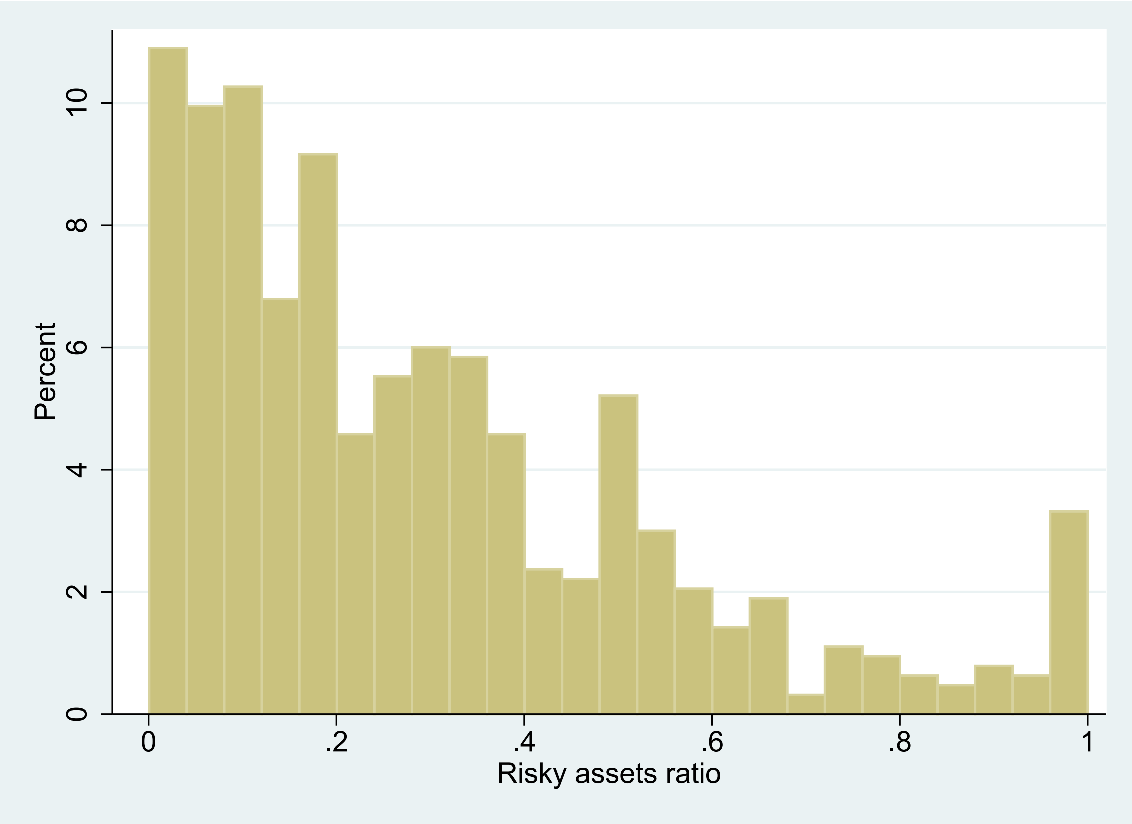


Figure 3.3: Distribution of risky assets ratio conditional on holding



Chapter 4

Individual Risk Attitudes: A Comparison of the U.S. and Japan

4.1 Introduction

Economists assign a central role to attitudes towards risk when studying behaviours of individuals. Risk attitudes will have an impact on any decision an individual will take that contains an element of risk. For example, risk attitudes will impact individual's fertility, political and health decisions, see De Paola (2013). Furthermore, risk attitudes will have a significant impact on an individual's financial and economic decisions such as, portfolio composition, buying insurance, indebtedness and choice of occupation (see, for example, Dohmen et al., 2011; Schildberg-Hörisch, 2018).

At the aggregate level, an increase in the proportion of individuals who are less willing to take risks has several implications on economic growth. For example, Guiso, Sapienza, and Zingales (2018) argue that this increase will impact investments which have high growth rate but risky profile since a proportion of entrepreneurs will prefer safer but lower growth investments. It will also increase the cost of capital and slow down capital accumulation since investors' required risk premium will increase as a result of more individuals being less willing to take risks. More importantly is the potential impact of risk attitudes on equity investment cost, especially in an ageing population such as Japan. This is because firms and small businesses are moving away from the traditional bank loans to the capital markets to raise funds, so policy makers are trying to encourage individuals to engage more in the stock markets. Moreover, the defined contribution pension scheme gives participants the option to choose the level of risk of their portfolios which is significantly influenced by their attitudes towards risk.

One of the most important aspects of risk attitudes to researchers and policy makers is identifying what determines individual risk attitudes. Examining the determinants of individuals' preferences towards risk and the stability of these preferences are critical in understanding behaviours of individuals which will then help in predicting economic outcomes (Dohmen et al., 2016; Hryshko, Luengo-Prado, & Sørensen, 2011; De Paola, 2013). For example, the financial behaviour of Japanese individuals is different from their U.S. and EU counterparts. The Bank of Japan (2017b) shows that the share of equity held by Japanese households was on average 10.0% in 2017 in comparison to 18.0% in the EU and 36.0% in the U.S.. This conservative investment approach by Japanese individuals has been linked in the literature to their less willingness to take risk nature.[1]

Another important aspect of risk attitudes that has received increasing interest from policy makers and from the academic circle is its stability and what causes its variation at the individual level. In order to understand and study individuals' behaviours over time, it is crucial to start by examining the stability of individuals' attitudes towards risk. Exogenous shocks, such as changes in economic conditions or experiencing natural disasters, can cause a permanent change in an individual's risk attitudes (Schildberg-Hörisch, 2018). By examining the stability of risk attitudes, policy makers can observe various vital realizations at the aggregate level such as: predicting labour market structure; predicting health related risky behaviours; and influencing investments, fertility and migration decisions.

With the exception of Dohmen et al. (2016) and Vieider et al. (2015) a comparison of the determinants of risk attitudes across countries is scarce in the literature.[2] Moreover, the impact of natural disasters on risk attitudes has only recently received attention from researchers within existing studies, furthermore, the findings are inconclusive. This chapter addresses aspects of risk attitudes in Japan and the U.S. using panel survey data from the "Preference Parameters Study of Osaka University" conducted in Japan and the U.S.. This survey asks identical questions in these

[1] This feature has been documented by the World Value Survey, where 73.0% of individuals interviewed in Japan between 2010 and 2014 described themselves as individuals who are less willing to take risk. This is compared to 39.0% in the U.S. and 51.0% the average response of 60 countries.

[2] Dohmen et al. (2016) compared the determinants of risk attitudes in Ukraine, a transition economy, and Germany, a mature capitalist economy. Vieider et al. (2015) compared students participated in experiments in 30 countries.

two countries. Therefore, this chapter compares risk attitudes and their determinants in two countries with a significant differences in the attitudes of individuals towards risks. Moreover, given the increasing frequency and severity of natural disasters, this chapter assesses the impact of experiencing natural disasters in each of these two countries. If the risk attitudes variables are valid proxies for actual risk-taking behaviours, one should expect these variables to explain a significant part of the cross-sectional variation in risky choices of individuals. Therefore, this chapter also test if the two risk attitudes measures used in this chapter explain individual's actual choices in a variety of contexts.

The contributions of this chapter to the existing literature are as follows. I am aware of no other empirical study that compares the determinants of risk attitudes between Japan and the U.S.. The literature on how risk attitudes are impacted by natural disasters is new and inconclusive. Most of the papers in the existing literature use one measure of natural disasters when examining changes in risk attitudes (see, for example, Cameron & Shah, 2015; van den Berg, Fort, & Burger, 2009; Eckel, El-Gamal, & Wilson, 2009). This chapter contributes to the existing literature by using a range of measures of natural disaster risk, an exogenous shock, to ascertain the impact of such shocks on risk attitudes. The validity of the "Preference Parameters Study" risk attitudes measures is checked by testing if these measures can predict various risky behaviours and financial choices. These validation exercises are further tested in a system of two equations to control for the endogeneity of the risk attitudes measures in the equations of risky behaviours and financial choices. This is another contribution to the existing literature as there are no empirical studies, to the best of my knowledge, that explore the relationship between individuals risky choices and their attitudes towards risk by employing a joint modelling approach.[3] The framework used to estimate this system of two equations is the conditional mixed-process (CMP) suite of tools developed by Roodman (2011).

[3] There is a number of studies that employ a joint modelling approach in the literature of household finance (see, for example, Brown & Taylor, 2008; Gray, 2014; Bridges & Disney, 2010).

The findings of this chapter indicate that a number of variables have a statistically significant impact on individual's risk attitudes and the impact of some of these variables is not the same across Japan and the U.S.. For example, the impacts of some variables are larger for Japanese individuals, such as age and the background risk variables. Whereas the magnitude of most of the other variables have a larger impact on U.S. respondents, such as being self-employed, level of education and income. More importantly, the empirical analysis reveals that considering only the effects of the regressors on the full sample and not controlling for gender differences masks considerable heterogeneity in the effects of some variables. For example, height is found to influence the risk attitudes of Japanese male individuals only, whereas only U.S. male individuals who live in cities are more willing to take risk compared to those who live in a rural areas. Overall, the findings of this chapter indicate that risk attitudes of male individuals has shown to be more influenced, in terms of statistical significance and magnitude, by the set of controls considered in this chapter than risk attitudes of female respondents. These results show the importance of controlling for gender differences in the analysis of topics related to risk attitudes, such as determinants, stability and susceptibility to change.

The risk of exposure to natural disasters impacts only the risk attitudes of Japanese male individuals and this impact is robust to the use of a number of earthquake risk measures. Specifically, the results obtained for the set of natural disaster risk measures show that the measure related to the number of days with an earthquake and the average intensity measure have no impact on individuals' risk attitudes. Whereas, the other three measures that capture earthquakes with high intensities do have an impact on risk attitudes, indicating that what matters are those earthquakes with high intensities not small and frequent earthquakes.

These results are intuitive given that Japan is a country which is exposed to a high risk of earthquake episodes, many of these episodes are small in terms of intensity and Japanese individuals adopted mechanisms and procedures which mitigated the impact of these earthquake. The finding of this chapter that earthquakes with large intensities impact the attitudes of Japanese individuals towards risk has important policy implications. For example, it indicates that the current policies adopted by the Japanese government are not efficient in making individuals aware of the risk of earthquakes and well-informed about their consequences, since individuals risk attitudes are still influenced by these disasters. Finally, the results of the validation exercises of the two measures of risk attitudes ascertain that these measures have considerable predictive power for a number of risky decisions in a variety of contexts.

This chapter is structured as follows; Section 4.2 will review the literature related to attitudes towards risk. Section 4.3 provides a discussion of the survey, dependent variables and the independent variables. Section 4.4 presents the methodologies employed in this chapter, whilst Section 4.5 and Section 4.6 discuss the results. Finally, Section 4.7 concludes the chapter.

4.2 Literature review

Given that risk attitudes are a fundamental factor in explaining individuals' behaviours, systematic changes in risk attitudes will have a significant impact on social, economic and political aggregate outcomes. Therefore, it is not surprising to see a growing empirical literature that considers different aspects of an individual's risk attitudes. One of these aspects is to try to identify what determines an individuals' risk attitudes by studying its association with various demographic and socio-economic characteristics. Another important aspect of individual's risk attitudes explored in the literature is how it can be observed and measured. A range of different methodologies to measure risk attitudes have been extensively discussed in the literature as risk attitudes is not an individual characteristic that is directly observed. Another aspect that gained popularity in recent years is the stability of risk attitudes across the life course. A growing number of studies start to question the claim which regards risk attitudes as a given attribute and time-invariant factor. These studies are triggered by the recent financial crisis and the increasing frequency and severity of natural disasters. I will now explore the literature in these distinct areas.

4.2.1 Measuring and validating individual's risk attitudes

Individual willingness to bear risk is not a characteristic that is directly observed and many different methodologies have been suggested in the literature. In general, individual risk attitudes could be measured in two different approaches: relying on survey questions (Barsky, Juster, Kimball, & Shapiro, 1997; Donkers, Melenberg, & Van Soest, 2001; Guiso & Paiella, 2008); or using an incentivized experiment (Binswanger, 1980; Holt & Laury, 2002; Eckel & Grossman, 2008).

Risk attitude measures based on experiments are accurate measures as they precisely quantify the risks under consideration (internal validity) since the experiment is implemented in a controlled situation and using real choices with real incentives. However, incentivized experiments' measures are not cheap to administer and time-consuming to implement. On the other hand, measures of risk attitudes that are based on survey questions can be collected easily along with other demographic and socio-economic information about participants (external validity). The main disadvantage of these measures is that they are more prone to measurement error as they might capture individuals' risk perception on top of their risk attitudes. In order to evaluate the trade-off between measurement accuracy against practicality, empirical research tend to test the predictive power of actual risky behaviours of each type of these measures. Theoretically, differences in risk attitudes across individuals should be the only factor that explain their actual choices in a variety of contexts as assumed by the theory of choice under uncertainty, Paiella, Guiso, et al. (2004).

Empirical researches show that survey elicited measures of risk attitudes outperform experimental measures in terms of their predictive power of actual risky behaviours. For example, Frey, Pedroni, Mata, Rieskamp, and Hertwig (2017) found that the correlation between 22 self-reported measures was higher than the correlation between 6 different behavioural (experimental) measures. Furthermore, Frey et al. (2017, p. 8) argue that *"self-reported impulsivity and self-control have been shown to have high predictive validity, and more so than behavioural measures, for a number of real-world outcomes, such as teenage pregnancy, drug use, and financial security."*

Dohmen et al. (2011) conducted validation tests between incentivized experimental measures and survey based measures (including hypothetical experiments) to address the concern that survey questions are able to generate a meaningful measure of risk attitudes in terms of actual risk-taking behaviours. To do so, Dohmen et al. (2011) conducted a field experiment using 450 German adults who answered the German Socio Economic Panel (SOEP) survey risk attitudes general and contexts specific questions as well as made choices in a real-stakes lottery experiment. Dohmen et al. (2011, p. 524) concluded that "*a simple, qualitative survey measure can generate a meaningful measure of risk attitudes, which maps into actual choices in lotteries with real monetary consequences.*" Moreover, Dohmen et al. (2011) confirm that all risk measures predict various risky behaviours such as; stock holdings, being self-employed, smoking and engaging in active sports.

To examine the role of risk attitudes in predicting individual behaviours, Paiella et al. (2004) used data on Italian households drawn from the 1995 wave of the Survey of Household Income and Wealth (SHIW). Paiella et al. (2004) used the Arrow-Pratt measure of absolute risk attitudes that is constructed using the maximum price the individual is willing to offer for a hypothetical investment. The results show that their measure of risk attitudes has strong predictive power on the following consumer decisions: occupational choice and entrepreneurship; portfolio choice; the decision to buy an insurance policy; the number of years of education; and the decision to migrate or to change jobs. Paiella et al. (2004) also address the importance of differences in risk attitudes in explaining income inequality by regressing the variability in expected earnings on risk attitudes and a set of controls. The findings of Paiella et al. (2004) indicate that differences in attitudes towards risk have the same power in explaining the standard deviation of expected earnings as other important controls including; age, gender and father's occupation.

4.2.2 Determinants of risk attitudes

Individuals' attitudes towards risk will shape the way they make their decisions in every aspect of their life. Identifying the factors that determine these choices is crucial for policy makers and institutions in order to understand and influence these choices.

A number of exogenous factors that influence individual's attitude towards risk are initially examined by Dohmen et al. (2011) before including a wide range of other variables. The exogenous factors are gender, age, height and parents' education. Dohmen et al. (2011) measure risk attitudes by exploring questions about the willingness of taking risk in general and in a number of specific contexts, which are drawn from the 2004 wave of the SOEP.[4] Furthermore, as a robustness check, they measure risk attitudes using a field experiment. All of these measures yield similar results, however, they conclude that the question related to taking risk in general can generate a meaningful measure of risk attitudes. Dohmen et al. (2011) found that females are less willing to take risk than males, willingness to take risks decreases significantly with age and the willingness to take risks increases significantly with the respondent's height. Willingness to take risk also increases with the level of parents education, the impact of both parents' education jointly and individually are statistically significant. These results are robust to the inclusion of a wide range of additional characteristics including wealth and income.

[4]The SOEP general risk question that is answered using an 11-point Likert scale is: "How willing are you to take risks, in general?". The survey also includes five additional questions about risk taking in specific contexts: car driving, financial matters, sports and leisure, health, and career.

Two waves of the (SOEP) (2004 and 2007) and the Ukrainian Longitudinal Monitoring Survey (ULMS) are used by Dohmen et al. (2016) to extend the work of Dohmen et al. (2011). Using questions about the willingness of taking risk in general and in a number of specific contexts, Dohmen et al. (2016) investigate whether the exogenous determinants discussed above are the same across the two countries and whether these determinants are stable over time. Comparing the summary statistics of the risk attitudes measures, Dohmen et al. (2016) find that, in general, Ukrainian individuals are less willing to take risk than respondents in Germany. This finding holds when using the general risk taking question and the context specific questions with the exception of risk taking in financial decisions where they observe the opposite. The regression results of risk attitudes determinants using the basic exogenous specification reveal that the negative impact of gender and age is larger for Ukrainian, whereas the coefficients of height and parents education are the same. Having data on Germany, a fully mature capitalist economy, and Ukraine, a transition economy, enabled Dohmen et al. (2016) to compare the impact of the recent great recession on individuals risk attitudes in the two countries. The main driver of changes in risk attitudes in both countries is a large macroeconomic shock, with the impact being stronger in the Ukrainian case. On the other hand, individual's life events and changes in the labour status of the individual have a minor impact on risk attitudes variation.

To examine the impact of education on individuals' risk attitudes, Hryshko et al. (2011) used the Panel Study of Income Dynamics (PSID) and the dates of implementing compulsory schooling laws in the U.S.. They found that growing up with more educated parents and in "good" counties result in an individual who is more willing to take risk in adulthood.[5] However, when using compulsory schooling laws as an instrument for educational level the county variables are no longer statistically

[5]The authors constructed a series of variables to measure the "quality" of the county where the respondent grew up based on a set of indicators such as: median income; the percentage of population aged 25 and older with a college degree; the median house value; and the percentage of urban population.

significant. Based on this finding, Hryshko et al. (2011, p. 4) conclude that "*risk attitudes is shaped partly by the environment and partly by parental education and that the compulsory schooling variables capture both effects*". Hryshko et al. (2011) also confirm that age and gender are significant determinants of risk attitudes. Moreover, they found that more risk averse parents have more risk averse children, older individuals and females are also more risk averse.

Using both survey and experimental measures of risk attitudes, De Paola (2013) investigates the determinants of risk attitudes on a sample of Italian students. The paper also focus on the role of intergenerational transmission of risk attitudes as this might be part of the explanation for family correlations in economic outcomes.[6] Specifically, De Paola (2013) looks at the effect of parents' risk attitudes on children's risk attitudes. Parents' employment choices, public sector employee or working as entrepreneurs, are used to proxy for their risk attitudes. De Paola (2013) findings indicate that job activity of the mother does not impact their children's risk attitudes, whereas if the father works in the public sector the child tend to be less willing to take risk.

4.2.3 Time varying risk attitudes

Stigler and Becker (1977) argue that preferences are stable at the level of the individual and any variation in preferences is due to measurement error. A growing literature from many different disciplines including economics, psychology, management, and marketing, has started to question the claim that regards preferences as a given attribute and time-invariant characteristic. For example, Campbell and Cochrane (1999) have shown that time-varying risk attitudes is necessary in order for the size of equity premium and the volatility of the stock returns to fit asset pricing models.

[6]See Bowles and Gintis (2002) for a good discussion on mechanisms of the intergenerational transmission of economic status.

A theoretical framework that outlines possible channels that might trigger changes in individual's risk attitudes is presented by Schildberg-Hörisch (2018).[7] Under this framework, risk attitudes for a representative individual is measured by one parameter that is characterised by a mean and a variance. According to this framework risk attitudes instability can be linked to three different possibilities. The first one is a change in the mean-level of risk attitudes measure over the individual life cycle. This change is documented in the empirical literature which argue that individuals become less willing to take risk as they get older. A second possibility in which attitudes towards risk can permanently change is through a sudden shift to the mean-level of risk attitudes measure triggered by exogenous shocks. These shocks could be idiosyncratic changes in economic conditions, like the recent financial crisis; changes in the individual's economic condition, job loss or changes in wealth; changes in the individual's socio-demographic conditions or a major life event, new child or divorce; and natural catastrophes or violent conflicts. Finally, attitudes towards risk can also temporarily change through a change in the variance of risk attitudes measure. This possibility is in line with the empirical literature which suggest that variation in emotions, self-control, or stress can result in risk attitudes to vary temporarily around an average level, Schildberg-Hörisch (2018). The following subsections will review papers that examine each of these possibilities.

Empirical studies which examine the stability of risk attitudes initially consider the correlation of an individual's risk attitudes across time. Chuang and Schechter (2015) provide an extensive review of the literature studying the stability of preferences in general, including risk attitudes. The reported risk attitudes correlation coefficient of the studies they reviewed range between 0.13 to 0.68, which is mostly statistically significant, for time horizons varying from a few days to five years. However, Chuang and Schechter (2015) found that the correlation coefficient of their data, using rural Paraguayan households, is positive and large but not significant. They argue that this result might be due to using a sample that include individuals

[7] See Schildberg-Hörisch (2018) page 142 for a graphical explanation.

with lower level of education compared to most of the other experiments. Schildberg-Hörisch (2018) argues that the correlation over time of risk attitudes that found in the literature support the stability of risk attitudes, at least partly. However, the strict stability of risk attitudes cannot be empirically supported given that the correlation coefficient is low in many studies. Moreover, Schildberg-Hörisch (2018) argues that measurement error in panel data cannot alone account for the deviation from perfect correlation of risk attitudes that is suggested in Stigler and Becker (1977).

To empirically examine how risk attitudes change over the life course, Dohmen, Falk, Golsteyn, Huffman, and Sunde (2017) used panel dataset from the Netherlands and Germany that include self-reported measures of risk attitudes. In Schildberg-Hörisch (2018) theoretical framework, an individual's age profile can cause changes to the mean level of measures of risk attitudes. The main difficulty in examining an age profile in this context is achieving identification as age may reveal cohort or calender period effects. However, even after controlling for these two effects, Dohmen et al. (2017) find that willingness to take risk decreases linearly with age until approximately the age of 65 after which the slope become flatter. The size of the age effect is substantial as attitudes towards risk decreases by around 0.24 standard deviations in the Dutch data and 0.22 in the German data for an increase of 10 years in society's median age.

Focusing on data from Germany, Schurer (2015) used the same SOEP dataset used by Dohmen et al. (2017) to examine how risk attitudes change over the life course and also to explore the heterogeneity of this change across the social spectrum. They also find that willingness to take risk declines strongly for all socio-economic groups from late adolescence up to age 45. The heterogeneity across socio-economic groups comes after the age of 45, where risk tolerance for individuals with low socio-economic status continues to decline but those with high socio-economic status, their risk tolerance stabilises or even increases after the age of 45.

10 waves of the U.S. Health and Retirement Study are used by Sahm (2012) to

investigate changes in risk attitudes over time and its heterogeneity across individuals. Sahm (2012) uses expected utility theory to map individual's response to a question relating to a gamble over life income to a standard metric of risk preference. This measure also accounts for the possibility that income gamble question generate a substitutional noise and that they provide an interval rather than a point estimate. Sahm (2012) results are consistent with relative risk aversion expectations as changes in individual's income and wealth do not impact his/her risk attitudes. However, the results show that differences in risk tolerance across individuals are significantly related to different levels of lifetime income. Sahm (2012) results also show that individual's risk attitudes is influenced by the life cycle, in that a one year increase in age is associated with 1.7% decline in individual's risk tolerance. Sahm (2012) also examine the impact of the business cycle and major life events on risk attitudes.[8] The index of consumer sentiment, as a proxy of the business cycle, has a strong impact on the level of risk tolerance. A ten-point increase in this index will increase risk tolerance by 9.0%. On the other hand, major life events do not change the willingness to take risk but they do reveal that risk tolerance individuals do choose a career that is risky and has a high chance of displacement. These results are in line with the findings of Dohmen et al. (2016) as large macroeconomic shocks are the main determinant of changes in risk attitudes, whereas life events have a minor impact on risk attitudes variation.

The impact of exogenous shocks: Macroeconomic environment and natural disasters

The impact of the macroeconomic environment individuals experienced over the course of their lives on the willingness to take financial risks is examined by a number of studies. For example, Malmendier and Nagel (2011) analysed repeated cross-section data from the U.S. Survey of Consumer Finances from 1960 to 2007. Malmendier and Nagel (2011) find that households who experienced lower stock

[8]This is the second possibility in Schildberg-Hörisch (2018) theoretical framework.

market returns express lower willingness to bear financial risk and are less likely to participate in the stock market. Moreover, the findings also show that recent shocks receive higher weights. The authors extrapolate that the effect of the recent financial crisis might have a long-lasting impact on investment behaviour, arguing that the impact will only fade-out after 30 years for those who were 30 years old in 2008.

To assess the impact of experiencing economic growth on risk attitudes versus experiencing a recession, Bucciol and Miniaci (2018) use panel data from the Dutch Household Survey covering the period 1995–2015, which includes recession as well as expansion periods. This paper uses a set of six measures of self-assessed risk attitudes to examine their association with contemporaneous macroeconomic indicators and personal experiences with portfolio risks and returns. The findings indicate that in general, measures of risk propensity, defined as the willingness to bear risk, are higher during periods of economic growth and lower during periods of recession except two measures that suggest preferences remain stable over time. These two measures of risk propensity are less related to expectations as they explicitly refer to safe investments. Therefore, Bucciol and Miniaci (2018) argue that the fluctuations observed in risk propensity can be mainly driven by changes in expectations. More importantly, the authors argue that the experience of past personal portfolio volatility is much less relevant to risk propensity than the exposure to market large past risk.

The literature on how risk attitudes are impacted by natural disasters and violent conflicts is new and inconclusive. Cameron and Shah (2015) measure risk taking of selected individuals in rural Indonesia, a country that is prone to natural disasters, using an experiment with monetary payoffs based on the risk game initially used by Binswanger (1980).[9] The findings indicate that individuals who have experienced a disaster, a flood or an earthquake in the past three years are more averse towards risk.

[9]This game is based on asking individuals to select one gamble from a set of six possible gambles, with the risk associated with each gamble increases as the player progresses.

The authors argue that those individuals attach a higher probability to experiencing another disasters, hence behave as though they face greater background risk which in turn causes them to take fewer risks.

The impact of the occurrence and intensity of natural disasters on an individual's attitude towards risk is also examined by van den Berg et al. (2009). van den Berg et al. (2009) measured risk attitudes using games with real money and hypothetical questions on the willingness to pay for a lottery ticket. The sample analysed is from two natural-hazard prone countries in Latin America, namely Nicaragua and Peru. Their results show that the risk attitudes measure that is based on real money games strongly support the hypothesis that experiencing natural shocks make individuals less willing to take risk. Whereas the risk attitudes measure that is based on hypothetical questions leads to unrealistic distributions of preferences. van den Berg et al. (2009, p. 23) argue that "*such disasters not only change the asset base of the affected population, but also the nature of their preferences and the weighing of alternative survival strategies. Put differently, risk management and coping strategies and policies that ex ante seemed optimal are not necessarily so after a major disaster has taken place.*".

On the other hand, Eckel et al. (2009) findings contradict the previous two papers. Based on a sample of Hurricane Katrina evacuees and another two samples of the same population in the U.S., the findings indicate that individuals in the sample taken from Hurricane Katrina evacuees are significantly more risk loving, especially females. Bchir and Willinger (2013) used an incentivized field experiment to measure risk preferences of two populations in Peru, one that is exposed to lahars hazard and volcanic eruption and another one which is exposed only to lahars hazard.[10] The analysis shows that those who are poor and exposed to both background risks are significantly more risk seeking and significantly more impatient. However, those who are in a higher income category, their risk and time preferences are unaffected

[10]Lahars are extremely destructive type of mud-flow or debris-flow that flow down from a volcano.

by the exposure to lahars risk.

The stability of risk attitudes of Japanese individuals after experiencing the 2011 Great East Japan Earthquake is examined by Hanaoka, Shigeoka, and Watanabe (2018). The authors used the seismic intensity of the Earthquake of different locations around the epicentre of the 2011 Earthquake along with a measure of risk attitudes elicited from a hypothetical lottery question in the Japan Household Panel Survey on Consumer Preferences and Satisfaction. Hanaoka et al. (2018) findings show that males who experienced higher intensity of the Earthquake become more risk loving and this effect is not a temporary one as they found that it lasts for even five years after the earthquake.

Finally, transitory changes in attitudes towards risk can be caused by variation in emotions, self-control, or stress. Guiso et al. (2018) examine the impact of the 2008 financial crisis on investor's willingness to take risk. Using survey data complimented with a lab experiment related to clients from an Italian bank they find support to the emotion channel. Guiso et al. (2018) found that, on average, willingness to take risk decreased in their sample after the 2008 financial crisis and argue that this might be related to an emotional fear response. For example, the reporting of Lehman's fired employees or knowing people who lost money in the market might have triggered this emotional response.[11] The emotion channel could be tested through the ability to answer the stock market expectation question after the 2008 crisis. Guiso et al. (2018) found that those who were not able to answer the question in 2009 but did answer it in 2007 exhibit a significantly higher decrease in their willingness to take risk. To further examine this argument, Guiso et al. (2018) asked half of a sample of a university students to watch a five minutes of a horror film to identify fear effect in a simple treatment and control framework. They measured risk attitudes using a hypothetical choices between a risky prospect and sequence of certain sums of money. The experiment shows that on average treated students have a 27 percent

[11]The authors also examined changes in wealth or expected income channels but found that they do not alter investor's risk attitudes.

higher risk premium than untreated one. In psychology, these results support the Affect Infusion Model (see, Forgas, 1995) which posits that individual in bad mood will be less willing to take risk since they are more attentive to downside risk.[12]

Support to the emotion channel is also found in Necker and Ziegelmeyer (2016) who used the German SAVE household panel data to examine the impact of the recent financial crisis on household's risk attitude, subjective expectations and planned risk taking behaviour. Necker and Ziegelmeyer (2016) found that actual changes to the level of wealth as a result of the crisis are unrelated to the change in risk tolerance and in planned risk-taking. Whereas, households attributing losses to the crisis (the shock of experiencing the wealth changes) decrease their risk tolerance, which the authors interpret as an emotional reaction to the crisis.

4.3 Data

This chapter uses panel survey data from the "Preference Parameters Study of Osaka University" conducted in Japan and the U.S. by the Central Research Service Inc. on behalf of Osaka University. Hereafter, this data is referred to as PPS. The sample from Japan is a random sample drawn from males and females aged 20-69 years old surveyed annually during the 2003–2013 period by a self-administered placement method. Fresh samples were selected and added to the sample in the 2004, 2006 and 2009 waves. The U.S. sample is drawn from males and females aged 18-99 years old surveyed annually during the 2005–2013 period by a self-administered placement method. Fresh samples were selected and added to the sample in the 2007, 2008 and 2009 waves. Identical survey questions were asked in each country, making it possible to make direct comparisons between Japan and the U.S..[13]

[12]The Mood Maintenance Hypothesis (Isen & Patrick, 1983) posits that subjects in a good mood avoid taking risk to protect their good mood, while those in a bad mood will take more risk to improve their mood.

[13]The survey starts to cover India and China from 2009. However, only data from Japan and the U.S. is used in this chapter to maintain a large panel as the chapter uses data up to 2010 only. For more detailed information on the survey, see http://www.iser.osaka-u.ac.jp/coe/journal/eng_-

The PPS data provides detailed information on respondents' socio-demographic characteristics and socio-economic attributes. However, the PPS data main focus is on individuals' preferences such as; risk attitudes, time preference, altruism, and habit formation. To collect information on individuals' risk attitudes, the PPS includes questions related to the willingness to pay for a lottery choice, gambling over life income and a general risk-taking question. Unfortunately each wave of the survey did not include the same set of questions that are measuring risk attitudes throughout the 2003-2013 period and the way the questions are structured changed for some questions. Specifically, the way lottery choice questions are phrased changed over time making it difficult to construct a consistent measure of risk attitudes using this method. However, gamble over life income questions are consistent only from 2005 to 2010 and the general risk-taking question is not available after 2010. Therefore, the sample used for Japan and the U.S. covers the period from 2005 to 2010 to maintain consistent measures of risk attitudes.[14]

The PPS data provides a number of measures relating to respondents' risky choices in finance and health such as, risky asset holdings, gambling activities, smoking and drinking. Moreover, the survey also asks questions related to respondents' risk of becoming unemployed in the near future and self-reported health status. Regarding geographical aggregation the PPS data has information about the place and the size of the local government where respondents reside. In the case of Japan the geographical information is provided at the prefecture level and it is at the state level for the U.S..[15]

The rich information that the PPS data has on individuals' risk attitudes and risky choices make it well-suited to examine the determinants and stability of risk attitudes, whilst also allowing a comparison of the findings across Japan and the

panelsummary.html.

[14] In this way the final sample will exclude the Great Japan Earthquake that happened in March 2011.

[15] There are 47 prefectures in Japan, each consists of local governments, including many cities, towns and villages.

U.S..[16] The final sample only includes those who are aged 20 to 69 in the U.S. sample to match the Japanese sample and all observations with missing values are excluded. The Japan sample consist of 15,498 observations and 6,256 individuals, whereas the U.S. sample has 13,836 observations and 8,628 individuals.

4.3.1 Dependent variables

The first part of this chapter examines the determinants of attitudes towards risk. As discussed in the previous section, this chapter will use two different methodologies that are available in the PPS data to measure risk attitudes. The first method is related to questions about gamble over life income and is refereed to as the hypothetical gamble measure. The second method is related to the general question about risk-taking and is refereed to as the subjective measure.

The first method was developed by Barsky et al. (1997) and is based on questions related to a gamble over life income. These questions are similar to those contained in the Health and Retirement Study (HRS) and have been used by Rosen and Wu (2004) amongst many others. Specifically, respondents were asked to choose between gambling on doubling their current income with some risk of the income being cut with a certain percentage or receiving small but guaranteed increase in their current income.[17] The question is:

1. *"Considering the following two ways of receiving your monthly income, which is preferable to you? Assume the job assignment is the same under these situations. If you are a dependent (e.g., student, housewife, etc.), answer this question taking your living expense as your monthly income."*

[16]The term risky choices used in this chapter refers to both engaging in risky activities and holdings of selected financial assets.

[17]The wording of these questions remains the same through out the 2005-2010 period. However, in 2010 the amount by which the income is guaranteed to increase changed from 5.0% to 3.0%. It could be argued that this small change is reflecting the change in economic conditions around that year and will not have an impact on the consistency of the risk attitudes measure.

(a) Your monthly income has a 50% chance of doubling, but also has 50% chance of decreasing by 30% $\Longrightarrow$ *answer question 2.*
(b) Your monthly income is guaranteed to increase by 5% $\Longrightarrow$ *answer question 3.*

2. *"Of the following two jobs, which would you prefer?"*

(a) Your monthly income has a 50% chance of doubling, but also has 50% chance of decreasing by 50%.
(b) Your monthly income is guaranteed to increase by 5%.

3. *"Of the following two jobs, which would you prefer?"*

(a) Your monthly income has a 50% chance of doubling, but also has 50% chance of decreasing by 10%.
(b) Your monthly income is guaranteed to increase by 5%.

