The European Monetary Policy at the Crossroads: Some Lessons from the Italian Case

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“Jak by było łatwo to każdy by to miał.”

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Abstract

This thesis investigates the regional monetary policy transmission mechanism (MPTM), from the European Central Bank (ECB) to the Italian Nomenclature of Territorial Units for Statistics (NUTS2) regions, between 1999q4-2017q1. Three MPTM elements are examined: the mark-up, the pass-through, and the speed of adjustment. This thesis's motivation is to bring knowledge on the MPTM underlying the European monetary policy after 20 years of operations: Since early 1990s, the Commission of the European Communities and the Treaty of European Union anticipated homogenous monetary policy operations, however, thereafter empirical studies found evidence of heterogeneous operations. Thus, MPTM proxies are estimated through a Vector Error Correction model (VECM) and an Autoregressive Distributed Lag (ARDL) model, using the European Main Refinancing Operations (MRO) rate and bank lending interest rates for each Italian NUTS2 region, controlling for two phases of the 2007-2008 Financial Crisis. Results show that the MPTM works differently across Italian NUTS2 regions, leading to different monetary policy effectiveness. Low mark-ups were observed across northern Italian regions whereas high levels were observed across southern regions. Moreover, high pass-through and speed of adjustment were identified in northern regions and low levels in southern regions. Lombardia, the region with the most effective monetary policy is simultaneously the region where the Italian stock exchange and the financial sector are located. This finding is unique, highlighting the influence of the financial sector on regional development. Similar regional patterns were found for the 2007–2008 Financial Crisis in comparison to the baseline results. These results suggest that the MPTM operates heterogeneously across regions, as supported by the literature, and that monetary policy is more effective in north Italy than in the south. Therefore, in order to achieve the ECB goals of economic development, the monetary policy has to be accompanied by other public policy measures.

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Introduction

1.1 Introduction

The 20th century was marked by numerous significant historic events, such as World War I (1914 – 1918), the Great Depression (1929 – late 1930s) and World War II (1939 – 1945), which led to millions of deaths, hunger and misery. Due to these terrible times a desire for peace, freedom and stability emerged in Europe. This was the foundation for the creation of European Union. The process began by creating the European Coal and Steel Community among six countries (Belgium, France, Germany, Italy, Luxembourg and the Netherlands) in 1952. Today (2019), the European Union consists of 28 countries amongst which 19 countries use the same currency, are part of the Euro Area and follow the same monetary policy conducted by the European Central Bank (ECB) creating the Euro Area, or also known as the Euro Zone. At the time of writing, it is 20 years since the ECB started conducting the common monetary policy.

The Maastricht Treaty represents a key point for the introduction and functioning of the common monetary policy and currency in Europe. This treaty, also known as the Treaty on European Union, was signed in 1992 by 12 countries (Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and the United Kingdom) creating the European Economic and Monetary Union (EMU). The Title II, Article G, point B of this treaty states that:

> '*The Community shall have as its task, by establishing a common market and an economic and monetary union and by implementing the common policies or activities referred to in Articles 3 and 3a, to promote throughout the Community a harmonious and balanced development of economic activities, sustainable and non-inflationary growth respecting the environment, a high degree of convergence of economic performance, a high level of employment and of social protection, the raising of the standard of living and quality of life, and*

> *economic and social cohesion and solidarity among Member States.*'
> (Treaty on European Union, 1992, p. 11 -12).

Therefore, it is the objective of the European Commission (EC) to enhance economic growth and employment across the member countries (EC, 2019a). This objective is achieved through the monetary policy conducted by the ECB. The ECB conducts the European monetary policy for the whole Euro Area through setting the monetary policy interest rate and hence securing price stability (ECB, 2019a; EC, 2019a).

This monetary policy interest rate, in turn, is the key interest rate influencing all Euro Area interest rates and its economies, flowing through the monetary policy transmission mechanism (MPTM). Therefore, the MPTM is the process which is used to achieve economic growth and employment leading to an alignment of Euro Area regions, also called convergence (ECB, 2019b; EC, 2019a; Commission of the European Communities, 1990).

Furthermore, two fundamental principles were stated in the Maastricht Treaty (Treaty on European Union, 1992), namely the gradual convergence process and the conditional satisfaction of convergence criteria, both prior to the creation of the EMU. In this way, the conditions for symmetric reactions to shocks and similar monetary policy operations were set across the monetary union. Furthermore, the Commission of European Communities (CEC) supported the argument of a similar monetary policy operation based on the ongoing convergence of regions during the operations of the EMU (Commission of the European Communities, 1990). Hence, symmetric reactions of countries to shocks as well as similar operations of the monetary policy across the Euro Area were anticipated.

However, empirical studies found heterogeneity in monetary policy operations when analysing the MPTM through mark-up, monetary policy pass-through and speed of adjustment across the Euro Area countries and on intra-national levels (Leroy and Lucotte, 2016; Montagnoli et al., 2016; ECB, 2013; Bogoev and Petrevski, 2012; Karagiannis et al., 2011; Gambacorta, 2008; de Bondt et al., 2005; Sander and Kleimeier, 2004; Angelini and Cetorelli, 2000).

Therefore, this discrepancy between theory and empirical findings is the motivation for this thesis, which contributes to the academic literature by researching three sub-mechanisms of the MPTM as suggested by the literature, namely the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment. In order to capture the MPTM from the ECB across the Euro Area regions, the beginning point of the analyses in this thesis is the ECB level (the supra-national level) concluding at the Italian Nomenclature of Territorial Units for Statistics (NUTS2) regions (the intra-national level). To capture the MPTM across the different levels each of the sub-mechanisms is empirically estimated by employing the ECB-set MRO rate and bank lending rates observed across the Italian NUTS2 regions. Hence, these particular characteristics, among other things, differentiate this thesis from other work done in this field. A further motivation for this thesis is to bring knowledge on a mechanism underlying the European monetary policy after 20 years of being in operation.

By following the MPTM literature, the hypothesis of this thesis is that the MPTM transmits in a heterogeneous way across the Italian NUTS2 regions. Hence, the objective of this thesis is to investigate whether the monetary policy of the EMU operated differently from the ECB across the Euro Area so far. This objective is achieved through examining the interest rate channel of the MPTM through indicators on commercial bank mark-up, monetary policy pass-through and speed of adjustment from the ECB across the NUTS2 regions of a particular country, such as Italy. Therefore, the empirical analysis of this thesis is conducted from a supra-national level across an intra-national level in Italy.

The contributions of this thesis are based on three key areas. First, the MPTM is investigated from the ECB level, the supra-national level, across Italian NUTS2 regions, the inter-regional level. This contribution is innovative because existing literature investigates the MPTM from the inter-bank lending market. Second, national factors contribute to the heterogeneity of the MPTM and hence interest rate channel. However, within this thesis the estimated commercial bank mark-up, the monetary policy pass-through and speed of adjustment proxies are computed in an environment of uniform national characteristics on an intra-national level. This approach is innovative and controls for national macroeconomic influences. Finally, each MPTM sub-mechanism indicator is estimated via Vector Error Correction Model (VECM) and Autoregressive Distributed Lag (ARDL) model with build in optimal lag-lengths and rank. Those models are empirically determined through pre-estimation tests. Furthermore, these models control endogenously for the 2007 – 2008 Financial Crisis.

The following section of this Chapter presents the theory on monetary unions as well as the history of the EMU. Section three describes monetary policy mechanisms. Section four explains the hypothesis of this thesis whilst section five states the research objectives, research questions and motivations. Section six presents the contributions of this thesis. Finally, section seven provides an outline of the thesis.

1.2 Monetary Union Theory and the History of the EMU

A monetary union is defined as a union between countries which share the same currency and hence follow the monetary policy conducted by one central bank for all the member countries (Mundell, 1961). The benefits of a monetary union are expected to occur primarily at the microeconomic level, whereas the costs are expected at the macroeconomic level (De Grauwe, 2012). The microeconomic gains are achieved through economic efficiency that result from the elimination of transaction costs and exchange rate uncertainty. The removal of transaction cost is the most noticeable gain because money does not need to be exchanged into different currencies any longer. Price transparency indirectly reduces transaction costs and contributes to the gains of a monetary union as consumers are in a more favourable position because they can compare prices more easily and can shop across the whole monetary union. This leads to higher competition and hence price reductions making consumers better off (De Grauwe, 2012).

The literature on the cost of a monetary union is vast and builds on Mundell (1961), McKinnon (1963) and Kenen (1969). The main cost of a monetary union is that each member state is giving up its own ability to conduct its own independent monetary policy. In other words, a monetary union member state is unable to change unilaterally the monetary policy interest rate and devaluate or revaluate its currency and therefore is unable to decide about the quantity of its currency in circulation (De Grauwe, 2012).

The ability to change monetary policy interest rates as well as to devaluate or revaluate a currency within an economy is an important tool, especially following an economic shock or a crisis. Following the mainstream view, the neoclassical school of thought, monetary policy is the main instrument to control for any disequilibria in an economy (Krugman, 1993). For example, if a country with sovereign monetary policy is affected by a negative demand shock for its products leading to an output reduction and a surge in unemployment, typically a currency devaluation and/or expansionary monetary policy is pursued in order to offset the shock, leading to output increases and unemployment decreases (Krugman, 1993; Mundell, 1961).

For the case that a similar shock impacts a monetary union, the exchange rate mechanism cannot be applied to rebalance the economies because exchange rates between the member states do not exist. The common monetary policy mechanism can be used to offset shocks within the monetary union, but only if these shocks are symmetrical (affect all member states in the same way). Shocks are symmetrical if member countries are similar or achieve similarity through convergence, forming what Mundell (1961) has termed an optimum currency area (OCA).

In the 1970s there were two different views on how similarities/convergence of countries could be achieved. The discussion took place between two groups: the ‘economists’ and the ‘monetarists’. According to the ‘economists’ a process of structural convergence was required before a monetary union was created (Chick and Dow, 2012). The monetarists, on the other hand, argued that through the introduction of a single currency, convergence across the member states of a monetary union would emerge, based on increased trade integration due to the realisation of higher economies of scale (Chick and Dow, 2012).

Frankel and Rose (1997) support the ‘monetarist’ view. They argue that the two significant optimal currency area criteria, trade integration and business cycle synchronisation, are endogenous and interrelated: when trade increases in a monetary union, integration and business cycle synchronisation will occur. Therefore, it is not crucial for a country to be integrated and have harmonised business cycles with other union members prior to the creation or entry of a monetary union.

In preparation for the creation of the EMU, in 1992 the Treaty on European Union, also referred to as the Maastricht Treaty, was signed by 12 of the European Union states (Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and the United Kingdom). This treaty contained a three-stage outline and a strategy consisting of two principles leading towards an OCA and therefore to the monetary union in Europe. In stage 1, referred to the time frame between 1st July 1990 and 31st December 1993, the free movement of capital between the member states was introduced. During stage 2, which lasted from 1st January 1994 until 31st December 1998, the member states' economic policies were aligned and a cooperation between the national central banks was introduced. In stage 3, which started on 1st January 1999 and lasts until today, the single monetary policy is conducted by the ECB and the Euro was introduced as a currency (ECB, 2019c).

The main two principles leading to an OCA are as follows. The first principle related to a gradual transition of several years prior to the establishment of the EMU and the second principle consisted of a conditional satisfaction of convergence criteria for the monetary union candidates at the creation point of the EMU (ECB, 2019c; De Grauwe, 2012).

The transition period took 12 years, during which the economy of the candidate countries had to undergo a process of convergence. To become a member of the EMU, the following convergence criteria had to be satisfied. The criteria stated that a potential member county's:

1. 'inflation rate is not more than 1.5% higher than the average of the three lowest inflation rates among the EU member states' (De Grauwe, 2012, p. 134)
2. 'long-term interest rate is not more than 2% higher than the average observed in these three low-inflation countries' (De Grauwe, 2012, p. 134)

3. ‘has joined the exchange rate mechanism of the EMS and has not experienced a devaluation during the two years preceding the entrance into the union’ (De Grauwe, 2012, p. 134)
4. ‘government budget deficit is not higher than 3% of its GDP…’ (De Grauwe, 2012, p. 134)
5. ‘government debt should not exceed 60% of GDP …’ (De Grauwe, 2012, p. 134)

By imposing these convergence criteria, the expectation was that the economies of the member states would align before the official introduction of the Euro which would consequently reduce the probability of asymmetric reactions to shocks by its members.

In addition, the Commission of the European Communities (1990) (CEC) stated that the union by itself would influence long-term convergence through the enhanced interaction in the form of trade between the countries and regions. In 1990, synergies across the member countries were seen by the CEC as the key drivers for the catch-up process of the regions. Within this document it was also emphasised that at the point in time of this study policies were already at work across the union, which reduced regional differences. Hence, policies were in place which would enhance the convergence of regions.

The ‘One Market, One Money’ (Commission of the European Communities, 1990) document showed that the CEC was in line with the Frankel and Rose (1997) argument, assuming that convergence across monetary union members will increase due to the workings of the monetary union. Hence, a similar monetary policy operation was anticipated across the monetary union members.