The answers given by respondents will be used to construct a variable with four distinct categories. This variable is decreasing in the willingness to take risk and takes the following values: 0 if the respondent answered (a) to question 1 and (a) to question 2; 1 if answered (a) to question 1, but (b) to question 2; 2 if answered (b) to question 1 and (a) to question 3; and finally 3 if answered (b) to both questions 1 and 3.

The second method measures risk attitudes by directly asking respondents to give a general assessment on their willingness to take risk. Similar measure is available in the SOEP data which is used by Dohmen et al. (2011) and Dohmen et al. (2016). The question is :
"As the proverb says, "Nothing ventured, nothing gained", there is a way of thinking that in order to achieve results, you need to take risks. On the other hand, as another proverb says, "A wise man never courts danger", meaning that you should avoid risks as much as possible. Which way of thinking is closest to the way you

think?
On a scale of 0-10, with 10 being completely in agreement with the thinking "Nothing ventured, nothing gained", and 0 being completely in agreement with the thinking "A wise man never courts danger", please rate your behavioral pattern."

The answers to this question is used to construct a subjective measure of risk attitudes based on an eleven-point likert scale. This measure has been reversed so that it is decreasing in the willingness to take risk.

Table 4.1 and Figure 4.1 present summary statistics relating to the distributions of both the subjective and the hypothetical gamble measures of risk attitudes. The statistics for the subjective measure indicates that Japanese individuals are less willing to take risk than their U.S. counterparts. The mean of the subjective measure for Japan is 6.01 whereas it is 4.37 for the U.S.. Moreover, the percentage of individuals who answered less than 5 (more than 5) for the subjective measure is 20.0% (57.0%) for Japan whereas this percentage is 53.0% (28.0%) for the U.S.. This distribution is also clear in Figure 4.1 where the mass of the distribution is to the right of the value five in the Japan distribution whereas it is to the left in the case of the U.S..[18]

The hypothetical measure of risk attitudes indicates that individuals in both samples have similar attitudes towards risk and in both samples they show tendency towards being less willing to take risk, with the mean of each sample being around (3.50), see Table 4.1 and Figure 4.2. However, an inspection of Table 4.1 shows that more Japanese individuals (10.0%) had a value of 1 (answered (a) to question 1, but (b) to question 2) than U.S. individuals (7.5%). Moreover, a higher percentage of U.S. individuals (68.0%) decided to choose the safest option (answered (b) to both questions 1 and 3) than the Japanese individuals (65.0%). Consequently, it seems

[18]Table 4.1 shows that the proportion of individuals in the first two categories for the subjective measure in Japan are small. The results, not reported in this chapter, do not change when these two categories are combined together. Moreover, Section 4.5.4 shows that the results discussed above are robust to the use of two alternative methodological approaches, one of which treats the responses to the two questions used to construct the measures of risk attitudes as continuous variable.

that Japanese respondents are slightly more willing to take risks than their U.S. counterparts when it comes to risk attitudes over life income.

This chapter follows Guiso et al. (2018) and excludes inconsistent answers for the risk attitudes measures. This means that individuals who report a value which indicates more willingness of taking risk in the hypothetical gamble measure (a value of 0) but the opposite in the subjective risk attitudes measure (a value larger than 7) are excluded (85 observations are deleted). Also exclude those who report a value which indicate more willing to take risk in the subjective measure (a value less than 3) but a value indicating less willingness to take risk in the hypothetical measure (a value of 3) of risk attitudes (325 observations are deleted).

The second part of this chapter examines the validity of the two measures of risk attitudes used in this chapter. Specifically, a set of indicators that captures risky choices is used in order to test if the risk attitudes measures discussed above have a predictive power on these choices.

The choices which are considered to be related to risky behaviours are: smoking; drinking; and gambling, which are also used by Paiella et al. (2004) using Italian sample and Dohmen et al. (2011) using German data. The PPS survey asks participants the following questions to indicate the level of their engagement in these activities.

Gambling

"Do you gamble in lotteries or at casinos, or bet on sporting events or horse races? 1: Don't gamble at all;2: Hardly gamble; 3: Several times a year or so; 4: Once a month or so 5: Once a week or so; 6: Almost everyday." To account for gambling activities, a dummy variable is created that equals to one if the participant answers (4, 5 or 6) to the above question and zero otherwise. Table 4.2 shows that on average, 15.0% of the Japanese sample engage in gambling compared to 12.0% of the U.S. sample.

Drinking

"Do you drink alcoholic beverages?

1: Don't drink at all; 2: Hardly drink; 3: Drink sometimes; 4: A can of beer (12 oz.) or its equivalent a day, everyday; 5: 3 cans of beer (12 oz. x 3) or its equivalent a day, everyday; 6: 5 cans of beer (12 oz. x 5) or its equivalent a day, everyday."

From the answers to this question a dummy variable is generated that equals one if the individual answers (4, 5 or 6) and zero otherwise. The summary statistics in Table 4.2 shows that in the Japanese sample, 29.0% of the participants do drink daily compared to only 10.0% of the participants in the U.S..

Smoking

"Do you smoke?

1: Don't smoke at all; 2: Hardly smoke; 3: Smoke sometimes; 4: About 10 cigarettes a day; 5: About a pack a day; 6: More than 2 packs a day; 7: I used to smoke but had quit."

Similar to the drinking question, a dummy variable is created that equals one if the individual answers (4, 5 or 6) and zero otherwise. On average, 24.0% of the Japanese individuals smoke whereas in the U.S. the proportion is only 11.0%, see Table 4.2.

The summary statistics presented in Table 4.2 show that Japanese individuals drink, smoke and gamble more that their U.S. counterparts. These figures are not surprising given the lifestyle differences in the two countries, specially the work environment. For example, Frone (2016, p. 387) argues that *"individuals may use alcohol to self-medicate the experience of negative affect and work fatigue resulting from exposure to work stressors"*. Furthermore, these figures can also be explained by using suicide rates as an indicator of societal well-being. The analysis provided by J. Chen, Choi, and Sawada (2009) shows that Japan's suicide rate is ranked second among OECD countries in 2004, whereas the ranking of U.S. was 12 for the same year.

The PPS survey asks participants to indicate their holdings of a set of financial assets. The exact question is as follows:

"Please indicate which of the following financial assets you own, chose all that apply. 1: Bank savings (including cooperative banks, credit unions and other associations); 2: Corporate bonds; 3: Life insurances; 4: Stocks; 5: Investment Trusts 6: Foreign currency deposits; 7: Futures/Options; 8: Government bonds; 9: Government bonds of foreign countries; 10: Private pensions (by life insurance companies or postal annuity pension system); 11: Company pensions; 12: Cash Savings; 13: None"

Following Guiso, Jappelli, and Haliassos (2002), these components are grouped into categories according to the degree of riskiness of the asset. Specifically, categories "Stocks" and "Futures/Options" are grouped under "Stock binary"; categories "Bank savings", "Government bonds" and "Cash Savings" are grouped under "Saving"; categories "Private pensions" and "Company pensions" are grouped under "Pension"; categories "Corporate bonds", "Life insurances" and "Investment Trusts" are kept as they are and categories "Foreign currency deposits" and "Government bonds of foreign countries" are dropped due to small holdings. Table 4.2 shows the proportion of holdings of each category in Japan and the U.S.. The table shows that the distribution of holdings is similar across the two countries for some categories (saving, life insurance, investment trusts and pension) but different for others (stock binary and corporate bonds). Holdings of risky assets, captured by the category "Stock binary", confirm that households financial portfolios in Japan have a very low share of risky financial assets in comparison to the U.S. and Europe, Bank of Japan (2017b). The PPS survey also asks a question related to the proportion of holdings of risky assets in the household financial portfolio. This measure has been used extensively in the literature (see, for example, Cardak & Wilkins, 2009; Guiso & Sodini, 2013).

The question is: *What percentage of your financial assets of your entire household are in the following:*

Bank savings, cash, government bonds (%).

Investment Trusts, Stocks, Futures/Options, Corporate Bonds, Foreign currency, deposits, Government bonds of foreign countries (%).

Table 4.2 shows that the percentage of risky asset holdings in Japan is 8.0%, whereas it is 25.0% in the U.S..

4.3.2 Independent variables

The PPS survey provides detailed information on the demographic and socio-economic characteristics of respondents. This chapter controls for a set of variables that are commonly used as determinants of risk attitudes in the literature, see Dohmen et al. (2011). However, one of the main contributions of this chapter is the analysis of natural disaster risk that might be important in explaining and understanding heterogeneity in the attitudes towards risk among individuals and between Japanese and the U.S. individuals. Being able to identify the determinants of risk attitudes is crucial in understanding individuals' risky behaviours and investment decisions. Table 4.3 provide a complete definition of these variables and Table 4.4 shows corresponding descriptive statistics.

Dohmen et al. (2011) argue that exogenous variables that directly influence individual's risk attitudes are gender, age, parents' education and height. These variables are first included in the short specifications. The full specification, however, includes a number of other variables potentially have an impact on individuals' risk attitudes. These variables are: employment status; the level of education; marital status; income; net wealth; subjective health; home ownership; the risk of being unemployed; borrowing constraints; whether respondent lives in a city; and the number of children in the household. Some of these variables might be potentially endogenous, for example, a greater propensity to take risk might lead to higher income and higher levels of wealth. However, these variables are important economic variables and would be informative to see how they influence individuals' attitudes towards risk and to assess if they have any deferential impact across Japan and the U.S.. Furthermore, this chapter contributes to the literature by examining the impact of natural disaster risk on risk attitudes and whether the impact of this risk is different across Japanese and U.S. individuals. To control for the macro environment, this chapter uses the growth rate of GDP at the prefecture level in Japan and state level in the U.S.. Finally, to account for financial development and accessibility, this chapter includes an index that captures the state/prefecture financial potential. Each of these variables will be discussed in detail next.

Considering the demographic characteristics mentioned above in more detail, Table 4.4 shows that the average age in the Japanese sample is 51 years old whereas it is only 45 years old for the U.S. sample. Individuals in the U.S. sample are, on average, taller than their Japanese counterparts with the mean being 172cm for the U.S. sample and 163cm for the Japanese sample. In both samples around 82.0% of the respondents are in a relationship.

The level of parental education shows a considerable heterogeneity between the two samples. Table 4.4 shows that only 45.0% of parents of the Japanese respondents completed high school compared to an average of 80.0% (75.0%) of the father (mother) of the U.S. respondents. A possible explanation to this heterogeneity might be related to culture differences between the two countries. In Japan, a couple will not have children before officially being married and on average marriage age is 30 years. In our sample the average age of participants is 51 years old, which means that they are born around 1955. Taking into account the average marriage age is 30, then the parents of this participant would have been born around 1925. This would mean that the parents of the average Japanese respondents attended high school around the second world war. Therefore, it is not surprising to see that only 45.0% of the Japanese sample completed a high school degree.

Table 4.4 shows that, based on the self-reported health question, the U.S. participants are more anxious about their health than their Japanese counterparts. Another important determinant of risk attitudes is whether there are children present in the household. Both samples show that, on average, households have two children. In terms of gender, the literature suggests that males and females usually exhibit different attitudes towards risk. The analysis controls for gender and both samples have equal number of males and females.

The risk of unemployment and borrowing constraints are two background risks that will influence respondent's risk attitudes level. Unemployment risk variable is a dummy indicator that takes the value of one if respondent answered one or two to the following question and zero otherwise, similar measures have been used by Paiella et al. (2004) and Sahm (2012). *"Do you think there is a possibility that you or someone in your family will be unemployed (in case of running your own business, the possibilities of discontinuing business) within 2 years? 1 "Strong possibility" 2 "Some possibility" 3 "Little possibility" 4 "Don't know""*. Borrowing constraints is also a dummy variable that equals one if the respondent has ever been rejected for a loan application (excluding housing loans), zero otherwise, similar measure also has been used by Guiso and Paiella (2008).

The financial variables that are controlled for at the household level are income and net wealth; the natural logarithm of these variables are reported in Table 4.4. For both income variables the natural logarithm is set to zero when the values of these variables are zero. In the case of negative net wealth, as a result of total debt being larger than assets, an inverse hyperbolic sine transformation is applied using "asinh" routine in STATA, see Oldham et al. (2010).

The number of years an individual spends in education is considered to be an investment that bears risk and uncertainty similar to investing in stocks. Paiella et al. (2004) argue that individuals who decide to obtain more education expose themselves to a risk. This risk will be materialised in financial form in case of failure and it consists of the forgone salary in the alternative job, any fees paid and the cost of living during study. The uncertainty part of investing in education comes from the fact that the return from education has a relatively long time span, hence the market value of the degree upon completion is uncertain. Therefore, theoretically individuals who spend more time in education are expected to be more willing to take risk. Table 4.4 shows that individuals who completed a high school or a college education are larger in the Japanese sample, whereas the U.S. sample has more individuals with a university degree or higher than the Japanese sample. To control for the respondent's current employment status the following binary variables are derived from the question listed in Table 4.3, employed (omitted category), unemployed, part-time work, self-employed and not in labour force (housewife/house-husband, students and retired individuals). The summary statistics related to employment status are similar across the two samples. Home ownership is also an important variable to control for, as this might be used by individuals as collateral when taking any decision that has some elements of risk, 85.0% of the sample's individuals own their house in Japan and 77.0% in the U.S.. Finally, 68.0% (72.0%) of the individuals in the Japanese (U.S.) sample live in a city.

Macroeconomic variables

Recent literature starts to focus on the impact of systematic changes on individuals' attitudes towards risk (see, for example, Sahm, 2012; Dohmen et al., 2016). The six-year panel used in this chapter provides a unique opportunity to test the impact of changes in the macro-economy and the risk of natural disasters on risk attitudes of Japanese and U.S. individuals. Specially that the time window of the samples used in this chapter coincide with a significant changes in the macro-economy, namely the financial crisis and the recession that followed it. Therefore, this chapter controls for the state of the macro-economy by including the growth rate of GDP and an index capturing the risk of natural disasters at the state level for the U.S. and at the prefecture level for Japan. These variables are included with a one year lag. The interview time for the PPS is in February and March, therefore, the impact of changes in these macroeconomic variables will be reflected in the measure of risk attitudes in the year after.

The validity of the risk attitude measures used in this chapter are explored by including them as a predictors in the equations of three risky behaviours and the equations of selected financial assets' holdings. Individual behaviours, specially financial behaviours, are influenced by the level of the financial development of the state/prefecture where the individual lives. Therefore, a measure of the financial development of the prefecture/state is included in these equations to control for its impact on individuals' risky choices. The measure used for the U.S. is the number of commercial banks in each state per 100,000 residents, see Celerier and Matray (2017) for a similar application of this measure. For Japan, this chapter uses an index of financial potential constructed by Ministry of Internal Affairs and Communications in Japan, which measures the balance of prefecture revenues to expenditures. Furthermore, we follow Sahm (2012) and Dohmen et al. (2016) and include GDP growth at the sate/prefecture level to capture the macro-environment surrounding respondents and how this might influence their risk attitudes levels. Table 4.4 provide summary statistics for these variables at the aggregate level, which shows that the mean of the GDP growth rate is negative for Japan while it is positive for the U.S. over the period 2005-2010.

Natural disaster risk

This chapter contributes to the literature by assessing whether individuals' risk attitudes change if they are exposed to a higher risk of natural disasters. Given the fact that Japan is one of the world's most earthquake-prone countries, this chapter will proxy natural disaster risk with an index that measurs the intensity of an earthquake. However, for the U.S., the natural disaster risk is proxied by the FEMA (The Federal Emergency Management Agency) disaster declarations. This information is provided by FEMA which include all federally declared disasters and features all three disaster declaration types: major disaster; emergency; and fire management assistance. All emergency and major disaster declarations are made solely at the discretion of the President of the U.S..[19] Table B3 shows the mean of the disasters declaration count for each state of the 51 U.S. states over the sample period 2005-2010.

For Japan, a measure of earthquake intensity is used in order to quantify and understand the impact of natural disasters on individual's risk attitudes. However, the ideal measure is the one that captures wide variation of earthquake impact for individuals who suffered most severely to those who are not affected at all. The seismic intensity of an earthquake (known as Shindo in Japan) is ideal measure to use in this context. The seismic intensity is a metric of the strength of an earthquake measured by the degree of shaking at a certain location. The commonly know magnitude measure (the Richter Magnitude scale) measures the amount of energy released at the earthquake's epicentre. Therefore, the Richter scale takes a single value for each earthquake, while the intensity measure takes different values depending on how far away from the epicentre the monitoring station is located. This measure is constructed by the Japan Meteorological Agency (JMA) and it is a well known scale by Japanese people and regularly reported by media. The intensity scale ranges from 0 to 7 and as the number increases the shaking and effects become greater. Table B4 provides a full description of the impact of each value of this scale.[20]

This chapter uses a number of different intensity measures to check the robustness of the results. Specifically, the main measure of intensity is the maximum intensity that have been recorded in one prefecture during one year. However, Japan is a country which is exposed to higher risk of earthquake episodes than any other country and earthquakes do occur at a regular bases. Therefore, it could be argued

[19] For detailed information about the disaster declaration process see https://www.fema.gov/disaster-declaration-process.

[20] The aim of including measures of natural disasters is to assess if these events have an impact on individual's risk attitudes not to make a direct comparison between their impacts on U.S. and Japanese individuals. This is because the natural disaster measures for the U.S. is broader one as it includes all natural disasters, while in Japan it reflects only earthquakes.

that the number of earthquake episodes that occurred might influence individuals' risk attitudes towards risk. On the other hand, Japanese might be well prepared, mentally and practically, for the occurrence of small and regular earthquakes. Hence, it could also be argued that only earthquakes with intensities that exceed a threshold will have an impact on individuals' risk attitudes. Therefore, to account for these possibilities, four alternative measures are used as a robustness check to the main measure (maximum intensity measure). The first one is the mean of the intensities of all earthquakes that happened in one prefecture during one year. The second one equals to the number of days within one year in which an earthquake has happened, regardless of the intensity. The other two measures are constructed based on measuring by how much an earthquake intensity exceeds certain thresholds on the intensity scale, these thresholds are 3 or 4. Summary statistics of these measures for the 47 Japanese prefectures and over the sample period 2005-2010 are provided in Table B3. The table shows that there is no variation in the average intensity between Japanese prefectures, which means that all prefectures have experienced some earthquakes. Whereas the maximum intensity measure shows that earthquakes experienced by some prefectures have a much higher intensities.

4.4 Methodology

4.4.1 Random effects probit model

In order to assess whether the measures of risk attitudes used in this chapter reveal actual individuals' risk attitudes, a series of tests are carried out to check whether these measures can predict various risky choices. Differences in risk attitudes across individuals should significantly explain their actual risky choices in a variety of contexts. The set of indicators that captures risky activities and holdings of financial assets that are used in these validity exercises are explained in Section 4.3.1. Most of these are binary response variables and therefore this chapter uses probit model to carry out the validity exercises. However, the share of holding risky assets is proportional in nature and there is a significant proportion of households hold no risky assets. Therefore, a tobit specification is used for this variable.[21]

The random effects probit model is interpreted in terms of an underlying latent variable, y_{it}^*, of which y_{it} is the realised observation, where the subscript i denotes the household index and t is a time index.[22] In this chapter y_{it}^* will be the propensity of the respondent to engage in these risky choices. The realised discrete choice made by the individual, y_{it} is defined according to the following choice rule:

$$y_{it} = \begin{cases} 1 & \text{if } y_{it}^* > 0 \\ 0 & \text{if } y_{it}^* \leq 0 \ . \end{cases} \tag{4.1}$$

The random effects probit model can be written in terms of the underlying or latent variable as:

$$y_{it}^* = X_{it}^{'}\boldsymbol{\beta} + \varepsilon_{it}, \quad i = 1, 2, ..., N \quad and \quad t = 1, 2, ...T, \tag{4.2}$$

$$\varepsilon_{it} = a_i + u_{it}, \tag{4.3}$$

where X_{it} is the vector of observable time varying and time invariant independent variables discussed above, $\boldsymbol{\beta}$ is the corresponding vector of parameters and a_i denotes the individual specific unobservable effect. In the random effects probit model the error term, u_{it}, is assumed to be normally, independently, and identically distributed, $u_{it} \sim N(0, \sigma_u^2)$. Furthermore, under the random effects specification it is also assumed that, conditional on the X_{it} , a_i is $N(0, \sigma_a^2)$ and are independent of u_{it} and X_{it}. This implies that the correlation between two successive error terms for

[21] Full formulation of the tobit model can be found in Greene (2012).
[22] This section draws heavily from Greene (2012) and Wooldridge (2015).

the same individual is a constant given by,

$$\rho = corr(\varepsilon_{it}, \varepsilon_{it-1}) = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_u^2} \ . \tag{4.4}$$

The parameters of Equation 4.2 are estimated by noting that the distribution of y_{it}^* conditional on a_i are independent normal. Formally, the probability that an individual randomly chosen from the population chooses $y_{it} = 1$ when faced with condition X_{it} is given by:

$$Prob(y_{it} = 1|a_i, X_{it}) = Prob(\frac{u_{it}}{\sigma_u} > \frac{-X_{it}^{'}\boldsymbol{\beta} - a_i}{\sigma_u}) = \Phi(Z_{it}), \tag{4.5}$$

where

$$Z_{it} = \frac{-(X_{it}^{'}\boldsymbol{\beta} + a_i)}{\sigma_u},$$

Φ is the standard normal distribution function for the probit model.

The above model is estimated using the Maximum Likelihood Estimation (ML), which is given by:

$$\prod_i \{\int_{-\infty}^{\infty} \prod_{t=1}^{T} [1 - \Phi\,(X_{it}^{'}\boldsymbol{\beta}^* + \sqrt{\frac{\rho}{1-\rho}}a^*)]^{1-y_{it}}\,[\Phi\,(X_{it}^{'}\boldsymbol{\beta}^* + \sqrt{\frac{\rho}{1-\rho}}a^*)]^{y_{it}}\,\phi\,(a^*)\,da^*\}, \tag{4.6}$$

$$\text{where} \quad \boldsymbol{\beta}^* = \frac{\boldsymbol{\beta}}{\sigma_u} \quad \text{and} \quad a^* = \frac{a}{\sigma_u}.$$

The marginal effects are used to interpret the magnitude of the relationship between a specific variable and the outcome of the probability, since the sign and significance of the coefficients provide the direction only. Specifically, the effect of changing one particular continuous covariate $x_j, j = 1, ...k$, by a small amount, on the outcome probability is given by:

$$\frac{\partial Prob(y_{it} = 1|X_{it})}{\partial X_{jit}} = \phi(\boldsymbol{X_{it}}'\boldsymbol{\beta})\beta_j \quad j = 1, ..., k, \tag{4.7}$$

where ϕ represents the probability density function of a standard normal variable. In this chapter, the average marginal effects of the regressors will be reported.

4.4.2 Random effects ordered probit model

The two measures of risk attitudes used in this chapter are constructed using the answers to a general assessment on respondents willingness to take risk question and to the question related to the hypothetical gamble over income. These responses are ordinal and cannot be expressed in an interval scale. Therefore, this chapter will use the random effects ordered probit model proposed by McKelvey and Zavoina (1975). This section draws heavily from Greene and Hensher (2010), who provides a full formation of the ordered probit model and other techniques used to model ordered choices.[23]

Similar to the binomial probit model, the central idea behind the ordinal outcomes is that there is a latent continuous metric (defined as y_{it}^*) that is linked to the observed ordinal response categories of y_{it}. The latent continuous variable, y_{it}^* is a linear combination of a vector of individual and household characteristics denoted by X_{it} and a set of unobservable characteristics represented by a_i and ε_{it}. Where a_i indicates a randomly generated, time invariant individual effect which is uncorrelated with the observable characteristics X_{it}. ε_{it} represents unobserved effects that are allowed to vary over both time and individuals, and is assumed to follow a white noise process. This can be formally expressed as:

$$y_{it}^* = \boldsymbol{\beta}' X_{it} + a_i + \varepsilon_{it}, \quad i = 1, 2, ..., N \quad and \quad t = 1, 2, ...T, \tag{4.8}$$

[23]The chapter will also use the interval regression as an alternative modelling approach. However, the results will only be reported in the appendix and serve as a robustness check of the ordered probit findings. Full formulation of the interval regression model can be found in Greene (2012).

where $\boldsymbol{\beta}$ is a vector of K parameters to be estimated.

The dependent variable y_{it}^{*} is unobserved, but what is observed is:

$$
\begin{aligned}
y_{it} &= 1 \quad \text{if } y_{it}^{*} \leq \mu_1 \\
y_{it} &= 2 \quad \text{if } \mu_1 < y_{it}^{*} \leq \mu_2 \\
y_{it} &= 3 \quad \text{if } \mu_2 < y_{it}^{*} \leq \mu_3, \\
&. \\
&. \\
y_{it} &= J \quad \text{if } \mu_{J-1} < y_{it}^{*} \leq \mu_J
\end{aligned}
\tag{4.9}
$$

where μ_j are the threshold parameters to be estimated with $\boldsymbol{\beta}$. These parameters are defined as $\mu_1 = -\infty$ and $\mu_J = +\infty$ and also defined to be strictly increasing in j so that the associated probabilities are positive. The concern in this model is to assess how changes in the explanatory variables translate into the probability of individual i at time t observing outcome j. Hence, an individual will report a value equals j if y_{it}^{*}, the latent variable, lies between the threshold values of μ_{j-1} *and* μ_j. Therefore, assuming that the error terms ε_{it} follow a cumulative normal distribution, the probability that at time t, individual i reports a value of j, conditional on the regressors and the random effects, is derived as:

$$p[y_{it} = j] = p[\mu_{j-1} < y_{it}^{*} \leq \mu_j]$$

substituting from Equation 4.8,

$$
\begin{aligned}
&= p[\mu_{j-1} < \boldsymbol{\beta}' \boldsymbol{X_{it}} + a_i + \varepsilon_{it} \leq \mu_j] \\
&= p[\mu_{j-1} - \boldsymbol{\beta}' \boldsymbol{X_{it}} - a_i < \varepsilon_{it} \leq \mu_j - \boldsymbol{\beta}' \boldsymbol{X_{it}} - a_i] \\
&= F(\mu_j - \boldsymbol{\beta}' \boldsymbol{X_{it}} - a_i) - F(\mu_{j-1} - \boldsymbol{\beta}' \boldsymbol{X_{it}} - a_i) \\
&= \Phi(\mu_j - \boldsymbol{\beta}' \boldsymbol{X_{it}} - a_i) - \Phi(\mu_{j-1} - \boldsymbol{\beta}' \boldsymbol{X_{it}} - a_i)
\end{aligned}
\tag{4.10}
$$

the F(.) is determined by the assumed distribution of ε_{it}, which is the cumulative standard normal distribution function Φ for the probit model.[24]

The log-likelihood function of the ordered probit model is based on the normality assumption for the ε_{it} and it is simply the product of the probabilities associated with each discrete outcome. This is formally written as:

$$lnL = \sum_{i=1}^{n} \sum_{j=0}^{J} log[F(\mu_j - \boldsymbol{\beta'} \boldsymbol{X_{it}}) - F(\mu_{j-1} - \boldsymbol{\beta'} \boldsymbol{X_{it}})] \tag{4.11}$$

Interpretation of the coefficients in the ordered probit model is complicated since there is no natural conditional mean function in the model. This is because the the observed ordinal response categories of y_{it} are merely a label for the unordered, non-quantitative outcomes. However, Greene and Hensher (2010, p. 113) argue that *"In order to attach meaning to the parameters, one typically refers to the probabilities themselves"*.

The marginal effect of x_i for the j-th response is given by:

$$\delta_j(\boldsymbol{X_i}) = \frac{\partial Prob(y = j|\boldsymbol{X_i})}{\partial \boldsymbol{X_i}} = [F(\mu_j - \boldsymbol{\beta'} \boldsymbol{X_i}) - F(\mu_{j-1} - \boldsymbol{\beta'} \boldsymbol{X_i})]\boldsymbol{\beta}. \tag{4.12}$$

4.4.3 A joint modelling framework

The common technique which is used in applied micro-econometrics to account for endogeneity issues is the instrumental variable approach. However, Wooldridge (2010) argues that in non-liner models, such as the probit and ordered probit models, dealing with the endogeneity issue requires careful consideration. This is because the standard instrumental variable methods such as the two stage least squares (2SLS) or Control Function (CF) approaches, which are used in linear models, may produce inconsistent estimates in non-liner models. Furthermore, Greene and Hensher

[24] The logit model uses the cumulative logistic function.

(2010) assert that instrumental variable approach is based upon the moments of the data which is not applicable in a non-linear model. Jointly modelling the determinants of individuals' risk attitudes and the probability of these individuals engaging in risky choices means that there could be unobserved factors that affect both equations.[25] Hence, the framework used to jointly estimate these two equations should allow the error terms in the regression equations to be correlated. Therefore, to account for both the endogeneity and to have contemporaneous cross-equation error correlation this chapter implement the "Conditional Mixed Process" (CMP) framework developt by Roodman (2011). The CMP framework estimates multi-equations where the dependent variable of each equation may have a different format, such as binary, ordered, categorical or censored equations. The CMP approach is based on a general seemingly unrelated regression (SUR) framework, by which the dependent variables are independent from each other but allows for correlations between their error terms. The estimations are performed in Stata 15 using the "cmp" command developed by Roodman (2011) where the first stage regression is probit and the second stage is ordered probit regression.

The CMP framework can be formally expressed as:

$$y^*_{it,1} = X'_{it,1}\boldsymbol{\beta}_1 + \gamma y_{it,2} + \varepsilon_{it,1}, \quad i = 1, 2, ..., N \quad and \quad t = 1, 2, ...T, \tag{4.13}$$

which represents the equations of the risky choices. The endogenous $y_{it,2}$ corresponds to the measure of risk attitudes. $y^*_{it,1}$ is as defined in Equation 4.1, $X'_{it,1}$ is a vector of observable characteristics and $\boldsymbol{\beta}_1$ is the corresponding vector of parameters. The equation of the risk attitudes measure is expressed as:

$$y^*_{it,2} = X'_{it,2}\boldsymbol{\beta}_2 + \varepsilon_{it,2}, \quad i = 1, 2, ..., N \quad and \quad t = 1, 2, ...T, \tag{4.14}$$

[25]The term risky choices used in this chapter refers to both engaging in risky activities and holdings of selected financial assets.

where $y^*_{it,2}$ is as defined in Equation 4.9, $X'_{it,2}$ is a vector of observable characteristics and $\boldsymbol{\beta}_2$ is the corresponding vector of parameters.

The error terms ($\varepsilon_{it,1}, \varepsilon_{it,2}$) are identically distributed, with a bivariate normal distribution, with a mean of zero and unit variance and correlation coefficient. That is, $\varepsilon_{it,1}, \varepsilon_{it,2} \sim N(0, 0, \sigma_1^2, \sigma_1^2, \rho)$. These error terms are correlated across the risky choices and the risk attitudes measure equations such that:

$$\begin{pmatrix} \varepsilon_{it,1} \\ \\ \varepsilon_{it,2} \end{pmatrix} \sim N \left[\begin{pmatrix} 0 \\ \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \\ \rho & 1 \end{pmatrix} \right] \tag{4.15}$$

In this specification, if $\rho \neq 0$ then a joint modelling estimation is characterised by greater efficiency as it accounts for the endogeneity of the attitudes towards risk measure in the risky choices equation.

The approach requires that the system be recursive, meaning that the measures of attitudes towards risk will affect risky choices but not the other way round. The identification of the two equations in the CMP framework is achieved by imposing exclusion restrictions. Specifically, in the risky choices equations the controls that are included in these regressions are similar to those included in the determinants of attitudes towards risk shown in Table 4.9. However, in the probit regressions, height of the respondents is excluded and a measure of financial potential at the state/prefecture levels is included, see Neymotin (2010). The latter variable is included to capture the financial sophistication of the state/prefecture, see Section 4.3.2 for full definition of this variable.

4.5 Empirical results

4.5.1 Correlations and transitions

Table 4.5 shows pairwise correlations between the two measures of risk attitudes and the measures of risk attitudes with risky choices. The subjective measure and the hypothetical measure of risk attitudes are positively and significantly correlated with each other in both countries but the correlation is stronger in Japan (0.21) than the U.S. (0.17). These correlations are higher than the one found in Ding, Hartog, and Sun (2010) (0.15) between a hypothetical lottery question and a general risk attitudes question using a sample of Chinese individuals but lower than the one found in Dohmen et al. (2011) (0.26) for a sample of German individuals. Moreover, the correlations of the two measures used in this chapter with risky behaviours and financial choices are also statistically significant and with the expected signs, indicating that those who are less willing to take risk engage less in risky activities. However, the correlations found for the U.S. and Japan are lower than what is been found in other studies. For example, Dohmen et al. (2011) found that the correlation between the willingness of taking risk in general and in a number of specific contexts to be around 0.50 for each context in a sample of German population. A notable observation from Table 4.5 is the stronger correlation of the risky behaviours and financial choices with the subjective measure of risk attitudes compared to the correlations with the hypothetical gamble measure in both countries. The same pattern has been found in Dohmen et al. (2011) and Ding et al. (2010). These statistically significant correlations between the two measures of risk attitudes and the risky choices serve as an initial confirmation to the validity of the risk attitudes measures in reflecting risky choices before formally, using probit regressions, confirming this validity jointly with other individual's characteristics in Section 4.6.

Risk attitudes are expected to be different between individuals given their characteristics and experiences, however, what is interesting to examine is whether individuals revise their risk attitudes over time. Table 4.6 and Table 4.7 examine the transition probabilities of respondents between the various categories of the two risk attitudes measures used in this chapter. In general, the two tables show that there is high transition rate between categories of the the subjective and hypothetical measures of risk attitudes over time. This transition rate is higher in Japan than in the U.S.. For example, Table 4.7 of the Japanese respondents that selected value zero (more willing to take risk) for the hypothetical gamble measure, only 25.84 percent subsequently choose the same value again, i.e. 25.84 percent remain in the "more willing to take risk" category over the six-year period. The remaining 21.28 percent of respondents transitioned to the value one in the next period, while 23.10 percent and 29.79 percent transitioned to values 2 and 3 respectively. For the U.S., the percentage that remained in the "more willing to take risk" category over the six-year period is 27.04 which slightly higher.

This high transition rate may indicate that respondents are inconsistent in their answers over time leading to some measurement error in the risk attitudes indices, especially the subjective measure since there is no clear differences between neighbouring values of this measure. However, such high transition rate is not observed from "less willing to take risk" values to "more willing to take risk" values, i.e. respondents have stronger preference to become less willing to take risk over time.[26] For example, Table 4.7 of the U.S. respondents that selected value 3 for the hypothetical gamble measure, 79.52 percent subsequently choose the same value and remain in the "less willing to take risk" category over the six-year period.[27] The findings in Table 4.6 and Table 4.7 show that individuals in the U.S. and Japan become less willing to take risk over time since a relatively high proportion of respondents revise their own risk attitudes. This clearly contradicts the assumption of fixed risk attitudes for individuals over time. Therefore, policies that are based on aggregate measures of risk attitudes might have to be revised periodically since

[26] Similar results are found in West and Worthington (2012)

[27] A similar transition behaviour is observed in the subjective measure of risk attitudes.

these measures will not be suitable over an extended horizon given the high rate of transition.

4.5.2 The determinants of risk attitudes: Baseline specification

This section outlines the main determinants of individuals' attitudes towards risk, focusing first on the role played by the exogenous variables as defined in the baseline specification. The baseline specification model includes variables that are argued in the literature to be exogenous determinants of risk attitudes, see Dohmen et al. (2011). The main purpose of analysing only these variables first is to see if they can explain individuals' risk attitudes in the same way as other studies found and whether these exogenous variables are equally important across Japan and the U.S.. As discussed in Section 4.4, this chapter uses two alternative econometric methodologies, ordered probit model and interval regressions model. However, the main discussion will be based on the ordered probit model and the interval regression results will only be reported in the appendix and serve as a robustness check of the ordered probit findings.

The subjective and hypothetical gamble measures of risk attitudes are decreasing in the willingness to take risks and the estimated coefficients of the ordered probit model are interpreted only in terms of their signs and statistical significance. Therefore, if the coefficient is positive, then an increase in the independent variable necessarily increases the probability of reporting a higher value of the risk attitudes measure "less willing to take risk" and decreases the probability of reporting a lower value of the risk attitudes measure, that is "more willing to take risk".

Panel A in Table 4.8 shows the regression results of the ordered probit model for both Japan and the U.S. using the subjective and hypothetical gamble measures of risk attitudes.[28] The table indicates that being male increases the probability

[28]The cut points of the categories of the two measures are tested to see if they are different from

of being more willing to take risk, the signs and the statistical significance are consistent in both countries and across both measures of risk attitudes. This result is consistent with the literature which suggests that male and female usually exhibit different attitudes towards risk, see Byrnes, Miller, and Schafer (1999). On the other hand, age influences risk attitudes in the opposite direction to gender. Panel A in Table 4.8 shows that as individuals in Japan and the U.S. advance in age, they become less willing to take risk as the age coefficient is positive and statistically significant at the 1% level. The results of age and gender are in line with most of the findings of other papers (see, for example, Dohmen et al., 2011; De Paola, 2013).

Interestingly, taller individuals are more likely to be more willing to take risk, but the coefficients are only statistically significant in Japan. Specifically, Panel A in Table 4.8 shows that the subjective and hypothetical gamble measures of risk attitudes correlate negatively with the respondent's height of Japanese individuals at the at the 10% and 1% respectively. Similar results are found by Dohmen et al. (2005) for a sample of German and by Addoum, Korniotis, and Kumar (2017) using data from several European countries and the U.S.. The channel through which taller individuals are more likely to be more willing to take risk is put forwards by Persico, Postlewaite, and Silverman (2004), who found that wage differences associated with height is similar, in terms magnitude, to the differences associated with race. They argue that an important channel for the emergence of the wage height premium might be through the impact of height in adolescence on confidence and self-esteem. Therefore, taller individuals will have greater confidence which will be translated into higher willingness to take risks and higher earnings potential.[29] Neymotin (2010, p. 998) also find similar results and argue that "*It is unclear whether*

each other. panel A of Table 4.8 indicates that the null hypothesis that the adjacent cut points are equal is rejected. For the sack of brevity the statistics related to the cut points are not reported in all the tables that follow.

[29] Dohmen et al. (2005) also argue that this results might reflect correlation with other factors, in particular parental education. Educated parents will provide better nutrition to their children and hence might have a taller children. However, parents' education attainments are controlled for in all specifications of this chapter.

this operates through a genetic pathway, social pathway or a combination of the two, although recent evidence points to a genetic dominance of taller individuals by cognitive abilities."

The results indicate that only father's education is a relevant determinant of risk attitudes and this variable is only significant for the hypothetical gamble measure. Specifically, having a father who completed high school increases the probability of being more willing to take risk. This variable is significant at the 10% level for Japan and 5% level for the U.S.. Mother's education is statistically insignificant for both countries and using both measures of risk attitudes. The literature has examined and documented the impact of parental variables, in particular parents' educational attainment, see Dohmen et al. (2011) and Dohmen et al. (2016). However, while Dohmen et al. (2011) found that the impact of both parents' education jointly and individually are statistically significant in the SOEP data, the results reported in panel A of Table 4.8 indicate that only father's education is statistically significant.

Following Dohmen et al. (2017) and Hanaoka et al. (2018), the baseline specification in panel A of Table 4.8 is repeated on a sample split by gender. The argument put forward in the literature in support of splitting the sample by gender is that emotional responses to negative shocks may change individuals' attitudes towards risk. On the other hand, the psychology literature suggests that gender is an important factor influencing such emotional responses. Therefore, panels B and C of Table 4.8 repeat the same regression specifications discussed in the previous section on males and females, respectively. Interestingly, the results reveal that the effects of the regressors in the full sample mask considerable heterogeneity in the effects of some variables. Specifically, panel B and C of Table 4.8 show that, for Japan, while risk attitudes of male individuals are only influenced by the father's level of education, females' risk attitudes are influenced by the mother's education only. Furthermore, the significance level of the height of the Japanese respondents is larger for males than for females. Specifically, while the height is statistically significant determinant of males' risk attitudes for both measures of risk attitudes, it is only statistically significant for the hypothetical gamble measure in the case of female individuals. The impact of age does not show any heterogeneity across gender as it is still significant and positive for both measures of risk attitudes and in both countries.

4.5.3 The determinants of risk attitudes: Full specification

This section discusses the results of the full specifications, where personal, household and regional characteristics are included in the ordered probit regressions. These additional explanatory variables are included to investigate if they have any predictive power on individuals' risk attitudes. The discussion of the result of each variable will be in relation to the full sample which is reported in Table 4.9, then the focus will move to gender differences and the related marginal effects of each variable.

The literature suggests the existence of gender differences in the determinants of risk attitudes, see Byrnes et al. (1999). Table 4.10 shows the determinants of attitudes towards risk for male respondents in panel A and for female respondents in panel B. Similar to the findings of the short specification, the table reveals significant differences in the determinants of risk attitudes between male and female individuals and these differences are not the same across Japan and the U.S..

The results reported in Table 4.9 and Table 4.10 reveal the direction of the impacts of the independent variables on the two measures of risk attitudes used in this chapter. However, other than the signs and the level of statistical significance, it is difficult to understand the size and importance of the impacts of these variables on the individual's attitude towards risk. Furthermore, it is informative to examine if the magnitude of the impact of each variable is different across gender and between Japan and the U.S.. Therefore, Table 4.11 and Table 4.12 report the marginal effects of the independent variables on the hypothetical gamble measure and subjective measure of risk attitudes respectively. However, for the sake of brevity only the magnitudes of the variables related to the hypothetical gamble measure of risk attitudes are discussed in the following subsections. The impacts of the variables on the subjective measure are similar to the results of the hypothetical gamble but the magnitudes are lower, see Table 4.12.

The marginal effects are estimated at the mean of the independent variables and reported only at selected outcomes of the subjective measure of risk attitudes for the sake of brevity. Specifically, the subjective measure of risk attitudes has 11 outcomes, of these outcomes the marginal effects of only selecting a value of 2 (outcome 3); a value of 4 (outcome 5); a value of 8 (outcome 9); and a value of 10 (outcome 11) are reported in Table 4.12. However, for the hypothetical gamble measure of risk attitudes, the marginal effects are reported at all possible outcomes which are related to being a signed the following values 0, 1, 2 and 3 in Table 4.11. These marginal effects represent the changes in the proportion of individuals belonging to one risk attitudes outcome when the independent variable increases by one unit if the variable is continuous, or evaluated with regards to the omitted category in the case of dummy variables.

Parental education

Table 4.9 shows the results of the full specification. Interestingly, the statistical significance disappears for parents' education after considering the full specification in both countries. This is in contrast to the findings of Dohmen et al. (2011) where the level of parental education remain statistically significant in the most comprehensive specification. Specifically, Table 4.9 shows that parents' education has no impact on the level of individual's risk attitudes in Japan and the U.S.. However, the literature argues that individual's income and wealth are highly correlated with parents' education (see, for example, Dohmen et al., 2005). Furthermore, empirical studies usually use parents' education as a proxy for the level of individual's income to control for endogeneity (see, for example, Sacerdote, 2011; Solon, 1999).[30] Therefore, this result is not surprising since the full specification has variables that might be correlated with the education level of the respondent's parents.

However, Table 4.10 shows that the impact of parents' education on risk attitudes retains its statistical significance when gender differences are taken into account. The results of the short specification discussed in Table 4.8 indicated that only father's education has an impact on the hypothetical gamble measure of risk attitudes and this impact is no longer statistically significant in Table 4.9 as the full specification is considered. However, Table 4.10 shows that father's level of education has a negative and statistically significant impact on the hypothetical gamble measure of risk attitudes of the U.S. male individuals. Table 4.11 shows that for the U.S. sample, having a father holding a high school degree or higher reduces the probability of the male individual reporting the highest value of the hypothetical gamble measure (increases the willingness of taking risk) by 5.80 percentage points.[31] Table 4.9 also shows that risk attitudes of Japanese female respondents are negativity influenced by their mother's education. Table 4.12 shows that having a mother holding a high school degree or higher reduces the probability of the female individual reporting the highest value of the subjective measure (increases the willingness of taking risk) by 0.24 percentage points. This result is an indication to the importance of considering gender differences in empirical studies examining individual attitudes towards risk, given that mother's education was not significant at all in the full sample.

Demographic variables

After considering the full specification the coefficients of some of the demographic variables show some significant heterogeneity between gender and across the two

[30] In unreported results, when income is excluded from the full specification, the impacts of parents' education regain the statistical significance found in Table 4.8.

[31] Recall that risk attitudes measures are decreasing in the willingness of taking risk. This means that the highest value of the risk attitudes measures indicate less willingness to take risk.

countries.[32] For example, age only have a statistically significant impact on Japanese male individuals using the hypothetical gamble measure, as seen in Table 4.10, while the impact is statistically significant for both male and female individuals for the U.S. sample. The magnitude of the impact of age is larger for Japanese male respondents than for U.S. male respondents. However, for the U.S. sample, the impact of age is larger for male than female individuals. For example, a one year increase in age increases the probability of the Japanese male individual reporting the highest value of the hypothetical gamble measure by 1.40 percentage points, while it will increase it by 1.10 percentage points for the U.S. male individuals. As for the U.S. female respondents, the probability of reporting the highest value of the hypothetical gamble measure will increase by 0.80 percentage points for a one year increase in age.

Height of the respondent remains, in the full specification, a statistically significant determinant of risk attitudes of Japanese individuals as found in Table 4.8. However, when considering the impact of height by gender, Table 4.10 shows that height is only statistically significant for Japanese male individuals. An increase in height by one centimetre reduces the probability of the male individual reporting the highest value of the hypothetical gamble measure by 0.28 percentage points. Table 4.9 shows that the correlation between being married and risk attitudes is positive for both measures in the U.S. sample but only for the subjective measure in the Japan sample. This means that in both countries those who are in a relationship are more likely to be less willing to take risk. However, this relationship is not as clear when considering gender differences. Specifically, Table 4.10 shows that U.S. married female respondents are more likely to be less willing to take risk in both measures. Whereas, Japanese married female respondents are likely to report more willingness to take risk in the subjective measure and the opposite for the hypothetical gamble measure. Table 4.11 shows that being in a relationship reduces

[32] The impacts of age, height and gender after considering the full specification, as shown in Table 4.9, are virtually unchanged to what have been found in Table 4.8 that shows the results of the short specification.

the probability of reporting the highest value of the hypothetical gamble measure by 5.80 percentage points for Japanese female respondents. Whereas, for the U.S. female respondents the probability increases by 5.03 percentage points.

The coefficient that captures the number of children in the household correlates negatively with risk attitudes of individuals. This is an interesting result as the coefficient of the marital status indicate that those who are in a relationship have a higher probability of reporting a higher value of risk attitudes. However, as the number of children increases the willingness of taking risk increases. This results is also found in Halek and Eisenhauer (2001, p. 20) who argue that *"These findings may reflect a self-selection process, in which those who are most risk averse are more inclined toward marriage and less inclined to have children in the first place."* The results presented in Table 4.10 show that only the risk attitudes of male individuals in Japan is negatively correlated with this variable, whereas for the U.S. it is the risk attitudes of female respondents that are negatively influenced by the number of children.

The literature suggests that those who live in cities are likely to be more willing to take risk than those who live in rural areas (see, for example, De Paola, 2013). The results of the full specification in Table 4.9 show that the place of residency of the respondent has no impact on both measures of risk attitudes for Japan and the U.S.. However, interesting results emerge when considering the impact of this variable on attitudes towards risk by gender. Specifically, Table 4.10 shows that this variable is statistically significant for the U.S. male individuals using both measures of risk attitudes. The correlation between this variable and risk attitudes of U.S. male individual is negative as expected. This means that those who live in a city are more willing to take risk since they are likely to report a lower value of risk attitudes compared to those who live in a rural areas.

Employment status

Employment status of individuals should correlate strongly with the their attitudes towards risk. For example, entrepreneurship or self-employment are typically associated with risk bearing as the return is volatile and uncertain. On the other hand, wage employment or public sector employment are relativity risk free since these types of employment have a higher job security and less income volatility. Hence, these types of employment will attract individuals who are less willing to take risk, whereas people who are self-employed will be those who are more willing to take risk. In line with the empirical literature (De Paola, 2013; Guiso et al., 2018), Table 4.9 shows that for Japan, the coefficients on the variables of being "unemployed" and "not in labour force" are positively correlated with the subjective measure of risk attitudes. This means that these individuals are less willing to take risk in comparison to those who are in full time employment, which is the omitted category.[33] Furthermore, the coefficient of being self-employed is negatively correlated with the hypothetical gamble measure of risk attitudes for Japan and both measures for the U.S. in support to the findings of Paiella et al. (2004) and Dohmen et al. (2011). This negative and statistically significant correlation between self-employment and risk attitudes for both Japan and the U.S. supports the argument that self-selection into occupations is triggered by heterogeneity in risk attitudes among individuals, see Paiella et al. (2004).

The impact of the employment status of the respondent on their risk attitudes does not change significantly when the sample is split by gender, only one exception is for those who are not in labour force. While the results in Table 4.9 indicate that respondents in this category are less willing to take risk in comparison to those who are in employment, this finding only holds for female respondents. Male respondents who are not in labour force actually report higher level of willingness to take risk than

[33]Other papers found no noticeable influence of employment on risk attitudes (see, for example, Halek & Eisenhauer, 2001).

those who are employed, although this is statistically significant only for Japanese individuals. In terms of magnitudes, Table 4.11 shows that for Japan, being in part-time employment reduces the probability of males reporting the highest value of the hypothetical gamble measure by 9.60 percentage points compared to those who are in full-time employment. This probability is reduced by 5.30 percentage points for those who are self-employed and by 6.40 percentage points for those who are not in labour force. The magnitude of the effect of self-employed is lower than those who are in the other categories which is surprising, but this is not the case for the U.S. sample. Panel B of Table 4.11 shows that, for the U.S., the self-employed category is the only significant category and with the impact being larger than that found for the Japanese male individuals. Specifically, being a self-employed male individual in the U.S. reduces the probability of the male individual reporting the highest value of the hypothetical gamble measure by 15.50 percentage points compared to those who are in full-time employment. For female U.S. respondents the results are as expected, in that, being self-employed female respondents increase the probability of being more willing to take risk by 9.50 percentage points, while not being in labour force increases this probability by 4.20 percentage points compared to those who are in full-time employment. The impact of employment status on the subjective measure of risk attitudes is in line with expectation for both countries, however, the impact is not as large as that found for the hypothetical gamble measure of risk attitudes.

The level of education

The literature suggests that the level of education of the respondent will have an impact on their attitudes towards risk. In line with the expected impact of education discussed in Section 4.3, Table 4.9 shows that in both Japan and the U.S. those who hold a university degree or higher are more willing to take risk than those who only completed a high school. Similar results are found in Guiso et al. (2018). However, these results are only statistically significant for the hypothetical gamble measure of risk attitudes. When considering the differences across gender, the results in Table 4.10 indicate that male individuals who hold a college degree in Japan are more willing to take risk than those who completed high school. The coefficient of holding a college degree was not significant for both countries and using both measures when the full sample is considered, see Table 4.9. Table 4.11 reveals that, in general, the magnitudes of the level of education impacts are lager for male compared to female individuals in the U.S., while the impacts are larger for female individuals for Japan. For example, using the hypothetical gamble measure of risk attitudes, the table shows that having a university degree or higher reduces the probability of the Japanese male individuals reporting the highest value by 6.30 percentage points compared to those who hold a high school degree, while the probability is reduced by 7.90 percentage points for Japanese female individuals. However, for the U.S. sample, the same probability is reduced by 12.30 percentage points for males and only by 4.30 percentage points for females.

Financial variables

The literature suggests that it is important to control for the level of income and wealth of the individual when examining their attitudes towards risk. High levels of income and wealth will cushion the impact of bad realisation and hence may increase individual's willingness to take risk.[34] Table 4.9 documents that the level of income is correlated with both measures of risk attitudes, across Japan and the U.S. with the expected sign. Table 4.10 also shows that while the same negative correlation is found in the male samples, household income for female respondents is now only correlated with the subjective measure of risk attitudes in both countries. On the other hand, net wealth does not have statistical significant impact on risk attitudes for both measures and across the two countries, in line with the findings of Dohmen et al. (2016). In terms of magnitude, the level of income of the household has a stronger impact on the U.S. male individuals compared to Japanese male

[34]The issue of potential endogeneity of these two variables is suggested in the literature as greater willingness to take risk will lead to more income and more wealth accumulation. Therefore, the discussion will be based on association rather than causation.

individuals. Specifically, Table 4.11 shows that an increase in household income by 1% reduces the probability of the Japanese male individuals reporting the highest value of the hypothetical gamble measure by 0.025 percentage points, while the probability is reduced by 0.034 percentage points for the U.S. male individuals.

Table 4.9 shows that home ownership is a significant determinant of risk attitudes. The hypothetical gamble measure of risk attitudes is positively correlated with home ownership for Japan, but for the U.S. it is the subjective measure that is positively correlated with home ownership. This means that respondents who own their homes have a higher probability of being less willing to take risk than those who do not. This result is in line with the literature which argue that home ownership can be considered as a source of background risk as a result of house price volatility (Cardak & Wilkins, 2009). However, other papers argue that home ownership could act as a collateral to facilitate borrowing and generate liquidity and smooth the impact of bad realisation (Mariotti et al., 2015). When considering gender differences, home ownership is only significant for the U.S. sample, where it is positively correlated with the hypothetical gamble measure for males and subjective measure for females. In terms of magnitude, being a home owner increases the probability of the U.S. male individuals reporting the highest value of the hypothetical gamble measure by by 3.90 percentage points.

Background risks

Risk attitudes might be influenced not only by individuals' characteristics but also by the environment faced by the individuals. This section examines the impact of a number of background risks on individuals' risk attitudes. Self-reported health status, the risk of unemployment and the risk of facing borrowing constraints are considered in this chapter which are faced at the individual level.

The self-reported health status indicator is increasing in good health. Table 4.9 reveals a negative and statistically significant correlation between health status and measures of risk attitudes, similar to the findings of Dohmen et al. (2011). Table 4.10 shows that the self-reported health status for the female samples of the U.S. and Japan correlate in the same way as that found using the full sample. In terms of magnitude, Table 4.12 shows that reporting not anxious about your health reduces the probability of the Japanese female individuals reporting the highest value of the subjective measure by 0.14 percentage points, this probability is reduced by 0.15 percentage points for U.S. female individuals. However, health status of male individuals in Japan does not have an impact on either risk attitudes measures, whereas health status of U.S. male individuals is correlated negatively with both measures of risk attitudes. The differential impact of health status in Japanese and U.S. male individuals might be related to the structure of health provision in these two countries. Accessing health services in Japan is completely free, while it is not the case for U.S. individual. In general, this negative correlation is expected and intuitive as those who are anxious about their health will anticipate exposure to financial expenses, hence will avoid taking any risk.

The hypothetical gamble measure correlates negatively with the risk of being unemployed in the near future.[35] This means that those who face an increased risk of losing their job are more willing to take risk. Interestingly, splitting the sample by gender, reveals the impact of this variable is only statistically significant for Japanese male and female individuals. For example, Table 4.11 shows that being exposed to the possibility of being unemployed decreases the probability of the Japanese (male and female) individuals, statistically significant at the 10% level, reporting the highest value of the hypothetical gamble measure by 2.50 percentage points. This relationship is expected and in line with the findings of other papers (see, for example, Paiella et al., 2004; Sahm, 2012). Occupations that involve a higher risk of being short-term and unstable are chosen by individuals who are more willing to take risk. However, this risk taking behaviour is not irrational as these occupations

[35] The impact of this measure is statistically significant at the 1% level for Japan but only at the 10% level for the U.S..

generally offer a higher return than similar but stable occupations. Interestingly, this relationship is significant only for the hypothetical gamble measure of risk attitudes, the measure that is related to gamble over life income.

Table 4.9 indicates that the risk of facing borrowing constraints correlates negatively with risk attitudes, meaning that individuals who are borrowing constrained are more willing to take risk.[36] The impact is statistically significant at the 1% level for both measures in Japan but only for the hypothetical gamble measure for the U.S.. This result contradicts the findings of Guiso and Paiella (2008), who found that those who are defined to be liquidity constrained are less willing to take risk.[37] Guiso and Paiella (2008, p. 1137) argue that *"liquidity constraints act to reduce the consumer horizon, thus limiting opportunities to "time diversify" any risk currently taken and accentuating risk attitudes"*. However, the results of this chapter indicate that those who are faced with borrowing constraints have a higher probability of reporting the lowest value of the risk attitudes measure. A possible explanation to this result is that those who are not credit constrained are those who behave more prudently and, in general, those who behave prudently are individuals who are less willing to take risk. The impact of facing the risk of borrowing constraints shows some significant heterogeneity between males and females. Specifically, borrowing constraints correlate significantly only with the subjective measure of risk attitudes of Japanese female respondents only. Whereas, U.S. female respondents risk attitudes is not influenced by the risk of facing borrowing constraints. Coefficients related to male individuals in both countries show the same correlation found in Table 4.9. In terms of magnitude, borrowing constraints have a similar impact across the two countries, however, the impact for Japanese female respondents risk

[36]The correlation between the risk of facing borrowing constraints and risk attitudes in the raw data is also negative.

[37]Guiso and Paiella (2008) measure of liquidity constrained is a wider measure than the one used in this chapter, although it refers to liquidity, their measure also capture the borrowing capacity of the individual. Specifically, their measure includes those who have a ratio of liabilities to total assets above 25.0%; or have financial assets amounting to less than 1.0% of their net worth as well as those who have been refused credit.

attitudes is larger than that for male individuals using the subjective measure, see Table 4.12.

Macroeconomic variables

The state of the macroeconomy and the risk of experiencing natural disaster are two background risks that will have an impact on respondent's attitudes. Table 4.9 shows that GDP growth impacts only the subjective measure of risk attitudes and this holds only for the U.S. sample. The coefficient indicates a negative relationship which means that U.S. individuals become more willing to take risk as the GDP growth increases. This finding is in line with the results from papers that examine the impact of the financial crisis on individuals' risk attitudes (see, for example, Necker & Ziegelmeyer, 2016; Malmendier & Nagel, 2011; Bucciol & Miniaci, 2018). For example, Malmendier and Nagel (2011) find that households who experienced lower stock market returns express lower willingness to bear financial risk and are less likely to participate in the stock market. However, Table 4.10 shows that the GDP growth only impact risk attitudes for male individuals in the U.S. sample, which means that U.S. male individuals become more willing to take risk during positive economic growth. In terms of the magnitude of the relationship, Table 4.12 shows that the impact of GDP growth is only statistically and economically significant for the U.S. male individuals. Specifically, a one unit increase in the growth of GDP will increases the probability of the U.S. male individuals reporting the lowest value of the subjective measure by 0.28 percentage points.

One of the main contributions of this chapter is to examine whether experiencing a natural disaster by individuals have an impact on their attitudes towards risk. Furthermore, it is interesting to see if Japanese individuals change their attitudes towards risk differently from U.S. individuals. As discussed in Section 4.3, the natural disaster measure for the U.S. is the number of FEMA disaster declarations. However, for Japan this chapter employs a number of different earthquake intensity measures that are taken at the prefecture level. Table 4.9 indicates that the number of disaster declarations has no impact on attitudes towards risk of U.S. individuals. However, for Japan, Table 4.9 indicates that the maximum earthquake intensity that was recorded a year before the interview has a statistically significant impact on the attitudes towards risk of Japanese individuals. This impact is positive and statistically significant at the 5% level of significance for the hypothetical gamble measure. However, Table 4.10 show that experiencing a natural disaster has a statistical significant impact only for male individuals. This means that as the earthquake intensity increases Japanese male individuals become less willing to take risk. The marginal effects of the impact of natural disaster risk will be explained in detail in the following section.

As discussed before, the impact of natural disasters on individuals attitudes towards risk are inconclusive. While the findings of this chapter are in line with, for example, Cameron and Shah (2015) and van den Berg et al. (2009), they contradict findings of Hanaoka et al. (2018) and Eckel et al. (2009). A possible explanation of this inconsistency might be related to the severity of the disasters examined in each study. Specifically, Eckel et al. (2009) and Hanaoka et al. (2018) consider the impact of severe disasters. Hurricane Katrina, examined by Eckel et al. (2009), was an extremely destructive and deadly disaster which caused 1,836 fatalities and the total economic impact exceeded $150 billions according to the National Hurricane Center of the U.S.. Similarly, Hanaoka et al. (2018) examined the impact of the Great East Japan Earthquake which resulted in 15,897 fatalities according to the National Police Agency of Japan and the estimated economic cost was US$235 billions, according to The World Bank, making it the costliest natural disaster in history. Therefore, it might be the case that individuals become more willing to take risk when experiencing rare and severe disaster but less willing to take risk when faced with moderate and regular natural disasters. To test the robustness of the impact of earthquake on risk attitudes, Section 4.5.4 will present the results of the alternative earthquake risk measures in detail.

Overall, the results of Table 4.10 indicate that the risk attitudes of male individuals are more influenced by the set of controls considered in this chapter than the risk attitudes of female respondents. These results are generally in line with the literature. For example, Hanaoka et al. (2018) findings indicate that males' risk attitudes are more likely to change than those of females. These results show the importance of controlling for gender differences in the analysis of topics related to risk a version, such as determinants, stability and susceptibility to change.

Similarly, the magnitudes of these determinants reveal that these determinants have a larger impact on the levels of risk attitudes of male individuals than on female individuals. This is clear when the hypothetical gamble measure of risk attitudes is concerned. As for the comparison between Japan and the U.S., the results are mixed. For example, the impact of some variable is larger for Japanese individuals, such as age and the background risk variables. Whereas the magnitude of most of the other variables have a larger impact on U.S. respondents, such as being self-employed, level of education and income. All of the employment status categories are statistically different from the omitted one (being in employment) in the case of Japan, whereas only being self-employed shown to be statically different from being employed in the sample of U.S. individuals.

4.5.4 Robustness checks

This section outlines the robustness checks for the results of the determinants of risk attitudes by using alternative estimation techniques. Furthermore, the robustness of the impacts of earthquake risk in the Japanese sample is further checked by using a number of different measures of earthquake risk.

Alternative estimation techniques

The results discussed above are robust to the use of two alternative methodological approaches, interval regressions and random effects OLS regressions, see

Table B1 and Table B2. Specifically, Dohmen et al. (2011) argue that interval regression can be used when the outcomes of the dependent variable have interval censoring. In other words, the ordered category into which each observation falls in the two measures of risk attitudes are known, but what is not known is the exact value of the observation. Interval regression accounts for the interval characteristic of the measure of risk attitudes by treating each value of the dependent variable as a left-censoring and right censoring observation. Another way to check the robustness of the ordered probit model findings is to treat the responses to the two questions used to construct the measures of risk attitudes as continuous variable. Therefore, the random effects OLS regression is also used to further check the findings of this chapter.

Table B1 and Table B2 show the results of these two alternative estimation techniques. The result in these two tables are, in general, similar to those found using the ordered probit regressions in Table 4.9. These results confirm the robustness of the ordered probit findings discussed above.

The impact of earthquake intensity

A number of different earthquake risk measures are now considered, to check the robustness of the impact of earthquake risk on risk attitudes found in Table 4.9. Specifically, the main measure of earthquake's intensity is the maximum intensity that have been recorded in one prefecture during one year, this is the measure which has been used in Table 4.9. However, Japan is a country which is exposed to higher risk of earthquake episodes than any other country and earthquakes do occur at a regular bases. Therefore, it could be argued that the number of earthquake episodes that occurred might influence individuals' attitudes towards risk. On the other hand, Japanese might be well prepared, mentally and practically, for the occurrence of small and regular earthquakes. Hence, it could also be argued that only earthquakes with intensities that exceed a threshold will have an impact on individuals' risk attitudes. Therefore, to account for these possibilities, four alternative measures are used as a robustness check to the maximum intensity measure used in Table 4.9. The first one is the mean of the intensities of all earthquakes that happened in one prefecture during one year. The second one equals the number of days within one year in which an earthquake has happened, regardless of the intensity. The other two measures are constructed by measuring how much an earthquake intensity exceeds certain thresholds on the intensity scale, these thresholds are 3 or 4.[38]

The results of the alternative measures of earthquake risk are displayed in Table 4.13. For the sake of brevity, the table only includes the coefficients of the earthquake risk measures. Each of these coefficients represents a separate regression which includes the same controls that are included in Table 4.9. Similar to the results found in Table 4.9, the results of Table 4.13 indicate that none of the earthquake measures have an impact on the subjective measure of risk attitudes. However, the results indicate that the hypothetical gamble measure of risk attitudes is influenced by some of these measures and the impacts are statistically significant. Specifically, the measure which captures the average mean of the intensities of all earthquakes has no impact on risk attitudes. Similarly, the number of earthquakes episodes that happened within one year in each prefecture also has no impact on risk attitudes of Japanese individuals. On the other hand, the earthquake risk measure that captures the maximum intensity that is recorded in one year for each prefecture has a significant positive impact on risk attitudes as been discussed before. Moreover, the two measures that capture earthquakes with intensities exceeding a threshold (3 and 4) also have statistically significant impacts on risk attitudes. The impacts of these three measures are positive and statistically significant at the 5% level. Which mean that as the intensities of earthquakes increase, Japanese individuals become less willing to take risk.

The results above reveal some interesting association between individuals' attitudes towards risk and the risk of exposure to natural disasters. Japan is a country

[38] Table B3 shows the means of the four measures used across the 47 Japanese prefectures and over the sample period 2005-2010.

which is exposed to a high risk of earthquake episodes, many of these episodes are small in terms of intensity. For example, Table B3 shows that on average, 44 earthquakes hit Japan in one year. A potential explanation to this is that Japanese individuals may have adopted mental coping mechanisms and safety procedures as a result of these regular earthquakes. However, the average intensity of these earthquakes is only 1.40, which would only be felt by some people according to Table B4. Therefore, the findings of Table 4.13 that only earthquake with high intensity have an impact on individuals are intuitive. The mechanisms and procedures that have been adopted by Japanese individuals might have mitigated the impact of small earthquakes but not large earthquakes. Specifically, the results confirm that the frequency of earthquake in Japan has no statistically significant impact on individuals' risk attitudes, what matters are those earthquakes with high intensities. These findings are in line with other papers that examine the impact of earthquakes on individuals' behaviours. For example, Maruyama, Kwon, and Morimoto (2001) examine the impact of the Great Hanshin-Awaji Earthquake on individuals mental health. The mental health status of those who experienced an earthquake intensity of 4 and above is affected differently from those who experienced an earthquake with intensity less than 4. Hanaoka et al. (2018) also suggest that intensities above a threshold should be accounted for as their results show that the impact of these intensities are different.

Similar to the analysis in the previous section, the impact of the alternative measures of earthquakes risk is further examined by gender. Table 4.13 panel B shows the analysis for male respondents while panel C shows the impact on females respondents. The table confirms the findings of Table 4.9, in which only male individuals are influenced by high earthquake intensities. The three measures that are statistically significant in the full sample (panel A) also have positive and statistically significant impact on the attitudes of male respondents towards risk, with the coefficients being larger compared to panel A and also significant at the 1% level of significance compared to 5% found in panel A.

The magnitudes of the impact of these measures are shown in Table 4.14, which only shows the marginal effects of the significant coefficients in Table 4.13. Specifically, panel A of Table 4.14 shows the marginal effects of the maximum intensity measure for male individuals at all four possible outcomes of the hypothetical gamble measure of risk attitudes. Panel A also shows the marginal effects of the all the controls that are included in the regression. Panel B and panel C of Table 4.14 only show the coefficients of the other two earthquake risk measures as the marginal effects for the controls are identical to those displayed in panel A, see Table B13 and Table B14 in Section 6.2.

In general, Table 4.14 shows that the three measures of earthquake risk have a sizeable impact on risk attitudes of Japanese male individuals. For example, all the measures are larger than the impact of a one year increase in age. A one year increase in age will increases the probability of the Japanese male individual reporting the highest value of the hypothetical gamble measure by by 1.30 percentage points, whereas experiencing an earthquake equals or larger than 4 will increase it by 4 percentage points. The results confirm the argument put forwards in the previous paragraph, in that earthquakes with high intensities have more impact on individuals' risk attitudes than low intensities earthquakes. Specifically, the table shows that the impact of having an earthquake equals or larger that 4 is larger that the impact of having an earthquake equals or larger than three and the impacts of these two measures are larger than the the impact of the maximum intensity measure. For example, experiencing an earthquake equals or larger than 4 increases the probability of the Japanese male individual reporting the highest value of the hypothetical gamble measure by 4 percentage points, while the probability will increase it by 3 percentage points for an earthquake equals or larger than 3.

4.6 Validation of the risk attitudes measures

In order to assess whether the measures of risk attitudes used in this chapter reveal actual attitudes towards risk, this section checks whether these measures are statistically and economically significant in predicting risky choices. The set of variables that are used to proxy for individuals' risky choices in the validity exercises covers a variety of contexts and are explained in Section 4.3.1. Specifically, smoking, drinking and gambling are the three risky behaviours that are influenced by the attitude an individual has towards risk. Holdings of financial assets are also used in these exercises since individuals' financial choices that form the composition of their financial portfolio are also influenced by the attitudes individuals have towards risk.

Table 4.15 shows the marginal effects of the random effects probit regressions related to the risky behaviours in panel A and the one related to the decisions to hold selected financial assets in panel B, these marginal effects are the average marginal effects of independent variables. Each coefficients represents a separate regression which includes the respective behaviour as dependent variable, a measure of risk attitudes and a set of controls. The full results of each regression are reported in the appendix, see Table B5 to Table B10. The controls that are included in these regressions are similar to those included in the determinants of risk attitudes equation shown in Table 4.9. However, height of the respondents is not included in these regression since the height of the individual affect financial decisions indirectly through its impact on risk attitudes, see Neymotin (2010).[39] Moreover, a measure of financial potential at the state/prefecture levels is included in the behaviours and financial choices equations to capture the financial sophistication of the state/prefecture, see Section 4.3.2 for full definition of this variable.

In general, panel A of Table 4.15 shows that the measures of risk attitudes used in this chapter have statistically significant impact on smoking, drinking and gambling

[39]This exclusion restriction is important in order to achieve identification in the two equations system presented in the following section.

activities of the respondents. Specifically, the table shows that the hypothetical gamble measure of risk attitudes is negatively correlated with gambling and drinking behaviours in the U.S. and gambling behaviour of Japanese individuals. These coefficients are statistically significant at the 1% level of significance for Japan and 5% level for the U.S.. Moreover, the subjective measure of risk attitudes is a powerful predictor of all risky behaviours in both countries except drinking behaviour in Japan. The coefficients of the subjective measure are negatively correlated with these activities and statistically significant at the 1% or 5% level of significance. The negative correlation between the measures of risk attitudes and the three variables capturing risky behaviours indicate that individuals who are less willing to take risk engage less in these activities.