In May 1998, 11 countries satisfied the convergence criteria, namely Austria, Belgium, Finland, France, Germany Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain.

On 1st January 1999, the ECB started conducting the monetary policy for the above-mentioned countries and the Euro was introduced as currency on 1st January 2002 (European Union, 2019a; De Grauwe, 2012).

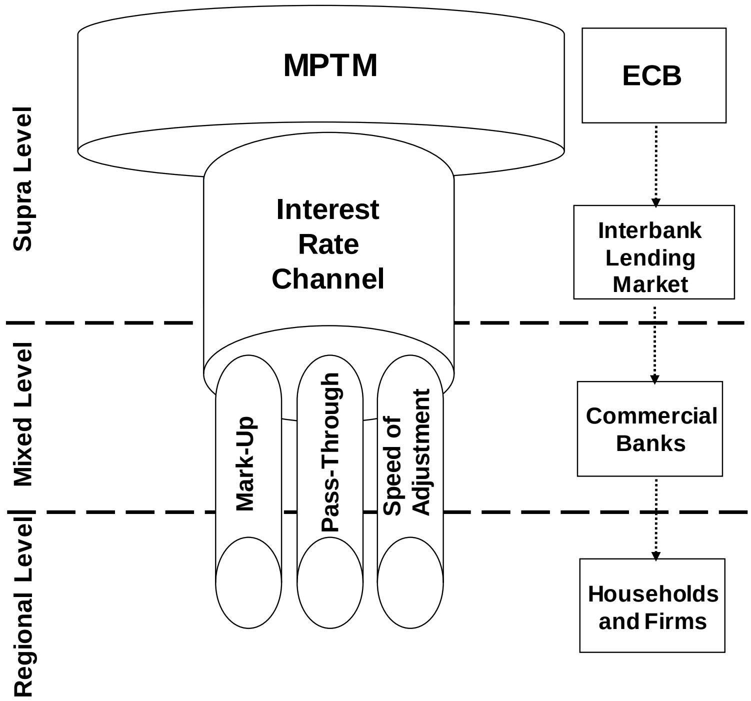
1.3 Monetary Policy Mechanisms

The main instrument of the monetary policy is the monetary policy interest rate, which influences an economy through the monetary policy transmission mechanism (MPTM) (ECB, 2019b). An MPTM is defined as “the process through which monetary policy decisions affect the economy in general” (ECB, 2019b). In fact, the MPTM is a process through which the monetary policy impulse, represented by changes in monetary policy, is transmitted to the economy (ECB, 2019b; Oesterreichische Nationalbank, 2019; Oliner and Rudebusch, 1995). The change in the monetary policy interest rate, in turn, influences many interest rates, such as all the different interest rates in the lending market (interest rates on consumer loans or mortgages), inter-bank interest rates, interest rates on deposits, as well as prices including asset prices and exchange rates (ECB, 2019b; Oesterreichische Nationalbank, 2019).

Therefore, the MPTM can be analysed through different channels. These are the interest rate channel, the credit channel, the exchange rate channel, the wealth channel or the balance sheet channel among others (Oesterreichische Nationalbank, 2019; ECB, 2019b). Within this thesis the interest rate channel is researched to examine how changes in the ECB monetary policy are transmitted to commercial bank lending interest rates across regions. More precisely, the interest rate channel is chosen because the MPTM will be approached empirically by estimating the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment. Therefore, the other channels are abstracted away and in the remainder of this thesis the terms interest rate channel and MPTM are used interchangeably.

Figure 1.1 summarises the MPTM interest rate channel. This Figure illustrates that the ECB-set interest rate transmits through the MPTM influencing the inter-bank rates and commercial bank interest rates and therefore impacting interest rates on loans for households and firms. Furthermore, Figure 1.1 shows also that the interest rate channel can be approached empirically through three sub-mechanisms of the MPTM: the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment.

Figure 1.1 The Interest Rate Channel



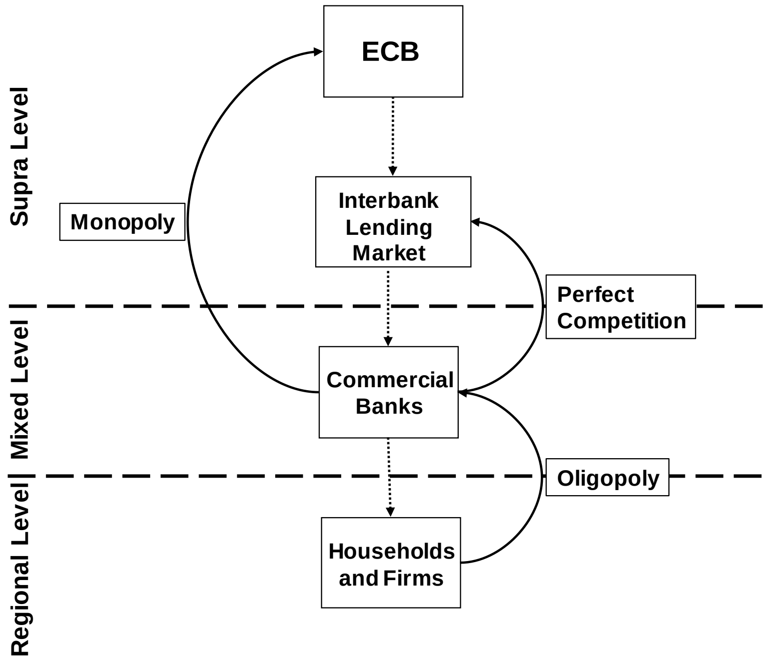
Source: Author's own illustration based on ECB (2019b) and Oesterreichische Nationalbank (2019).

The European monetary policy is set by the ECB for all Euro Area countries, so that the MPTM starts at the supra-national level (ECB, 2019k). As mentioned above, the ECB-set interest rate influences other interest rates such as interest rates in the inter-bank lending market but also interest rates set by the commercial banks. The inter-bank lending market in the Euro Zone is part of the supra-national level because all banks of the Euro Area can participate in it through lending funds to each other across the Euro Zone (European Banking Federation, 2019). The commercial banks take the ECB-set rate as a benchmark and pass it on to their own customers with a mark-up. Therefore, the ECB-set interest rate influences also the commercial bank lending market but it operates mostly on the national level, although commercial banks also exist across nations, such as Deutsche Bank in Spain and Santander in Germany. Therefore, in this thesis it is referred to as the mixed geographical level also shown in Figure 1.1. Furthermore, commercial banks are represented by branches across regions of a country where households and firms have access to loans. Thus, commercial banks operate also on the regional level.

Moreover, the interest rate channel is defined through a positive relationship between the monetary policy interest rate and bank lending rates

(Oesterreichische Nationalbank, 2019). Figure 1.2 depicts this structure. Following the arrows in Figure 1.2, a change in the monetary policy interest rate set by ECB influences bank lending interest rates as follows: a monetary policy increase set by the ECB, also called monetary tightening, leads to a decrease in reservable deposits and an increase in market interest rates, which in turn, has a positive impact on bank lending rates (Oesterreichische Nationalbank, 2019; Gambacorta 2008). Hence, an increase in the monetary policy interest rate leads to an increase across the lending interest rates for households and firms.

Figure 1.2 Operation of the Interest Rate Channel



Source: Author's own illustration based on ECB (2019b) and Oesterreichische Nationalbank (2019).

Furthermore, as shown in Figure 1.2, in practice commercial banks are operating across the three different market forms within the interest rate channel, namely monopoly, oligopoly and perfect competition. For instance, by following the bended arrows, commercial banks can borrow funds directly from the ECB at the interest rate set by the ECB. By doing so they do not need to use the inter-bank lending market. The ECB has a monopoly over the interest rate (ECB, 2019d; European Union, 2019b). As a result, the commercial banks manoeuvre in a monopolistic market form.

Commercial banks can also obtain funding from the inter-bank lending market. As mentioned above, all the commercial banks of the Euro Area have access to it. Therefore, this market can be viewed as being a perfectly competitive one, because on this supra-national level all commercial banks are small and take the interest rate as given by the inter-bank lending market. Euro Interbank Offered Rate (EURIBOR) and Euro Overnight Index Average (EONIA) are examples of the interest rates used within the inter-bank lending market (European Banking Federation, 2019; ECB, 2019e). In this case, commercial banks are operating in a perfectly competitive market form.

Finally, commercial banks are lending money to households and firms. In most Euro Zone countries, the commercial bank lending market is characterised by a few commercial banks (European Banking Federation, 2019; Rousseas, 1985). Therefore, the interest rate setting by these commercial banks can be understood as on an oligopolistic market. Hence, commercial banks are also operating in an oligopolistic market.

1.4 Main Hypothesis of the Thesis

Building on the theories and arguments presented in Sections 1.2 and 1.3, the European monetary policy should operate homogenously across the member countries/regions. This is due to the following points:

1. As highlighted in Section 1.2, in a monetary union all member countries are unable to conduct their own independent monetary policy; instead, monetary policy is conducted by one central bank for all member states (Mundell, 1961).
2. Based on the neoclassical school of thought, monetary policy is the main instrument which is utilised to offset shocks in an economy (Krugman, 1993).
3. Additionally, according to Article 2 of the Treaty on European Union (1992) and the European Commission’s objective, balanced and harmonised economic activity, non-inflationary and sustainable growth and high employment levels can be accomplished across the member countries through the monetary policy conducted by the ECB.
4. Because only one monetary policy is conducted for all member countries of a monetary union, the member countries are expected to

create an OCA, meaning that all countries are affected by a shock in a similar way and therefore requiring the same monetary policy for intervention. Furthermore, in order to achieve a harmonised economic activity, non-inflationary growth and high employment, all member countries should require the same monetary policy (Mundell, 1961).

5. As discussed in Section 1.2, prior to the creation of the EMU, the Treaty on European Union (1992) was signed and contained a three-stage outline and a strategy, consisting of two principles, leading towards an OCA among the candidate countries. The first principle referred to the gradual convergence process of 12 years during which the economies of the candidate countries had to undergo a process of convergence in order to create an OCA. The second principle refers to a conditional satisfaction of convergence criteria by the monetary union candidates at the creation point of the EMU.
6. Additionally, in order to ensure a similar operation of monetary policy across the monetary union interest rate and inflation were two of the five key convergence criteria which had to be met by candidates who wanted to be part of the monetary union (De Grauwe, 2012).

   More precisely, the interest rate criterion was important to avoid capital gains and losses during the creation of the monetary union which would result from large long-term interest rate differences across the countries. For example, in Italy, Spain, Greece, Ireland and Portugal, these interest rates were significantly higher before entering the EMU. If convergence would have not been required capital from low-yield regions would have flown to these high-yield regions which could have led to disruption in the capital markets. As a result of the convergence criterion for interest rates, long-term interest rates in Italy, Spain, Greece, Ireland and Portugal strongly declined during the convergence process to avoid such a dynamic (De Grauwe, 2012).

   Moreover, inflation convergence across the candidate countries was required due to the fear of potential inflation bias at the point of the monetary union creation. Before stage 3 of the Maastricht Treaty was introduced each governments’ stance on inflation was central. It was important that the candidates shared the same view of targeting low inflation rates as otherwise countries of low inflation, such as Germany, would have lost out at the entry of the monetary union due to the imported inflation from high inflation countries leading to higher prices in Germany. During the convergence process disinflation took place across the candidate countries with high inflation, such as in Italy, showing their willingness of fighting inflation in order to pursue the same objective on low inflation and price stability (De Grauwe, 2012).

Thus, both requirements show that candidate countries aligned their interest rates and inflation levels to the required levels. Once interest rates and inflation, among other things, were aligned across the candidate countries, a common monetary policy was introduced which, in turn, was conducted by the ECB.

7. Furthermore, as per the 'One Market, One Money' (Commission of the European Communities, 1990) document, it was assumed that converge across the monetary union members will increase due to the workings of the monetary union.

Based on the argumentation presented above, a homogenous monetary policy hypothesis should be assumed. However, studies investigating the mechanisms of the European monetary policy found heterogeneity in monetary policy operations (Leroy and Lucotte, 2016; Montagnoli et al., 2016; ECB, 2013; Bogoev and Petrevski, 2012; Karagiannis et al., 2011; Gambacorta, 2008; de Bondt et al., 2005; Sander and Kleimeier, 2004; Angelini and Cetorelli, 2000). For instance, risk (ECB, 2013), the competition level in the banking sector (Horváth and Podpiera, 2012; Karagiannis et al., 2011), liquidity preferences (Dow and Rodriguez-Fuentes, 1997), financial innovations and volatility in the interest rates (de Bondt et al., 2005) could influence the existence of heterogeneity in the MPTM.

Therefore, the main hypothesis of this thesis is based on a heterogeneous monetary policy operation across regions and researches the extent of the heterogeneity/differences across the investigated regions. Since three different MPTMs are investigated in this thesis, namely the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment, the hypothesis of each chapter is that each of the MPTMs transmits heterogeneously across the regions. Furthermore, it is analysed whether regional patterns can be identified.