A further confirmation of the behavioural validity of the two risk measures used in this chapter can be observed from panel B of Table 4.15. The table shows the marginal effects of the probit regressions of the decision to hold certain financial assets as well as the proportion of holding stocks in the respondent's financial portfolio. Holdings of stocks is regarded as a risky choice given the relative riskiness of this financial investment compared to keeping assets in banks' saving accounts. The negative correlation between these coefficients and the two measures of risk attitudes indicates that individuals who are less willing to take risk hold less stocks in their portfolios. These results are in line with the standard portfolio theory which predicts that individual's risk attitudes will determine the amount of wealth the individual is willing to invest in risky assets. These findings are in line with the validation tests performed by Paiella et al. (2004) using Italian sample and Dohmen et al. (2011) using German data.

Overall, these results are as expected and are in line with the findings of other papers (see, for example, Dohmen et al., 2011; Paiella et al., 2004; Jung & Treibich, 2015; Beauchamp, Cesarini, & Johannesson, 2017). Moreover, similar to the findings of this chapter, Dohmen et al. (2011) indicate that subjective survey based measure of risk attitudes have more predictive power on the behavioural outcomes than the hypothetical gamble measure and these power. In terms of magnitudes, the marginal effects of the two risk attitudes measures shown in Table 4.15 indicate that the risk attitudes measures have stronger predictive power for risky behaviours than for the decisions of holdings various financial assets, especially for the U.S.. For example, an increase in the subjective measure of risk attitudes by one unit, decreases the probability of engaging in gambling activities by 0.7% for Japan and 1.0% for the U.S.. Similarly, an increase in the hypothetical gamble measure by one will decrease the probability of holing stock by 0.6% for Japan and by 1.7% for the U.S. holding other controls constant. Similar to Beauchamp et al. (2017), the results indicate that these predictive powers are more pronounced, statistically and economically, in the three risky behaviours compared to the financial related choices.

4.6.1 A Joint modelling framework

The results in the previous section indicate a strong relationship between the measures of attitudes towards risk on a range of behavioural outcomes in a variety of contexts. Specifically, the results show that individuals who are less willing to take risk tend to undertake safer actions when allocating their financial assets or when deciding on engaging in risk activities. However, it may be the case that the relationship between taking risky choices and attitudes towards risk is endogenous. This would mean that those who are less willing to take risk sort themselves into choices with lower exposure to risk leading to a problem when examining the impact of risk on choices. Specifically, there could be unobserved factors that affect both the determinants of attitudes towards risk and holdings of financial assets or engaging in risky activities. Therefore, to deal with this potential issue, a system of two equations is estimated to account for this possible endogeneity by using the Conditional Mixed Process (CMP) framework. Since the interest of this section is to test the predictive power of the measures of risk attitudes, the two equations system is modelled as a recursive system, meaning that the measures of attitudes towards risk will affect holding of assets or engaging in risky activities but not the other way round.

In the existing literature there are no empirical studies, to the best of my knowledge, that explore the relationship between individuals risky choices and their attitudes towards risk by employing a joint modelling approach. However, there is a number of studies that employ a joint modelling approach in the literature of household finance. For example, Brown and Taylor (2008) used a bivariate tobit model to examine the determinants of debt and assets at the household level. Brown and Taylor (2008) findings indicated that in the presence of inter-dependent decision-making with respect to financial assets and liabilities a joint estimation is preferred as it is characterized by greater efficiency. Gray (2014) used the German SOEP to examine the relationship between the household's financial position and overall life satisfaction. The author used a recursive bivariate ordered probit specification to account for the potential endogeneity of the household's subjective financial measures in the determinants of overall life satisfaction. Gray (2014) findings revealed that the relationship between the unobserved characteristics of the overall life satisfaction and subjective financial position equations is statistically significant, advocating the use of a joint modelling approach. Bridges and Disney (2010) explored the relationship between subjective debt burden and depression in Britain by employing a joint modelling approach. The findings revealed a statistically significant correlation between the unobserved components of the self-reported depression equation and the equation of the subjective debt measure.

The results of the joint modelling of the determinants of risk attitudes equations and the equations of engaging in risky choices are reported in Table 4.16. Each coefficient in each panel is a separate regression of a system of two equations linked via their error processes. The correlation between the errors of the system of two equations can also be recovered and examined in the joint modelling approach. These correlation shows the impact that unobservable characteristics have on the various dependent variables and referred to by the coefficient ρ which is reported beneath the related coefficient in Table 4.16.

The results in Table 4.16 show that the predictive power of the two measures of risk attitudes used in this chapter is consistent with the findings of Table 4.15 even after controlling for the potential endogeneity issue. These findings indicate that the two measures of risk attitudes constructed from the PPS survey are reliable measures in predicting actual individuals' risk attitudes. However, the results in Table 4.16 also indicate to a statistically significant relationship between the unobserved characteristics of a number of risky choices and attitudes towards risk equations, implying there is interdependency between these equations. The positive correlations, indicated by ρ, between the unobserved characteristics found in most of the regressions in Table 4.16 indicate that unobserved characteristics which cause individuals to report being less willing to take risk also lead to individuals reporting engaging in risky activities and holding risky assets. Furthermore, Table 4.15 shows that once a recursive model is utilised, the subjective measure of risk attitude become a statistically significant determinant in the drinking decision equation of the Japan sample.

The findings of Table 4.16 are important as they suggest that the relationships between risky choices and the two measures of attitudes towards risk presented in the previous section are potentially biased due to endogeneity. This finding advocate the use of a joint modelling approach as it will take into account the endogeneity of the risk attitudes measure in the risky choices equations and provide more efficient coefficient estimates. Therefore, this section concludes that individuals' risk attitudes can be accurately measured using survey questions and policy makers can rely on these measures in predicting various behavioural outcomes. This is because the predictive power of the two risk attitudes measures is still statistically significant even in the joint modelling approach

4.7 Conclusion

The theory of choice under uncertainty assumes that the observed differences in behaviours among individuals are attributed to differences in their attitudes towards risk. In the existing literature, major developments have been made in examining the determinants of individuals' attitudes towards risk. However, with the exception of Dohmen et al. (2016) and Vieider et al. (2015), a comparison of the determinants of risk attitudes across countries is scarce in the literature. This chapter has compared risk attitudes and their determinants in Japan and the U.S. and examined how these determinants are influenced by natural disasters.

This chapter has contributed to the existing literature by examining risk attitudes in two countries that differ significantly in the attitudes of their individuals towards risks. To do so, six waves of the "Preference Parameters Study" conducted in Japan and the U.S. and ask identical questions in both countries were used. Another contribution of this chapter was the robust assessment of the impact of natural disasters, an exogenous shock, on risk attitudes by employing a set of different measures of natural disaster risk. Moreover, this chapter examined the validity of the "Preference Parameters Study" measures of risk attitudes by assessing whether these measures reflect actual risk taking behaviours of individuals.

In general, the findings of this chapter showed that a number of variables had a statistically significant impact on individual's risk attitudes and the impacts of some of these variables were not the same across Japan and the U.S.. For example, the magnitudes of some variables were larger for Japanese individuals, such as: age; being exposed to the risk of unemployment in the near future; and the risk of facing borrowing constraints. Whereas the magnitude of other variables had a larger impact on U.S. respondents, such as: being self-employed; level of education; income; and self-reported health status. More importantly, the empirical analysis revealed that considering only the effects of the regressors on the full sample and not splitting the sample by gender masked considerable heterogeneity of the effects of some variables. For example, height of the individual and the risk of experiencing an earthquake were found to influence the risk attitudes of Japanese male individuals only. Similarly, the state of the economy had a statistically significant impact on risk attitudes of U.S. male individuals and only U.S. male individuals who live in cities were more willing to take risk than those who live in a rural areas.

Overall, the findings of this chapter indicated that risk attitudes of male individuals were more influenced, in terms of statistical significance and in terms of magnitudes, by the set of controls considered in this chapter than risk attitudes of female respondents. These results showed the importance of splitting the sample by gender in the analysis of topics related to risk attitudes, such as determinants, stability and susceptibility to change.

The impact of earthquake risk on the attitudes of Japanese individuals towards risk was robust to the use of five different earthquake risk measures. The results showed that the number of days with an earthquake and the average intensity of earthquakes measures had no impact on individuals' risk attitudes. These results are intuitive given that Japan is a country which is exposed to a high risk of earthquake episodes, many of these episodes are small in terms of intensity and Japanese individuals adopted mechanisms and procedures which mitigated the impact of these earthquake. On the other hand, the other three measures, that capture earthquakes with high intensities, were found to have a statistically significant impact on risk attitudes of Japanese male individuals. These results indicated that what matters are those earthquakes with high intensities not small and frequent earthquakes.

The results of the validation exercises of the two measures of risk attitudes ascertained that these measures have considerable predictive power for a number of risky choices in a variety of contexts. Specifically, the results showed that individuals who are less willing to take risk tend to undertake safer actions when allocating their financial assets or when deciding on engaging in risk activities such as smoking, drinking and gambling. The results indicated that the prediction power of the two measures of risk attitudes was more pronounced in the risky behaviours than the financial choices outcomes. Moreover, the results also showed that the subjective measure of risk attitudes had a stronger predictive power than the hypothetical gamble measure. Furthermore, the statistically significant relationship between the unobserved characteristics of a number of risky choices and attitudes towards risk equations advocated the use of a joint modelling approach as it will provide more efficient coefficients estimates.

Overall, this chapter provided a detailed insight into the determinants of risk attitudes of Japanese and U.S. individuals. The findings of this chapter can help identify the causes of the differentials in attitudes towards risk between Japan and the U.S.. Moreover, important policy conclusions about individuals' risk attitudes in Japan and the U.S. can be drawn from the findings of this chapter. For example, the variables that are identified to have an impact on individuals risk attitudes can be targeted by policy makers to influence individuals' behaviours and achieve various vital realizations at the aggregate level such as: predicting labour market structure; predicting health related risky behaviours; and influencing investments, fertility and migration decisions. Moreover, the findings indicated that experiencing earthquakes of large intensities can alter the attitudes towards risk of Japanese male individuals. This means that policy makers should expect systematic changes in the attitudes towards risk of Japanese male individuals after earthquakes with large intensities. Finally, the findings of this chapter confirmed that survey based measures of risk attitudes had a considerable predictive power in explaining individuals' decisions in a variety of contexts. This predictive power makes these measures valid instruments for policy makers to rely on in predicting individuals' behaviour and in explaining inequality in income and wealth distribution. Therefore, devoting more resources to data collections on individuals preferences and developing comprehensive preferences questions will enrich further researches concerning individuals' preferences.

This chapter examined the determinates of risk attitudes of Japanese and U.S. individuals. However, the literature concerning individuals preferences is still sparse. For example, the presence of endogeneity issues when examining determinants of individuals' risk attitudes using non-experimental data prevents researchers from drawing a strong causal inference. Therefore, efforts should be made to identify direct causal effect of some of the variables considered in this chapter on individuals' risk attitudes. Furthermore, examining differences in time preferences and the marginal propensity to consume between Japanese and U.S. individuals are identified as areas for further research in this field.

4.8 Tables

Table 4.1: Summary statistics: Risk attitudes measures

	Subjective measure		Hypothetical measure	
	Japan	U.S.	Japan	U.S.
Mean	6.01	4.37	3.47	3.52
Standard Deviation	1.92	2.39	0.83	0.8
Percentage of each category				
0	0.43%	4.19%	4.01%	4.15%
1	0.35%	5.55%	10.03%	7.51%
2	1.52%	14.88%	21.16%	20.65%
3	7.42%	15.45%	64.8%	67.69%
4	10.4%	12.67%		
5	23.27%	19.36%		
6	13.99%	7.34%		
7	22.42%	8.36%		
8	9.57%	6.69%		
9	6.16%	2.93%		
10	4.47%	2.57%		
Observations	15,498	13,836	15,498	13,836
Number of ID	6,264	8,628	6,264	8,628

Table 4.2: Summary statistics: Financial assets holdings and risky behaviours

	Japan				U.S.			
	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
Stock share	0.08	0.18	0	1	0.25	0.34	0	1
Holdings of assets	Percentage holding				Percentage holding			
Stock binary	19.59%				45.61%			
Saving	89.87%				82.41%			
Bonds	62.33%				7.73%			
Life insurance	64.14%				59.34%			
Investment trusts	13.20%				12.27%			
Pension	32.82%				41.93%			
Risky activities	Percentage engaging				Percentage engaging			
Gamble risk	15.49%				11.57%			
Drink risk	28.57%				9.10%			
Smoke risk	24.02%				10.86%			
Observations	15,498				13,836			

Table 4.3: Independent Variables: Definitions

Variable Name	**Definition**
Father's education	1 if the respondent's father completed high school, 0 otherwise.
Mother's education	1 if the respondent's mother completed high school, 0 otherwise.
Height	The height of the respondent in centimetres.
Male	1 if the respondent is male, 0 if female.
Age	Respondent's age in years.
Married	1 if the respondent is married or cohabiting, 0 otherwise.
Number of children	Number of children (under the age of 16) present in the household.
Lives in a city	1 if the respondent is in a major city, 0 otherwise.
Region	See Table B4 for a list of prefectures and states.
Employment status-(currently employed is the omitted category)	
Part-time	1 if the respondent is in part-time employment, 0 otherwise.
Unemployed	1 if the respondent is studying, 0 otherwise.
Self-employed	1 the respondent is self-employed, 0 otherwise.
Not in labour force	1 the respondent is student, housewife/husband or retired, 0 otherwise.
Education level-(Below high school is the omitted category)	
High school	1 if the respondent's highest level of education is high school level, 0 otherwise.
College	1 if the respondent's highest level of education is college, 0 otherwise.
University+	1 if the respondent's highest level of education is university or higher, 0 otherwise.
Self-Reported Health Status:	5 values from the agreement to the statement: I have anxieties about my health, where:
1	It is particularly true for you.
5	It doesn't hold true at all for you.
Financial Measures	
Log of income	Log of household total income.
Net-wealth	Inverse hyperbolic sine transformation of the total value of household financial and non-financial assets minus total debt.
Home ownership	1 if the respondent's owns his/her house.
Background risk	
Risk of unemployment	1 if there is a possibility that the respondent or someone in his/her family will be unemployed.
Borrowing constraint	1 if the respondent has ever been rejected for a loan application (excluding housing loans)
GDP growth	The growth rate of the state/prefecture level of GDP.
Risk of a natural disaster	See Table B3 and Table B4 for more details.

Table 4.4: Summary statistics: Independent variables

	Japan				U.S.			
Continuous variables	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
Age	50.66	12.74	20	77	44.38	13.87	20	77
Respondent's height	162.35	8.52	135	188	171.43	10.69	102	216
Anxieties about health	2.77	1.05	1	5	3.15	1.19	1	5
Log of household income	6.34	0.63	5	8	4.02	0.72	2	6
Log of net-wealth	14.26	9.53	-18	20	11.59	5.10	-13	15
Number of children	1.79	1.06	0	8	1.60	1.67	0	15
Growth rate of GDP	-0.01	3.56	-5	4	0.58	2.47	-3	3
Financial potential	0.65	0.29	0	1	2.59	2.63	0	16
Risk of a natural disaster	3.12	1.39	0	7	55.23	99.34	0	763
Dummy variables	Percentage				Percentage			
Mother's education	45%				80%			
Father's education	45%				74%			
Male	49%				49%			
Married	83%				81%			
Employment:								
Employed(omitted)	53%				62%			
Unemployed	4%				4%			
Part-time	12%				8%			
Self-employed	9%				7%			
Not in labour force	23%				20%			
Education:								
High School(omitted)	59%				45%			
College	16%				11%			
University+	25%				44%			
Home ownership	84%				77%			
Lives in a city	67%				72%			
Unemployment risk	29%				33%			
Borrowing constraints	8%				18%			
Observations	15,498				13,836			

Table 4.5: Correlations between risk attitudes and behavioural outcomes

Japan	Subjective	Hypothetical	Stock binary	Saving	Bonds	Life insurance	Inves. trusts	Pension	Gambling	Drinking	Smoking
Subjective	1.00										
Hypothetical	0.21***	1.00									
Stock binary	-0.05***	-0.04***	1.00								
Saving	0.01	-0.00	0.11***	1.00							
Bonds	0.06***	0.03***	0.11***	0.23***	1.00						
Insurance	-0.02	-0.01	0.12***	0.16***	0.21***	1.00					
Investment trusts	-0.02	-0.02**	0.29***	0.10***	0.12***	0.11***	1.00				
Pension	-0.01	0.00	0.21***	0.11***	0.15***	0.27***	0.19***	1.00			
Gambling	-0.11***	-0.06***	0.01	-0.02**	-0.06***	0.04***	-0.03***	-0.01	1.00		
Drinking	-0.10***	-0.04***	0.02**	0.02*	-0.02*	0.03***	0.01	0.00	0.13***	1.00	
Smoking	-0.10***	-0.02**	-0.06***	-0.07***	-0.14***	-0.02*	-0.08***	-0.05***	0.17***	0.16***	1.00
U.S.	Subjective	Hypothetical	Stock binary	Saving	Bonds	Insurance	Inves. trusts	Pension	Gambling	Drinking	Smoking
Subjective	1.00										
Hypothetical	0.17***	1.00									
Stock binary	-0.07***	-0.06***	1.00								
Saving	-0.03***	-0.01	0.29***	1.00							
Bonds	-0.03***	-0.04***	0.25***	0.11***	1.00						
Insurance	-0.01	0.04***	0.22***	0.26***	0.09***	1.00					
Investment trusts	-0.02*	-0.00	0.13***	0.11***	0.11***	0.11***	1.00				
Pension	-0.01	0.04***	0.24***	0.23***	0.10***	0.29***	0.10***	1.00			
Gambling	-0.16***	-0.04***	0.03***	0.03***	0.01	0.05***	0.01	0.06***	1.00		
Drinking	-0.13***	-0.06***	0.09***	0.07***	0.05***	0.03**	0.02**	0.04***	0.18***	1.00	
Smoking	-0.05***	0.00	-0.11***	-0.13***	-0.06***	-0.07***	-0.03**	-0.07***	0.12***	0.10***	1.00

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.6: Transitions table of the subjective measure of risk attitudes

	Subjective measure of risk attitudes											
Japan	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
0	27.78	11.11	16.67	11.11	8.33	13.89	5.56	2.78	0	0	2.78	100
1	11.11	18.52	11.11	22.22	14.81	7.41	0	7.41	0	0	7.41	100
2	3.65	3.65	16.06	24.82	16.79	13.14	7.3	11.68	2.19	0.73	0	100
3	0.45	0.45	5.07	31.19	23.43	14.63	8.81	10.15	3.43	1.79	0.6	100
4	0	0.1	1.54	17.47	21.99	26.31	15.52	12.23	3.39	1.03	0.41	100
5	0.19	0.14	0.84	4.8	11.1	42.21	13.85	16.18	5.22	3.22	2.24	100
6	0.08	0.15	0.85	3.24	11.34	21.91	26.54	24.23	6.79	3.47	1.39	100
7	0.05	0	0.29	2.91	6.73	17	16.56	35.88	13.32	4.99	2.28	100
8	0.11	0	0.22	2.99	3.21	13.62	9.97	32	21.59	12.4	3.88	100
9	0	0.36	0	1.78	3.38	12.99	7.12	21.53	17.97	23.67	11.21	100
10	0.48	0	0.24	0.71	1.66	14.73	3.56	13.78	15.44	16.63	32.78	100
Total	**0.32**	**0.27**	**1.28**	**7.23**	**10.61**	**23.58**	**14.62**	**22.48**	**9.69**	**6.01**	**3.9**	**100**
U.S.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
0	33.87	17.74	11.29	6.99	5.38	10.75	2.69	1.61	1.61	1.61	6.45	100
1	9.19	26.5	28.98	11.31	6.36	7.42	2.47	3.18	2.12	1.41	1.06	100
2	4.27	11.66	29.66	21.24	11.4	9.72	3.76	4.27	2.72	0.65	0.65	100
3	1.66	3.8	19.6	26.6	17.1	14.96	6.41	5.7	3.21	0.48	0.48	100
4	1.56	2.81	9.05	24.02	19.34	19.66	9.2	7.18	5.62	1.25	0.31	100
5	1.82	1.07	8.23	10.47	14.53	40.71	7.69	7.16	4.17	2.14	2.03	100
6	0.54	2.17	6.5	13.55	12.74	18.7	17.07	15.18	8.13	3.79	1.63	100
7	0.23	0.92	6.68	8.06	9.22	13.82	12.67	23.73	17.05	4.61	3	100
8	0.85	2.28	4.56	5.98	9.4	13.11	9.4	21.65	19.94	7.12	5.7	100
9	1.32	1.32	7.28	6.62	4.64	11.26	6.62	13.91	21.19	16.56	9.27	100
10	8.47	2.54	5.93	4.24	5.08	21.19	4.24	5.93	10.17	10.17	22.03	100
Total	**3.56**	**5.57**	**14.15**	**15.86**	**12.85**	**19**	**7.71**	**9.23**	**6.89**	**2.75**	**2.44**	**100**

Table 4.7: Transitions table of the hypothetical gamble measure of risk attitudes

	Hypothetical gamble measure				
Japan	**0**	**1**	**2**	**3**	**Total**
1	25.84	21.28	23.1	29.79	100
2	6.93	27.61	26.95	38.5	100
3	4.15	13.26	44.13	38.46	100
4	1.91	5.88	13.65	78.55	100
Total	**3.74**	**10.15**	**21.82**	**64.29**	**100**
U.S.	**0**	**1**	**2**	**3**	**Total**
1	27.04	15.82	23.98	33.16	100
2	12.18	15.01	25.5	47.31	100
3	4.56	8.94	43.16	43.34	100
4	1.6	4.77	14.11	79.52	100
Total	**3.95**	**6.81**	**21.54**	**67.7**	**100**

Table 4.8: Determinants of risk attitudes measures: Baseline specification

	Japan		U.S.	
Panel A	Subjective	Hypothetical	Subjective	Hypothetical
Mother's education	-0.057	-0.007	-0.036	-0.016
	(0.036)	(0.042)	(0.041)	(0.050)
Father's education	-0.017	-0.075*	-0.016	-0.101**
	(0.037)	(0.043)	(0.038)	(0.046)
Respondent's height	-0.006*	-0.009***	-0.003	-0.001
	(0.003)	(0.003)	(0.002)	(0.002)
Male	-0.440***	-0.179***	-0.157***	-0.335***
	(0.050)	(0.054)	(0.039)	(0.047)
Age	0.011***	0.019***	0.006***	0.008***
	(0.001)	(0.002)	(0.001)	(0.001)
cut1	-4.556***	-3.034***	-2.777***	-2.476***
	(0.497)	(0.528)	(0.312)	(0.367)
cut2	-4.224***	-2.114***	-2.154***	-1.713***
	(0.495)	(0.528)	(0.311)	(0.366)
cut3	-3.579***	-1.132**	-1.276***	-0.667*
	(0.494)	(0.527)	(0.311)	(0.365)
cut4	-2.536***		-0.647**	
	(0.493)		(0.310)	
cut5	-1.851***		-0.187	
	(0.493)		(0.310)	
cut6	-0.877*		0.547*	
	(0.492)		(0.310)	
cut7	-0.371		0.885***	
	(0.492)		(0.311)	
cut8	0.571		1.383***	
	(0.492)		(0.311)	
cut9	1.178**		1.998***	
	(0.493)		(0.311)	
cut10	1.844***		2.485***	
	(0.493)		(0.312)	
Observations	15498	15498	13459	13459
Number of ID	6264	6264	8376	8376
Panel B: Male				
Mother's education	-0.024	-0.006	-0.005	-0.077
	(0.053)	(0.060)	(0.060)	(0.071)
Father's education	-0.100*	-0.068	-0.046	-0.249***
	(0.053)	(0.060)	(0.057)	(0.067)
Respondent's height	-0.007*	-0.008*	-0.002	-0.001
	(0.004)	(0.004)	(0.003)	(0.003)
Age	0.010***	0.024***	0.009***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	7528	7528	6604	6604
Number of ID	3060	3060	4033	4033
Panel C: Female				
Mother's education	-0.088*	-0.008	-0.063	0.056
	(0.050)	(0.060)	(0.056)	(0.070)
Father's education	0.063	-0.083	0.008	0.040
	(0.051)	(0.060)	(0.051)	(0.064)
Respondent's height	-0.003	-0.009*	-0.004	0.000
	(0.004)	(0.005)	(0.003)	(0.003)
Age	0.011***	0.015***	0.003**	0.008***
	(0.002)	(0.002)	(0.001)	(0.002)
Observations	7970	7970	6855	6855
Number of ID	3204	3204	4364	4364

[1] Ordered probit coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each column in each panel is a separate regression.

Table 4.9: Determinants of risk attitudes measures: Full specification

	Japan		U.S.	
	Subjective	Hypothetical	Subjective	Hypothetical
Mother's education	-0.048	0.025	-0.017	0.008
	(0.036)	(0.043)	(0.041)	(0.050)
Father's education	-0.005	-0.036	0.005	-0.051
	(0.037)	(0.043)	(0.038)	(0.046)
Respondent's height	-0.005*	-0.007**	-0.002	-0.000
	(0.003)	(0.003)	(0.002)	(0.002)
Male	-0.384***	-0.160***	-0.118***	-0.298***
	(0.053)	(0.057)	(0.039)	(0.046)
Age	0.038***	0.017	0.015**	0.033***
	(0.010)	(0.011)	(0.007)	(0.008)
Age-squared	-0.030***	0.002	-0.012*	-0.027***
	(0.010)	(0.011)	(0.007)	(0.009)
Married	0.123***	-0.020	0.085**	0.191***
	(0.045)	(0.051)	(0.040)	(0.046)
Number of children	-0.040**	0.017	0.001	-0.030***
	(0.017)	(0.019)	(0.010)	(0.011)
Lives in a city	0.037	0.003	-0.022	-0.062
	(0.038)	(0.041)	(0.036)	(0.042)
Employment:				
Unemployed	0.135**	-0.025	0.124*	-0.147*
	(0.059)	(0.074)	(0.065)	(0.080)
Part-time	0.047	-0.018	0.052	0.046
	(0.041)	(0.050)	(0.046)	(0.058)
Self-employed	-0.077	-0.133**	-0.265***	-0.383***
	(0.048)	(0.055)	(0.050)	(0.057)
Not in Labour force	0.128***	-0.032	0.092**	0.053
	(0.037)	(0.044)	(0.039)	(0.048)
Education:				
College	-0.044	-0.066	-0.018	-0.038
	(0.042)	(0.047)	(0.046)	(0.056)
University+	-0.039	-0.201***	0.018	-0.258***
	(0.041)	(0.045)	(0.033)	(0.039)
Anxieties about health	-0.033***	-0.006	-0.038***	-0.017
	(0.011)	(0.014)	(0.011)	(0.013)
Risk of unemployment	0.007	-0.080***	-0.029	-0.056*
	(0.024)	(0.030)	(0.026)	(0.032)
Borrowing constraint	-0.249***	-0.136***	-0.131***	0.002
	(0.045)	(0.052)	(0.034)	(0.042)
Log of household income	-0.082***	-0.056**	-0.161***	-0.071***
	(0.023)	(0.027)	(0.023)	(0.027)
Log of net-wealth	-0.002	-0.001	-0.002	-0.006**
	(0.001)	(0.002)	(0.003)	(0.003)
Home ownership	0.062	0.079*	0.083**	0.068
	(0.043)	(0.047)	(0.036)	(0.043)
State GDP growth	0.000	-0.005	-0.010*	0.001
	(0.005)	(0.007)	(0.006)	(0.007)
Risk of a natural disaster	0.011	0.033**	-0.000	0.000
	(0.010)	(0.013)	(0.000)	(0.000)
State Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	15498	15498	13459	13459
Number of ID	6264	6264	8376	8376

[1] Ordered probit coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each column in each panel is a separate regression. [5] Omitted groups: *Education:* High school. *Employment Status:* Employed.

Table 4.10: Determinants of risk attitudes measures: By gender

	Japan		U.S.	
Panel A: Male	Subjective	Hypothetical	Subjective	Hypothetical
Mother's education	-0.010	0.026	0.031	-0.034
	(0.053)	(0.061)	(0.060)	(0.070)
Father's education	-0.072	-0.012	-0.016	-0.172***
	(0.053)	(0.061)	(0.057)	(0.066)
Respondent's height	-0.006	-0.008*	-0.001	-0.001
	(0.004)	(0.004)	(0.003)	(0.003)
Age	0.058***	0.040***	0.011	0.033***
	(0.014)	(0.015)	(0.010)	(0.011)
Age-squared	-0.048***	-0.017	-0.002	-0.026**
	(0.014)	(0.015)	(0.011)	(0.012)
Married	0.123*	0.094	0.022	0.180***
	(0.064)	(0.071)	(0.058)	(0.063)
Number of children	-0.115***	-0.019	-0.014	-0.025
	(0.025)	(0.027)	(0.014)	(0.016)
Lives in a city	0.040	-0.009	-0.100*	-0.137**
	(0.053)	(0.057)	(0.052)	(0.059)
Employment:				
Unemployed	0.196**	-0.007	0.106	-0.093
	(0.088)	(0.108)	(0.097)	(0.116)
Part-time	-0.163	-0.280*	0.029	0.015
	(0.129)	(0.153)	(0.081)	(0.097)
Self-employed	-0.030	-0.158**	-0.343***	-0.436***
	(0.058)	(0.067)	(0.065)	(0.071)
Not in Labour force	0.018	-0.190**	0.034	-0.073
	(0.066)	(0.079)	(0.065)	(0.075)
Education:				
College	-0.217***	-0.154*	-0.043	-0.026
	(0.076)	(0.083)	(0.070)	(0.081)
University+	-0.093*	-0.186***	-0.040	-0.358***
	(0.052)	(0.056)	(0.047)	(0.053)
Anxieties about health	-0.022	-0.029	-0.032**	-0.031*
	(0.016)	(0.019)	(0.016)	(0.018)
Risk of unemployment	0.008	-0.073*	-0.018	-0.052
	(0.034)	(0.041)	(0.037)	(0.043)
Borrowing constraint	-0.229***	-0.206***	-0.258***	-0.043
	(0.057)	(0.065)	(0.050)	(0.058)
Log of household income	-0.071**	-0.075*	-0.205***	-0.100***
	(0.033)	(0.038)	(0.034)	(0.038)
Log of net-wealth	-0.002	-0.001	-0.003	-0.006
	(0.002)	(0.002)	(0.004)	(0.004)
Home ownership	0.046	0.072	0.077	0.116**
	(0.060)	(0.065)	(0.052)	(0.059)
State GDP growth	-0.003	-0.004	-0.016**	-0.003
	(0.008)	(0.009)	(0.008)	(0.010)
Risk of a natural disaster	0.017	0.066***	-0.000	0.000
	(0.015)	(0.018)	(0.000)	(0.000)
Observations	7528	7528	6604	6604
Number of ID	3060	3060	4033	4033

Table 4.10: Determinants of risk attitudes measures: By gender. *(Continued)*

	Japan		U.S.	
	Subjective	Hypothetical	Subjective	Hypothetical
Panel B: Female				
Mother's education	-0.088*	0.018	-0.066	0.063
	(0.050)	(0.061)	(0.056)	(0.071)
Father's education	0.069	-0.048	0.016	0.066
	(0.051)	(0.061)	(0.051)	(0.065)
Respondent's height	-0.002	-0.006	-0.003	0.001
	(0.005)	(0.005)	(0.003)	(0.003)
Age	0.006	-0.013	0.014	0.028**
	(0.014)	(0.016)	(0.009)	(0.012)
Age-squared	0.002	0.029*	-0.015	-0.023*
	(0.014)	(0.016)	(0.010)	(0.013)
Married	0.135**	-0.190**	0.155***	0.179***
	(0.064)	(0.076)	(0.056)	(0.068)
Number of children	0.038	0.039	0.015	-0.033**
	(0.025)	(0.028)	(0.013)	(0.016)
Lives in a city	0.021	0.017	0.062	0.028
	(0.054)	(0.060)	(0.049)	(0.060)
Employment:				
Unemployed	0.040	-0.031	0.140	-0.180
	(0.081)	(0.102)	(0.089)	(0.112)
Part-time	0.065	0.066	0.041	0.068
	(0.046)	(0.056)	(0.056)	(0.074)
Self-employed	-0.209**	-0.124	-0.171**	-0.299***
	(0.085)	(0.100)	(0.078)	(0.096)
Not in Labour force	0.150***	0.075	0.102**	0.156**
	(0.046)	(0.055)	(0.050)	(0.065)
Education:				
College	0.053	-0.045	-0.005	-0.028
	(0.052)	(0.059)	(0.060)	(0.077)
University+	0.073	-0.244***	0.060	-0.152***
	(0.070)	(0.075)	(0.046)	(0.057)
Anxieties about health	-0.050***	0.015	-0.042***	0.003
	(0.016)	(0.020)	(0.015)	(0.019)
Risk of unemployment	0.006	-0.082*	-0.039	-0.063
	(0.035)	(0.043)	(0.036)	(0.047)
Borrowing constraint	-0.285***	-0.021	-0.012	0.059
	(0.072)	(0.089)	(0.048)	(0.062)
Log of household income	-0.107***	-0.034	-0.126***	-0.054
	(0.032)	(0.039)	(0.031)	(0.039)
Log of net-wealth	-0.002	-0.002	0.001	-0.007
	(0.002)	(0.002)	(0.003)	(0.005)
Home ownership	0.076	0.105	0.087*	0.026
	(0.061)	(0.068)	(0.049)	(0.062)
State GDP growth	0.004	-0.006	-0.004	0.003
	(0.007)	(0.009)	(0.008)	(0.010)
Risk of a natural disaster	0.005	-0.003	0.000	0.000
	(0.014)	(0.018)	(0.000)	(0.000)
Observations	7970	7970	6855	6855
Number of ID	3204	3204	4364	4364

[1] Ordered probit coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each column in each panel is a separate regression. [5] Omitted groups: *Education:* High school. *Employment Status:* Employed. [6] State fixed effects and year fixed effects are included in all the regressions.