1.5 Research Objectives, Research Questions and Motivation

The main objective of this thesis is to investigate the monetary policy operations of the EMU from the ECB across the Euro Area within its 20 years of operations. This objective is achieved by examining the interest rate channel from the ECB across Italy. Italy was chosen as a case study due to its north-south regional divide which mirrors the division across the Euro Area countries. To examine this main objective the analysis of the interest rate channel in this thesis is based on the ECB-set Main Refinancing Operation (MRO) interest rate and revocable loan interest rate per Italian Nomenclature of Territorial Units for Statistics (NUTS2) region.

As discussed in Sections 1.2 to 1.4, the underlying theory of the EMU anticipated similar workings of the monetary policy across the member states due to the alignment of their economies prior to the creation of the monetary union and due to trade integration throughout the union’s existence (Commission of the European Communities, 1990). However, empirical studies show otherwise, namely a heterogeneous transmission of the monetary policy (Montagnoli et al., 2016; Gambacorta, 2008; de Bondt et al., 2005; Sander and Kleimeier, 2004). Therefore, the motivation for this thesis is to analyse to which extent the ECB conducted monetary policy operates in a heterogeneous way and varies across the Euro Area after 20 years in operation and the 12 years of preparation.

The overall research question of this thesis is how the MPTM, through its interest rate channel, varies across Italian regions. This overall question is answered by researching the MPTM interest rate channel between the ECB-set MRO rate and the observed revocable loan interest rates for the Italian NUTS2 regions. Three sub-mechanisms are analysed: the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment. The period of the analysis is 1999q4 – 2017q1.

The objective of the commercial bank mark-up analysis in Chapter 3 is to understand the interest rate channel between commercial banks and households and firms across regions. For instance, regions differ in terms of observed average interest rates due to differences in industrial structure and probabilities to default. Chapter 3 examines the mark-up that banks add on average to the MRO rate and how those differ across regions. Therefore, the main research question of this Chapter is how the levels of the mark-up differ across regions. The motivation of this Chapter is to analyse the market power of commercial banks across Italian regions.

The objective of the monetary policy pass-through analysis in Chapter 4 is to understand the extent of the monetary policy change which is transmitted to the bank lending rates in the long- and short-run. Furthermore, the interest is to identify how the monetary policy pass-through differs across regions in long- and short-run. Therefore, the research question of this Chapter is how the level of monetary policy pass-through differ across regions. The motivation for the pass-through analysis is to obtain insights on how quickly ECB monetary policy changes are absorbed in regional interest rates in the long- and short-run across Italian regions.

Finally, the objective of the speed of adjustment analysis in Chapter 5 is to examine how the regional interest rates adjust towards a long-run equilibrium with the ECB-set rate within a quarter. This Chapter researches how the speed of adjustment differs across the Italian NUTS2 regions. Hence, the research question of this Chapter is how the extent of the speed of adjustment differs across regions. The motivation of the speed of adjustment analysis is to obtain knowledge on monetary policy effectiveness across regions through an additional indicator than the monetary policy pass-through.

This approach adopted in this thesis provides an analysis of MPTM from the supra level to an intra-national level. This is unique because it allows to investigate the ‘whole’ MPTM, beginning at the point of interest rate setting (ECB) and concluding at the Italian NUTS2 regions. Conversely, other empirical studies are beginning their analysis at the inter-bank lending market (Montagnoli et al., 2016), hence omitting the ECB, and concluding either at the national or intra-national levels. Overall, through analysing the key instrument of the monetary union, namely monetary policy, provides insight of the monetary union operations in real life.

1.6 Contributions

Angeloni et al. (2003) presented results of the research project conducted by the European Monetary Transmission Network in a book where the authors examined the MPTM in the Euro Area a few years after the creation of the monetary union. Findings across these studies were inconclusive therefore, the authors suggested further analysis especially when longer time-series are available.

Therefore, to better understand the monetary policy operations, the main aim of this thesis is to explore the Euro Area MPTM using longer time-series data. The Maastricht Treaty stage 3 was introduced 20 years ago, meaning that the common monetary policy is in operation for 20 years now. Therefore, the findings in literature and the 20 years of the European monetary policy operation by itself provide the motivation for this thesis's research and creates a contribution to this literature.

Based on Article 2 of the Maastricht Treaty (Treaty on European Union, 1992), the 'One Market, One Money' document (Commission of the European Communities, 1990), the stated objectives of the European Commission and the ECB as well as the fulfilment of the convergence criteria prior to the entry of the monetary union (De Grauwe, 2012), a similar working of the monetary policy across regions was assumed. However, empirical studies found heterogeneity in monetary policy operations when analysing the interest rate channel through mark-up, monetary policy pass-through and speed of adjustment across the Euro Area countries and on intra-national levels (Leroy and Lucotte, 2016; Montagnoli et al., 2016; ECB, 2013; Bogoev and Petrevski, 2012; Karagiannis et al., 2011; Gambacorta, 2008; de Bondt et al., 2005; Sander and Kleimeier, 2004; Angelini and Cetorelli, 2000).

One gap in the above-mentioned literature is that it omits the supra-national level, namely the ECB in their analyses when researching the interest rate channel from the inter-bank lending to countries or to the intra-national level.

This thesis adds to the literature by incorporating the ECB into the analysis of the interest rate channel and filling this gap.

Furthermore, literature shows that national factors contribute to the heterogeneity of the interest rate (ECB, 2013; Tai et al.,2012; Sander and Kleimeier, 2004). However, the estimated commercial bank mark-up proxies, the monetary policy pass-through proxies and the speed of adjustment proxies in this thesis are computed in an environment of uniform national characteristics on an intra-national level. This approach is innovative as it allows to control for national macroeconomic influences when estimating interest rate channel indicators, which contributes to the current literature.

Each of the interest rate channels investigated in this thesis are estimated by means of regional VECM and ARDL models. The regional aspect is accredited to the point that optimal lag-length and rank are built-in into each regional estimation. The regional lag-lengths and ranks, in turn, are established through pre-estimation tests based on each region's time-series in conjunction with the MRO rate time-series. Also, since the 2007 – 2008 Financial Crisis is within the sample period, a unique approach is used to control for the Crisis. First the timing of the Crisis is empirically determined through the Zivot and Andrews (1992) unit-root test for each time-series. Second, within the regional estimations, a dummy variable or trend variable are introduced in order to control for the identified Crisis break points. This approach of incorporating data characteristics into the estimations and the particular approach to control for the Crisis is also innovative within estimations of interest rate channel indicators and contributes to current literature.

The results of this thesis show that the MPTM works differently across Italian NUTS2 regions, leading to different levels of monetary policy effectiveness. This means that the ECB's objective of price stability in the Euro Zone, which in turn, supports to enhance economic growth and employment in the Euro Zone, operates differently across areas. Furthermore, the Financial Crisis impacted the MPTMs differently across regions. As a result, other supporting mechanisms to foster economic growth and employment should be introduced, especially for the 'poorer' regions where risk and competition level in the banking sector influences the interest rate on loans.

1.7 Outline of the Thesis

This thesis consists of six chapters. Chapter 2 presents the data obtained for the empirical investigation of this thesis, analyses and discusses potential estimation strategies which could be applied in order to estimate the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment. Chapter 3 elaborates on the commercial bank mark-up, including a discussion on various mark-up estimation approaches, the method employed to estimate the commercial bank mark-up proxies for this Chapter and presents the obtained results. Chapter 4 discusses the monetary policy pass-through, by providing information on several estimation strategies used to estimated monetary policy pass-through, the method employed to estimate the monetary policy pass-through proxies for this Chapter and summarises the results of this proxy. Chapter 5 examines the speed of adjustment, including the estimation approaches for this indicator, the estimation strategy used to estimate speed of adjustment proxy and elaborates on the obtained results. Finally, Chapter 6 concludes this thesis.

Chapter 2
Methodology

2.1 Introduction

The aim of this thesis is to empirically examine the monetary policy transmission mechanism (MPTM) starting at the ECB level and concluding at the Italian Nomenclature of Territorial Units for Statistics 2 (NUTS2) level. As presented in Chapter 1, this aim is achieved by researching the three sub-mechanisms of MPTM, namely the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment. Each of these three sub-mechanisms will be estimated using the same data throughout this thesis. Therefore, this Chapter presents, discusses and justifies the data used, and the methodology followed, to estimate these MPTMs.

In detail, the Main Refinancing Operation (MRO) rate is proposed as the monetary policy interest rate for analysis because this interest rate is directly set by the ECB Governing Council for fund lending operations to the Euro Area commercial banks. On the other hand, the revocable loan interest rates are selected for each Italian NUTS2 regions in order to evaluate the impact of the monetary policy change on Italian intra-national level.

In methodological terms, VECM was selected as the appropriate model to estimate the three MPTMs due to two key reasons: On one hand, this model provides all the required indicators for the MPTMs calculations within one estimation step. Moreover, the autoregressive distributed lag (ARDL) model also provides long- and short-run coefficients. Both models help to identify the impact of the Financial Crisis on regional interest rates.

This Chapter is divided in four sections. Section two introduces all data used in Chapters 3, 4 and 5, justifies the selection of these variables, presents descriptive statistics and a visual analysis, which provides insight on the change of the spread across Italian NUTS2 regions over time. The spread is defined as the difference between each regional revocable loan and the MRO for each period. In section three various estimation strategies are discussed. This section concludes by identifying the VECM and ARDL as the preferred estimation strategies. The VECM estimation strategy is preferred because calculations of all three MPTM sub-mechanism can be obtained within one estimation step. Furthermore, the ARDL model is also considered as a potential estimation model for the estimations of this thesis because it provides long- and short-run proxies. Section four provides the conclusion of this Chapter.

2.2 Data Description and Summary Statistics

Since the aim of this thesis is to empirically examine the three identified sub-mechanisms of the MPTM from the ECB level across Italian NUTS2 regions, in this section the geographical regions are defined, the employed data for this empirical examination is introduced and a descriptive statistics analysis is provided for the identified spread between interest rates of each Italian NUTS2 region and the MRO rate.

2.2.1 Regions and Data

To examine the MPTM, Italy provides an interesting case: First, the Italian economy is known for having a significant north-south divide. This geographical distinction is interesting and allows to examine whether monetary policy is transmitted differently across regions with different economic conditions since the EMU introduction. Furthermore, the north-south divide in Italy can be seen as a reflection of the Euro Zone on a smaller scale and may provide useful insights. Based on GDP and economic composition, the northern NUTS2 regions of Italy are more representative of Euro Zone core countries, whilst the southern regions of Italy as the Euro Zone periphery. Central Italian regions can represent transition regions/countries. As a result, the analysis across Italian NUTS2 regions can provide important insight on how monetary policy transmits across different economies.

Second, in terms of GDP at current market prices, the Italian economy was considered as the third largest economy in the Euro Zone prior to the 2007 – 2008 Financial Crisis (Eurostat, 2015). However, the impact of the Financial Crisis had severe effects on the Italian economy, and it is evident until today, indicating the sensitivity of the Italian economy to economic changes, also understood as exogenous shocks. This sensitivity of the Italian economy to shocks, in turn, is used in this thesis to research the impact of monetary policy interest rate changes on Italian NUTS2 regions. Therefore, the combination of the north-south divide with the sensitivity to exogenous shocks creates conditions and a fruitful foundation to research the MPTMs.

According to Eurostat (2011), Italy is divided into five NUTS1 regions: North-west, north-east, centre, the south and the islands which are illustrated in Figure 2.1. Each of them is further subdivided into 20 NUTS2 regions grouped as follows:1

- North-west consists of four NUTS2 regions: Piemonte (ICT1), Valle d'Aosta (ICT2), Liguria (ICT3) and Lombardia (ICT4).
- North-east has four regions: Provincia Autonoma di Trento (ITH2), Veneto (ITH3), Friuli-Venezia Giulia (ITH4), Emilia-Romagna (ITH5).
- The centre region contains four areas: Toscana (ITI1), Umbria (ITI2), Marche (ITI3) and Lazio (ITI4), where Roma is located.
- The south region has six regions: Abruzzo (ITF1), Molise (ITF2), Campania (ITF3), Puglia (ITF4), Basilicata (ITF5) and Calabria (ITF6).
- The islands include Sicilia (ITG1) and Sardegna (ITG2).

[1] The European Union established the NUTS regional definition for Europe more than 30 years ago in order to specify a homogenous regional definition for statistical purposes (Eurostat, 2011).

Figure 2.1 Italian NUTS1 and NUTS2 Regions

Source: Eurostat (2011).

2.2.2 Variable Selection

The aim of this thesis is to investigate the operations of the European monetary policy from the ECB level across Italian NUTS2 regions. According to the Guideline of the European Central Bank (European Union, 2014), the European System of Central Banks' (ESCB)2 main objective is to maintain price stability by defining and implementing the monetary policy of the Union. Open market operations, standing facilities and minimum reserve requirements are the tools employed in the Eurosystem3 in order to implement monetary policy.

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[2] The ESCB consists of the ECB and National Central Banks (NCB) of all EU Member States, whether the Euro is adopted as a currency or not (ECB, 2019k).

[3] The Eurosystem consists of the ECB and the NCBs of those countries which adopted the Euro as a currency (ECB, 2019k).

In 1999, the ECB Governing Council began to conduct the European monetary policy. This Council consists of six members of the Executive Board and 19 governors of the national central banks in the Euro Area countries. In the light of this thesis, one of the key responsibilities of this Council is to formulate the monetary policy for the Euro Area every six weeks by setting three key interest rates: The rate on deposit facility (ECB, 2019f), the rate on main refinancing operations (MRO) (ECB, 2019f) and the rate on marginal lending facility (MLF) (ECB, 2019g).

The deposit interest rate is the rate which commercial banks in the Euro Area receive when they deposit money with the ECB overnight (ECB, 2019h). The MRO rate is the interest rate at which commercial banks in the Euro Area can borrow liquidity from the ECB for a week (ECB, 2019i). The MLF rate is the interest rate at which commercial banks in the Euro Area can borrow liquidity from the ECB overnight.

The difference between the MRO rate and the MLF rate is the maturity of the ‘loan’. The MRO rate applies to borrowing for a week and the MLF rate applies to borrowing for only overnight. A further difference between the latter two rates is that the MRO rate is lower than the MLF rate. Therefore, the MRO rate is the lowest interest rate that commercial banks in the Euro Area have access to if they wish to borrow liquidity from the ECB.

Because the MRO rate is set by the ECB Governing Council and because this rate is the lowest interest rate at which commercial banks in the Euro Area can borrow liquidity from the ECB at a longer maturity than the MLF rate, the MRO rate is determined as the main variable of interest in this thesis to indicate the monetary policy interest rate set by the ECB. Data for the MRO is taken from the ECB Statistical Data Warehouse. Therefore, the MRO can be interpreted as the interest rate which the ECB uses to steer the economy below, but close to, a 2% inflation target (ECB, 2019a).

To measure how changes in the monetary policy rate transmit to regional interest rates across Italy, regional interest rates are required, such as revocable loans interest rates observed across Italian NUTS2 regions. These interest rates are charged by commercial banks for revocable loans and are set differently across the NUTS2 regions. This interest rate allows to measure directly the regional interest rate levels on loans. Data on the total revocable loan interest rate is collected from the Italian Central Bank Statistical Bulletins (Bank of Italy, 2017b).

As mentioned before, the ECB Governing Council began to conduct monetary policy in 1999. However, according to Angeloni et al. (2003), it is likely that local national monetary policies still had some influence during a short period of 1999. Therefore, in order to control for this issue, a short time lag must be considered when studying the European monetary policy.

As a result, the time-series used in this thesis is 1999q4 – 2017q1, in order to eliminate the influence of national monetary policy. Thus, the time-lagged national policy impact is reduced, and the data sample consists of 70 consecutive quarter for each of the 20 Italian NUTS2 regions. Furthermore, it is important to emphasise that the 2007 – 2008 Financial Crisis is in the middle of the time-series sample and must be controlled for.

2.2.3 Visual Analysis of Data

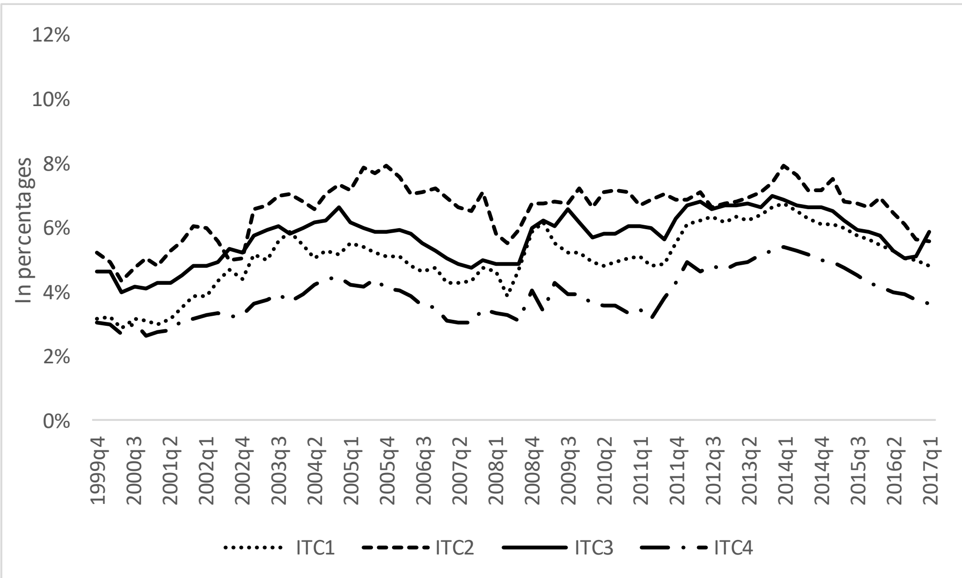
The time-series data employed in this thesis is presented in Appendices A.1-A.5, where the time-series are shown. Table 2.1 summarises the NUTS1 and NUTS2 regions and their corresponding NUTS2 region abbreviations. Furthermore, Figures 2.2 to 2.6 show the evolution of the spread, defined as the difference between each regional revocable loan observation in quarter t and the MRO observed in the same quarter. For example, the difference between the time observation of Piemonte and the MRO rate will be referred as the Piemonte spread from now on. Hence, the spread can be interpreted as the margin or the mark-up established by commercial banks. These figures show a remarkable difference in spread across the Italian regions. Chapter 3 provides a detailed examination of the mark-up across regions.

Table 2.1 NUTS1 and NUTS2 Regions Overview

NUTS1	NUTS2	NUTS2 abbreviations
North West	Piemonte	ITC1
	Valle d'Aosta/Vallée d'Aoste	ITC2
	Liguria	ITC3
	Lombardia	ITC4
North East	Provincia Autonoma di Trento	ITH2
	Veneto	ITH3
	Friuli-Venezia Giulia	ITH4
	Emilia-Romagna	ITH5
Centre	Toscana	ITI1
	Umbria	ITI2
	Marche	ITI3
	Lazio (Roma)	ITI4
South	Abruzzo	ITF1
	Molise	ITF2
	Campania	ITF3
	Puglia	ITF4
	Basilicata	ITF5
	Calabria	ITF6
The Islands	Sicilia	ITG1
	Sardegna	ITG2

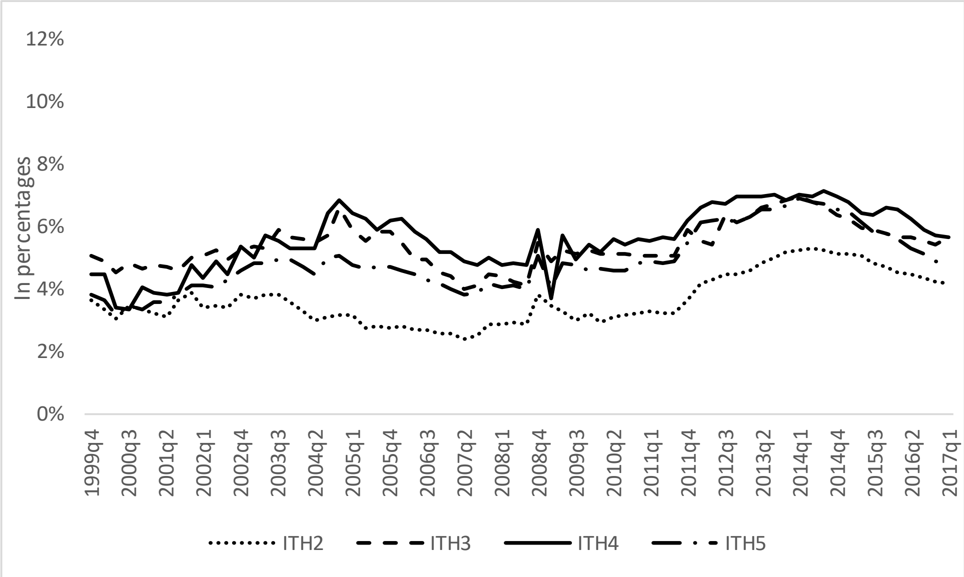
Source: Author's representation using Eurostat (2011)

Figure 2.2 The Spread between the Revocable Loan Interest Rates for the North-West NUTS2 Regions and the MRO Rate



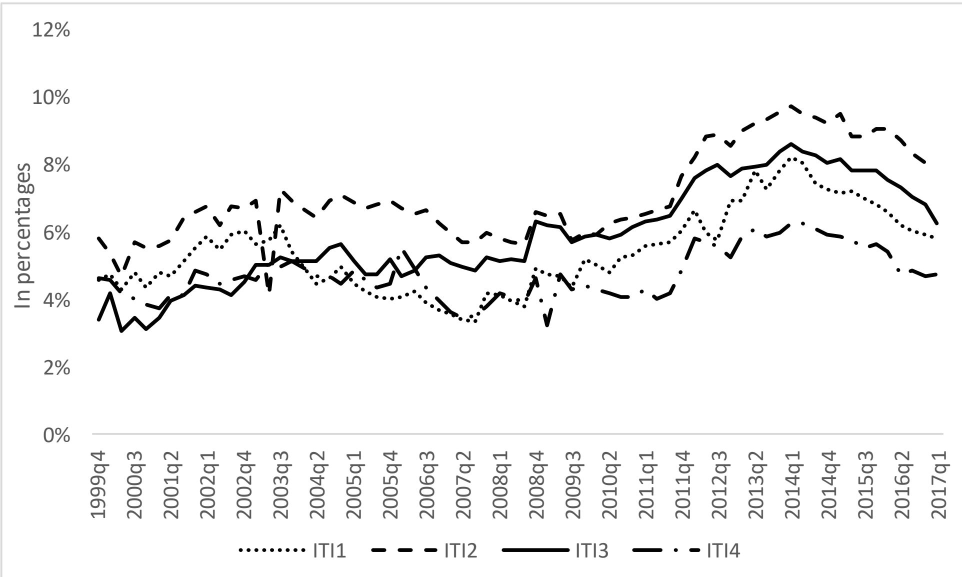
Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d)

Figure 2.3 The Spread between the Revocable Loan Interest Rates for the North-East NUTS2 Regions and the MRO Rate



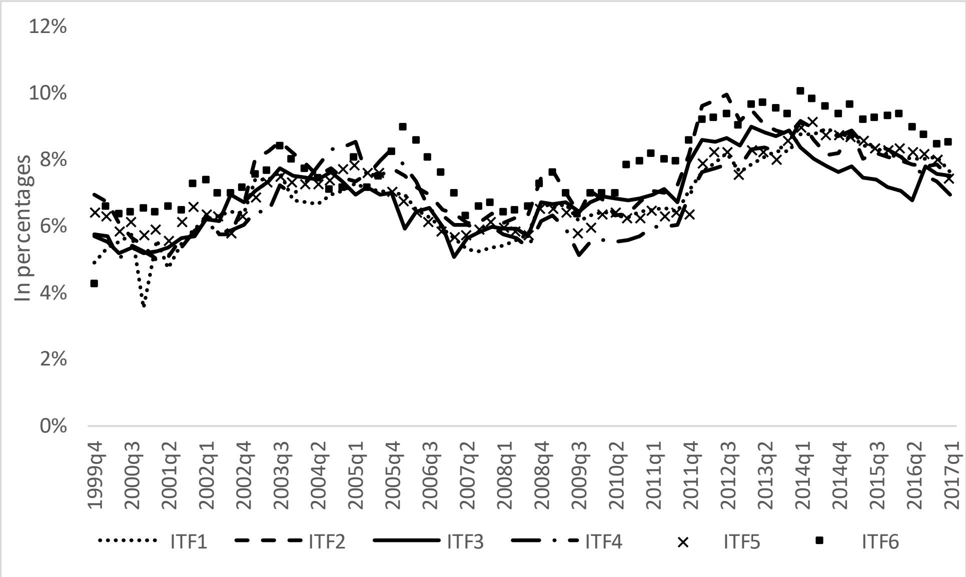
Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d)

Figure 2.4 The Spread between the Revocable Loan Interest Rates for the Central NUTS2 Regions and the MRO Rate



Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d)

Figure 2.5 The Spread between the Revocable Loan Interest Rates for the Southern NUTS2 Regions and the MRO Rate



Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d)

Figure 2.6 The Spread between the Revocable Loan Interest Rates for the Island NUTS2 Regions and the MRO Rate

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d)

Figures 2.2 to 2.6 reveal two underlying facts. First, across all spread time-series a structural break is visible at late 2008. This is due to drastic reductions in the MRO rate and the regional interest rates resulting from the 2007 – 2008 Financial Crisis. Hence, the momentum of the 2007 – 2008 Financial Crisis across all 20 NUTS2 regions is visible. Second, the spreads differ considerably across regions and across time.