Table 4.11: Marginal effects: Hypothetical gamble measure of risk attitudes

	Male				Female			
Panel A: Japan	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Mother's education	-0.0011	-0.0030	-0.0046	0.0087	-0.0003	-0.0017	-0.0037	0.0057
Father's education	0.0005	0.0013	0.0021	-0.0039	0.0007	0.0045	0.0096	-0.0149
Respondent's height	0.0003*	0.0009*	0.0015*	-0.0028*	0.0001	0.0006	0.0012	-0.0019
Age	-0.0017***	-0.0046***	-0.0072***	0.0135***	0.0002	0.0013	0.0027	-0.0041
Age-squared	0.0007	0.0019	0.0030	-0.0056	-0.0004*	-0.0027*	-0.0058*	0.0089*
Married	-0.0040	-0.0108	-0.0169	0.0317	0.0027**	0.0178**	0.0379**	-0.0584**
Number of children	0.0008	0.0021	0.0033	-0.0063	-0.0006	-0.0037	-0.0079	0.0121
Lives in a city	0.0004	0.0010	0.0015	-0.0029	-0.0002	-0.0016	-0.0033	0.0052
Employment:								
Unemployed	0.0003	0.0008	0.0012	-0.0022	0.0005	0.0031	0.0063	-0.0099
Part-time	0.0144	0.0345*	0.0470**	-0.0959*	-0.0009	-0.0062	-0.0133	0.0205
Self-employed	0.0073**	0.0185**	0.0274**	-0.0532**	0.0022	0.0131	0.0248	-0.0402
Not in Labour force	0.0090**	0.0226**	0.0327**	-0.0644**	-0.0011	-0.0070	-0.0150	0.0231
Education:								
College	0.0063*	0.0176*	0.0281*	-0.0521*	0.0006	0.0040	0.0091	-0.0137
University+	0.0079***	0.0215***	0.0337***	-0.0631***	0.0040***	0.0252***	0.0495***	-0.0787***
Anxieties about health	0.0012	0.0033	0.0052	-0.0097	-0.0002	-0.0014	-0.0031	0.0047
Risk of unemployment	0.0031*	0.0083*	0.0130*	-0.0243*	0.0012*	0.0077*	0.0163*	-0.0251*
Borrowing constraint	0.0087***	0.0235***	0.0368***	-0.0690***	0.0003	0.0020	0.0042	-0.0065
Log of household income	0.0032*	0.0085*	0.0133*	-0.0250*	0.0005	0.0032	0.0067	-0.0103
Log of net-wealth	0.0000	0.0001	0.0002	-0.0003	0.0000	0.0002	0.0003	-0.0005
Home ownership	-0.0031	-0.0082	-0.0129	0.0242	-0.0015	-0.0098	-0.0209	0.0322
State GDP growth	0.0002	0.0005	0.0008	-0.0014	0.0001	0.0006	0.0013	-0.0020
Risk of a natural disaster	-0.0028***	-0.0076***	-0.0119***	0.0222***	0.0000	0.0003	0.0006	-0.0009
Panel B: U.S.								
Mother's education	0.0015	0.0031	0.0067	-0.0113	-0.0007	-0.0040	-0.0129	0.0176
Father's education	0.0077**	0.0160***	0.0343***	-0.0580***	-0.0008	-0.0042	-0.0137	0.0187
Respondent's height	0.0000	0.0001	0.0001	-0.0002	-0.0000	-0.0001	-0.0002	0.0003
Age	-0.0015***	-0.0031***	-0.0066***	0.0111***	-0.0003**	-0.0018**	-0.0057**	0.0078**
Age-squared	0.0011**	0.0024**	0.0051**	-0.0087**	0.0003*	0.0014*	0.0047*	-0.0064*
Married	-0.0081***	-0.0168***	-0.0361***	0.0609***	-0.0021**	-0.0113***	-0.0368***	0.0503***
Number of children	0.0011	0.0023	0.0049	-0.0083	0.0004*	0.0021**	0.0068**	-0.0093**
Lives in a city	0.0061**	0.0127**	0.0273**	-0.0461**	-0.0003	-0.0017	-0.0057	0.0077
Employment:								
Unemployed	0.0040	0.0086	0.0189	-0.0315	0.0027	0.0134	0.0387	-0.0548
Part-time	-0.0006	-0.0013	-0.0030	0.0049	-0.0008	-0.0042	-0.0141	0.0190
Self-employed	0.0265***	0.0473***	0.0817***	-0.1554***	0.0053**	0.0244***	0.0650***	-0.0947***
Not in Labour force	0.0031	0.0067	0.0148	-0.0246	-0.0015**	-0.0089**	-0.0315**	0.0419**
Education:								
College	0.0008	0.0020	0.0055	-0.0083	0.0003	0.0016	0.0057	-0.0076
University+	0.0156***	0.0335***	0.0736***	-0.1226***	0.0018**	0.0098***	0.0316***	-0.0432***
Anxieties about health	0.0014*	0.0029*	0.0063*	-0.0106*	-0.0000	-0.0002	-0.0006	0.0009
Risk of unemployment	0.0023	0.0048	0.0103	-0.0175	0.0008	0.0040	0.0130	-0.0177
Borrowing constraint	0.0019	0.0040	0.0085	-0.0144	-0.0007	-0.0038	-0.0122	0.0167
Log of household income	0.0045**	0.0093***	0.0200***	-0.0337***	0.0006	0.0034	0.0111	-0.0151
Log of net-wealth	0.0003	0.0006	0.0013	-0.0022	0.0001	0.0004	0.0014	-0.0019
Home ownership	-0.0052*	-0.0108**	-0.0232**	0.0392**	-0.0003	-0.0017	-0.0054	0.0074
State GDP growth	0.0001	0.0003	0.0006	-0.0011	-0.0000	-0.0002	-0.0007	0.0009
Risk of a natural disaster	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000

[1] Ordered probit marginal effect estimates. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [2] Omitted groups: *Education:* High school. *Employment Status:* Employed. [6] State fixed effects and year fixed effects are included in all the regressions. [7] Outcome 1 refers to choosing value 0, while outcome 4 refers to value 3.

Table 4.12: Marginal effects: Subjective measure of risk attitudes

	Male				Female			
Panel A: Japan	Outcome 3	Outcome 5	Outcome 9	Outcome 11	Outcome 3	Outcome 5	Outcome 9	Outcome 11
Mother's education	0.0001	0.0014	-0.0009	-0.0002	0.0003*	0.0081*	-0.0112*	-0.0024*
Father's education	0.0008	0.0103	-0.0065	-0.0014	-0.0002	-0.0064	0.0088	0.0019
Respondent's height	0.0001	0.0008	-0.0005	-0.0001	0.0000	0.0002	-0.0002	-0.0000
Age	-0.0007***	-0.0082***	0.0052***	0.0011***	-0.0000	-0.0005	0.0007	0.0002
Age-squared	0.0006***	0.0068***	-0.0043***	-0.0009***	-0.0000	-0.0002	0.0002	0.0001
Married	-0.0014*	-0.0176*	0.0111*	0.0024*	-0.0004*	-0.0124**	0.0172**	0.0037**
Number of children	0.0013***	0.0164***	-0.0104***	-0.0022***	-0.0001	-0.0035	0.0049	0.0011
Lives in a city	-0.0005	-0.0057	0.0036	0.0008	-0.0001	-0.0019	0.0026	0.0006
Employment:								
Unemployed	-0.0018***	-0.0270**	0.0194**	0.0047*	-0.0001	-0.0039	0.0051	0.0010
Part-time	0.0023	0.0238	-0.0135	-0.0026	-0.0002	-0.0061	0.0082	0.0016
Self-employed	0.0004	0.0043	-0.0027	-0.0006	0.0009*	0.0228**	-0.0247***	-0.0039***
Not in Labour force	-0.0002	-0.0025	0.0016	0.0003	-0.0004***	-0.0136***	0.0195***	0.0042***
Education:								
College	0.0029**	0.0317***	-0.0185***	-0.0036***	-0.0002	-0.0049	0.0067	0.0015
University+	0.0011*	0.0134*	-0.0085*	-0.0018*	-0.0002	-0.0066	0.0093	0.0021
Anxieties about health	0.0003	0.0031	-0.0020	-0.0004	0.0001***	0.0046***	-0.0064***	-0.0014***
Risk of unemployment	-0.0001	-0.0012	0.0008	0.0002	-0.0000	-0.0005	0.0008	0.0002
Borrowing constraint	0.0027***	0.0327***	-0.0207***	-0.0045***	0.0008***	0.0263***	-0.0364***	-0.0079***
Log of household income	0.0008**	0.0101**	-0.0064**	-0.0014**	0.0003***	0.0099***	-0.0136***	-0.0030***
Log of net-wealth	0.0000	0.0002	-0.0001	-0.0000	0.0000	0.0002	-0.0002	-0.0000
Home ownership	-0.0005	-0.0065	0.0041	0.0009	-0.0002	-0.0070	0.0097	0.0021
State GDP growth	0.0000	0.0004	-0.0003	-0.0001	-0.0000	-0.0003	0.0004	0.0001
Risk of a natural disaster	-0.0002	-0.0024	0.0015	0.0003	-0.0000	-0.0005	0.0007	0.0002
Panel B: U.S.								
Mother's education	-0.0055	0.0001	0.0019	0.0003	0.0106	0.0025	-0.0051	-0.0008
Father's education	0.0028	-0.0001	-0.0010	-0.0001	-0.0027	-0.0006	0.0013	0.0002
Respondent's height	0.0002	-0.0000	-0.0001	-0.0000	0.0004	0.0001	-0.0002	-0.0000
Age	-0.0019	0.0000	0.0007	0.0001	-0.0023	-0.0005	0.0011	0.0002
Age-squared	0.0004	-0.0000	-0.0001	-0.0000	0.0024	0.0006	-0.0012	-0.0002
Married	-0.0040	0.0001	0.0014	0.0002	-0.0251***	-0.0060***	0.0120***	0.0018***
Number of children	0.0025	-0.0001	-0.0009	-0.0001	-0.0025	-0.0006	0.0012	0.0002
Lives in a city	0.0179*	-0.0004	-0.0061*	-0.0008*	-0.0101	-0.0024	0.0048	0.0007
Employment:								
Unemployed	-0.0185	-0.0008	0.0071	0.0010	-0.0219*	-0.0064	0.0114	0.0018
Part-time	-0.0051	-0.0000	0.0018	0.0003	-0.0067	-0.0016	0.0032	0.0005
Self-employed	0.0647***	-0.0095***	-0.0167***	-0.0019***	0.0293**	0.0036***	-0.0114**	-0.0015**
Not in Labour force	-0.0061	-0.0001	0.0022	0.0003	-0.0162**	-0.0044*	0.0081**	0.0012*
Education:								
College	0.0077	-0.0002	-0.0026	-0.0004	0.0008	0.0002	-0.0004	-0.0001
University+	0.0073	-0.0001	-0.0025	-0.0003	-0.0097	-0.0024	0.0047	0.0007
Anxieties about health	0.0058**	-0.0001	-0.0020**	-0.0003*	0.0068***	0.0016***	-0.0033***	-0.0005***
Risk of unemployment	0.0032	-0.0001	-0.0011	-0.0001	0.0062	0.0015	-0.0030	-0.0004
Borrowing constraint	0.0464***	-0.0011	-0.0157***	-0.0022***	0.0019	0.0005	-0.0009	-0.0001
Log of household income	0.0369***	-0.0008	-0.0125***	-0.0017***	0.0203***	0.0048***	-0.0097***	-0.0015***
Log of net-wealth	0.0006	-0.0000	-0.0002	-0.0000	-0.0001	-0.0000	0.0001	0.0000
Home ownership	-0.0139	0.0003	0.0047	0.0006	-0.0141*	-0.0034*	0.0067*	0.0010*
State GDP growth	0.0028**	-0.0001	-0.0010*	-0.0001*	0.0006	0.0002	-0.0003	-0.0000
Risk of a natural disaster	0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0000

[1] Ordered probit marginal effect estimates. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [2] Omitted groups: *Education:* High school. *Employment Status:* Employed. [6] State fixed effects and year fixed effects are included in all the regressions. [7] Outcome 3 refers to choosing value 2, while outcome 11 refers to value 10.

Table 4.13: Robustness check for the impact of earthquake risk.

	Hypothetical					Subjective				
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Full sample										
Average intensities	0.042 (0.030)					0.020 (0.024)				
No. of days with earthquake		0.001 (0.001)					0.000 (0.001)			
Max. intensity recorded			0.033** (0.013)					0.011 (0.010)		
Max. intensity recorded=3+				0.037** (0.018)					0.001 (0.014)	
Max. intensity recorded=4+					0.059** (0.027)					-0.007 (0.021)
Males										
Average intensities	0.058 (0.043)					0.052 (0.035)				
No. of days with earthquake		0.001 (0.001)					-0.001 (0.001)			
Max. intensity recorded			0.067*** (0.018)					0.018 (0.015)		
Max. intensity recorded=3+				0.090*** (0.025)					0.001 (0.020)	
Max. intensity recorded=4+					0.118*** (0.037)					-0.027 (0.030)
Female										
Average intensities	0.024 (0.043)					-0.008 (0.033)				
No. of days with earthquake		-0.000 (0.001)					0.001 (0.001)			
Max. intensity recorded			-0.003 (0.018)					0.006 (0.014)		
Max. intensity recorded=3+				-0.020 (0.026)					-0.000 (0.020)	
Max. intensity recorded=4+					-0.010 (0.039)					0.007 (0.030)

[1] Ordered probit coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each coefficient in each panel is a separate regression. [5] All controls that are in Table 4.9 are included in each regression.

Table 4.14: Marginal effects of the hypothetical gamble measure on male individuals

	Japanese male individuals			
Panel A	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Max. intensity recorded	-0.0028***	-0.0076***	-0.0119***	0.0222***
Mother's education	-0.0011	-0.0030	-0.0046	0.0087
Father's education	0.0005	0.0013	0.0021	-0.0039
Respondent's height	0.0003*	0.0009*	0.0015*	-0.0028*
Age	-0.0017***	-0.0046***	-0.0072***	0.0135***
Age-squared	0.0007	0.0019	0.0030	-0.0056
Married	-0.0040	-0.0108	-0.0169	0.0317
Number of children	0.0008	0.0021	0.0033	-0.0063
Lives in a city	0.0004	0.0010	0.0015	-0.0029
Employment:				
Unemployed	0.0003	0.0008	0.0012	-0.0022
Part-time	0.0144	0.0345*	0.0470**	-0.0959*
Self-employed	0.0073**	0.0185**	0.0274**	-0.0532**
Not in Labour force	0.0090**	0.0226**	0.0327**	-0.0644**
Education:				
College	0.0063*	0.0176*	0.0281*	-0.0521*
University+	0.0079***	0.0215***	0.0337***	-0.0631***
Anxieties about health	0.0012	0.0033	0.0052	-0.0097
Risk of unemployment	0.0031*	0.0083*	0.0130*	-0.0243*
Borrowing constraint	0.0087***	0.0235***	0.0368***	-0.0690***
Log of household income	0.0032*	0.0085*	0.0133*	-0.0250*
Log of net-wealth	0.0000	0.0001	0.0002	-0.0003
Home ownership	-0.0031	-0.0082	-0.0129	0.0242
State GDP growth	0.0002	0.0005	0.0008	-0.0014
State Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Panel B				
Max. intensity recorded=3+	-0.0038***	-0.0101***	-0.0158***	0.0297***
Panel C				
Max. intensity recorded=4+	-0.0050***	-0.0133***	-0.0209***	0.0391***
Panel D				
Average intensities	-0.0024	-0.0064	-0.0101	0.0189
Panel E				
No. of days with earthquake	-0.0001	-0.0002	-0.0002	0.0005

[1] Ordered probit marginal effects estimates. [2] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [3] Each panel is a separate regression. [4] All controls that are in panel A are included in panel B and panel C regressions. [5] Outcome 1 refers to choosing value 0, while outcome 4 refers to value 3.

Table 4.15: Validation of the risk attitudes measures: Marginal effects

Dependent variables	Explanatory variables			
	Japan		U.S.	
	Subjective	Hypothetical	Subjective	Hypothetical
Panel A: Risky behaviour				
Gambling	-0.007***	-0.009***	-0.010***	-0.007**
	(0.001)	(0.003)	(0.001)	(0.003)
Drinking	-0.002	-0.001	-0.002**	-0.011***
	(0.001)	(0.002)	(0.001)	(0.003)
Smoking	-0.003**	0.003	-0.003***	0.003
	(0.001)	(0.003)	(0.001)	(0.002)
Panel B: Assets choice				
Stock share	-0.004***	-0.004***	-0.005***	-0.009***
	(0.001)	(0.001)	(0.000)	(0.003)
Stock binary	-0.006***	-0.006*	-0.007***	-0.017***
	(0.001)	(0.003)	(0.000)	(0.005)
Saving	0.001	-0.002	-0.001	-0.004
	(0.001)	(0.003)	(0.523)	(0.004)
Bonds	0.007***	0.007	-0.002*	-0.006**
	(0.002)	(0.004)	(0.011)	(0.003)
Life insurance	-0.004*	-0.006	-0.003	0.012**
	(0.002)	(0.005)	(0.103)	(0.005)
Trust	-0.003**	-0.006**	-0.001	-0.001
	(0.001)	(0.003)	(0.270)	(0.004)
Pension	-0.002	-0.002	-0.002	0.011**
	(0.002)	(0.004)	(0.329)	(0.005)

[1] Probit marginal effects estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each coefficient in each panel is a separate regression were the dependent variables are the behavioural outcomes. [5] All controls that are in Table B5 are included in each regression.

Table 4.16: Validation of the risk attitudes measures: A joint modelling approach

	Japan		U.S.	
	Subjective	Hypothetical	Subjective	Hypothetical
Panel A: Risky behaviours				
Gambling	-0.4092***	-0.2352***	-0.4556***	-0.2480***
	(0.0461)	(0.0664)	(0.0392)	(0.0577)
ρ	0.4146***	0.1825**	0.4735***	0.3163***
	(0.0661)	(0.0845)	(0.0709)	(0.0930)
Drinking	-0.2993***	-0.1094	-0.2115***	-0.1911***
	(0.0751)	(0.0913)	(0.0645)	(0.0542)
ρ	0.3013***	0.0950	0.2056**	0.1058**
	(0.0917)	(0.1039)	(0.0841)	(0.0754)
Smoking	-0.4500***	-0.1589	-0.2387***	-0.2564
	(0.0556)	(0.0985)	(0.0485)	(0.0856)
ρ	0.4183***	0.2355	0.3568***	0.0568
	(0.0782)	(0.0596)	(0.0587)	(0.0568)
Panel B: Holdings of assets				
Stock share	-0.0879***	-0.1225***	-0.0559***	-0.0936***
	(0.0182)	(0.0208)	(0.0129)	(0.0141)
ρ	0.0541**	0.1212***	0.0389***	0.0823***
	(0.0209)	(0.0250)	(0.0159)	(0.0183)
Stock binary	-0.2487***	-0.3206***	-0.2387***	-0.2869***
	(0.0526)	(0.0607)	(0.0410)	(0.0501)
ρ	0.2011***	0.3340***	0.2618***	0.3201***
	(0.0657)	(0.0826)	(0.0613)	(0.0804)
Savings	0.0347	-0.0145	-0.0796*	-0.0138
	(0.0349)	(0.0445)	(0.0443)	(0.0583)
ρ	-0.0410	-0.0081	0.1150*	-0.0314
	(0.0487)	(0.0634)	(0.0662)	(0.0892)
Bonds	0.1088***	0.0141	-0.0196	-0.0931
	(0.0327)	(0.0422)	(0.0519)	(0.0632)
ρ	-0.0825**	0.0106	-0.0541	0.0571
	(0.0418)	(0.0541)	(0.0788)	(0.0983)
Life insurance	-0.0523**	-0.0798**	-0.0351	0.1006**
	(0.0263)	(0.0335)	(0.0392)	(0.0489)
ρ	0.0443	0.0768*	-0.0144	-0.0831
	(0.0353)	(0.0456)	(0.0556)	(0.0728)
Trust	-0.1088**	-0.2752***	-0.0559	0.0305
	(0.0541)	(0.0622)	(0.0349)	(0.0438)
ρ	0.0677	0.2730***	0.0647	-0.0580
	(0.0666)	(0.0837)	(0.0552)	(0.0711)
Pension	-0.0907***	-0.0637	-0.0363	0.0586
	(0.0305)	(0.0389)	(0.0340)	(0.0426)
ρ	0.1029**	0.0673	0.0397	-0.0418
	(0.0397)	(0.0511)	(0.0501)	(0.0646)

[1] Risky behaviours and assets choices equations are a random effects probit model. The equation of the share of stock is a fractional probit model. The equations of the two risk attitudes measures are a random effects ordered probit model. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each coefficient in each panel is a separate regression of a system of two equations linked via their error processes. [5] All controls that are in Table B5 are included in each regression. However, to achieve identification, in the risky choices equations, height of the respondents is excluded and a measure of financial potential at the state/prefecture levels is included. [6] ρ is the "atanhrho" which is an unbounded transformation of "rho" using arc-hyperbolic tangents. This coefficient represents the correlation between the residuals of the two equations for each regression.

4.9 Figures

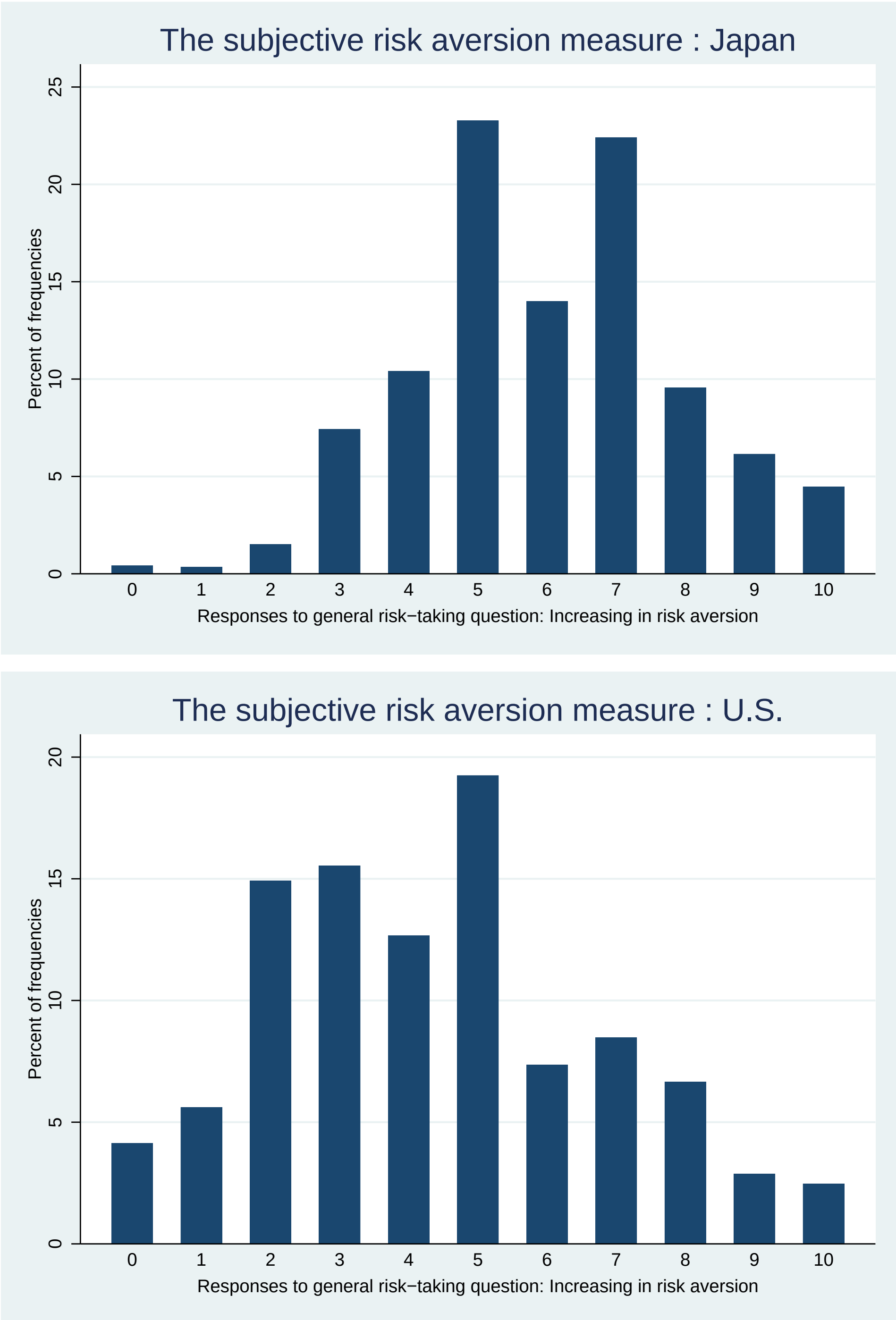


Figure 4.1: The distributions of the subjective risk attitudes measure

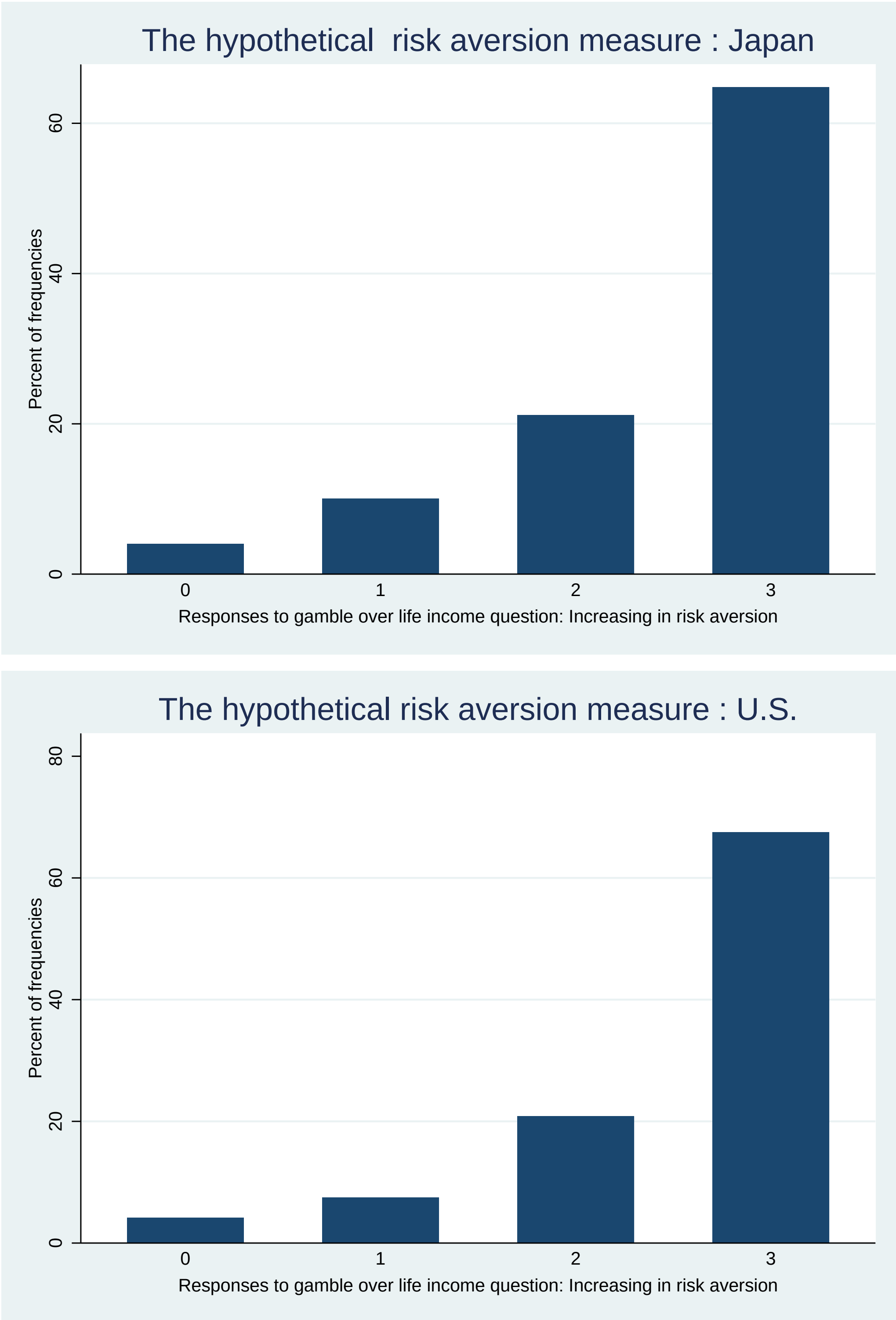


Figure 4.2: The distributions of the hypothetical gamble risk attitudes measure

Chapter 5

Conclusion

5.1 Conclusion

The overall aim of this thesis was to contribute to the existing literature relating to financial institutions' risk appetite and the household sector's risk profile. The level of financial risk in the economy has recently received increased academic attention as a result of the 2008 financial crisis. Using advanced macro-econometric and micro-econometric techniques, this thesis explored issues that have far reaching implications for the banking sector, household sector, policy makers and for the economy as a whole.

5.1.1 Thesis summary

The first empirical chapter was motivated by the excessive risk taking behaviours of banks during periods of low interest rate. The link between monetary policy and financial institutions' appetite for risk has received increased attention from researchers since this link has been identified as a potential cause of the 2008 financial crisis. Furthermore, there is strong evidence in the current literature that the responses of banks to an expansionary monetary policy shock vary across different types of banks. Therefore, the first empirical chapter used the Global Vector Autoregression (GVAR) methodology, developed by Pesaran et al. (2004), to examine three interrelated questions that concern the risk-taking channel of monetary policy. The chapter initially examined the impact of a downward exogenous change of the policy rate on banks' risk taking activities, profitability and lending behaviours. The heterogeneity of banks' behaviours in response to monetary policy shocks formed the second focus. Finally, the presence of spillover effects of credit risk within the banking system was examined.

To address these questions, bank level data relating to 30 banks from the largest 100 banks in the U.S., in terms of assets size, was examined over the period of 1985Q1-2007Q4. The data was extracted from the Consolidated Report of Condition and Income ("Call Reports"); all insured commercial banks in the U.S. have to submit this report to the Federal Reserve in each quarter.

Generally, the findings of this chapter supported the link between the interest rate and banks' risk taking, but also revealed that this relationship is more complex than earlier thought. In particular, the results indicated that while the increase in risk seems to be more pronounced and often more significant in larger, well capitalized banks, some banks do decrease risk. This observation is entirely consistent with the theoretical model presented in Chapter 2 Section 2.2 and with Dell'Ariccia et al. (2017) who discussed the role of capital structure in relation to banks' risk taking behaviours. The reactions of banks' profitability and lending behaviours to expansionary monetary policy shocks showed that these shocks can introduce fragility into the financial system as both indicators decline in the medium to the long-run.

The impulse response functions presented clear evidence of spillover effects of risk, as shocks originating from larger and riskier banks had lasting effects on the whole system. These results indicated a strong co-movement amongst banks' nonperforming loans in the sample and stressed the importance of a healthy banking system as a whole as well as at the bank level. The linkages among banks' variables are further confirmed by the results of the impact elasticity of the starred (foreign) variables on the domestic variables and the results of the GFEVD, which showed the relative contributions of each bank to the explanation of the forecast error variance of a simulated shock. The results of the first empirical chapter are robust to the use of two alternative measures of a bank's risk; nonperforming loans and the Z-score. Moreover, the results are also robust to the use of the Romer and Romer (2004) measure as an alternative proxy of monetary policy shock.

The second empirical chapter was motivated by the increasing interest in understanding households' financial decisions especially in a country like Japan where its ageing population problem is a crucial concern to the Japanese government. Within the current household finance literature, major developments have been made in explaining the determinants of risky asset holdings. However, only a small number of papers have empirically analysed these determinants for Japanese households. Increasing household risky asset holdings is likely to have a significant role in promoting growth and enhancing capital allocation efficiency; it is therefore imperative to understand the fundamental influences upon households risky asset holdings, such as those associated with households' socio-economic characteristics and financial variables. However, as well as these variables, households risky asset holdings are likely to be determined by factors which are associated with the investment environment in which households take their financial decisions. The focus of the second empirical chapter was to ascertain the determinants that influence the composition of Japanese households' financial portfolios.

The second empirical chapter analysed data drawn from the Keio Household Panel Survey (KHPS) available from the Panel Data Research Centre at Keio University to provide further insight into the determinants of risky asset holdings in Japan. All waves of the KHPS data set (2004 to 2015) were initially used to examine the determinants of risky asset holdings. Subsequently, the focus was only on wave 10 since in this wave respondents were asked detailed questions regarding their perceived risk of selected assets and respondents' opinions about the functioning of the stock market that potentially explain their financial decisions.

This chapter has contributed to the existing literature by exploring the role of key explanatory variables on holdings of risky assets as well as controlling for the standard socio-economic characteristics and financial variables. The key explanatory variables were related to three themes. The first is related to attitudinal factors and included: savings preferences; risk preferences; a variable that captures how comfortable individuals are about future income; and a variable that reflects the trust an individual has in government policies. The second set of variables is related to households' impressions of the overall reliability of the stock market and included variables related to trust in the profitability, fairness, efficiency and prudential supervision of the stock market. Individuals' trust in the stock market has been recently identified in the literature as an important factor in explaining stock market participation, but there are no studies that explore the role of this factor in Japan.[1] The final set of variables reflects a household's personal interpretation of the riskiness of selected assets. Furthermore, the second empirical chapter has contributed to the existing literature by using four different methodological approaches to assess whether the model employed affects the estimated parameter coefficients. The findings of the second empirical chapter are of importance to both policy makers and financial advisors. For example, to maximise households' asset returns, financial advisors have to advise individuals according to their socio-economic characteristics and personal circumstances.

The findings of the second empirical chapter indicated statistically significant impacts from the key explanatory variables considered in this chapter, revealing new channels which influence Japanese households' financial decisions. For example, household satisfaction with retirement income was found to have the most important impact on risky asset holdings in terms of magnitude amongst all the variables in the sets of key explanatory variables. This finding might reflect households' concerns about the ageing population issue in Japan and its consequences for who is going to fund future retirement income. Similarly, trust in the current government was also found to have an important impact on risky asset holdings. The results reported in this chapter confirmed that variables related to households' impressions of the overall reliability of the stock market are mostly negatively correlated with households' holdings of risky asset, and these negative effects are statistically significant across most of the modelling approaches. The results of the variables related to an individual's perception of risk associated with selected assets generally suggest that households invest in a manner which is consistent with their risk perceptions

[1] Guiso et al. (2008) examined the role of trust using data from the Dutch National Bank (DNB) Household Survey and data from the Italian Bank customers survey. Delis and Mylonidis (2015) also explored this factor using Dutch household survey data from the Longitudinal Internet Studies for the Social sciences (LISS) panel.

of saving accounts and investments in stocks.

Moreover, the four alternative methodological approaches employed in the analysis reinforced the robustness of the impact of the variables considered in this chapter and also revealed considerable heterogeneity in the effect of some variables across the different modelling approaches. The results were broadly consistent across the tobit model, the one-part FRM and the binary part of the two-part FRM. However, there were significant differences in terms of the magnitude of the marginal effects across these three models. Furthermore, the analysis showed that, when examining risky asset holdings conditional on participation, the coefficients differ not only in terms of magnitude but also in terms of sign and the level of significance. The CQR model revealed that considering only the effects of the regressors on the mean holdings of risky asset masks considerable heterogeneity in the effects of some variables. This confirms that each model unmasked an important aspect of the financial behaviour of Japanese households.

The third empirical chapter was motivated by the cautious attitudes of Japanese individuals towards risk compared to individuals from the U.S.. The conservative investment behaviour of Japanese households in risky asset holdings is one of the indicators of their strong aversion to risk.[2] In the existing literature, major developments have been made in ascertaining the determinants of individuals' attitudes towards risk. However, with the exception of Dohmen et al. (2016) and Vieider et al. (2015), comparisons of the determinants of risk attitudes across countries are scarce in the literature. Furthermore, it is important to understand how individuals' risk attitudes vary when they face a high risk of exposure to natural disasters, since systematic changes in risk attitudes will have a significant impact on social, economic and political aggregate outcomes.

[2]The Global Entrepreneurship Monitor (GEM) figures show that only 3.8% of adults engage in starting up a new business in Japan compared to 13.8% in the U.S. and an average of 8.0% of 29 countries.

The third empirical chapter has contributed to the existing literature by comparing the determinants of risk attitudes in two countries, Japan and the U.S., that differ significantly in the attitudes of their individuals towards risks. Another contribution of this chapter was the robust assessment of the impact of natural disasters, an exogenous shock, on risk attitudes by employing a set of different measures of natural disaster risk. In addition, this chapter examined the validity of the "Preference Parameters Study" measures of risk attitudes by assessing whether these measures reflect the actual risk taking behaviours of individuals. To achieve this, six waves (2005 to 2010) of the "Preference Parameters Study" conducted in Japan and the U.S. were analysed.