For example, the spread of Lombardia as shown by ITC4 in Figure 2.2 is smaller than the spread of Calabria, ITF6 in Figure 2.5. According to the EC (2019b), Lombardia is not only one of the richest regions in Italy but also in Europe, driven by the financial sector as well as the heavy and light industries. Calabria, on the other hand, is a poorer region which depends strongly on the public budget, with a large proportion of the workforce employed by the public sector. The key industries of Calabria are agriculture, chemistry and steel (EC, 2019b). Therefore, data shows that the spread is smaller in richer regions in comparison to poorer regions.

Also, Figure 2.2 illustrates that Piemonte and Lombardia had similar spread between 1999 and 2001. As of the end of 2001 the spreads started to diverge at a relatively consistent rate. Since 2001, the spread in Lombardia remained considerably lower compared to the spread in Piemonte. This is interesting as the banking sector is one of the main industries in Lombardia in comparison to Piemonte. More precisely, the Italian Stock Exchange, one of the main European stock markets, is based in Milano, the capital city of Lombardia. Piemonte, on the other hand, is mainly characterised by a traditional industry, such as the automotive industry (FIAT), agro-industry and the recently emerged information and communication technology industry (EC, 2019b). Hence, data indicate that revocable loans rates were lower in the banking sector dominated region than in relatively rich regions but of different industrial structure. Furthermore, in January 2002 the European hard currency was introduced into the system (ECB, 2019j). It is likely that this fundamental change impacted the two differently structured regional economies in different ways and led to the divide in the spreads.

2.2.4 Descriptive Statistics of Spread

Figures 2.2 to 2.6 motivated a more detailed spread analysis and led to the following descriptive statistics. As already mentioned in Section 2.2.3, the spread is defined as the difference between each regional revocable loan time observation and the MRO time observation. Hence, the spread can be interpreted as the average regional margin or the mark-up established by commercial banks over the MRO rate. Table 2.2 presents basic descriptive statistics on the spread for the total sample period.

Table 2.2 Descriptive statistics of the spread

NUTS1	NUTS2	Abbreviations	Average	Maximum	Minimum	Difference on Means Statistical Significance
North West	Piemonte	ITC1	5.1	6.8	2.9	***
	Valle d' Aosta	ITC2	6.6	8.0	4.4	***
	Liguria	ITC3	5.7	7.0	4.0	***
	Lombardia	ITC4	3.9	5.4	2.7	***
North East	Provincia Autonoma di Trento	ITH2	3.7	5.3	2.4	***
	Veneto	ITH3	5.4	7.0	4.0	***
	Friuli-Venezia Giulia	ITH4	5.6	7.1	3.3	***
	Emilia-Romagna	ITH5	4.9	6.9	3.1	***
Centre	Toscana	ITI1	5.4	8.2	3.4	***
	Umbria	ITI2	7.1	9.7	4.1	***
	Marche	ITI3	5.9	8.6	3.1	***
	Lazio	ITI4	4.8	6.3	3.2	***
South	Abruzzo	ITF1	6.8	8.9	3.5	***
	Molise	ITF2	7.4	10.0	5.0	***
	Campania	ITF3	6.9	9.0	5.1	***
	Puglia	ITF4	6.9	9.2	5.0	***
	Basilicata	ITF5	7.0	9.2	5.6	***
	Calabria	ITF6	7.9	10.1	4.2	***
Island	Sicilia	ITG1	6.3	9.0	4.0	***
	Sardegna	ITG2	4.8	5.9	3.3	***

Source: Author's own computation using Bank of Italy (2017b) and ECB (2019d). First the difference between the revocable loan interest rate per region and their respective MRO rate for each quarter was computed. Statistical significance is based on a *t*-test per NUTS2 region. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively. The table shows the overall minimum and maximum spreads per region.

Descriptive statistics of Table 2.2 indicate that across all calculated spreads the global minimum occurred in Provincia Autonoma di Trento, a north-eastern region, at 2.4%; the global maximum was identified in the southern region of Calabria at 10.1%, which imply that regional differences exist and that mark-up levels in the northern NUS2 regions are lower than in the southern NUTS2 regions. On average, the north-east region has the lowest spread observed, whereas the southern regions have the highest. Results on the spread are highly statistically significant.

Table 2.3 reports the differences in means for each regional time-series for the period before and after the Financial Crisis. Following Erkens et al. (2012), 2008q4 was excluded from this analysis as the authors argue that from October 2008 the following months are identified as a turbulent time across financial markets. Additionally, during 2008q4 turbulent times were reported by the Bank of Italy (2020). Therefore, the pre-crisis sample is defined as 1999q4-2008q3 and the post-crisis sample is defined as 2009q1-2017q1.

Table 2.3 Difference in Means for the Pre- and Post-Crisis Period

NUTS2	Abbreviation	Difference	t-stat
Piemonte	ITC1	1.065	6.659***
Valle d'Aosta	ITC2	1.713	9.600***
Liguria	ITC3	1.329	8.437***
Lombardia	ITC4	1.456	9.550***
Provincia Autonoma di Trento	ITH2	1.248	6.093***
Veneto	ITH3	1.599	11.35***
Friuli-Venezia Giulia	ITH4	1.201	8.958***
Emilia-Romagna	ITH5	0.953	6.338***
Toscana	ITI1	0.741	3.311***
Umbria	ITI2	0.605	3.146***
Marche	ITI3	-0.202	-1.197
Lazio	ITI4	1.571	9.708***
Abruzzo	ITF1	0.962	8.116***
Molise	ITF2	1.016	5.725***
Campania	ITF3	1.095	7.030***
Puglia	ITF4	1.517	8.709***
Basilicata	ITF5	1.297	9.168***
Calabria	ITF6	0.907	5.760***
Sicilia	ITG1	0.388	2.787***
Sardegna	ITG2	2.588	10.81***

Source: Author's own computation using Bank of Italy (2017b) and ECB (2019d).
Note: Statistical significance is based on a *t*-test per NUTS2 region. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

Table 2.3 shows the results for the differences in means before and after the crisis per region. The differences in column 'Difference' are all positive, which indicates that the average of the interest rate after the crisis is higher than before, with the exception of Marche. Column 't-stat' shows that all results are statistically significant at 1% significance level with the exception of Marche.

Overall, the graphs and the descriptive statistics analysis show varying differences across all NUTS2 regions in relation to the ECB determined rates. A fundamental finding of the visual and statistical investigation is that mark-up levels and hence interest rates differ between rich and poor regions but also across rich regions of different industrial structure. In particular, in the Italian case, it appears that regions where the banking sector is the main industry experience lower commercial bank mark-up levels and hence lower interest rates in comparison to rich regions of different, non-financial industrial structure.

This finding is the foundation for this thesis's research and the motivation for further research to identify the relations as well as the transmission mechanism between the monetary policy interest rate and NUTS2 prevailing interest rates.

2.3 Estimation Models and Methods

Chapter 1 showed that according to the OCA theory and the Commission of the European Communities (1990), similar operations of the European monetary policy across regions were anticipated. However, empirical studies researching the European MPTM found evidence of heterogeneous operations (Montagnoli et al., 2016; Gambacorta, 2008; de Bondt, 2005).

The objective of this thesis is to investigate the extent of the heterogeneity in the European monetary policy after 20 years of being in operation. The MPTM in this thesis is examined through three sub-mechanisms, namely the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment.

In the previous section the MRO rate has been identified as a monetary policy indicator and the revocable loan interest rate per Italian NUTS2 region as the observed interest rate across Italy. Based on the obtained data the MPTM can then be examined from the ECB, the supra-level, across Italian NUTS2 regions, the intra-national level, quarterly for the period 1999q4 – 2017q1.

In this section the most appropriate estimation technique is identified in combination with the obtained data and its characteristics in order to estimate the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment per Italian NUTS2 region and therefore to examine the MPTM. Moreover, it is discussed how to control for the 2007-2008 Financial Crisis. Hence, this section elaborates on various econometrical estimation processes best suited for the available data.

2.3.1 A Simple Static Model

The ordinary least square (OLS) estimation is a traditional method based on the Classical Linear Regression Model (CLRM) and is referred to as the standard, static OLS approach henceforth. In the context of the data employed in this thesis this estimation model and method can provide insight on the general relationship between the revocable loan interest rate data ($y_{R,t}$) for region R in quarter t and the MRO (x_t) expressed as follows.

$$y_{Rt} = \alpha + \beta x_t + \varepsilon_{Rt} \tag{2.1}$$

where β, the slope, could be interpreted as the pass-through from the ECB-set rate towards the regional rates, α is the constant term and could be interpreted as the average commercial bank mark-up and ε_{Rt} represents the error term. Therefore, the static model used in equation (2.1) allows for the estimation of only two average MPTM indicators, namely the commercial bank mark-up and the monetary policy pass-through. Equation (2.1) is unable to provide estimates for speed of adjustment which is a disadvantage.

From an application perspective, a critical requirement for the OLS estimation approach is that of stationary data, otherwise estimation outputs are spurious (Asteriou and Hall, 2016). Spurious OLS results are grounded on the calculation technique of the OLS slope coefficients (β) and the constant (α), taken form equation (2.1).

Since the coefficient and constant estimation in OLS is based on the variance and covariance relationships between the two variables of a model, the variance of those variables must behave similarly in order to apply the conventional asymptotic theory (Maddala and Kim, 1998). In other words, for OLS estimations data on both variables must be of same order because in that case the variance of each variable behaves identically and hence asymptotic theory is valid (Maddala and Kim, 1998). A detailed argument on spurious regressions, stationary versus non-stationary data and cointegration is provided in Section 2.3.3.

An alternative estimation approach which could be adopted here and which controls for heterogeneity across regions is panel data estimations. A panel data set usually consist of information for entities or units (N), such as countries, firms or individuals, across different time periods (T). Panel data analysis is usually recommended when N exceeds T (Kennedy, 2013; Asteriou and Hall, 2016).

The advantage of panel data analysis versus standard OLS consists of the estimation of intercepts for each entity, whereas in standard OLS estimations a single intercept is estimated for all entities. However, Figures 2.2 to 2.6 of Section 2.2.3 show considerable differences in spread across regions. By applying panel data analysis such heterogeneity across different regions can be accounted for in two different ways, through a fixed and a random effect model approach. Both approaches allow for varying intercepts across different entities and therefore account for heterogeneity across different regions (Kennedy, 2013).

The difference between both models is that the fixed effect model assumes an individual intercept term for each entity and the random effect assumes that each entity differs in the error term (Kennedy, 2013). Following the random effect approach, an entity specific intercept is then calculated based on the entity specific error term.

In this thesis's context, a model following the fixed effect approach would contain a dummy variable for each Italian region and omit the model intercept, allowing to have a different intercept for each region. The random effect in this thesis's context could provide a NUTS2 region specific error term and the region-specific intercept would be calculated in an additional step (Asteriou and Hall, 2016; Kennedy, 2013).

Overall, a fixed and a random effect would provide an intercept per region, which could be interpreted as a regional commercial bank mark-up (Asteriou and Hall, 2016). However, both panel data approaches are estimated via OLS and the stationarity precondition of data holds. In addition, this thesis's objective is to examine the monetary policy pass-through and speed of adjustment in order to research the MPTM throughout the last 20 years and panel data analysis is not able to provide these estimation coefficients.

A further factor which is important in this thesis is time. In particular the long-run influence from the MRO on regional interest rates is of interest in this thesis. For example, long- and short-run coefficients could provide insight on how the MRO influenced regional interest rates in the long- and short-run and hence how MRO changes transmit through the MPTM across time. However, in order to obtain long- and short-run coefficients, dynamic models are required, and particular conditions must hold. In short, time lagged variables are employed as independent variables in dynamic models.

An OLS model is a linear single-equation static model and therefore is unable to provide results on coefficients which indicate the relationship between the employed variables in the long- and short-run. An OLS containing some lagged variables could be estimated, however by following this approach it is not accounted for a long-term trend.

Another reason why long- and short-run coefficients are of interest in this thesis is that both indicators can help to identify the impact and the adjustment process following a shock, such as the 2007 – 2008 Financial Crisis. OLS and panel data analysis are based on static models and the adjustment processes following a shock are not able to be identified. As a result, static models are identified as not preferred for this thesis. This finding is based not on assumptions of static models, such as OLS, but rather due to the main objective of this thesis.

Dynamic models can account for this time factor. Time-series analysis, for example, elevates time-lagged variables to a significant component of a model. As a result, the following sections are discussing dynamic models and time-series analysis in detail.

2.3.2 Dynamic Estimation Models

In general, the advantage of dynamic models is that long- and short-run coefficients can be estimated and shocks, such as the 2007 – 2008 Financial Crisis, can be visible in data after some time elapsed. Therefore, dynamic models can capture the consequence of the time path (Asteriou and Hall, 2016).

There are two types of dynamic models: Distributed lag models and autoregressive models. Distributed lag models contain lagged terms of the independent variable whereas autoregressive models contain lagged terms of the dependent variable (Asteriou and Hall, 2016).

Furthermore, a distributed lag model can provide information on how time lagged independent variables influence the dependent variable today. In this case, coefficients of the immediate time lagged independent variables, such as x_{t-1}, x_{t-2} or x_{t-3}, can be interpreted as short-run influences. Autoregressive models, on the other hand, can provide information on how lagged dependent variables influence the dependent variable today (Asteriou and Hall, 2016). In the light of this thesis, this type of short-run information would provide important insight on the MPTM.

Also, an addition of further variables is not desired because the aim is to investigate the relationship between the ECB-set interest rate, the MRO rate, and a revocable loan interest rate per NUTS2 region. In other words, the mark-up, the pass-through and the speed of adjustment between the two interest rates are investigated in order to identify how the monetary policy transmits between them and whether the monetary policy transmits heterogeneously across different regions of one country. Hence, national macroeconomic influences should be restricted. Therefore, if an additional variable is included into the estimation this would alter the influences on transmission mechanism which is not desired in this analysis. Therefore, a trade-off exists between the econometric specification and the actual monetary policy analysis from a theoretical perspective.

In summary, OLS is a static model based on linear relationship between variables and does not provide short- and long-run dynamic coefficients. The OLS coefficients provide a general correlation between an independent variable, x, and a dependent one, y. The downside of this model and estimation method is that no dynamic adjustment or time lags are taken into consideration (Asteriou and Hall, 2016).

2.3.3 Stationarity, Non-Stationarity and Cointegration in Time-Series Dynamic Modelling

Time-series analysis is based on distributed lag models (Asteriou and Hall, 2016). The time-series econometrics framework can be divided into forecasting and dynamic modelling. However, both frameworks can also be understood as sequential processes: First, a model must be estimated providing reliable outputs, which then can be used for forecasting or dynamic modelling purposes. The common feature in both frameworks is to exploit historical information from a given time-series and employ this dynamic structure of data in the estimation process (Maddala and Kim, 1998). However, the purpose of both approaches is very different. The main purpose of forecasting is to find out what may happen in the future based on what have been observed so far. In time-series modelling, the relationship between variables over time is important. Since dynamic modelling is of interest for this thesis, the emphasis is put on dynamic modelling henceforth.

More detailed, dynamic modelling controls for time-variant features by including lagged dependent variables and theoretically determined independent variables as well as their lags. Through the inclusion of lagged variables two main insights are obtained from dynamic models: First, how current and past lags of dependent and independent variables are impacting the current dependent variable. In this way, short-run influences on the dependent variable can be identified providing information on the adjustment process throughout time. Second, impacts of economic shocks, which might filter through the economy slowly, can be detected through the inclusion of lagged variables. Most economic time-series adjust slowly to shocks and through this modelling approach it is possible to identify the adjustment process (Asteriou and Hall, 2016). For example, a shock in this thesis's context could be a sudden and significant change of the MRO rate, such as a change on the monetary policy interest rate following the 2007 – 2008 Financial Crisis. Therefore, a dynamic model can identify the impact of such a shock on regional interest rates as well as the adjustment process.

A further significant feature of a dynamic model is that the involved time-series must be tested for a long-run trend. If the time-series follows a long-run trend, then, with the employment of a dynamic model (under particular conditions), long-run coefficients and hence effects can be estimated. More detailed, if the dependent and independent variables are cointegrated, dynamic models can provide short-run and long-run effects. The latter are captured by the error correction term and its coefficient, which is interpreted as the speed of adjustment (Asteriou and Hall, 2016).

The cointegration of the time-series ensures the long-run association between the time-series and, hence, it is possible to measure changes towards a common long-run equilibrium. The long-run equilibrium rate is found between the employed time-series. Hence, at this point it must be emphasised that this long-run equilibrium concept is based on empirical grounds and not on theoretical grounds and will be referred to as the empirical long-run equilibrium henceforth.

If the long-run equilibrium holds, the coefficient of the error correction term equals zero. However, during periods of disequilibrium the coefficient of the error correction term does not equal to zero. In this case, the speed of adjustment provides information on the extent of the disequilibrium correction within one period (Asteriou and Hall, 2016).

As previously mentioned, in order to use OLS and panel data analysis, the employed data must be stationary, whereas the precondition for estimating a dynamic model, such as the Error Correction Model (ECM) and the Vector Error Correction Model (VECM), is that data are non-stationary and are cointegrated.

Stationarity of data is characterised by a constant expected value, variance and covariance for any time-series sample (Asteriou and Hall, 2016). In order to develop the stationarity concept, the following autoregressive model of order one, AR(1), is explored:

$$y_t = \phi y_{t-1} + e_t \tag{2.2}$$

where y_t is the dependent variable at present, y_{t-1} is the one-period lagged value of y_t and e_t represents a white-noise process. The underlying assumption here is that the behaviour of y_t is mainly determined by y_{t-1}, its own lagged value. Also, it is assumed that the expected value of y_t is zero $E[y_t]$ = 0 (Asteriou and Hall, 2016). The variance of y_t is time variant, var$[y_t]$ = $T\sigma^2$, meaning that the process is not covariance stationary.

The stationary condition holds if $|\phi|$<1. In the case that $|\phi|$>1 the time-series behaves in an explosive way, which means that the change in the dependent variables is much more sensitive to the change in the independent variable. If $|\phi|$>1, then the change in the dependent variable is transmitted more than one hundred percent. Finally, when $|\phi|$=1, the time-series has a unit-root and is non-stationary, therefore, y_{t-1} can be subtracted from both sides of equation 2.2 and can be expressed as follows:

$$(y_t - y_{t-1}) = 1(y_{t-1}) + e_t - y_{t-1} \qquad (2.3)$$

Or, as:

$$\Delta y_t = e_t \qquad (2.4)$$

where e_t is white-noise process and the change in y_t (Δy_t) is said to be stationary. In other words, if stationarity of a time-series is achieved through first difference, it is said that the time-series is integrated of order one and is represented as $y_t \sim I(1)$ or just $I(1)$. In general, if a time-series requires d number of times to be differenced until stationarity is achieved, then it is said that the series is integrated of order d, denoted as $y_t \sim I(d)$ or $I(d)$ (Asteriou and Hall, 2016; Kennedy, 2013).

Nevertheless, stationarity is important because using non-stationary data in OLS estimations leads to spurious results (Maddala and Kim, 1998). An OLS regression based on non-stationary data can lead to statistically significant results with very high R^2. This misleading result is grounded on the fact that the OLS estimation method provides estimation parameters which minimises the sum of squared errors. Granger and Newbold (1974) emphasise that economic time-series data are often not stationary in levels and showed that the estimated parameter does not converge to the population parameter, leading to biased, spurious, results.

Asteriou and Hall (2016) explain spurious results as follows: An estimation based on equation (2.1) is grounded on the assumption of a stationary time-series y_t and x_t and both processes require a zero mean and constant variance. However, if y_t and x_t are non-stationary, y_t and x_t wander around. A positive relationship refers to the two cases of both series moving in the same direction, either downwards or upwards, whereas the negative relationship is the expression of the situation where y_t and x_t move in different directions across time even though both series are not related.

A further problem relates to the fact that through the differencing process the model is unable to provide unique long-run solutions, as the long-run relationship is differenced out. This is shown through the following case: If x_t takes a particular value, for example x_t=10, and the relationship between y_t and x_t is expressed as y_t = 0.5 x_t, then y_t=5. In this case the dynamic solution for y_t is converging to a unique value, 5. However, if the model is expressed in change per unit in time, such as $y_t - y_{t-1} = 0.5(x_t - x_{t-1})$ and x_t=10, a unique value for y_t is only obtained if past values for y_t and x_t are known. In the case that the lagged values of y_t and x_t are not known, a unique value of y_t cannot be computed (Asteriou and Hall, 2016).

In summary, it is important that stationary data is used when calculating relationships via OLS for the purpose of result validity. Otherwise, estimation specifications are required which support the employment of non-stationary data. In order to account for non-stationary issues, the inclusion of lags is often needed, which characterises a model as dynamic.

2.3.4 Vector Autoregressive (VAR) Model

The previous section discussed static and dynamic models as well as the distinction between stationary and non-stationary data. The following section provides an example of dynamic model, the Vector Autoregressive (VAR) model, and the implication of its potential coefficients in the monetary policy analysis.

A VAR model belongs to the group of autoregressive dynamic models because it incorporates time lagged dependent variables as regressors. However, in order to estimate a VAR model, the condition of stationarity in the employed data must be satisfied.

Such model is used for either forecasting or to research the relationships between time-series variables. The popularity of the VAR model in economics is that it allows for an analysis of system dynamics (Stock and Watson, 2012). In short, a VAR model contains the core of an autoregressive integrated moving average (ARIMA) model, but it does not incorporate the lagged error term (Kennedy, 2013). More precisely, all variables in a VAR are endogenous, where each variable is expressed as a linear function of its own lags and of all additional lagged variables x_{t-k}. In other words, a VAR is a vector of aligned own lagged variables and other lagged variables in a linear function plus an error-term (Stock and Watson, 2012).

The fundamental relationship researched in this thesis is that of between the revocable loan interest rates of a particular Italian NUTS2 region $y_{R,t}$ and the ECB-set MRO rate x_t. Expressing this data as a VAR model leads to the equations (2.5) and (2.6), a two-equation model which could be estimated via OLS as follows:

$$y_t = \beta_{10} + \beta_{11}y_{t-1} + \cdots + \beta_{1p}y_{t-p} + \gamma_{11}x_{t-1} + \cdots + \gamma_{1p}x_{t-p} + \varepsilon_{1\,t} \qquad (2.5)$$

$$x_t = \beta_{20} + \beta_{21}y_{t-1} + \cdots + \beta_{2p}y_{t-p} + \gamma_{21}x_{t-1} + \cdots + \gamma_{2p}x_{t-p} + \varepsilon_{2\,t} \qquad (2.6)$$

where β_{11} indicates the lagged coefficient of y_t, the lagged interest rate, β_{1p} represents the general notation of the y_t coefficient for any number of lags y_{t-p}, γ_{11} shows the coefficient of the once lagged $x_t(x_{t-1})$, the lagged MRO rate, and γ_{1p} denotes also the general notation of the x_t coefficient for any number of lags x_{t-p}. The same variable definition holds for equation (2.6). $\varepsilon_{1\,t}$ and $\varepsilon_{2\,t}$ are the error terms of equations (2.5) and (2.6) respectively. Prior to each VAR model specification, additional econometric tests must be undertaken in order to identify the appropriate lag length4, henceforth referred to as pre-estimation tests (Asteriou and Hall,2016).

In the VAR model, as shown by equations (2.5) and (2.6), the current value of each time-series is not incorporated in either right-hand side of both equations. This means that in this model the current value of x_t does not influence y_t, and y_t does not impact x_t, assumption which is questionable (Kennedy, 2013).

The evaluation whether to use a VAR model or not depends on the statistical characteristics of the data employed which are identified with the help of preliminary tests, like stationarity of the time series. The calculated VAR

[4] There are a variety of different tests to examine the optimal lag length: the sequential likelihood-ratio (LR), Akaike information criterion (AIC), Bayesian Information Criterion (BIC), Hannan-Quinn information criterion (HQIC) and Schwarz Bayesian information criterion (SBIC) tests.

coefficients provide information on how particular variables of a certain lag influence the dependent variable. This means that estimations on the short-run relationship are observed, but no long-run relationships as they are not directly specified as parameters.

Within this thesis's context, long-run coefficients could show two points: First whether a long-term relationship or association between the ECB-set interest rate and regional interest rates exists or not. Second, if a long-run association exists between the MRO rate and a regional interest rate, short- and long-run effects can be estimated as well as the speed of adjustment for the cases of disequilibrium. The latter would provide information about the transmission process toward an empirical equilibrium.

Overall, these parameters would provide insightful information on the adjustment process when the MRO changes and how this change transmits from the MRO rate to regional interest rates through the MPTM, indicating the effectiveness of the monetary policy.

2.3.5 Autoregressive Distributed Lag (ARDL) Model

In this section a further dynamic model is presented, the Autoregressive Distributed Lag (ARDL) model, as well as the implication of its coefficients in the monetary policy context.

An ARDL model is the application of equation (2.1) to a time-series context meaning, that the current dependent variable (y_t) is determined by the lagged dependent variables ($y_{t-\mathrm{n}}$), the current independent variable (x_t) and its lags ($x_{t-\mathrm{m}}$) (Narayan, 2005). Therefore, an ARDL model belongs to the group of distributed lag models (Stock and Watson, 2012).

Following Asteriou and Hall (2016), equation (2.7) represents a two-variable (y_t and x_t) ARDL model in this thesis's context:

$$y_t = \alpha_0 + \beta_1 y_{t-1} + \cdots + \beta_k y_{t-k} + \gamma_0 x_t + \gamma_1 x_{t-1} + \cdots + \gamma_k x_{t-k} + \varepsilon_t \qquad (2.7)$$

where α_0 indicates the constant, β_p represents the lagged coefficient of the p-th lag of the regional interest rate $t_{t-p}$with p∈[1;k],.γ_0 shows the coefficient of x_t, the current MRO interest rate, γ_1 is the coefficient of the once lagged x_t (x_{t-1}), γ_p indicates also the general notation of x_t coefficient for any number of lags (x_{t-p}) and finally ε_t is the independently and identically distributed (iid) error term.