The results indicated that a number of variables have a statistically significant impact on individuals' risk attitudes in both countries. However, the magnitude and the statistical significance of some variables differed across Japan and the U.S.. For example, the magnitudes of some variables were larger for Japanese individuals, such as: age; being exposed to the risk of unemployment in the near future; and the risk of facing borrowing constraints. Whereas the magnitudes of other variables had a larger impact on U.S. respondents, such as: being self-employed; the level of education; income; and self-reported health status. The risk of exposure to natural disasters was found to only influence Japanese male individuals. Specifically, as the earthquake intensity increases, Japanese male individuals become less willing to take risk, and this finding was robust to the use of different earthquake risk measures. An interesting finding of this chapter was that the determinants, stability and susceptibility to change of attitudes towards risk were different depending on the gender and the country of the individual. The validity of the risk attitudes measures used in the final chapter was confirmed as they had considerable predictive power in explaining individuals' decisions in a variety of contexts. Moreover, the validity of these measures was further confirmed using a system of two equations to account for possible endogeneity between risky choices and attitudes towards risk.

5.1.2 Policy implications

Important policy implications can be drawn from the findings of this thesis. From the first empirical chapter, and consistent with the literature, it is evident that there is a link between changes in the interest rate and banks' risk taking. This link is relevant and important to both monetary policy authorities and academic circles. Given that the findings indicated that central banks can inadvertently destabilize the functioning of the financial markets, an integrated macroprudential regulation requires that the monetary authority's responsibilities may have to be extended beyond price stability and aggregate demand to encompass financial stability.

Important policy conclusions about Japanese households' financial decisions can be drawn from the findings of the second empirical chapter. For example, the motivation for using the two-part FRM was to understand which variables authorities and financial institutions might need to target in order to promote a culture of participation in the stock market in Japan given its historical performance, and which variables to target if the level of holdings was of concern. Education, age, gender, impressions about the stock market and future retirement income were found to impact the decision to participate in stock market. Whereas, only employment status, wealth and marital status were found to influence the level of risky asset holding. Such information cannot be deduced from the tobit and one-part FRM models as in these models the differential impacts that the covariates have on the decision to participate in stock market and the level of participation is not accounted for.

Finally, the findings of the third empirical chapter are potentially important to policy makers given that the attitude an individual has towards risk is a fundamental factor in explaining her/his behaviour. For example, by understanding individual risk attitudes, policy makers can achieve various vital realizations at the aggregate level such as: predicting labour market structure; predicting health related risky behaviours; and influencing investments, fertility and migration decisions. Furthermore, based on the findings of the third empirical chapter, it is possible that policy makers may locate and predict where policies, which aim to influence the risk profile of individuals, will have the greatest impact. Furthermore, the findings related to experiencing earthquakes mean that policy makers should expect systematic changes in the attitudes towards risk of Japanese male individuals after earthquakes with large intensities.

Chapter 6

Appendices

6.1 Appendix to Chapter 2

6.1.1 Tables

Table A1: Definitions of the Call Reports codes

Code	Definition
(rcfd3210)	Total equity capital.
(rcfd2170)	Total assets.
(rcfd1400)	Total loans and leases, gross.
(rcfd1975)	Loans to individuals.
(rcfd1600)	Commercial and industrial loans.
(rcfd1410)	Loans secured by real estate.
(rcfd1407)	Total loans and lease finance receivables, past due 90 days and more and still accruing.
(rcfd1403)	Total loans and lease finance receivables: nonaccrual.
(riad4340)	Net income (loss).
(rcfd1350)	Federal funds sold and securities purchased.
(rcfd2800)	Federal funds purchased and securities sold.

Table A2: Unit root tests for the domestic variables at the 5% significance level

	Nonperforming loans				Return on assets				Loan to assets			
	+Trend	**Level**	**1st diff.**	**2nd diff.**	**+Trend**	**Level**	**1st diff.**	**2nd diff.**	**+Trend**	**Level**	**1st diff.**	**2nd diff.**
Critical values	-3.450	-2.890	-2.890	-2.890	-3.450	-2.890	-2.890	-2.890	-3.450	-2.890	-2.890	-2.890
Bank2	-2.046	-0.986	-6.365	-9.506	-3.730	-3.738	-11.115	-7.763	-2.329	-1.176	-6.354	-7.609
Bank3	-2.498	-1.066	-5.221	-6.963	-2.681	-2.052	-4.028	-8.262	-2.595	-1.417	-4.937	-6.568
Bank4	-2.589	-2.566	-4.736	-6.605	-3.412	-3.435	-6.493	-8.884	-1.990	-1.828	-7.538	-8.285
Bank5	-2.669	-2.173	-4.124	-8.845	-3.650	-3.390	-6.050	-8.339	-1.994	-1.637	-5.161	-8.728
Bank6	-2.038	-2.058	-6.431	-7.153	-5.324	-2.490	-6.215	-7.945	-2.544	-2.822	-7.011	-7.075
Bank7	-2.236	-2.328	-3.715	-12.317	-2.792	-1.535	-6.259	-9.114	-2.321	-0.999	-5.911	-7.999
Bank11	-0.498	-0.997	-2.975	-7.964	-1.610	-1.950	-5.360	-7.372	-2.550	-0.526	-6.342	-8.463
Bank13	-2.267	-1.480	-3.850	-11.586	-6.936	-6.937	-9.633	-12.693	-0.815	-1.917	-6.641	-7.327
Bank15	-2.533	-1.327	-6.356	-7.665	-3.799	-3.546	-10.158	-8.749	-1.188	-1.495	-3.706	-10.497
Bank16	-2.594	-2.545	-5.453	-7.217	-1.841	-1.574	-10.549	-8.232	-2.035	-1.192	-5.165	-7.201
Bank17	-1.980	-1.616	-3.748	-10.356	-2.417	-2.202	-7.949	-9.449	-1.254	0.460	-5.106	-8.603
Bank19	-2.632	-1.414	-5.011	-9.142	-3.548	-3.570	-9.618	-8.726	-2.123	-1.066	-6.683	-7.471
Bank21	-2.226	-2.560	-4.130	-13.609	-3.395	-2.061	-7.713	-10.138	-2.320	-1.102	-4.602	-7.843
Bank25	-2.922	-2.998	-4.744	-11.593	-0.235	-0.312	-7.827	-10.435	-2.597	-2.086	-7.150	-8.968
Bank26	-3.462	-2.716	-5.720	-6.912	-2.458	-2.759	-9.361	-11.681	-2.085	0.277	-13.668	-7.754
Bank29	-1.813	-1.962	-4.262	-7.498	-2.841	-2.935	-8.702	-7.206	-2.919	-1.796	-4.231	-14.424
Bank30	-3.263	-3.996	-5.694	-8.351	-2.848	-2.985	-7.018	-9.025	-2.159	-1.215	-5.270	-7.436
Bank33	-2.406	-2.220	-4.842	-8.294	-1.863	-1.341	-7.304	-9.018	-3.003	-1.743	-4.100	-10.754
Bank36	-0.256	-1.406	-5.689	-7.412	-0.002	-1.274	-5.203	-8.084	-2.297	-1.447	-7.657	-8.060
Bank38	-1.884	-2.399	-5.983	-7.477	-3.153	-3.262	-6.562	-8.644	-4.664	-2.014	-7.882	-7.339
Bank39	-2.191	-2.246	-5.536	-7.916	-1.581	-2.229	-7.429	-10.249	-2.673	-2.904	-4.875	-6.398
Bank42	-2.786	-1.271	-6.891	-9.344	-1.820	-1.909	-11.746	-8.591	-1.368	0.175	-5.499	-8.086
Bank46	-3.517	-3.365	-6.917	-7.743	-3.335	-3.550	-9.384	-16.927	-1.922	-2.071	-7.433	-7.197
Bank51	-1.791	-1.284	-7.342	-7.449	-2.352	-2.378	-7.779	-8.528	-1.048	-0.980	-5.319	-8.092
Bank53	-2.048	-1.697	-4.858	-7.336	-1.902	-1.821	-2.848	-8.399	-1.985	-1.588	-6.096	-7.863
Bank54	-2.748	-1.874	-4.645	-6.653	-1.889	-1.141	-8.510	-13.032	-1.874	-2.317	-3.995	-8.831
Bank56	-1.967	-2.546	-6.736	-7.804	-2.405	-1.366	-7.767	-7.927	-1.991	-0.961	-3.693	-10.181
Bank58	-1.699	-1.441	-6.189	-8.360	-3.718	-3.247	-6.241	-7.293	-2.491	-1.969	-5.614	-7.373
Bank59	-1.460	-1.115	-6.614	-8.855	-3.344	-0.840	-10.302	-10.024	-1.942	-0.933	-2.768	-8.711
Bank61	-2.685	-2.466	-3.089	-11.357	-2.454	-1.928	-5.145	-8.435	-2.681	-2.607	-4.085	-7.301

Table A3: Unit root tests for the foreign variables at the 5% significance level

	Nonperforming loans				Return on assets				Loan to assets			
	+Trend	**Level**	**1st diff.**	**2nd diff.**	**+Trend**	**Level**	**1st diff.**	**2nd diff.**	**+Trend**	**Level**	**1st diff.**	**2nd diff.**
Critical Value	-3.24	-2.55	-2.55	-2.55	-3.24	-2.55	-2.55	-2.55	-3.45	-2.55	-2.55	-2.55
Bank2	-2.184	-1.870	-4.017	-6.774	-1.915	-1.915	-7.427	-7.831	-2.728	-1.936	-4.206	-8.223
Bank3	-1.539	-1.435	-5.922	-9.427	-4.617	-4.392	-9.710	-7.590	-2.299	-0.777	-6.475	-8.794
Bank4	-1.477	-1.387	-5.854	-9.202	-3.863	-3.579	-5.855	-7.681	-2.545	-0.704	-6.501	-7.727
Bank5	-1.486	-1.402	-5.857	-9.292	-3.883	-3.656	-5.779	-7.596	-2.351	-0.751	-6.376	-7.474
Bank6	-1.481	-1.394	-5.815	-9.165	-3.890	-3.650	-5.834	-7.654	-2.385	-0.706	-6.418	-8.709
Bank7	-1.473	-1.390	-5.804	-9.172	-3.881	-3.570	-5.833	-7.649	-2.351	-0.692	-6.435	-7.513
Bank11	-1.481	-1.391	-5.788	-9.129	-3.902	-3.611	-5.838	-7.679	-2.365	-0.718	-6.392	-8.628
Bank13	-1.486	-1.409	-5.801	-9.033	-3.869	-3.537	-5.861	-7.773	-2.380	-0.848	-6.337	-8.479
Bank15	-1.484	-1.398	-5.807	-9.180	-3.905	-3.647	-5.841	-7.670	-2.355	-0.720	-6.390	-8.610
Bank16	-1.477	-1.394	-5.802	-9.138	-3.911	-3.621	-5.834	-7.651	-2.365	-0.712	-6.411	-8.688
Bank17	-1.436	-1.409	-5.654	-8.911	-3.917	-4.258	-5.806	-7.625	-2.349	-0.893	-6.494	-8.558
Bank19	-1.481	-1.398	-5.797	-9.144	-3.900	-3.627	-5.819	-7.641	-2.368	-0.745	-6.391	-8.626
Bank21	-1.478	-1.398	-5.805	-9.150	-3.900	-3.635	-5.830	-7.666	-2.374	-0.717	-6.405	-8.672
Bank25	-1.481	-1.395	-5.794	-9.143	-3.906	-3.620	-5.818	-7.643	-2.388	-0.704	-6.400	-8.711
Bank26	-1.470	-1.400	-5.796	-9.166	-3.899	-3.632	-5.832	-7.669	-2.361	-0.742	-6.403	-7.518
Bank29	-1.481	-1.396	-5.811	-9.170	-3.895	-3.625	-5.829	-7.659	-2.384	-0.712	-6.411	-8.689
Bank30	-1.482	-1.396	-5.820	-9.175	-3.894	-3.634	-5.828	-7.654	-2.379	-0.707	-6.401	-7.513
Bank33	-1.483	-1.395	-5.840	-9.206	-3.901	-3.648	-5.830	-7.651	-2.385	-0.710	-6.411	-7.533
Bank36	-1.482	-1.395	-5.813	-9.159	-3.904	-3.643	-5.831	-7.672	-2.376	-0.719	-6.399	-8.678
Bank38	-1.482	-1.395	-5.839	-9.200	-3.903	-3.649	-5.833	-7.652	-2.385	-0.709	-6.404	-7.519
Bank39	-1.488	-1.392	-5.888	-9.265	-3.906	-3.681	-5.835	-7.650	-2.392	-0.688	-6.408	-7.572
Bank42	-1.479	-1.400	-5.824	-9.197	-3.878	-3.642	-5.805	-7.643	-2.381	-0.763	-6.445	-8.715
Bank46	-1.483	-1.394	-5.846	-9.213	-3.900	-3.652	-5.830	-7.651	-2.389	-0.706	-6.406	-7.531
Bank51	-1.474	-1.404	-5.712	-9.024	-3.883	-3.573	-5.820	-7.677	-2.357	-0.754	-6.389	-8.598
Bank53	-1.470	-1.404	-5.709	-9.048	-3.873	-3.554	-5.815	-7.658	-2.370	-0.768	-6.420	-8.632
Bank54	-1.489	-1.392	-5.892	-9.272	-3.903	-3.682	-5.823	-7.633	-2.392	-0.688	-6.411	-7.574
Bank56	-1.474	-1.401	-5.751	-9.095	-3.886	-3.592	-5.826	-7.658	-2.373	-0.744	-6.410	-8.653
Bank58	-1.472	-1.403	-5.713	-9.047	-3.871	-3.552	-5.817	-7.655	-2.367	-0.768	-6.409	-8.633
Bank59	-1.474	-1.406	-5.687	-9.011	-3.869	-3.545	-5.819	-7.657	-2.363	-0.782	-6.415	-8.617
Bank61	-1.482	-1.396	-5.823	-9.185	-3.897	-3.635	-5.829	-7.652	-2.382	-0.717	-6.406	-7.515

Table A4: Panel unit root tests for the domestic variables

	+Trend	Level	1st diff.	2nd diff.
Nonperforming loans	-0.598	-0.687	-12.451	-27.687
	(0.275)	(0.246)	(0.000)	(0.000)
Return on assets	6.382	3.5693	-36.968	-20.913
	(0.998)	(0.988)	(0.000)	(0.000)
Loan to assets	-0.443	-1.318	-14.611	-25.138
	(0.329)	(0.114)	(0.000)	(0.000)

The table shows the Levin–Lin–Chu bias-adjusted t statistic (Levin et al. (2002)) and the p-values in parentheses. The number of lags for each panel is set by minimizing the AIC, subject to a maximum of 10 lags. H0: Panels contain unit roots, H1: Panels are stationary.

Table A5: Test for weak exogeneity at the 5% significance level

Bank's name	**F test**	**Critical value 5%**	**Nonperf. loans**	**return on assets**	**Loan to assets**	**GDP**	**Interest rate**	**hpi**
Bank2	F(2,76)	3.1170	3.4775	2.7901	1.1392	5.7994	0.0127	0.7164
Bank3	F(1,77)	3.9651	0.0009	5.1588	0.1122	2.1454	0.4877	1.7710
Bank4	F(1,77)	3.9651	1.5094	1.9309	0.8267	0.8158	0.0072	0.3070
Bank5	F(3,75)	2.7266	0.9018	0.1347	0.3269	1.5914	2.0194	0.3593
Bank6	F(1,77)	3.9651	0.0412	0.0553	1.4257	0.0643	0.0640	3.9422
Bank7	F(3,75)	2.7266	0.5578	2.9591	1.4253	1.2630	7.2486	0.4582
Bank11	F(3,75)	2.7266	0.8892	2.1146	2.4606	0.9227	0.3254	0.9293
Bank13	F(3,75)	2.7266	0.4823	4.2033	2.4025	1.6600	3.8017	1.7200
Bank15	F(2,76)	3.1170	2.3757	1.0253	1.5619	2.6316	0.4066	1.5268
Bank16	F(1,77)	3.9651	0.3926	0.7289	0.1981	0.1039	0.8308	0.2694
Bank17	F(1,77)	3.9651	0.1077	1.5679	1.4994	0.6576	0.4908	1.0246
Bank19	F(2,76)	3.1170	0.7606	2.1864	1.0255	0.5495	0.9425	1.2365
Bank21	F(2,76)	3.1170	0.0665	4.6269	2.9454	1.9350	2.4128	1.7943
Bank25	F(2,76)	3.1170	0.4716	0.3736	5.8730	0.4513	0.1984	3.8645
Bank26	F(2,76)	3.1170	1.4335	2.3407	0.9013	0.3357	4.3716	0.2398
Bank29	F(1,77)	3.9651	1.2707	0.2132	1.1634	1.2994	0.4682	0.2249
Bank30	F(2,76)	3.1170	0.1343	0.8612	2.9386	0.3735	3.3881	0.7690
Bank33	F(3,75)	2.7266	1.1061	4.5798	0.4717	1.5142	0.5416	0.2772
Bank36	F(1,77)	3.9651	0.4226	2.0718	0.8569	4.7184	0.9441	1.3861
Bank38	F(3,75)	2.7266	0.7324	0.3926	2.4811	0.9101	7.2336	1.2041
Bank39	F(1,77)	3.9651	0.9952	0.0377	1.6445	0.2445	0.3726	0.0984
Bank42	F(2,76)	3.1170	0.8712	0.1628	1.9042	1.6287	1.2571	0.0213
Bank46	F(1,77)	3.9651	0.0097	1.4337	0.1994	8.5880	0.0048	1.6164
Bank51	F(2,76)	3.1170	1.6700	3.8676	0.6857	0.1578	1.3134	0.1268
Bank53	F(2,76)	3.1170	1.9231	0.2885	0.1015	1.0184	1.9646	0.0007
Bank54	F(3,75)	2.7266	0.1378	4.4748	0.9187	1.4493	1.2937	0.5683
Bank56	F(3,75)	2.7266	0.1013	2.4943	0.4794	0.9546	3.0382	1.0555
Bank58	F(3,75)	2.7266	0.7165	3.5846	0.8237	0.1425	2.1528	1.3477
Bank59	F(2,76)	3.1170	0.3865	0.3588	0.0683	0.0968	4.7613	0.0283
Bank61	F(2,76)	3.1170	1.4397	4.3236	1.7975	2.0857	5.0037	0.1572

Table A6: Average pairwise cross-section correlations: variables and residuals

	Nonperforming loans			Return on Assets			Loan to assets		
	Level	**1st Diff.**	**VECMX***	**Level**	**1st Diff.**	**VECMX***	**Level**	**1st Diff.**	**VECMX***
Bank2	0.6262	0.2070	-0.1004	0.0959	0.0186	-0.0729	-0.1016	0.0556	-0.0193
Bank3	0.6271	0.2351	0.0060	0.2925	0.1304	0.0406	0.0091	0.0766	0.0212
Bank4	0.4342	0.1928	0.0440	0.0732	0.0577	0.0441	0.0215	0.0371	0.0027
Bank5	0.5217	0.1688	-0.0095	0.1682	0.0747	0.0395	-0.1111	0.0020	-0.0022
Bank6	0.3987	0.1030	0.0168	0.2375	0.0791	0.0853	0.1501	0.0364	0.0081
Bank7	0.3773	0.1884	0.0002	-0.1873	0.0289	0.0464	0.1081	0.0570	0.0323
Bank11	0.5037	0.1884	0.0016	0.2276	0.1494	0.0856	0.0700	0.0739	0.0427
Bank13	0.5664	0.1025	-0.0342	-0.0141	0.0299	0.0357	-0.0651	0.0185	-0.0088
Bank15	0.4785	0.1337	0.0166	0.2232	0.1097	0.0107	0.1482	0.0561	0.0093
Bank16	0.3368	0.0868	0.0252	0.0549	0.0257	0.0190	0.1037	0.0438	0.0028
Bank17	0.6446	0.1225	0.0148	0.2945	0.0714	0.0194	-0.0548	-0.0026	-0.0001
Bank19	0.5610	0.0424	-0.0238	0.1025	0.0005	-0.0407	-0.0223	0.0398	0.0712
Bank21	0.5141	0.0823	0.0157	0.2706	0.1307	0.0593	0.1128	0.0582	-0.0107
Bank25	0.3743	0.1545	0.0340	0.1030	-0.0261	0.0192	-0.0348	0.0420	0.0236
Bank26	0.4633	0.0834	-0.0064	0.2031	0.1616	0.0304	-0.0413	0.0250	-0.0242
Bank29	0.5481	0.1825	0.0643	0.1728	0.0570	0.0608	0.1174	0.0688	0.0054
Bank30	0.2182	0.0819	0.0059	0.1416	0.0011	0.0393	0.0220	0.0622	0.0449
Bank33	0.4276	0.1331	0.0009	-0.0063	0.0175	0.0050	0.0274	0.0701	-0.0270
Bank36	0.5142	0.1014	0.0453	0.3146	0.0945	0.0274	0.0820	0.0196	0.0050
Bank38	0.5652	0.1466	0.0217	0.2428	0.1174	0.0488	0.0317	-0.0129	0.0215
Bank39	0.3760	0.1228	0.0336	0.3304	0.0833	0.0214	-0.0397	0.0128	0.0446
Bank42	0.5055	0.0941	0.0071	0.2909	0.0724	0.0047	-0.0368	0.0391	0.0208
Bank46	0.0977	0.0302	0.0153	0.1155	0.0339	0.0438	-0.0118	0.0048	0.0162
Bank51	0.4464	0.0343	-0.0315	0.2710	0.1142	0.0427	-0.0339	0.0441	0.0256
Bank53	0.4130	0.1784	-0.0153	0.1616	0.0626	0.0215	0.1733	0.0300	-0.0095
Bank54	0.3853	-0.0036	-0.0150	0.2367	0.0830	-0.0051	-0.0610	0.0770	0.0615
Bank56	0.2955	0.0510	0.0168	0.2447	0.0546	0.0178	0.1248	0.0396	0.0243
Bank58	0.3619	0.0223	-0.0087	0.1919	0.0114	0.0159	0.0717	-0.0031	0.0066
Bank59	0.5834	0.0209	0.0161	0.2528	-0.0494	-0.0422	0.1040	0.0915	0.0250
Bank61	0.4052	0.1383	-0.0178	-0.0678	0.0425	0.0783	0.1724	0.1068	0.0398

Table A7: Corresponding Moduli of the eigenvalues of the GVAR Model

Moduli	Count
1	1
1	2
1	3
1	4
1	5
1	6
1	7
1	8
1	9
1	10
1	11
1	12
1	13
1	14
1	15
1	16
1	17
1	18
1	19
1	20
1	21
1	22
1	23
1	24
1	25
1	26
1	27
1	28
1	29
1	30
1	31
1	32
1	33
0.97903148	34
0.97903148	35
.	.
.	.
.	.
.	.

Table A8: Generalized forecast error variance decompositions: A positive standard error unit shock to Bank2 nonperforming loans

Quarter		**0**	**1**	**2**	**4**	**8**	**12**	**24**
Bank2	Nonperforming loans	0.313	0.238	0.155	0.090	0.046	0.037	0.027
Bank2	Return on assets	0.002	0.010	0.010	0.011	0.013	0.011	0.010
Bank2	Loans to assets	0.011	0.078	0.067	0.097	0.116	0.151	0.148
Bank3	Nonperforming loans	0.117	0.111	0.114	0.125	0.159	0.150	0.112
Bank3	Return on assets	0.002	0.027	0.044	0.090	0.088	0.089	0.075
Bank3	Loans to assets	0.002	0.007	0.013	0.020	0.025	0.028	0.020
Bank4	Nonperforming loans	0.076	0.056	0.084	0.067	0.050	0.044	0.042
Bank4	Return on assets	0.002	0.023	0.031	0.036	0.022	0.016	0.011
Bank4	Loans to assets	0.011	0.013	0.014	0.024	0.037	0.038	0.034
Bank5	Nonperforming loans	0.005	0.005	0.004	0.004	0.003	0.002	0.003
Bank5	Return on assets	0.001	0.003	0.003	0.003	0.002	0.002	0.002
Bank5	Loans to assets	0.001	0.001	0.002	0.003	0.002	0.002	0.002
Bank6	Nonperforming loans	0.005	0.004	0.004	0.003	0.002	0.002	0.002
Bank6	Return on assets	0.002	0.003	0.004	0.004	0.003	0.002	0.002
Bank6	Loans to assets	0.001	0.002	0.004	0.004	0.004	0.004	0.003
Bank7	Nonperforming loans	0.001	0.002	0.002	0.002	0.002	0.002	0.001
Bank7	Return on assets	0.001	0.001	0.002	0.002	0.002	0.002	0.001
Bank7	Loans to assets	0.001	0.001	0.002	0.002	0.001	0.001	0.001
Bank11	Nonperforming loans	0.002	0.002	0.002	0.002	0.002	0.001	0.001
Bank11	Return on assets	0.001	0.003	0.003	0.004	0.002	0.002	0.002
Bank11	Loans to assets	0.001	0.001	0.002	0.002	0.002	0.001	0.001
Bank13	Nonperforming loans	0.010	0.007	0.008	0.007	0.005	0.004	0.004
Bank13	Return on assets	0.002	0.003	0.003	0.003	0.003	0.002	0.002
Bank13	Loans to assets	0.002	0.003	0.003	0.003	0.002	0.002	0.002
Bank15	Nonperforming loans	0.002	0.002	0.003	0.003	0.002	0.003	0.002
Bank15	Return on assets	0.001	0.002	0.003	0.003	0.002	0.002	0.002
Bank15	Loans to assets	0.002	0.002	0.005	0.005	0.004	0.003	0.003
Bank16	Nonperforming loans	0.007	0.006	0.007	0.006	0.005	0.004	0.003
Bank16	Return on assets	0.001	0.002	0.002	0.003	0.002	0.002	0.002
Bank16	Loans to assets	0.001	0.002	0.003	0.006	0.007	0.007	0.006
Bank17	Nonperforming loans	0.013	0.010	0.015	0.009	0.006	0.005	0.004
Bank17	Return on assets	0.001	0.003	0.002	0.003	0.002	0.003	0.004
Bank17	Loans to assets	0.002	0.003	0.003	0.005	0.004	0.003	0.003
Bank19	Nonperforming loans	0.001	0.002	0.002	0.002	0.002	0.002	0.001
Bank19	Return on assets	0.001	0.001	0.002	0.002	0.002	0.002	0.002
Bank19	Loans to assets	0.001	0.001	0.002	0.002	0.002	0.002	0.001
Bank21	Nonperforming loans	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Bank21	Return on assets	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Bank21	Loans to assets	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Bank25	Nonperforming loans	0.004	0.003	0.005	0.006	0.007	0.007	0.007
Bank25	Return on assets	0.001	0.002	0.005	0.007	0.006	0.006	0.005
Bank25	Loans to assets	0.002	0.002	0.006	0.005	0.005	0.005	0.005
Bank26	Nonperforming loans	0.001	0.002	0.003	0.003	0.003	0.003	0.002
Bank26	Return on assets	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Bank26	Loans to assets ratio	0.001	0.002	0.003	0.003	0.003	0.004	0.003
Bank29	Nonperforming loans	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank29	Return on assets	0.001	0.002	0.003	0.003	0.002	0.002	0.002
Bank29	Loans to assets	0.001	0.001	0.002	0.002	0.002	0.002	0.002

Table A8: Generalized forecast error variance decompositions: A positive standard error unit shock to Bank2 nonperforming loans. *(Continued)*

Quarter		**0**	**1**	**2**	**4**	**8**	**12**	**24**
Bank30	Nonperforming loans	0.001	0.002	0.002	0.002	0.002	0.002	0.001
Bank30	Return on assets	0.001	0.001	0.001	0.001	0.002	0.001	0.001
Bank30	Loans to assets	0.001	0.001	0.001	0.002	0.002	0.002	0.001
Bank33	Nonperforming loans	0.001	0.001	0.002	0.002	0.002	0.002	0.001
Bank33	Return on assets	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Bank33	Loans to assets	0.001	0.002	0.001	0.002	0.002	0.002	0.001
Bank36	Nonperforming loans	0.003	0.003	0.004	0.003	0.003	0.003	0.002
Bank36	Return on assets	0.001	0.002	0.002	0.003	0.003	0.004	0.003
Bank36	Loans to assets	0.001	0.001	0.002	0.002	0.002	0.001	0.001
Bank38	Nonperforming loans	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Bank38	Return on assets	0.001	0.001	0.001	0.002	0.002	0.001	0.001
Bank38	Loans to assets	0.001	0.001	0.001	0.002	0.002	0.002	0.002
Bank39	Nonperforming loans	0.002	0.002	0.003	0.002	0.003	0.003	0.003
Bank39	Return on assets	0.002	0.002	0.003	0.002	0.002	0.002	0.002
Bank39	Loans to assets	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Bank42	Nonperforming loans	0.005	0.005	0.006	0.006	0.006	0.007	0.005
Bank42	Return on assets	0.001	0.002	0.002	0.003	0.002	0.002	0.002
Bank42	Loans to assets	0.001	0.002	0.002	0.006	0.011	0.014	0.011
Bank46	Nonperforming loans	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Bank46	Return on assets	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Bank46	Loans to assets	0.001	0.002	0.003	0.004	0.003	0.003	0.002
Bank51	Nonperforming loans	0.001	0.002	0.002	0.003	0.003	0.004	0.003
Bank51	Return on assets	0.001	0.001	0.002	0.002	0.001	0.001	0.001
Bank51	Loans to assets	0.001	0.001	0.002	0.002	0.002	0.001	0.001
Bank53	Nonperforming loans	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Bank53	Return on assets	0.001	0.001	0.002	0.002	0.002	0.002	0.001
Bank53	Loans to assets	0.002	0.002	0.001	0.002	0.002	0.002	0.002
Bank54	Nonperforming loans	0.001	0.002	0.002	0.002	0.002	0.001	0.001
Bank54	Return on assets	0.001	0.001	0.002	0.002	0.002	0.002	0.002
Bank54	Loans to assets	0.001	0.002	0.002	0.002	0.001	0.001	0.001
Bank56	Nonperforming loans	0.001	0.001	0.002	0.002	0.002	0.002	0.001
Bank56	Return on assets	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Bank56	Loans to assets	0.001	0.001	0.002	0.004	0.008	0.008	0.007
Bank58	Nonperforming loans	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Bank58	Return on assets	0.001	0.001	0.002	0.002	0.002	0.002	0.001
Bank58	Loans to assets	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Bank59	Nonperforming loans	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Bank59	Return on assets	0.001	0.002	0.001	0.002	0.002	0.002	0.002
Bank59	Loans to assets	0.001	0.002	0.002	0.002	0.002	0.001	0.001
Bank61	Nonperforming loans	0.001	0.001	0.001	0.002	0.002	0.001	0.001
Bank61	Return on assets	0.001	0.001	0.002	0.002	0.002	0.002	0.001
Bank61	Loans to assets	0.001	0.001	0.002	0.002	0.001	0.001	0.001
Global	GDP	0.007	0.016	0.018	0.025	0.023	0.033	0.043
Global	Interest rate	0.016	0.042	0.048	0.065	0.138	0.120	0.190
Global	hpi	0.006	0.016	0.021	0.028	0.045	0.051	0.075

Notes: Proportion of the N-step ahead forecast error variance of of the historical shock to the Bank2 nonperforming loans.

Table A9: Generalized forecast error variance decompositions: A positive standard error unit shock to Bank61 nonperforming loans

Quarter		**0**	**1**	**2**	**4**	**8**	**12**	**24**
Bank2	Nonperforming loans	0.025	0.066	0.049	0.081	0.045	0.035	0.024
Bank2	Return on assets	0.008	0.021	0.018	0.010	0.012	0.012	0.009
Bank2	Loans to assets	0.012	0.018	0.017	0.025	0.028	0.031	0.042
Bank3	Nonperforming loans	0.005	0.030	0.024	0.073	0.098	0.131	0.109
Bank3	Return on assets	0.002	0.006	0.006	0.015	0.053	0.058	0.054
Bank3	Loans to assets	0.001	0.002	0.003	0.005	0.008	0.015	0.013
Bank4	Nonperforming loans	0.005	0.024	0.019	0.049	0.054	0.053	0.039
Bank4	Return on assets	0.003	0.009	0.009	0.013	0.024	0.019	0.010
Bank4	Loans to assets	0.003	0.006	0.008	0.016	0.036	0.055	0.048
Bank5	Nonperforming loans	0.003	0.003	0.003	0.004	0.003	0.003	0.002
Bank5	Return on assets	0.002	0.002	0.002	0.002	0.003	0.003	0.002
Bank5	Loans to assets	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank6	Nonperforming loans	0.002	0.003	0.003	0.003	0.003	0.003	0.002
Bank6	Return on assets	0.002	0.002	0.002	0.002	0.003	0.002	0.002
Bank6	Loans to assets	0.001	0.002	0.002	0.002	0.003	0.003	0.003
Bank7	Nonperforming loans	0.002	0.002	0.002	0.003	0.003	0.003	0.002
Bank7	Return on assets	0.003	0.003	0.002	0.003	0.002	0.002	0.001
Bank7	Loans to assets	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank11	Nonperforming loans	0.003	0.002	0.002	0.003	0.003	0.002	0.002
Bank11	Return on assets	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Bank11	Loans to assets	0.001	0.002	0.002	0.002	0.002	0.001	0.001
Bank13	Nonperforming loans	0.002	0.005	0.005	0.007	0.006	0.005	0.004
Bank13	Return on assets	0.001	0.003	0.002	0.002	0.003	0.003	0.002
Bank13	Loans to assets	0.002	0.002	0.003	0.003	0.003	0.003	0.002
Bank15	Nonperforming loans	0.003	0.003	0.003	0.004	0.004	0.004	0.002
Bank15	Return on assets	0.002	0.003	0.003	0.002	0.002	0.002	0.002
Bank15	Loans to assets ratio	0.002	0.002	0.002	0.003	0.003	0.003	0.003
Bank16	Nonperforming loans	0.001	0.004	0.003	0.006	0.005	0.004	0.004
Bank16	Return on assets	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Bank16	Loans to assets	0.001	0.001	0.002	0.002	0.005	0.006	0.006
Bank17	Nonperforming loans	0.002	0.007	0.007	0.014	0.011	0.008	0.005
Bank17	Return on assets	0.001	0.003	0.003	0.003	0.003	0.003	0.003
Bank17	Loans to assets	0.002	0.002	0.002	0.002	0.005	0.006	0.004
Bank19	Nonperforming loans	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank19	Return on assets	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank19	Loans to assets	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank21	Nonperforming loans	0.002	0.002	0.002	0.002	0.002	0.003	0.002
Bank21	Return on assets	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank21	Loans to assets	0.002	0.002	0.001	0.002	0.001	0.002	0.001
Bank25	Nonperforming loans	0.001	0.003	0.003	0.004	0.008	0.010	0.009
Bank25	Return on assets	0.002	0.003	0.003	0.003	0.007	0.008	0.007
Bank25	Loans to assets	0.002	0.004	0.003	0.005	0.007	0.009	0.008
Bank26	Nonperforming loans	0.002	0.003	0.002	0.003	0.004	0.004	0.003
Bank26	Return on assets	0.002	0.002	0.001	0.002	0.002	0.002	0.001
Bank26	Loans to assets	0.007	0.006	0.004	0.003	0.006	0.006	0.005
Bank29	Nonperforming loans	0.001	0.003	0.002	0.002	0.003	0.003	0.002
Bank29	Return on assets	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank29	Loans to assets	0.001	0.002	0.002	0.002	0.002	0.002	0.002

Table A9: Generalized forecast error variance decompositions: A positive standard error unit shock to Bank61 nonperforming loans. *(Continued)*

Quarter		**0**	**1**	**2**	**4**	**8**	**12**	**24**
Bank30	Nonperforming loans	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank30	Return on assets	0.001	0.002	0.001	0.001	0.002	0.002	0.001
Bank30	Loans to assets	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank33	Nonperforming loans	0.001	0.001	0.001	0.001	0.002	0.002	0.001
Bank33	Return on assets	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank33	Loans to assets	0.001	0.002	0.002	0.002	0.002	0.002	0.001
Bank36	Nonperforming loans	0.001	0.002	0.002	0.003	0.003	0.003	0.002
Bank36	Return on assets	0.002	0.002	0.002	0.002	0.003	0.003	0.002
Bank36	Loans to assets	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank38	Nonperforming loans	0.003	0.003	0.003	0.002	0.002	0.002	0.001
Bank38	Return on assets	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Bank38	Loans to assets	0.001	0.002	0.001	0.002	0.002	0.002	0.002
Bank39	Nonperforming loans	0.003	0.003	0.002	0.003	0.003	0.003	0.002
Bank39	Return on assets	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank39	Loans to assets	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank42	Nonperforming loans	0.001	0.004	0.004	0.006	0.008	0.009	0.008
Bank42	Return on assets	0.001	0.002	0.002	0.002	0.003	0.003	0.002
Bank42	Loans to assets	0.002	0.002	0.002	0.003	0.009	0.013	0.012
Bank46	Nonperforming loans	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank46	Return on assets	0.001	0.001	0.002	0.001	0.002	0.002	0.002
Bank46	Loans to assets	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank51	Nonperforming loans	0.005	0.004	0.004	0.003	0.005	0.007	0.006
Bank51	Return on assets	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank51	Loans to assets	0.004	0.003	0.003	0.002	0.003	0.003	0.002
Bank53	Nonperforming loans	0.001	0.002	0.002	0.002	0.002	0.002	0.001
Bank53	Return on assets	0.003	0.003	0.002	0.002	0.002	0.002	0.001
Bank53	Loans to assets	0.003	0.003	0.002	0.002	0.003	0.003	0.003
Bank54	Nonperforming loans	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Bank54	Return on assets	0.002	0.002	0.002	0.001	0.002	0.002	0.002
Bank54	Loans to assets	0.001	0.002	0.001	0.002	0.002	0.002	0.001
Bank56	Nonperforming loans	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank56	Return on assets	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank56	Loans to assets	0.002	0.002	0.002	0.002	0.006	0.008	0.007
Bank58	Nonperforming loans	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank58	Return on assets	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank58	Loans to assets	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank59	Nonperforming loans	0.003	0.002	0.002	0.002	0.002	0.003	0.002
Bank59	Return on assets	0.002	0.003	0.002	0.002	0.002	0.002	0.001
Bank59	Loans to assets	0.002	0.002	0.002	0.002	0.002	0.002	0.001
Bank61	Nonperforming loans	0.555	0.358	0.266	0.099	0.070	0.066	0.049
Bank61	Return on assets	0.007	0.016	0.011	0.009	0.005	0.006	0.004
Bank61	Loans to assets	0.025	0.020	0.057	0.040	0.047	0.048	0.039
Global	GDP	0.021	0.026	0.042	0.051	0.101	0.093	0.088
Global	Interest rate	0.251	0.213	0.311	0.233	0.175	0.112	0.207
Global	hpi	0.011	0.021	0.030	0.022	0.033	0.052	0.065

Notes: Proportion of the N-step ahead forecast error variance of of the historical shock to the Bank61 nonperforming loans.

Table A10: Bilateral exposure weights

Bank	Bank2	Bank3	Bank4	Bank5	Bank6	Bank7	Bank11	Bank13	Bank15	Bank16	Bank17	Bank19	Bank21	Bank25	Bank26
Bank2	0.000	0.535	0.573	0.557	0.557	0.545	0.536	0.527	0.556	0.543	0.453	0.538	0.546	0.546	0.548
Bank3	0.182	0.000	0.109	0.106	0.105	0.105	0.104	0.107	0.105	0.104	0.100	0.103	0.104	0.104	0.104
Bank4	0.132	0.074	0.000	0.055	0.052	0.056	0.056	0.067	0.051	0.054	0.077	0.054	0.053	0.054	0.053
Bank5	0.077	0.043	0.033	0.000	0.031	0.034	0.033	0.039	0.031	0.032	0.045	0.032	0.031	0.032	0.032
Bank6	0.042	0.023	0.017	0.017	0.000	0.017	0.017	0.021	0.016	0.017	0.025	0.017	0.016	0.017	0.016
Bank7	0.059	0.033	0.026	0.026	0.025	0.000	0.026	0.031	0.025	0.026	0.034	0.026	0.025	0.026	0.026
Bank11	0.028	0.016	0.013	0.013	0.012	0.013	0.000	0.015	0.012	0.012	0.016	0.012	0.012	0.012	0.012
Bank13	0.111	0.066	0.061	0.060	0.059	0.060	0.059	0.000	0.058	0.059	0.062	0.058	0.058	0.059	0.059
Bank15	0.034	0.019	0.014	0.014	0.013	0.014	0.014	0.017	0.000	0.014	0.020	0.014	0.013	0.013	0.013
Bank16	0.030	0.017	0.013	0.013	0.012	0.013	0.013	0.015	0.012	0.000	0.017	0.013	0.012	0.013	0.013
Bank17	0.047	0.031	0.035	0.034	0.034	0.033	0.032	0.031	0.034	0.033	0.000	0.033	0.033	0.033	0.033
Bank19	0.010	0.006	0.004	0.004	0.004	0.005	0.004	0.005	0.004	0.004	0.006	0.000	0.004	0.004	0.004
Bank21	0.017	0.010	0.007	0.007	0.007	0.007	0.007	0.009	0.007	0.007	0.010	0.007	0.000	0.007	0.007
Bank25	0.034	0.019	0.014	0.014	0.014	0.015	0.015	0.017	0.014	0.014	0.020	0.014	0.014	0.000	0.014
Bank26	0.032	0.018	0.013	0.013	0.013	0.014	0.014	0.016	0.013	0.013	0.019	0.013	0.013	0.013	0.000
Bank29	0.013	0.007	0.005	0.005	0.005	0.005	0.005	0.006	0.005	0.005	0.007	0.005	0.005	0.005	0.005
Bank30	0.013	0.007	0.005	0.005	0.005	0.005	0.005	0.007	0.005	0.005	0.008	0.005	0.005	0.005	0.005
Bank33	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001
Bank36	0.020	0.011	0.008	0.008	0.007	0.008	0.008	0.010	0.007	0.008	0.012	0.008	0.008	0.008	0.008
Bank38	0.013	0.007	0.005	0.005	0.004	0.005	0.005	0.006	0.004	0.005	0.008	0.005	0.004	0.005	0.004
Bank39	0.014	0.007	0.004	0.004	0.004	0.005	0.005	0.006	0.004	0.004	0.009	0.004	0.004	0.004	0.004
Bank42	0.031	0.017	0.013	0.013	0.012	0.013	0.013	0.016	0.012	0.013	0.018	0.013	0.012	0.013	0.012
Bank46	0.006	0.003	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.003	0.002	0.002	0.002	0.002
Bank51	0.017	0.010	0.010	0.009	0.009	0.009	0.009	0.010	0.009	0.009	0.010	0.009	0.009	0.009	0.009
Bank53	0.005	0.003	0.003	0.003	0.002	0.003	0.002	0.003	0.002	0.002	0.003	0.002	0.002	0.002	0.002
Bank54	0.012	0.006	0.003	0.004	0.003	0.004	0.004	0.005	0.003	0.004	0.007	0.004	0.003	0.003	0.003
Bank56	0.007	0.004	0.004	0.004	0.003	0.004	0.004	0.004	0.003	0.003	0.004	0.003	0.003	0.003	0.003
Bank58	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Bank59	0.005	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Bank61	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001

Table A10: Bilateral exposure weights. *(Continued)*

Bank	Bank29	Bank30	Bank33	Bank36	Bank38	Bank39	Bank42	Bank46	Bank51	Bank53	Bank54	Bank56	Bank58	Bank59	Bank61
Bank2	0.548	0.557	0.566	0.553	0.566	0.597	0.550	0.569	0.499	0.494	0.598	0.519	0.497	0.485	0.556
Bank3	0.104	0.104	0.104	0.104	0.104	0.106	0.104	0.105	0.101	0.101	0.106	0.102	0.101	0.100	0.104
Bank4	0.052	0.050	0.047	0.051	0.047	0.040	0.053	0.046	0.064	0.064	0.039	0.058	0.063	0.066	0.049
Bank5	0.031	0.030	0.028	0.031	0.029	0.024	0.031	0.028	0.038	0.038	0.024	0.035	0.037	0.039	0.030
Bank6	0.016	0.015	0.014	0.016	0.014	0.012	0.016	0.014	0.020	0.020	0.012	0.018	0.020	0.021	0.015
Bank7	0.025	0.024	0.023	0.025	0.023	0.021	0.025	0.023	0.029	0.029	0.021	0.027	0.029	0.030	0.024
Bank11	0.012	0.012	0.011	0.012	0.011	0.010	0.012	0.011	0.014	0.014	0.010	0.013	0.014	0.014	0.012
Bank13	0.058	0.058	0.057	0.058	0.058	0.057	0.059	0.057	0.060	0.059	0.057	0.059	0.059	0.059	0.058
Bank15	0.013	0.012	0.011	0.013	0.012	0.010	0.013	0.011	0.016	0.016	0.009	0.015	0.016	0.017	0.012
Bank16	0.012	0.012	0.011	0.012	0.011	0.010	0.012	0.011	0.015	0.015	0.010	0.014	0.014	0.015	0.012
Bank17	0.034	0.034	0.035	0.034	0.035	0.038	0.034	0.036	0.029	0.029	0.038	0.031	0.029	0.028	0.034
Bank19	0.004	0.004	0.004	0.004	0.004	0.003	0.004	0.004	0.005	0.005	0.003	0.005	0.005	0.005	0.004
Bank21	0.007	0.007	0.006	0.007	0.006	0.005	0.007	0.006	0.008	0.008	0.005	0.008	0.008	0.009	0.007
Bank25	0.014	0.013	0.012	0.013	0.013	0.011	0.014	0.012	0.016	0.016	0.011	0.015	0.016	0.017	0.013
Bank26	0.013	0.012	0.011	0.013	0.012	0.010	0.013	0.011	0.015	0.015	0.010	0.014	0.015	0.016	0.012
Bank29	0.000	0.005	0.004	0.005	0.004	0.004	0.005	0.004	0.006	0.006	0.004	0.005	0.006	0.006	0.005
Bank30	0.005	0.000	0.004	0.005	0.004	0.003	0.005	0.004	0.006	0.006	0.003	0.006	0.006	0.006	0.004
Bank33	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Bank36	0.007	0.007	0.007	0.000	0.007	0.006	0.008	0.007	0.010	0.010	0.005	0.009	0.009	0.010	0.007
Bank38	0.004	0.004	0.004	0.004	0.000	0.003	0.004	0.004	0.006	0.006	0.003	0.005	0.006	0.006	0.004
Bank39	0.004	0.003	0.003	0.004	0.003	0.000	0.004	0.003	0.006	0.006	0.001	0.005	0.006	0.007	0.003
Bank42	0.012	0.012	0.011	0.012	0.011	0.009	0.000	0.011	0.015	0.015	0.009	0.014	0.015	0.015	0.011
Bank46	0.002	0.002	0.002	0.002	0.002	0.001	0.002	0.000	0.003	0.003	0.001	0.002	0.003	0.003	0.002
Bank51	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.000	0.009	0.009	0.009	0.009	0.009	0.009
Bank53	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.000	0.002	0.002	0.002	0.002	0.002
Bank54	0.003	0.003	0.002	0.003	0.002	0.001	0.003	0.002	0.005	0.005	0.000	0.004	0.005	0.006	0.003
Bank56	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.003	0.000	0.004	0.004	0.003
Bank58	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.000	0.002	0.002
Bank59	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.000	0.003
Bank61	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000

6.1.2 Weights construction: Estimating bilateral exposure with incomplete information

For a system of N banks the aim is to estimate a matrix of the form:[1]

$$
\begin{array}{cc}
\mathbf{X} = \begin{bmatrix}
x_{1,1} & \cdots & x_{1,j} & \cdots & x_{1,N} \\
 & & . & & \\
x_{i,1} & \cdots & x_{i,j} & \cdots & x_{i,N} \\
 & & . & & \\
x_{N,1} & \cdots & x_{N,j} & \cdots & x_{N,N}
\end{bmatrix} & \begin{array}{c} a_1 \\ . \\ a_i \\ . \\ a_N \end{array} \\
\begin{array}{ccccc} l_1 & \cdots & l_j & \cdots & l_N \end{array} &
\end{array}
$$

where x_{ij} denotes outstanding loans made by bank i to bank j, $a_i = \sum\limits_j x_{i,j}$ and $l_j = \sum\limits_i x_{i,j}$ are respectively, bank i's interbank total assets and liabilities.[2] In general, since one can only observe each bank's total interbank debt (l_j) and credits (a_i) further restrictions are required in order to identify bilateral bank exposure (x_{ij}). In the absence of any further information, a sensible approach suggested by the literature is to assume that banks maximise the uncertainty of their interbank activity, see Upper and Worms (2004) and Wells (2004). This implies that the amount lent by bank i to bank j, is increasing in both bank i's share of total lending and of bank j's share of total borrowing. Normalizing $\sum\limits_{i=1}^{N} a_i = \sum\limits_{j=1}^{N} l_j = 1$, the individual exposure will be given by $x_{ij} = a_i l_j$. In this specification, exposures reflect the relative importance of each institution in the interbank market.

[1] $\mathbf{X}$ contains N^2 while the a and l provides only $2N$ pieces of information. Therefore, identification of X will require $N(N-2)$ restrictions on $\mathbf{X}$.

[2] Note that a_i is computed by summing across row i while summing down across column j gives l_j.

Note, the above problem does not account for the restriction that a bank cannot be exposed to itself. However, it is straightforward to impose the restriction that the diagonal elements of $\mathbf{X}$ are equal to zero. Given an initial estimate of $\mathbf{X}^0$, one can solve a minimisation problem to find a matrix $\mathbf{X}$ as close as possible to $\mathbf{X}^0$ subject to row and column adding up restrictions (i.e. $a_i = \sum_j x_{i,j}$ and $_j = \sum_i x_{i,j}$).[3] A suitable distance measure for this type of problem is the cross-entropy between two matrices, see Fang, Rajasekera, and Tsao (2012). Following this approach the appropriate interbank structure is given by the solution to:

$$\min \sum_{i=1}^{N} \sum_{j=1}^{N} x_{ij} \ln \left(\frac{x_{ij}}{x_{ij}^0} \right)$$

subject to

$$\sum_{i=1}^{N} x_{ij} = l_j$$

$$x_{ij} \geq 0$$

Note also that $x_{ij} = 0$ if, and only if $x_{ij}^0 = 0$, and $ln(0/0) = 0$. This sort of problem is solved numerically by using RAS algorithm.[4]

[3]The elements of $\mathbf{X}^0$ are given by

$$x_{ij}^0 = \left\{ \begin{array}{c} 0 \text{ if } i = j \\ a_i l_j \text{ , otherwise} \end{array} \right\}$$

[4]For further details see Censor and Zenios (1997).

6.2 Appendix to Chapter 4

Table B1: Determinants of risk attitudes measures: Interval regression

	Japan		U.S.	
	Subjective	Hypothetical	Subjective	Hypothetical
Mother's education	-0.065	0.026	-0.042	0.009
	(0.048)	(0.044)	(0.070)	(0.052)
Father's education	-0.005	-0.037	-0.003	-0.054
	(0.049)	(0.045)	(0.065)	(0.049)
Respondent's height	-0.007	-0.007**	-0.004	-0.000
	(0.004)	(0.003)	(0.003)	(0.002)
Male	-0.509***	-0.166***	-0.198***	-0.316***
	(0.070)	(0.059)	(0.068)	(0.049)
Age	0.048***	0.018	0.027**	0.035***
	(0.013)	(0.011)	(0.012)	(0.008)
Age-squared	-0.039***	0.002	-0.022*	-0.029***
	(0.013)	(0.011)	(0.013)	(0.009)
Married	0.161***	-0.020	0.156**	0.201***
	(0.060)	(0.053)	(0.069)	(0.049)
Number of children	-0.052**	0.018	0.001	-0.032***
	(0.023)	(0.020)	(0.016)	(0.012)
Lives in a city	0.049	0.003	-0.038	-0.066
	(0.050)	(0.043)	(0.061)	(0.044)
Employment:				
Unemployed	0.173**	-0.027	0.222**	-0.158*
	(0.078)	(0.076)	(0.113)	(0.085)
Part-time	0.059	-0.018	0.085	0.048
	(0.054)	(0.052)	(0.079)	(0.062)
Self-employed	-0.103	-0.138**	-0.431***	-0.405***
	(0.063)	(0.057)	(0.086)	(0.061)
Not in Labour force	0.171***	-0.033	0.162**	0.055
	(0.049)	(0.046)	(0.067)	(0.051)
Education:				
College	-0.059	-0.069	-0.031	-0.043
	(0.056)	(0.049)	(0.079)	(0.059)
University+	-0.044	-0.208***	0.026	-0.270***
	(0.055)	(0.046)	(0.056)	(0.041)
Anxieties about health	-0.043***	-0.006	-0.065***	-0.018
	(0.015)	(0.014)	(0.018)	(0.014)
Risk of unemployment	0.011	-0.083***	-0.054	-0.059*
	(0.032)	(0.031)	(0.045)	(0.034)
Borrowing constraint	-0.320***	-0.142***	-0.216***	0.002
	(0.059)	(0.054)	(0.059)	(0.045)
Log of household income	-0.110***	-0.058**	-0.275***	-0.075***
	(0.031)	(0.028)	(0.040)	(0.029)
Log of net-wealth	-0.002	-0.001	-0.002	-0.007**
	(0.002)	(0.002)	(0.004)	(0.003)
Home ownership	0.083	0.082*	0.131**	0.071
	(0.057)	(0.048)	(0.061)	(0.045)
State GDP growth	0.000	-0.005	-0.017*	0.001
	(0.007)	(0.007)	(0.010)	(0.007)
Risk of a natural disaster	0.014	0.034**	-0.000	0.000
	(0.013)	(0.013)	(0.000)	(0.000)
Constant	6.092***	4.242***	5.149***	3.164***
	(0.706)	(0.598)	(0.628)	(0.450)
State Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	15498	15498	13459	13459
Number of ID	6264	6264	8376	8376

[1] Interval regression coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each column in each panel is a separate regression. [5] Omitted groups: *Education:* High school. *Employment Status:* Employed.

Table B2: Determinants of risk attitudes measures: OLS random effects

	Japan		U.S.	
	Qualitative	Quantitative	Qualitative	Quantitative
Mother's education	-0.060	0.018	-0.048	0.003
	(0.047)	(0.021)	(0.068)	(0.023)
Father's education	-0.006	-0.015	-0.003	-0.027
	(0.048)	(0.021)	(0.063)	(0.021)
Respondent's height	-0.006	-0.003*	-0.004	0.000
	(0.004)	(0.002)	(0.003)	(0.001)
Male	-0.505***	-0.081***	-0.186***	-0.143***
	(0.069)	(0.028)	(0.065)	(0.022)
Age	0.048***	0.012**	0.027**	0.016***
	(0.013)	(0.005)	(0.011)	(0.004)
Age-squared	-0.038***	-0.003	-0.022*	-0.014***
	(0.013)	(0.005)	(0.012)	(0.004)
Married	0.160***	0.005	0.152**	0.091***
	(0.058)	(0.025)	(0.067)	(0.022)
Number of children	-0.049**	0.009	0.001	-0.013**
	(0.023)	(0.010)	(0.016)	(0.005)
Lives in a city	0.049	0.002	-0.037	-0.026
	(0.049)	(0.020)	(0.059)	(0.020)
Employment:				
Unemployed	0.176**	-0.007	0.202*	-0.081**
	(0.077)	(0.035)	(0.109)	(0.037)
Part-time	0.057	0.003	0.083	0.013
	(0.053)	(0.024)	(0.076)	(0.026)
Self-employed	-0.099	-0.075***	-0.401***	-0.201***
	(0.062)	(0.027)	(0.082)	(0.028)
Not in Labour force	0.163***	-0.007	0.161**	0.015
	(0.048)	(0.021)	(0.065)	(0.022)
Education:				
College	-0.054	-0.024	-0.039	-0.023
	(0.055)	(0.024)	(0.076)	(0.025)
University+	-0.044	-0.099***	0.016	-0.110***
	(0.054)	(0.023)	(0.054)	(0.018)
Anxieties about health	-0.040***	-0.004	-0.062***	-0.009
	(0.015)	(0.007)	(0.018)	(0.006)
Risk of unemployment	0.012	-0.037**	-0.049	-0.023
	(0.031)	(0.015)	(0.043)	(0.015)
Borrowing constraint	-0.308***	-0.071***	-0.200***	0.001
	(0.058)	(0.026)	(0.057)	(0.020)
Log of household income	-0.106***	-0.026**	-0.270***	-0.027**
	(0.030)	(0.013)	(0.038)	(0.013)
Log of net-wealth	-0.002	-0.001	-0.002	-0.003*
	(0.002)	(0.001)	(0.004)	(0.001)
Home ownership	0.083	0.041*	0.119**	0.038*
	(0.056)	(0.024)	(0.059)	(0.020)
State GDP growth	-0.000	-0.004	-0.015*	0.000
	(0.007)	(0.003)	(0.009)	(0.003)
Risk of a natural disaster	0.013	0.018***	-0.000	0.000
	(0.013)	(0.006)	(0.000)	(0.000)
Constant	6.514***	3.628***	5.669***	3.229***
	(0.697)	(0.287)	(0.608)	(0.201)
State Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	15498	15498	13459	13459
Number of ID	6264	6264	8376	8376

[1] OLS random effects coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each column in each panel is a separate regression. [5] Omitted groups: *Education:* High school. *Employment Status:* Employed.

Table B3: Means of the natural disasters measures by state/prefecture

Prefecture	Average intensity	Number of days	Maximum intensity	Intensity above 3	Intensity above 4	State	Disaster Declarations
Japan	1.40	34.38	2.90	0.49	0.15	U.S.	306.00
Hokkaido	1.51	249.90	4.42	1.42	0.42	Alabama	45.00
Aomori	1.41	18.18	2.67	0.17	0.00	Alaska	6.17
Iwate	1.43	80.87	3.92	0.92	0.42	Arizona	14.17
Miyagi	1.58	58.57	4.17	1.17	0.33	Arkansas	64.50
Akita	1.58	14.10	2.83	0.33	0.00	California	41.50
Yamagata	1.76	8.02	2.33	0.00	0.00	Colorado	17.50
Fukushima	1.63	61.31	4.00	1.00	0.17	Connecticut	6.33
Ibaraki	1.65	113.54	4.33	1.33	0.33	Delaware	1.33
Tochigi	1.47	17.92	3.17	0.50	0.00	Columbia	0.67
Gumma	1.32	4.85	1.83	0.00	0.00	Florida	49.83
Saitama	1.04	3.83	1.33	0.00	0.00	Georgia	45.50
Chiba	1.66	84.74	4.58	1.58	0.58	Hawaii	3.83
Tokyo	1.43	71.36	4.33	1.33	0.33	Idaho	10.17
Kanagawa	1.25	10.88	2.42	0.42	0.25	Illinois	43.00
Niigata	1.65	85.41	4.67	1.67	0.83	Indiana	71.67
Toyama	1.08	1.83	1.17	0.00	0.00	Iowa	74.33
Ishikawa	1.61	35.67	3.92	1.08	0.58	Kansas	111.50
Fukui	1.63	14.17	3.00	0.17	0.00	Kentucky	92.33
Yamanashi	1.41	14.25	2.50	0.17	0.00	Louisiana	76.50
Nagano	1.30	46.03	3.33	0.67	0.00	Maine	19.00
Gifu	1.46	18.69	3.00	0.33	0.00	Maryland	10.17
Shizuoka	1.48	27.11	3.67	0.67	0.33	Massachusetts	14.67
Aichi	1.57	20.30	3.00	0.33	0.00	Michigan	15.83
Mie	1.49	9.94	2.75	0.42	0.25	Minnesota	42.67
Shiga	1.40	11.84	2.67	0.17	0.00	Mississippi	45.50
Kyoto	1.42	19.86	2.83	0.17	0.00	Missouri	144.00
Osaka	1.42	2.33	1.67	0.17	0.00	Montana	12.00
Hyogo	1.32	12.58	2.33	0.00	0.00	Nebraska	83.50
Nara	1.23	4.93	1.83	0.00	0.00	Nevada	13.33
Wakayama	1.29	81.79	3.50	0.50	0.00	Hampshire	15.17
Tottori	1.36	15.54	2.33	0.17	0.00	New Jersey	14.00
Shimane	1.59	12.99	3.00	0.17	0.00	New Mexico	13.00
Okayama	0.99	2.13	1.17	0.00	0.00	New York	31.33
Hiroshima	1.25	3.00	1.50	0.00	0.00	North Carolina	35.33
Yamaguchi	1.61	4.17	2.17	0.00	0.00	North Dakota	45.83
Tokushima	1.37	8.67	2.17	0.00	0.00	Ohio	41.00
Kagawa	0.50	0.83	0.67	0.00	0.00	Oklahoma	142.83
Ehime	1.51	37.05	3.67	0.67	0.00	Oregon	16.83
Kochi	1.23	6.38	2.00	0.33	0.00	Pennsylvania	23.50
Fukuoka	1.38	21.50	2.75	0.42	0.25	Rhode Island	3.50
Saga	0.75	1.00	0.83	0.00	0.00	South Carolina	9.00
Nagasaki	1.49	10.73	2.33	0.00	0.00	South Dakota	51.67
Kumamoto	1.40	41.43	3.83	0.83	0.17	Tennessee	34.83
Oita	1.54	41.74	4.17	1.17	0.50	Texas	282.33
Miyazaki	1.47	32.40	3.50	0.67	0.17	Utah	8.00
Kagoshima	1.40	94.74	3.83	0.83	0.00	Vermont	4.50
Okinawa	1.39	76.67	4.00	1.00	0.33	Virginia	46.17
						Washington	28.33
						West Virginia	26.17
						Wisconsin	23.50
						Wyoming	1.17

Table B4: Definition of the JMA Seismic Intensity Scale (Shindo)

Seismic intensity	Human perception and reaction
0	Imperceptible to people, but recorded by seismometers.
1	Felt slightly by some people keeping quiet in buildings.
2	Felt by many people keeping quiet in buildings. Some people may be awoken.
3	Felt by most people in buildings. Felt by some people walking. Many people are awoken.
4	Most people are startled. Felt by most people walking. Most people are awoken.
5 Lower	Many people are frightened and feel the need to hold onto something stable.
5 Upper	Many people find it hard to move; walking is difficult without holding onto something stable.
6 Lower	It is difficult to remain standing.
6 Upper	It is impossible to remain standing or move without crawling.
7	People may be thrown through the air.
Seismic intensity	**Indoor situation**
0	-
1	-
2	Hanging objects such as lamps swing slightly.
3	Dishes in cupboards may rattle.
4	Hanging objects such as lamps swing significantly, and dishes in cupboards rattle. Unstable ornaments may fall.
5 Lower	Hanging objects such as lamps swing violently. Dishes in cupboards and items on bookshelves may fall. Many unstable ornaments fall. Unsecured furniture may move, and unstable furniture may topple over.
5 Upper	Dishes in cupboards and items on bookshelves are more likely to fall. TVs may fall from their stands, and unsecured furniture may topple over.
6 Lower	Many unsecured furniture moves and may topple over. Doors may become wedged shut.
6 Upper	Most unsecured furniture moves, and is more likely to topple over.
7	Most unsecured furniture moves and topples over, or may even be thrown through the air.
Seismic intensity	**Outdoor situation**
0	-
1	-
2	-
3	Electric wires swing slightly.
4	Electric wires swing significantly. Those driving vehicles may notice the tremor.
5 Lower	In some cases, windows may break and fall. People notice electricity poles moving. Roads may sustain damage.
5 Upper	Windows may break and fall, unreinforced concrete-block walls may collapse, poorly installed vending machines may topple over, automobiles may stop due to the difficulty of continued movement.
6 Lower	Wall tiles and windows may sustain damage and fall.
6 Upper	Wall tiles and windows are more likely to break and fall. Most unreinforced concrete-block walls collapse.
7	Wall tiles and windows are even more likely to break and fall. Reinforced concrete-block walls may collapse.

Table B5: Validation of the hypothetical gamble risk attitudes measure: Risky behaviours

	Gambling		Drinking		Smoking	
	Japan	U.S.	Japan	U.S.	Japan	U.S.
Hypothetical	-0.113***	-0.074**	-0.018	-0.199***	0.056	0.088
	(0.035)	(0.036)	(0.041)	(0.045)	(0.049)	(0.056)
Mother's education	-0.313***	-0.125	0.028	0.094	0.030	0.117
	(0.097)	(0.093)	(0.118)	(0.135)	(0.133)	(0.143)
Father's education	0.129	-0.147*	0.018	0.313**	0.041	-0.188
	(0.098)	(0.089)	(0.121)	(0.131)	(0.134)	(0.131)
Male	2.161***	0.507***	4.264***	1.364***	3.839***	0.394***
	(0.109)	(0.074)	(0.170)	(0.125)	(0.140)	(0.106)
Age	0.102***	0.071***	0.342***	0.053**	0.230***	0.150***
	(0.028)	(0.017)	(0.039)	(0.024)	(0.036)	(0.025)
Age-squared	-0.121***	-0.044**	-0.306***	-0.022	-0.283***	-0.156***
	(0.028)	(0.018)	(0.039)	(0.025)	(0.037)	(0.027)
Married	-0.219*	-0.120	0.338**	-0.063	-0.752***	0.305**
	(0.116)	(0.097)	(0.146)	(0.134)	(0.153)	(0.144)
Number of children	-0.052	-0.064***	0.308***	-0.095***	0.028	-0.132***
	(0.048)	(0.024)	(0.065)	(0.034)	(0.062)	(0.036)
Lives in a city	0.178*	0.111	0.139	-0.093	0.070	-0.255**
	(0.104)	(0.087)	(0.134)	(0.120)	(0.134)	(0.122)
Employment:						
Unemployed	-0.100	-0.420**	-0.405**	-0.492**	-0.737***	0.188
	(0.158)	(0.170)	(0.190)	(0.243)	(0.239)	(0.208)
Part-time	-0.034	-0.219*	-0.057	-0.302*	-0.047	-0.084
	(0.122)	(0.129)	(0.131)	(0.162)	(0.153)	(0.184)
Self-employed	-0.120	-0.026	0.218	0.033	-0.072	0.204
	(0.119)	(0.118)	(0.154)	(0.155)	(0.167)	(0.174)
Not in Labour force	-0.265**	-0.090	-0.216*	-0.316**	-0.368***	-0.065
	(0.107)	(0.096)	(0.118)	(0.139)	(0.135)	(0.145)
Education:						
College	-0.329***	-0.142	0.067	-0.177	-0.953***	-0.732***
	(0.119)	(0.110)	(0.142)	(0.155)	(0.159)	(0.153)
University+	-0.650***	-0.486***	-0.177	-0.159	-1.667***	-1.499***
	(0.113)	(0.082)	(0.157)	(0.108)	(0.154)	(0.122)
Anxieties about health	0.008	-0.039	0.041	0.016	-0.057	0.039
	(0.030)	(0.026)	(0.035)	(0.036)	(0.040)	(0.039)
Risk of unemployment	0.083	0.110*	0.125*	0.288***	0.037	0.108
	(0.063)	(0.064)	(0.074)	(0.081)	(0.087)	(0.094)
Borrowing constraint	0.352***	0.393***	0.081	0.059	0.367**	0.618***
	(0.106)	(0.082)	(0.130)	(0.116)	(0.149)	(0.113)
Log of household income	0.048	0.162***	0.187**	0.381***	-0.034	-0.517***
	(0.062)	(0.056)	(0.076)	(0.081)	(0.080)	(0.082)
Log of net-wealth	-0.004	0.000	-0.006	0.023**	-0.011**	0.001
	(0.003)	(0.006)	(0.004)	(0.010)	(0.004)	(0.009)
Home ownership	-0.198*	-0.238***	-0.183	-0.111	-0.523***	-0.471***
	(0.114)	(0.087)	(0.156)	(0.122)	(0.150)	(0.123)
State GDP growth	0.021	0.029*	-0.017	-0.004	-0.003	0.015
	(0.014)	(0.015)	(0.016)	(0.018)	(0.019)	(0.021)
Risk of a natural disaster	0.013	-0.000	-0.044	0.000	0.040	-0.001
	(0.027)	(0.000)	(0.030)	(0.001)	(0.037)	(0.001)
Financial potential	0.035	-0.158	0.903	0.125	0.735	-0.151
	(0.920)	(0.194)	(1.046)	(0.243)	(1.219)	(0.274)
Constant	-4.484***	-4.878***	-16.059***	-7.640***	-7.609***	-5.930***
	(0.815)	(0.908)	(1.164)	(1.186)	(1.062)	(1.211)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15498	13459	15498	13459	15498	13459
Number of ID	6264	8376	6264	8376	6264	8376

[1] Probit coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each column is a separate regression. [5] Omitted groups: *Education:* High school. *Employment Status:* Employed.