In an ARDL model the lag length can vary between the dependent and independent variables, which represents an advantage of this model. Lags of the dependent variable are included to deal with autocorrelation of the error term. Therefore, the general notation of an ARDL model is ARDL(p, q) where p relates to the number of lags of the dependent variable and q relates to the number of independent variables. Pre-estimation test, such as the sequential likelihood-ratio (LR), Akaike information criterion (AIC), Bayesian Information Criterion (BIC), Hannan-Quinn information criterion (HQIC) and Schwarz Bayesian information criterion (SBIC) tests can be applied to identify the appropriate lag-length per time-series and to determine the appropriate specification. The popularity of the ARDL model originates from the fact that it can deal with variables of different levels of stationarity.

If the employed time-series are cointegrated of order 1, I(1), (Pesaran and Shin, 1999), then equation (2.5) can be represented in a long-run solution, defined as the point where y_t and x_t stabilise to constant steady state levels meaning that time-series follow the same underlying long-run trend. Therefore, if time-series are cointegrated, then a long-run relationship can be inferred and an ARDL model can be estimated as an ARDL-EC model. (Asteriou and Hall, 2016). As a result, long- and short-run coefficients can be estimated. Following Asteriou and Hall (2016) an ARDL model in its long-run solution is represented by the following equation:

$$\Delta y_t = \alpha + \sum_{i=1}^{k} \beta_i \Delta y_{t-i} + \sum_{i=0}^{k} \gamma_i \Delta x_{t-i} - \pi \hat{e}_{t-1} + \varepsilon_t \qquad (2.8)$$

where α represents the constant, and following Stock and Watson (2012) β_i is the cumulative dynamic multiplier based on lag-length of y_t, similarly γ_i is the cumulative dynamic multiplier based on lag-length of x_t, $\hat{e}_{t-1}$ denotes the error correction term for short-term deviations from the equilibrium path and π is its coefficient; ε_t indicates the error term. Due to cointegration of the variables, the error correction term $\hat{e}_{t-1}$ is I(0) for exogeneous x_t and ε_t is iid.

In the context of this thesis, α can be interpreted as the commercial bank mark-up indicator. Similarly γ_i could potentially represent the MRO long-run influence on a regional interest rate. The error correction coefficient is also called the adjustment coefficient and in the context of this thesis this coefficient could indicate how much of the adjustment to equilibrium takes place in each period. As a result, π can be interpreted as the monetary policy speed of adjustment proxy.

Distributed lag models rely on the following four assumptions: First, the independent variable (x_t) is exogenous, meaning that the current error term given all lags of x_t has a zero mean. Second, the random variables y_t and x_t are stationary and both random variables as well as their lags become independent as the quantity of lags increases. Third, large outliers are unlikely, assuming that variables have more than eight finite, nonzero moments. The final assumption is that there is no perfect multicollinearity between the control variables (Stock and Watson, 2012). If the assumption of x_t being exogenous is satisfied, distributed lag models can be estimated by OLS, achieving best linear unbiased estimators (BLUE) (Asteriou and Hall, 2016).

In order to find the appropriate model specification for the given data, pre-estimation tests need to be conducted to avoid spurious results (Narayan, 2005). For example, the bounds testing procedure is conducted to examine whether the underlying time series follow the same long-run trend. The advantage of ARDL models is that the model yields consistent long-run coefficient estimates which are asymptotically normal even if the underlying time-series have mixed levels of cointegration, i.e. I(1) or I(0) (Pesaran and Shin, 1999). Moreover, this model performs well even for small sample sizes and requires estimating only a single equation. The challenge of an ARDL model is to find the right model specification, which requires several pre-estimation tests.

In summary, because the ARDL model provides a simple way to obtain long- and short-run proxies, this model can be applied to the regional interest rate and the MRO interest rate data in order to obtain proxies on the commercial bank mark-up, the monetary policy pass-through and the monetary policy speed of adjustment and therefore achieve the objective of this thesis.

2.3.6 Error Correction Model (ECM)

If the underlying time series are not stationary but do follow the same long-run trend, the ECM is the appropriate model specification. An ECM is a dynamic model based on a single equation which provides long- and short-run coefficients. Estimating these coefficients in the MPTM context are of high interest within this thesis because both parameters can provide insights on the fact whether a long-run association exists between the ECB and regional interest rates. If so, the long- and short-run parameters could provide information about the adjustment process towards an empirical equilibrium between the interest rates. Therefore, if an ECM is estimated on the data presented in Section 2.2, the obtained coefficients could provide insights on the MPTM and the effectiveness of the European monetary policy. A key difference between static and VAR models in comparison to ECMs is that the latter are defined in terms of change.

As per Asteriou and Hall (2016), a representation of an ECM is as follows:

$$\Delta y_t = a_0 + \beta_1 \Delta x_t - \pi \hat{u}_{t-1} + e_t \qquad (2.9)$$

where Δ indicates the change, a_0 is the intercept, e_t denotes the error term of the estimation, and β_1 represents the short-run influence of the change in x_t, the ECB MRO rate, on the change in y_t, the regional revocable loan rate, ceteris paribus. β_1 is also called the impact multiplier and indicates the immediate effect of the change in x_t on the change in y_t. The term "immediate effect" derives from the point that the influence of Δx_t on Δy_t takes place in the current period. $\hat{u}_{t-1}$ is the error correction term from the previous period5. π embodies the adjustment or feedback effect, which is interpreted as the measure of how much a disequilibrium is corrected within one period towards the empirical equilibrium level. In other words, π indicates the speed of adjustment towards an equilibrium in the current period from the disequilibrium level in the previous period.

One advantage of this model is that it contains long- and short-term components in its one equation representation. Overall, the long-term

[5] The error correction term from the previous period is defined as:

$$\hat{u}_{t-1} = y_{t-1} - \hat{\beta}_1 - \hat{\beta}_2 x_{t-1}$$

elements are captured in the $\pi\hat{u}_{t-1}$component and the short-term dynamics are described by coefficient β_1. A further advantage of ECM is that the short-run components act as adjustment processes towards an equilibrium, given the existence of a long-run relationship between the variables.

The precondition for the estimation of an ECM is that the employed time-series variables are of the same order and are cointegrated. This means that x_t and y_t must be at least integrated of order one, I(1), and the linear combination of both time-series variables must be cointegrated of order zero I(0). Said differently, a long-run relationship between the variables must exist.

The Engle-Granger method can be employed to test for cointegration and to obtain the long- and short-run coefficients, as well as the ECM adjustment coefficient. According to Asteriou and Hall (2016) there are four steps to follow. The first step states the preconditions for an ECM model estimation, namely non-stationary and cointegrated data. In the second step the long-run equilibrium relationship is estimated via an OLS regression6 and the residuals are obtained as stated by $\hat{u}_{t-1}$in equation (2.9). The next step entails checking the order of the error term, e_t, obtained through the long-run OLS estimation, by undertaking a Dickey-Fuller (DF) unit-root test. The final step consists of estimating the ECM by incorporating the estimated disturbance term in the OLS regression along differenced variables. This final estimation provides long- and short-run coefficients as well as an adjustment coefficient of the lagged residual term.

Even though the output of this Engle-Granger estimation method provides interesting results, especially in light of this thesis's objectives, this approach contains drawbacks. One disadvantage of the ECM is that the whole estimation process consists of two estimation stages; the first where the long-run residual is estimated via OLS regression and the second estimation stage is the actual ECM estimation. The two-step estimation process provides room for carried over miscalculations which means that any occurring errors in the first estimation process are carried over into the actual ECM estimation (Asteriou and Hall, 2016). A second undesirable feature of the ECM

[6] Represented as: $y_t = \beta_1 + \beta_2 x_t + e_t$

framework is the reverse causality which means that the direction of causality can run in both ways. But in the time-series context, this can be examined using the granger causality test. In large samples, the results should be asymptotically the same. However, in practice large samples based on economic data are rare. As a result, residual cointegration tests based on the estimation of small samples may differ in comparison to the residual cointegration test grounded on the x_t on y_t estimation. However, thanks to Johansen's cointegration approach those mentioned disadvantages can be overcome (Johansen, 1988).

2.3.7 The Vector Error Correction Model (VECM)

One way to address the potential shortcomings of the two-stage ECM estimation approach, which can potentially lead to miscalculations, is the Vector Error Correction Model (VECM) estimation approach (Asteriou and Hall, 2016). The VECM estimates the relationship of a dynamic system and provides long- and short-run coefficients in one estimation step. Due to these characteristics and its simplicity in estimation, this specification is the preferred for this thesis. However, the precondition for a VECM estimation is that the employed time-series is not stationary and is cointegrated. This section analyses the VECM estimation and discusses how the VECM coefficients can be interpreted in the MPTM context.

Based on the preconditions for the VECM estimation mentioned before, two points can be made: First, the cointegration between the MRO rate and a regional revocable loan interest rate can show if a long-run association between the variables exist or not. Second, if a long-run association exists between the time-series, long- and short-run effects can be estimated as well as the speed of adjustment in cases of disequilibrium.

In this thesis's context, long- and short-run coefficients could provide insights on how the MRO influences regional interest rates in the long- and short-run and hence how MRO changes transmit through the MPTM across time. Another reason why long- and short-run coefficients are of interest in this thesis is that both indicators can help to identify the impact and the adjustment process following a shock, such as the 2007 – 2008 Financial Crisis. Whilst the speed of adjustment coefficient would provide information about the transmission process toward an empirical equilibrium.

Overall, these estimations would provide insightful information on the adjustment process when the MRO changes and how this change transmits from the MRO rate to regional interest rates through the MPTM indicating the monetary policy effectiveness. The implementation of a VECM on data of regional revocable loan interest rates and the ECB-set interest rate provides interesting interpretation opportunities since the VECM is a two-equation, dynamic system.

In order to achieve the objectives of this thesis, a VECM can be estimated for each Italian NUTS2 region, R, separately in order to obtain regional coefficients. Based on Yang and Allen (2004), the VECM is represented by the following two equations:

$$\Delta y_{R,t} = c_{y_R} + \sum_{i=1}^{k} \beta_{y_{R,i}} \Delta y_{R,t-i} + \sum_{i=1}^{k} \theta_{y_{R,i}} \Delta x_{t-i} + \gamma_{y_R} Z_{R,t-1} + \varepsilon_{y_{R,t}} \quad (2.10)$$

$$\Delta x_t = c_x + \sum_{i=1}^{k} \beta_{x_i} \Delta y_{R,t-i} + \sum_{i=1}^{k} \theta_{x_i} \Delta x_{t-i} + \gamma_{x_i} Z_{R,t-1} + \varepsilon_{x,t} \quad (2.11)$$

then, two interpretation approaches are established from this system of equations, one for how ECB-set rate influences the regional rates (equation (2.10)), and the second for how regional interest rates influence the ECB-set rate (equation (2.11)).

In both cases, the regional revocable loan interest rate of each 20 NUTS2 regions is set as $y_{R,t}$, and the ECB-set MRO rate as x_t. However, in equation (2.10) the former is set as the dependent variable, and the latter as the independent variable. In equation (2.11), the reverse case of variable specification applies.

Following the model specification defined above, equation (2.10) presents information on the extent with which ECB interest rate changes influence regional interest rate changes in the long- and short-run, ceteris paribus. This means that equation (2.10) provides information on the long- and short-run MPTMs from the ECB towards each of the 20 Italian NUTS2 regions. Additionally, this equation also allows to examine how previous revocable loan interest rate changes affect the current revocable loan interest rate change of a particular region. Hence, equation (2.10) is of the main interest for this thesis.

On the other hand, the dependent variable of equation (2.11) is the ECB-set interest rate, explained by changes in the regional revocable loan interest rate. From a modelling perspective, this system provides information about how changes in the regional interest rates influence changes on the ECB-set rate in the short- and long-run. This equation also indicates to what degree past MRO rate changes affect the current change in the MRO rate. Therefore, equation (2.11) and its components are explored for completeness and consistency in the analysis.

The individual components of the VECM presented in equation (2.10) and equation (2.11) are defined as follows. c_{y_R} is the constant of a particular NUTS2 region's interest rate and could be interpreted as the short-run average value by which regional interest rates adjusts, or as the short-run regional commercial bank mark-up. c_x represents the constant of the MRO rate and is the short-run mean by which the current change in the MRO rate adjusts. $Z_{R,t-1}$ denotes the error correction term. Furthermore, $\varepsilon_{y_{R,t}}$ and $\varepsilon_{x,t}$ are white noise error terms and entail the unexplained influence on the dependent variables $y_{R,t}$ and x_t respectively.

The number of past quarters included in the analysis of both equations (2.10) and (2.11) depends on the optimal lag-length determined in the pre-estimation tests mentioned before. Moreover, the optimal lag-length is likely to vary across regions due to regional heterogeneity.