Table B6: Validation of the subjective risk attitudes measure: Risky behaviours

	Gambling		Drinking		Smoking	
	Japan	U.S.	Japan	U.S.	Japan	U.S.
Subjective	-0.082***	-0.114***	-0.032	-0.043**	-0.050**	-0.065***
	(0.016)	(0.013)	(0.019)	(0.017)	(0.022)	(0.019)
Mother's education	-0.315***	-0.124	0.027	0.093	0.025	0.104
	(0.097)	(0.091)	(0.119)	(0.133)	(0.131)	(0.140)
Father's education	0.122	-0.137	0.018	0.313**	0.044	-0.173
	(0.098)	(0.086)	(0.122)	(0.128)	(0.132)	(0.129)
Male	2.110***	0.477***	4.273***	1.377***	3.817***	0.358***
	(0.108)	(0.072)	(0.194)	(0.103)	(0.137)	(0.105)
Age	0.104***	0.071***	0.345***	0.050**	0.230***	0.142***
	(0.027)	(0.016)	(0.041)	(0.023)	(0.035)	(0.025)
Age-squared	-0.123***	-0.044**	-0.309***	-0.019	-0.280***	-0.146***
	(0.028)	(0.017)	(0.040)	(0.024)	(0.036)	(0.027)
Married	-0.207*	-0.116	0.344**	-0.068	-0.737***	0.311**
	(0.115)	(0.094)	(0.148)	(0.132)	(0.151)	(0.142)
Number of children	-0.058	-0.062***	0.311***	-0.092***	0.025	-0.121***
	(0.048)	(0.023)	(0.067)	(0.033)	(0.061)	(0.035)
Lives in a city	0.183*	0.108	0.140	-0.086	0.071	-0.234*
	(0.103)	(0.085)	(0.138)	(0.117)	(0.133)	(0.120)
Employment:						
Unemployed	-0.083	-0.371**	-0.396**	-0.478**	-0.717***	0.216
	(0.158)	(0.166)	(0.191)	(0.242)	(0.237)	(0.203)
Part-time	-0.027	-0.205	-0.058	-0.290*	-0.047	-0.072
	(0.122)	(0.127)	(0.132)	(0.160)	(0.152)	(0.179)
Self-employed	-0.123	-0.063	0.214	0.052	-0.071	0.169
	(0.118)	(0.116)	(0.156)	(0.155)	(0.164)	(0.170)
Not in Labour force	-0.251**	-0.068	-0.213*	-0.313**	-0.362***	-0.044
	(0.106)	(0.094)	(0.119)	(0.136)	(0.135)	(0.143)
Education:						
College	-0.332***	-0.149	0.064	-0.163	-0.952***	-0.710***
	(0.118)	(0.108)	(0.144)	(0.152)	(0.157)	(0.149)
University+	-0.641***	-0.470***	-0.183	-0.131	-1.673***	-1.502***
	(0.112)	(0.080)	(0.163)	(0.106)	(0.151)	(0.123)
Anxieties about health	0.004	-0.044*	0.040	0.015	-0.055	0.032
	(0.030)	(0.025)	(0.035)	(0.036)	(0.040)	(0.038)
Risk of unemployment	0.087	0.112*	0.126*	0.287***	0.038	0.115
	(0.063)	(0.063)	(0.074)	(0.081)	(0.086)	(0.092)
Borrowing constraint	0.342***	0.364***	0.077	0.041	0.369**	0.647***
	(0.105)	(0.080)	(0.131)	(0.115)	(0.147)	(0.110)
Log of household income	0.046	0.131**	0.187**	0.371***	-0.036	-0.482***
	(0.061)	(0.055)	(0.077)	(0.079)	(0.079)	(0.081)
Log of net-wealth	-0.004	-0.000	-0.006	0.024**	-0.011**	0.002
	(0.003)	(0.006)	(0.004)	(0.010)	(0.004)	(0.009)
Home ownership	-0.194*	-0.229***	-0.182	-0.120	-0.517***	-0.447***
	(0.114)	(0.084)	(0.159)	(0.120)	(0.148)	(0.121)
State GDP growth	0.021	0.026*	-0.017	-0.003	-0.003	0.016
	(0.014)	(0.015)	(0.016)	(0.018)	(0.019)	(0.021)
Risk of a natural disaster	0.012	-0.000	-0.043	0.000	0.044	-0.001
	(0.027)	(0.000)	(0.030)	(0.001)	(0.037)	(0.001)
Financial potential	0.024	-0.140	0.885	0.134	0.746	-0.115
	(0.917)	(0.191)	(1.048)	(0.242)	(1.207)	(0.267)
Constant	-4.350***	-4.462***	-16.033***	-8.221***	-7.113***	-4.674***
	(0.808)	(0.882)	(1.211)	(1.130)	(1.045)	(1.175)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15498	13459	15498	13459	15498	13459
Number of ID	6264	8376	6264	8376	6264	8376

[1] Probit coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each column is a separate regression. [5] Omitted groups: *Education:* High school. *Employment Status:* Employed.

Table B7: Validation of the hypothetical gamble risk attitudes measure: Assets choice Japan

	Tobit	Probit					
	Stock share	Stock binary	Saving	Bonds	Life insurance	Trust	Foreign
main							
Hypothetical measure	-0.013***	-0.067*	-0.018	0.035	-0.026	-0.075**	-0.012
	(0.004)	(0.035)	(0.028)	(0.022)	(0.020)	(0.036)	(0.022)
Mother's education	0.011	-0.042	0.175**	0.052	0.087*	0.005	0.051
	(0.012)	(0.099)	(0.072)	(0.061)	(0.052)	(0.096)	(0.058)
Father's education	0.034***	0.448***	-0.039	0.058	0.061	0.278***	0.065
	(0.012)	(0.099)	(0.071)	(0.061)	(0.052)	(0.098)	(0.058)
Male	0.032**	0.417***	0.048	-0.428***	-0.108**	-0.194**	-0.041
	(0.013)	(0.103)	(0.063)	(0.061)	(0.048)	(0.099)	(0.056)
Age	0.011***	0.157***	0.009	0.008	0.118***	0.080***	0.122***
	(0.003)	(0.030)	(0.017)	(0.016)	(0.013)	(0.029)	(0.016)
Age-squared	-0.004	-0.099***	-0.002	0.009	-0.114***	-0.018	-0.098***
	(0.003)	(0.029)	(0.017)	(0.016)	(0.013)	(0.028)	(0.016)
Married	0.036**	0.396***	0.360***	0.398***	0.480***	0.346***	0.234***
	(0.016)	(0.135)	(0.078)	(0.073)	(0.062)	(0.133)	(0.075)
Number of children	-0.030***	-0.143***	-0.141***	-0.062**	-0.023	-0.195***	-0.095***
	(0.006)	(0.051)	(0.030)	(0.029)	(0.024)	(0.051)	(0.028)
Lives in a city	0.014	0.146	-0.136**	-0.253***	0.069	0.160	0.046
	(0.013)	(0.108)	(0.066)	(0.062)	(0.050)	(0.107)	(0.059)
Employment:							
Unemployed	0.034*	0.314**	-0.043	0.057	-0.116	-0.040	-0.075
	(0.019)	(0.157)	(0.113)	(0.099)	(0.086)	(0.157)	(0.098)
Part-time	-0.006	-0.024	-0.094	-0.008	-0.037	-0.128	-0.157**
	(0.014)	(0.110)	(0.080)	(0.069)	(0.061)	(0.114)	(0.068)
Self-employed	-0.002	-0.250*	0.050	0.115	0.147**	0.020	-0.058
	(0.016)	(0.134)	(0.091)	(0.078)	(0.068)	(0.130)	(0.077)
Not in Labour force	0.043***	0.291***	0.044	0.211***	-0.018	0.223**	0.075
	(0.012)	(0.098)	(0.072)	(0.062)	(0.052)	(0.095)	(0.059)
Education:							
College	0.058***	0.523***	0.226***	0.178**	0.123**	0.441***	0.129*
	(0.014)	(0.118)	(0.079)	(0.071)	(0.059)	(0.117)	(0.068)
University+	0.127***	1.062***	0.258***	0.448***	-0.007	0.933***	0.214***
	(0.014)	(0.115)	(0.077)	(0.069)	(0.056)	(0.112)	(0.065)
Anxieties about health	0.010***	0.059*	0.036	0.001	0.033**	0.058*	0.011
	(0.004)	(0.031)	(0.022)	(0.019)	(0.017)	(0.031)	(0.019)
Risk of unemployment	0.009	0.020	-0.137***	-0.011	0.026	0.048	-0.061
	(0.008)	(0.064)	(0.049)	(0.041)	(0.036)	(0.066)	(0.040)
Borrowing constraint	-0.054***	-0.300**	-0.601***	-0.381***	-0.139**	-0.351**	-0.266***
	(0.016)	(0.136)	(0.073)	(0.073)	(0.063)	(0.150)	(0.076)
Log of household income	0.075***	0.672***	0.463***	0.230***	0.346***	0.337***	0.401***
	(0.008)	(0.065)	(0.044)	(0.039)	(0.033)	(0.062)	(0.038)
Log of net-wealth	0.004***	0.024***	0.015***	0.012***	0.009***	0.036***	0.013***
	(0.000)	(0.004)	(0.002)	(0.002)	(0.002)	(0.005)	(0.002)
Home ownership	0.070***	0.576***	0.407***	0.176**	0.344***	0.234*	0.334***
	(0.016)	(0.132)	(0.071)	(0.071)	(0.058)	(0.131)	(0.072)
State GDP growth	0.002	0.018	0.009	0.005	-0.002	-0.006	0.005
	(0.002)	(0.014)	(0.012)	(0.009)	(0.008)	(0.014)	(0.009)
Risk of a natural disaster	0.001	-0.001	0.006	-0.027	-0.007	0.016	0.033**
	(0.003)	(0.026)	(0.023)	(0.017)	(0.016)	(0.026)	(0.017)
Financial potential	0.238**	1.837**	0.745	0.466	0.361	0.534	0.277
	(0.106)	(0.871)	(0.746)	(0.583)	(0.519)	(0.927)	(0.566)
Constant	-1.483***	-15.189***	-2.381***	-2.016***	-5.145***	-10.833***	-7.881***
	(0.102)	(0.911)	(0.543)	(0.489)	(0.414)	(0.897)	(0.502)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15498	15456	15498	15498	15498	15498	15498
Number of ID	6264	6244	6264	6264	6264	6264	6264

[1] Probit and tobit coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each column is a separate regression. [5] Omitted groups: *Education:* High school. *Employment Status:* Employed.

Table B8: Validation of the subjective risk attitudes measure: Assets choice Japan

	Tobit	Probit					
	Stock share	Stock binary	Saving	Bonds	Life insurance	Trust	Pension
main							
Subjective measure	-0.014***	-0.067***	0.006	0.037***	-0.016*	-0.041**	-0.012
	(0.002)	(0.016)	(0.012)	(0.010)	(0.009)	(0.017)	(0.010)
Mother's education	0.009	-0.049	0.175**	0.056	0.085	0.001	0.050
	(0.012)	(0.098)	(0.072)	(0.061)	(0.052)	(0.096)	(0.058)
Father's education	0.034***	0.451***	-0.038	0.058	0.061	0.283***	0.065
	(0.012)	(0.099)	(0.071)	(0.061)	(0.052)	(0.098)	(0.058)
Male	0.025**	0.385***	0.054	-0.410***	-0.115**	-0.211**	-0.047
	(0.013)	(0.103)	(0.063)	(0.061)	(0.048)	(0.099)	(0.057)
Age	0.011***	0.159***	0.009	0.007	0.118***	0.081***	0.123***
	(0.003)	(0.030)	(0.017)	(0.016)	(0.013)	(0.029)	(0.016)
Age-squared	-0.004	-0.101***	-0.001	0.010	-0.115***	-0.019	-0.099***
	(0.003)	(0.029)	(0.017)	(0.016)	(0.013)	(0.028)	(0.016)
Married	0.038**	0.412***	0.359***	0.390***	0.483***	0.352***	0.235***
	(0.016)	(0.135)	(0.078)	(0.073)	(0.062)	(0.133)	(0.075)
Number of children	-0.031***	-0.147***	-0.141***	-0.060**	-0.024	-0.196***	-0.096***
	(0.006)	(0.051)	(0.030)	(0.029)	(0.024)	(0.051)	(0.028)
Lives in a city	0.015	0.150	-0.136**	-0.254***	0.069	0.161	0.047
	(0.013)	(0.108)	(0.066)	(0.062)	(0.050)	(0.107)	(0.059)
Employment:							
Unemployed	0.038**	0.334**	-0.044	0.051	-0.114	-0.037	-0.074
	(0.019)	(0.158)	(0.113)	(0.099)	(0.086)	(0.157)	(0.098)
Part-time	-0.005	-0.023	-0.094	-0.010	-0.037	-0.129	-0.156**
	(0.014)	(0.110)	(0.080)	(0.069)	(0.061)	(0.114)	(0.068)
Self-employed	-0.003	-0.256*	0.053	0.117	0.147**	0.018	-0.058
	(0.016)	(0.133)	(0.091)	(0.078)	(0.068)	(0.130)	(0.077)
Not in Labour force	0.046***	0.308***	0.042	0.206***	-0.015	0.229**	0.077
	(0.012)	(0.098)	(0.072)	(0.062)	(0.052)	(0.095)	(0.059)
Education:							
College	0.058***	0.517***	0.227***	0.180**	0.123**	0.443***	0.128*
	(0.014)	(0.118)	(0.079)	(0.071)	(0.059)	(0.117)	(0.068)
University+	0.127***	1.061***	0.260***	0.445***	-0.005	0.938***	0.215***
	(0.014)	(0.115)	(0.077)	(0.069)	(0.056)	(0.113)	(0.065)
Anxieties about health	0.009**	0.055*	0.036	0.003	0.032*	0.056*	0.010
	(0.004)	(0.031)	(0.022)	(0.019)	(0.017)	(0.031)	(0.019)
Risk of unemployment	0.010	0.024	-0.137***	-0.013	0.027	0.053	-0.060
	(0.008)	(0.064)	(0.049)	(0.041)	(0.036)	(0.066)	(0.040)
Borrowing constraint	-0.057***	-0.318**	-0.597***	-0.373***	-0.143**	-0.363**	-0.269***
	(0.016)	(0.136)	(0.073)	(0.073)	(0.063)	(0.150)	(0.076)
Log of household income	0.074***	0.667***	0.464***	0.232***	0.345***	0.334***	0.400***
	(0.008)	(0.065)	(0.044)	(0.038)	(0.033)	(0.063)	(0.038)
Log of net-wealth	0.004***	0.024***	0.015***	0.012***	0.009***	0.036***	0.013***
	(0.000)	(0.004)	(0.002)	(0.002)	(0.002)	(0.005)	(0.002)
Home ownership	0.070***	0.575***	0.406***	0.174**	0.345***	0.232*	0.335***
	(0.016)	(0.132)	(0.071)	(0.071)	(0.058)	(0.131)	(0.072)
State GDP growth	0.002	0.019	0.009	0.005	-0.002	-0.005	0.005
	(0.002)	(0.014)	(0.012)	(0.009)	(0.008)	(0.014)	(0.009)
Risk of a natural disaster	0.001	-0.002	0.006	-0.027	-0.008	0.014	0.033**
	(0.003)	(0.026)	(0.023)	(0.017)	(0.016)	(0.026)	(0.017)
Financial potential	0.239**	1.870**	0.735	0.467	0.359	0.570	0.278
	(0.106)	(0.872)	(0.745)	(0.583)	(0.519)	(0.928)	(0.566)
Constant	-1.448***	-15.016***	-2.472***	-2.115***	-5.131***	-10.846***	-7.849***
	(0.101)	(0.907)	(0.541)	(0.486)	(0.412)	(0.897)	(0.500)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15498	15498	15498	15498	15498	15498	15498
Number of ID	6264	6264	6264	6264	6264	6264	6264

[1] Probit and tobit coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each column is a separate regression. [5] Omitted groups: *Education:* High school. *Employment Status:* Employed.

Table B9: Validation of the hypothetical gamble risk attitudes measure: Assets choice U.S.

	Tobit	Probit					
	Stock share	Stock binary	Saving	Bonds	Life insurance	Trust	Foreign
main							
Hypothetical measure	-0.017***	-0.113***	-0.031	-0.087**	0.069**	-0.005	0.057**
	(0.006)	(0.031)	(0.032)	(0.036)	(0.027)	(0.026)	(0.024)
Mother's education	0.022	0.126	0.281***	0.207**	0.037	0.008	0.038
	(0.016)	(0.086)	(0.082)	(0.101)	(0.074)	(0.067)	(0.065)
Father's education	0.035**	0.222***	0.164**	0.128	-0.071	0.095	0.059
	(0.015)	(0.079)	(0.076)	(0.092)	(0.069)	(0.062)	(0.060)
Male	0.059***	0.255***	0.031	0.109	-0.129**	-0.084*	0.001
	(0.011)	(0.062)	(0.061)	(0.069)	(0.054)	(0.047)	(0.046)
Age	0.015***	0.117***	-0.003	-0.004	0.103***	0.005	0.119***
	(0.003)	(0.015)	(0.014)	(0.016)	(0.013)	(0.011)	(0.011)
Age-squared	-0.010***	-0.087***	0.020	0.041**	-0.085***	0.011	-0.081***
	(0.003)	(0.016)	(0.015)	(0.017)	(0.013)	(0.012)	(0.012)
Married	-0.060***	-0.164*	-0.057	-0.017	0.421***	-0.021	0.208***
	(0.016)	(0.085)	(0.081)	(0.099)	(0.073)	(0.067)	(0.065)
Number of children	-0.009**	-0.051**	-0.036*	-0.085***	0.105***	0.007	-0.009
	(0.004)	(0.020)	(0.019)	(0.024)	(0.018)	(0.015)	(0.015)
Lives in a city	0.032**	0.164**	0.060	-0.106	-0.104	-0.029	0.094*
	(0.014)	(0.075)	(0.071)	(0.085)	(0.065)	(0.057)	(0.056)
Employment:							
Unemployed	-0.185***	-0.699***	-0.746***	-0.456*	-0.732***	-0.470***	-0.851***
	(0.032)	(0.158)	(0.118)	(0.251)	(0.123)	(0.157)	(0.127)
Part-time	-0.029	0.030	0.043	-0.114	-0.300***	0.018	-0.285***
	(0.018)	(0.090)	(0.099)	(0.118)	(0.083)	(0.079)	(0.074)
Self-employed	-0.048**	-0.068	-0.340***	0.183	-0.314***	0.115	-0.782***
	(0.020)	(0.104)	(0.101)	(0.114)	(0.090)	(0.082)	(0.083)
Not in Labour force	-0.017	0.059	-0.225***	0.277***	-0.347***	-0.037	-0.457***
	(0.016)	(0.080)	(0.080)	(0.093)	(0.071)	(0.066)	(0.065)
Education:							
College	0.084***	0.387***	0.284***	0.269**	0.254***	0.252***	0.256***
	(0.018)	(0.094)	(0.091)	(0.115)	(0.083)	(0.074)	(0.072)
University+	0.157***	0.803***	0.868***	0.496***	0.324***	0.234***	0.313***
	(0.013)	(0.070)	(0.075)	(0.080)	(0.060)	(0.053)	(0.052)
Anxieties about health	0.009**	0.070***	0.040*	0.032	0.022	-0.003	0.017
	(0.004)	(0.022)	(0.022)	(0.027)	(0.019)	(0.018)	(0.017)
Risk of unemployment	0.007	-0.013	-0.004	0.027	-0.122***	-0.017	-0.057
	(0.010)	(0.052)	(0.055)	(0.065)	(0.047)	(0.045)	(0.042)
Borrowing constraint	-0.109***	-0.508***	-0.518***	-0.387***	-0.114*	-0.276***	-0.214***
	(0.015)	(0.074)	(0.065)	(0.111)	(0.061)	(0.068)	(0.057)
Log of household income	0.195***	1.054***	0.778***	0.591***	0.597***	0.309***	0.640***
	(0.009)	(0.057)	(0.053)	(0.065)	(0.045)	(0.040)	(0.041)
Log of net-wealth	0.010***	0.047***	0.030***	0.053***	0.021***	0.035***	0.012***
	(0.001)	(0.006)	(0.005)	(0.011)	(0.004)	(0.006)	(0.004)
Home ownership	0.135***	0.695***	0.543***	0.221**	0.498***	0.269***	0.484***
	(0.015)	(0.077)	(0.069)	(0.105)	(0.063)	(0.068)	(0.060)
State GDP growth	-0.004*	0.000	0.018	0.012	0.011	0.005	0.017*
	(0.002)	(0.011)	(0.012)	(0.014)	(0.010)	(0.010)	(0.009)
Risk of a natural disaster	0.000*	0.000	-0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Financial potential	-0.022	0.030	-0.186	-0.237	-0.102	-0.069	-0.016
	(0.029)	(0.150)	(0.163)	(0.175)	(0.138)	(0.127)	(0.122)
Constant	-1.417***	-9.488***	-2.957***	-6.539***	-5.362***	-3.673***	-7.605***
	(0.135)	(0.744)	(0.706)	(0.885)	(0.634)	(0.580)	(0.579)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13459	13459	13459	13459	13459	13459	13459
Number of ID	8376	8376	8376	8376	8376	8376	8376

[1] Probit and tobit coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each column is a separate regression. [5] Omitted groups: *Education:* High school. *Employment Status:* Employed.

Table B10: Validation of the subjective risk attitudes measure: Assets choice U.S.

	Tobit	Probit					
	Stock share	Stock binary	Saving	Bonds	Life insurance	Trust	Pension
main							
Subjective measure	-0.009***	-0.044***	-0.007	-0.033**	-0.015	-0.010	-0.008
	(0.002)	(0.011)	(0.011)	(0.013)	(0.009)	(0.009)	(0.008)
Mother's education	0.021	0.124	0.280***	0.206**	0.036	0.008	0.038
	(0.016)	(0.086)	(0.082)	(0.101)	(0.074)	(0.067)	(0.065)
Father's education	0.035**	0.224***	0.164**	0.131	-0.072	0.095	0.057
	(0.015)	(0.079)	(0.076)	(0.092)	(0.069)	(0.062)	(0.060)
Male	0.059***	0.260***	0.033	0.117*	-0.142***	-0.085*	-0.008
	(0.011)	(0.062)	(0.061)	(0.069)	(0.054)	(0.046)	(0.046)
Age	0.015***	0.116***	-0.003	-0.005	0.105***	0.005	0.120***
	(0.003)	(0.015)	(0.014)	(0.016)	(0.013)	(0.011)	(0.011)
Age-squared	-0.010***	-0.086***	0.021	0.042**	-0.086***	0.010	-0.082***
	(0.003)	(0.016)	(0.015)	(0.017)	(0.013)	(0.012)	(0.012)
Married	-0.060***	-0.165*	-0.060	-0.021	0.429***	-0.020	0.214***
	(0.016)	(0.085)	(0.081)	(0.100)	(0.073)	(0.066)	(0.065)
Number of children	-0.009**	-0.049**	-0.035*	-0.084***	0.104***	0.007	-0.010
	(0.004)	(0.020)	(0.019)	(0.024)	(0.018)	(0.015)	(0.015)
Lives in a city	0.032**	0.164**	0.061	-0.107	-0.106	-0.029	0.092*
	(0.014)	(0.075)	(0.071)	(0.085)	(0.065)	(0.057)	(0.056)
Employment:							
Unemployed	-0.181***	-0.680***	-0.743***	-0.455*	-0.733***	-0.468***	-0.854***
	(0.032)	(0.158)	(0.118)	(0.252)	(0.123)	(0.156)	(0.127)
Part-time	-0.029	0.032	0.042	-0.117	-0.298***	0.019	-0.283***
	(0.018)	(0.090)	(0.099)	(0.119)	(0.083)	(0.079)	(0.074)
Self-employed	-0.048**	-0.062	-0.335***	0.186	-0.334***	0.111	-0.797***
	(0.020)	(0.104)	(0.100)	(0.114)	(0.090)	(0.081)	(0.083)
Not in Labour force	-0.016	0.062	-0.223***	0.277***	-0.344***	-0.035	-0.453***
	(0.016)	(0.080)	(0.080)	(0.093)	(0.071)	(0.066)	(0.065)
Education:							
College	0.084***	0.387***	0.284***	0.275**	0.253***	0.251***	0.253***
	(0.018)	(0.094)	(0.091)	(0.116)	(0.083)	(0.074)	(0.072)
University+	0.159***	0.817***	0.870***	0.507***	0.317***	0.235***	0.307***
	(0.013)	(0.070)	(0.075)	(0.081)	(0.060)	(0.053)	(0.052)
Anxieties about health	0.009**	0.068***	0.040*	0.031	0.021	-0.004	0.016
	(0.004)	(0.022)	(0.022)	(0.027)	(0.019)	(0.018)	(0.017)
Risk of unemployment	0.007	-0.013	-0.004	0.025	-0.124***	-0.017	-0.057
	(0.010)	(0.052)	(0.055)	(0.065)	(0.047)	(0.045)	(0.042)
Borrowing constraint	-0.111***	-0.519***	-0.519***	-0.392***	-0.117*	-0.278***	-0.216***
	(0.015)	(0.074)	(0.065)	(0.112)	(0.061)	(0.068)	(0.057)
Log of household income	0.193***	1.043***	0.776***	0.587***	0.591***	0.306***	0.635***
	(0.010)	(0.057)	(0.053)	(0.065)	(0.045)	(0.040)	(0.041)
Log of net-wealth	0.010***	0.048***	0.030***	0.054***	0.021***	0.035***	0.012***
	(0.001)	(0.006)	(0.005)	(0.011)	(0.004)	(0.006)	(0.004)
Home ownership	0.135***	0.693***	0.543***	0.221**	0.502***	0.270***	0.488***
	(0.015)	(0.076)	(0.068)	(0.106)	(0.063)	(0.068)	(0.060)
State GDP growth	-0.004*	-0.001	0.018	0.011	0.010	0.004	0.017*
	(0.002)	(0.011)	(0.012)	(0.014)	(0.010)	(0.010)	(0.009)
Risk of a natural disaster	0.000*	0.000	-0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Financial potential	-0.021	0.041	-0.185	-0.237	-0.105	-0.068	-0.019
	(0.029)	(0.150)	(0.163)	(0.175)	(0.138)	(0.127)	(0.122)
Constant	-1.431***	-9.660***	-3.024***	-6.680***	-5.052***	-3.637***	-7.364***
	(0.134)	(0.738)	(0.700)	(0.881)	(0.627)	(0.573)	(0.574)
State Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13459	13459	13459	13459	13459	13459	13459
Number of ID	8376	8376	8376	8376	8376	8376	8376

[1] Probit and tobit coefficient estimates. [2] Standard errors in parentheses. [3] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [4] Each column is a separate regression. [5] Omitted groups: *Education:* High school. *Employment Status:* Employed.

Table B11: Subjective risk attitudes measure: Average Marginal Effects

	Japan				
	Outcome 1	Outcome 4	Outcome 6	Outcome 8	Outcome 10
Panel A: Full sample					
Mother's education	0.000	0.007	-0.000	-0.006	-0.001
Father's education	0.000	0.002	-0.000	-0.002	-0.000
Respondent's height	0.000*	0.001*	-0.000	-0.001*	-0.000*
Male	0.000***	0.053***	-0.001	-0.049***	-0.010***
Age	-0.000***	-0.001***	0.000	0.001***	0.000***
Panel B: Male					
Mother's education	0.000	0.004	-0.001	-0.002	-0.000
Father's education	0.000*	0.015*	-0.004*	-0.009*	-0.002*
Respondent's height	0.000*	0.001*	-0.000*	-0.001*	-0.000*
Age	-0.000***	-0.001***	0.000***	0.001***	0.000***
Panel C: Female					
Mother's education	0.000	0.008*	0.004*	-0.012*	-0.002*
Father's education	-0.000	-0.006	-0.003	0.008	0.002
Respondent's height	0.000	0.000	0.000	-0.000	-0.000
Age	-0.000**	-0.001***	-0.001***	0.002***	0.000***
	U.S.				
	Outcome 1	Outcome 4	Outcome 6	Outcome 8	Outcome 10
Panel A: Full sample					
Mother's education	0.002	0.001	-0.003	-0.002	-0.000
Father's education	0.001	0.000	-0.001	-0.001	-0.000
Respondent's height	0.000	0.000	-0.000	-0.000	-0.000
Male	0.009***	0.003***	-0.012***	-0.011***	-0.001***
Age	-0.000***	-0.000***	0.000***	0.000***	0.000***
Panel B: Male					
Mother's education	0.000	-0.000	-0.000	-0.000	-0.000
Father's education	0.003	-0.000	-0.004	-0.003	-0.000
Respondent's height	0.000	-0.000	-0.000	-0.000	-0.000
Age	-0.001***	0.000	0.001***	0.001***	0.000***
Panel C: Female					
Mother's education	0.003	0.003	-0.005	-0.005	-0.001
Father's education	-0.000	-0.000	0.001	0.001	0.000
Respondent's height	0.000	0.000	-0.000	-0.000	-0.000
Age	-0.000**	-0.000**	0.000**	0.000**	0.000**

[1] Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table B12: Hypothetical gamble risk attitudes measures: Average Marginal Effects

	Japan			
	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Panel A: Full sample				
Mother's education	0.000	0.001	0.001	-0.002
Father's education	0.002*	0.008*	0.015*	-0.025*
Respondent's height	0.000***	0.001***	0.002***	-0.003***
Male	0.004***	0.019***	0.036***	-0.059***
Age	-0.000***	-0.002***	-0.004***	0.006***
Panel B: Male				
Mother's education	0.000	0.001	0.001	-0.002
Father's education	0.003	0.008	0.013	-0.023
Respondent's height	0.000*	0.001*	0.002*	-0.003*
Age	-0.001***	-0.003***	-0.005***	0.008***
Panel C: Female				
Mother's education	0.000	0.001	0.002	-0.002
Father's education	0.001	0.008	0.018	-0.026
Respondent's height	0.000*	0.001*	0.002*	-0.003*
Age	-0.000***	-0.001***	-0.003***	0.005***
	U.S.			
	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Panel A: Full sample				
Mother's education	0.000	0.001	0.003	-0.005
Father's education	0.002**	0.008**	0.022**	-0.032**
Respondent's height	0.000	0.000	0.000	-0.000
Male	0.007***	0.026***	0.074***	-0.107***
Age	-0.000***	-0.001***	-0.002***	0.002***
Panel B: Male				
Mother's education	0.003	0.007	0.017	-0.027
Father's education	0.009***	0.023***	0.056***	-0.088***
Respondent's height	0.000	0.000	0.000	-0.000
Age	-0.000***	-0.001***	-0.002***	0.003***
Panel C: Female				
Mother's education	-0.001	-0.003	-0.012	0.016
Father's education	-0.000	-0.002	-0.009	0.012
Respondent's height	-0.000	-0.000	-0.000	0.000
Age	-0.000***	-0.000***	-0.002***	0.002***

[1] Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table B13: Marginal effects of the hypothetical gamble measure on male individuals: Measure 2

	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Max. intensity recorded=3+	-0.0038***	-0.0101***	-0.0158***	0.0297***
	(0.001)	(0.003)	(0.005)	(0.009)
Mother's education	-0.0011	-0.0029	-0.0046	0.0087
	(0.003)	(0.007)	(0.011)	(0.020)
Father's education	0.0005	0.0012	0.0019	-0.0036
	(0.003)	(0.007)	(0.011)	(0.021)
Respondent's height	0.0003*	0.0009*	0.0015*	-0.0027*
	(0.000)	(0.000)	(0.001)	(0.001)
Age	-0.0017***	-0.0047***	-0.0073***	0.0137***
	(0.001)	(0.002)	(0.003)	(0.005)
Age-squared	0.0007	0.0019	0.0030	-0.0057
	(0.001)	(0.002)	(0.003)	(0.005)
Married	-0.0040	-0.0107	-0.0168	0.0316
	(0.003)	(0.008)	(0.013)	(0.024)
Number of children	0.0008	0.0022	0.0034	-0.0064
	(0.001)	(0.003)	(0.005)	(0.009)
Lives in a city	0.0003	0.0007	0.0012	-0.0022
	(0.002)	(0.007)	(0.010)	(0.019)
Employment:				
Unemployed	0.0003	0.0007	0.0012	-0.0022
	(0.004)	(0.012)	(0.019)	(0.035)
Part-time	0.0140	0.0335	0.0459*	-0.0934*
	(0.010)	(0.021)	(0.024)	(0.054)
Self-employed	0.0072**	0.0184**	0.0272**	-0.0528**
	(0.003)	(0.008)	(0.011)	(0.023)
Not in Labour force	0.0090**	0.0225**	0.0326**	-0.0642**
	(0.004)	(0.010)	(0.013)	(0.027)
Education:				
College	0.0063*	0.0174*	0.0279*	-0.0516*
	(0.004)	(0.010)	(0.015)	(0.029)
University+	0.0078***	0.0214***	0.0336***	-0.0628***
	(0.003)	(0.007)	(0.010)	(0.019)
Anxieties about health	0.0013	0.0034	0.0053	-0.0099
	(0.001)	(0.002)	(0.003)	(0.006)
Risk of unemployment	0.0031*	0.0084*	0.0132*	-0.0248*
	(0.002)	(0.005)	(0.007)	(0.014)
Borrowing constraint	0.0087***	0.0234***	0.0367***	-0.0688***
	(0.003)	(0.007)	(0.012)	(0.022)
Log of household income	0.0032*	0.0087**	0.0136**	-0.0255**
	(0.002)	(0.004)	(0.007)	(0.013)
Log of net-wealth	0.0000	0.0001	0.0002	-0.0003
	(0.000)	(0.000)	(0.000)	(0.001)
Home ownership	-0.0031	-0.0082	-0.0128	0.0241
	(0.003)	(0.007)	(0.012)	(0.022)
State GDP growth	0.0001	0.0003	0.0005	-0.0009
	(0.000)	(0.001)	(0.002)	(0.003)
State Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

[1] Ordered probit marginal effects estimates. [2] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [3] Each panel is a separate regression. [4] Outcome 1 refers to choosing value 0, while outcome 4 refers to value 3.

Table B14: Marginal effects of the hypothetical gamble measure on male individuals: Measure 3

	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Max. intensity recorded=4+	-0.0050***	-0.0133***	-0.0209***	0.0391***
	(0.002)	(0.004)	(0.007)	(0.013)
Mother's education	-0.0011	-0.0030	-0.0046	0.0087
	(0.003)	(0.007)	(0.011)	(0.020)
Father's education	0.0004	0.0011	0.0017	-0.0032
	(0.003)	(0.007)	(0.011)	(0.021)
Respondent's height	0.0003*	0.0009*	0.0015*	-0.0027*
	(0.000)	(0.000)	(0.001)	(0.001)
Age	-0.0017***	-0.0047***	-0.0073***	0.0137***
	(0.001)	(0.002)	(0.003)	(0.005)
Age-squared	0.0007	0.0020	0.0031	-0.0057
	(0.001)	(0.002)	(0.003)	(0.005)
Married	-0.0040	-0.0107	-0.0167	0.0314
	(0.003)	(0.008)	(0.013)	(0.024)
Number of children	0.0008	0.0021	0.0033	-0.0062
	(0.001)	(0.003)	(0.005)	(0.009)
Lives in a city	0.0002	0.0007	0.0010	-0.0020
	(0.002)	(0.007)	(0.010)	(0.019)
Employment:				
Unemployed	0.0002	0.0004	0.0007	-0.0012
	(0.004)	(0.012)	(0.019)	(0.035)
Part-time	0.0139	0.0333	0.0456*	-0.0928*
	(0.010)	(0.021)	(0.024)	(0.054)
Self-employed	0.0072**	0.0183**	0.0271**	-0.0526**
	(0.003)	(0.008)	(0.011)	(0.023)
Not in Labour force	0.0089**	0.0224**	0.0325**	-0.0638**
	(0.004)	(0.010)	(0.013)	(0.027)
Education:				
College	0.0063*	0.0175*	0.0280*	-0.0518*
	(0.004)	(0.010)	(0.015)	(0.029)
University+	0.0079***	0.0215***	0.0336***	-0.0630***
	(0.003)	(0.007)	(0.010)	(0.019)
Anxieties about health	0.0013	0.0034	0.0053	-0.0099
	(0.001)	(0.002)	(0.003)	(0.006)
Risk of unemployment	0.0032*	0.0086*	0.0135*	-0.0254*
	(0.002)	(0.005)	(0.007)	(0.014)
Borrowing constraint	0.0088***	0.0236***	0.0370***	-0.0694***
	(0.003)	(0.007)	(0.012)	(0.022)
Log of household income	0.0032*	0.0087**	0.0137**	-0.0256**
	(0.002)	(0.004)	(0.007)	(0.013)
Log of net-wealth	0.0000	0.0001	0.0001	-0.0003
	(0.000)	(0.000)	(0.000)	(0.001)
Home ownership	-0.0030	-0.0081	-0.0127	0.0238
	(0.003)	(0.007)	(0.012)	(0.022)
State GDP growth	0.0000	0.0000	0.0000	-0.0000
	(0.000)	(0.001)	(0.002)	(0.003)
State Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

[1] Ordered probit marginal effects estimates. [2] * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. [3] Each panel is a separate regression. [4] Outcome 1 refers to choosing value 0, while outcome 4 refers to value 3.

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