$\beta_{y_{R,i}}$ and β_{x_i} in both equations (2.10) and (2.11) are the short-run parameters. $\beta_{y_{R,i}}$ in equation (2.10) denotes how the percentage change of the lagged regional interest rate $\Delta y_{R,t-i}$ affects the change of the current regional interest rate $\Delta y_{R,t}$, ceteris paribus. This parameter can be interpreted as the short-run regional pass-through from the lagged regional interest rate change $\Delta y_{R,t-i}$, to the current regional interest rate change $\Delta y_{R,t}$. The higher this coefficient is, the greater is the influence from the changes in previous quarters on the change in the current quarter within one region.

Similarly, β_{x_i} from equation (2.11) can be interpreted as a short-run pass-through, which indicates how percentage changes of regional interest rate of previous periods $\Delta y_{R,t-i}$ influence the change of the current MRO rate Δx_t, ceteris paribus. From a modelling perspective, this parameter indicates whether the past regional interest rate variations affect current changes in the MRO rate. Based on the model specification and the context of this thesis, this coefficient could indicate whether the ECB considers regional interest rate movements when setting their MRO rate. The higher the coefficient is, the larger the regional influence on the MRO rate change.

$\theta_{y_{R,t}}$ and θ_{x_t} are also short-run parameters. $\theta_{y_{R,t}}$ is obtained from equation (2.10) and denotes to what extent a one percentage point change of the MRO rate Δx_{t-i} influences the change in the current regional interest rate $\Delta y_{R,t}$, ceteris paribus. Said differently, the $\theta_{y_{R,t}}$ parameter measures the average commercial bank reaction to a change of the MRO rate change in the short run. The larger the coefficient value, the larger influence of the central bank on the regional revocable loan rate in the short-term. Overall, this parameter can be understood as the short-run monetary policy pass-through or, as the intermediate multiplier per region R (Sander and Kleimeier, 2004).

θ_{x_t}, taken from equation (2.11), indicates the short-run influence from the lagged MRO rate percentage change Δx_{t-i} on the current MRO rate percentage change Δx_t, ceteris paribus. Hence, this parameter shows to what extent the short-run lagged MRO rate influences the current MRO rate. The larger the coefficient's value the larger is the influence in the short run.

The next components of equations (2.10) and (2.11) are the error correction terms $\gamma_{y_R} Z_{R,t-1}$ and $\gamma_{x_i} Z_{R,t-1}$, consisting of its parameters γ_{y_R} and γ_{x_i} respectively, and the lagged error terms $Z_{R,t-1}$. Before defining these components in detail, a brief explanation on the empirical long-run equilibrium is provided as next.

As already mentioned, two preconditions must be met if estimating a VECM, the non-stationarity of the employed data and the cointegration of the employed series in the estimation. The cointegration condition ensures the long-run association between the time-series and hence it is possible to measure changes towards a common long-run equilibrium. Based on equations (2.10) and (2.11) and the employed data, the long-run equilibrium rate is found between the two time-series, namely the MRO rate and each regional interest rate independently. Hence, at this point it must be emphasised that this long-run equilibrium concept is based on empirical grounds and not on theoretical foundations and will be referred to as the empirical long-run equilibrium henceforth.

Therefore, $\gamma_{y_{R,t}}$ and γ_{x_t} indicate the speed of adjustment towards a long-run equilibrium rate between the two employed time-series. Both parameters demonstrate how the current regional interest rate and the current MRO rate, respectively, adjust in one period in order to achieve the long-run equilibrium rate.

$\gamma_{y_{R,t}}$, estimated from equation (2.10), indicates the speed of adjustment within one period of the current regional rate towards the long-run equilibrium rate. More precisely, if a particular region's interest rate is not in equilibrium with MRO rate, then $\gamma_{y_{R,t}}$ indicates the speed of adjustment in the regional rate within one period in order to reach the empirical long-run equilibrium. This parameter could also be interpreted as the speed of the commercial banks reacting to ECB-set interest rate changes towards the long-run equilibrium rate within one period, also named as the regional monetary policy. The larger $\gamma_{y_{R,t}}$, the quicker is the adjustment process towards that long-run equilibrium rate. A smaller $\gamma_{y_{R,t}}$ indicates a slower regional interest rate reaction to MRO changes, which means that regional lending rates are stickier and more inert to monetary policy changes.

On the other hand, γ_{x_i} from equation (2.11) represents the speed of adjustment of lagged MRO changes towards the long-run equilibrium rate within one period. Considering the MPTM context, this parameter can be interpreted as whether or how quickly the ECB tries to achieve the empirical long-run equilibrium rate in order to achieve the inflation target. A low γ_{x_i} value denotes a slow influence on the change in current MRO rate towards the equilibrium rate, whereas a high value of γ_{x_i} can be understood as a quick adjustment process in current MRO rate change towards the equilibrium rate.

In order to finalise the VECM parameter interpretation, the error-correction term is analysed. As stated, the error-correction term in a VECM provides information about the empirical long-run equilibrium between the two employed time-series variables. Equations (2.10) and (2.11) represent a bi-variate VECM which is equivalent to a two-variable VAR(k) model in first differences, improved by the introduction of error correction terms Z_{t-1}. More precisely, in this thesis's context the error-correction term Z_{t-1} is stated in equation (2.12) and consists of a linear relationship between lagged interest rate of a particular region $y_{R,t-1}$, this region's constant C_R as well as the lagged MRO rate x_{t-1}:

$$Z_{R,t-1} = y_{R,t-1} - C_R - \alpha_R x_{t-1}, \qquad (2.12)$$

where the α_R parameter denotes the cointegrating vector, also called the long-run monetary policy pass-through. Considering the error correction $Z_{R,t-1}$ of equation (2.10), the α_R parameter from equation (2.12) indicates the extent of the long-run influence from the lagged MRO rate x_{t-1} towards a region's current interest rate change, ceteris paribus. Furthermore, this coefficient can indicate the long-run reaction of commercial banks to ECB interest rate changes.

As per Sander and Kleimeier (2004), the α_R parameter can be viewed as the long-run multiplier. There are three interesting cases of the α_R value. First, an optimal or complete long-run MPTM is indicated if α_R equals one (α_R=1). An incomplete or imperfect long-run MPTM is denoted by α_R being smaller than one (α_R<1). And finally, an overshooting long-run MPTM is suggested by α_R being larger than one (α_R>1).

On the other hand, α_R obtained from equation (2.12) is interpreted as the long-run pass-through from lagged MRO and regional interest rates to current MRO rate changes. Said differently, this parameter can be characterised as the long-run monetary policy rule from the past ECB rates towards the current change of the MRO rate. In this context, α_R of equation (2.11) indicates the long-run monetary policy adjustment process in order to achieve the ECB's objective of price stability at the long-run equilibrium rate.

Another component of the error-correction term is the long-run cointegrating equation constant C_R. In the context of MPTM, the C_R estimated from equation

(2.10) can be interpreted as the long-run commercial bank mark-up per region, or the long-run average value by which the regional interest rate changes in order to reach the long-run equilibrium rate.

Overall, when implementing a VECM on the MRO and the revocable loan interest rate data, when a long-run association between the time-series exists, long- and short-run parameters can be obtained per Italian NUTS2 region. If disequilibrium between the time-series prevails, then speed of adjustment parameters could be observed. The latter would provide information about the transmission process toward an empirical long-run equilibrium.

In summary, the cointegrating equation constant, the long- and short-run pass-through, as well as the speed of adjustment parameters represent proxies for commercial bank mark-up levels, long- and short-run pass-through and the speed of adjustment respectively.

As mentioned before, a VECM specification is the preferred estimation strategy for this thesis because it provides empirical evidence on the largest quantity of MPTM proxies compared to other estimation strategies. Moreover, interesting insights can be obtained on the MPTM if each particular MPTM sub-mechanism is compared across the Italian NUTS2 regions. In order to employ VECM as the estimation method, the underlying time-series must be non-stationary and cointegrated of order one I(1). These characteristics of data are researched in pre-estimation tests shown in Appendix B.

2.3.8 Testing for the Impact of the 2007 – 2008 Financial Crisis

According to the Bank of Italy (2017), Italy was affected by two phases of the Crisis: Phase 1 (denoted as FCP1) related to the Lehman Brothers fall in September 2008, and phase 2 (denoted as FCP2) related to the Italian Sovereign Debt Crisis beginning in late 2010.

Figures 2.2 to 2.6 of Section 2.2.3 highlight the presence of potential economic shocks on the Italian economy, which are represented as structural breaks at the end of 2008 in the revocable loan interest rate data.

Furthermore, the analysis on differences in means of Section 2.2.4 showed that the differences in means were statistically significant before and after the

Financial Crisis. This indicates that the Financial Crisis of 2007 – 2008 is likely to have influenced the NUTS2 regions. Shocks have a significant impact on estimations and must be controlled for in the estimation process. Hence, the purpose of this section is to discuss how to proceed to control for structural breaks in the following estimation process.

Numerous tests exist that can be used to investigate the impact of structural breaks on time-series and cointegration relationships. These tests check for a unit-root (whether in univariate series or in cointegrating relationships), potentially with a single unknown structural break point or examine a structural change in regression coefficients with stationary series (Gregory et al., 1996).

One such test is the Zivot and Andrews (1992) unit-root test which allows for one structural break in the intercept, trend or both and another one is the Gregory and Hanson (1996) cointegration test. The latter allows for three forms of structural change: a level shift, a level shift with trend and a regime.

An example of a unit-root test allowing for a break point is the Zivot and Andrews (1992) unit root test. Banerjee, Lumsdaine and Stock (1992), Perron and Vogelsang (1992) and Zivot and Andrews (1992) test a null hypothesis "of a unit-root in a univariate time series against the alternative of stationarity, while allowing for a structural break in the deterministic component of the series". (Gregory and Hansen, 1996, p. 100). More detailed, Zivot and Andrews (1992) developed a unit-root testing procedure that has three different alternative versions of incorporating structural breaks. The first version, called Model A hereafter, tests for a structural break in the intercept and can be represented by the following equation:

$$y_t = \mu^A + \theta^A DU_t(\lambda) + \beta^A t + \alpha^A y_{t-1} + \sum_{j=1}^{k} c_j^A \Delta y_{t-j} + e_t \quad \text{(A)}$$

where y_t is the time-series at the current period t, y_{t-1} represents the time-series in the previous period, μ indicates the mean and e_t is the error term. The superscript 'A' represents model A and t represents a time trend. Moreover, μ, θ, β, α and c are the coefficients of the relevant model components. This model tests for a structural break in the intercept, where DU_t indicates the dummy variable for the mean shift which takes the value of 1 from the quarter when the structural break is identified until the end of the series and 0 otherwise.

The second alternative model, referred to as Model B hereafter, tests for a structural break in the trend and can be presented by the following equation:

$$y_t = \mu^B + \beta^B t + \gamma^B DT_t^*(\lambda) + \alpha^B y_{t-1} + \sum_{j=1}^{k} c_j^B \Delta y_{t-j} + e_t \quad \text{(B)}$$

where the superscript 'B' represents model B and the structural break in the trend is indicated by DT_t^*. To analyse a structural break in the trend a trend variable is set which takes the value 1+1 from the quarter when the structural break is identified until the end of the series and 0 otherwise. In other words, the trend variable starts with 1 at the point of the structural break and increases by 1 for every following quarter and otherwise 0.

And finally, the following equation (C), Model C hereafter, tests for a structural break in both trend and intercept:

$$y_t = \mu^C + \theta^C DU_t(\lambda) + \beta^C t + \gamma^C DT_t^*(\lambda) + \alpha^C y_{t-1} + \sum_{j=1}^{k} c_j^C \Delta y_{t-j} + e_t \quad \text{(C)}$$

where the superscript 'C' represents model C. In this specification, the dummy variable and trend variable are incorporated into the equation. Both variables are defined as mentioned under Model A and Model B. These tests are useful in that they indicate whether or not a structural break is likely to occur in the time series.

To test for a structural break in a cointegrating relationship the Gregory and Hanson (1996) test could be performed. This test investigates cases where the time-series are cointegrated, meaning that the linear combination of the non-stationary variables is stationary, but contain a structural break at an unknown point in time. It is therefore important to test whether a long-run relationship between the variables shifts to a new long-run relationship following a regime shift (Gregory and Hanson, 1996).

Gregory and Hansen (1996) developed an extension of the ADF-, Z_α-, and Z_t-type tests to research the null hypothesis of no cointegration against the alternative hypothesis of cointegration in the presence of a potential regime shift.

To model a structural change, Gregory and Hanson (1996) present three forms of structural change: a level shift, a level shift with trend and a regime shift in the cointegrating relationship. In the case of a level shift, the structural break exists in the intercept (μ) whilst the slope coefficient (α) is held constant and is modelled as follows:

$$y_{1t} = \mu_1 + \mu_2\varphi_{t\tau} + \alpha^{\mathrm{T}}y_{2t} + e_t \qquad t = 1, \dots, n. \quad \text{(CS)}$$

where y_{1t} is the current series and y_{2t} is an m – vector, e_t indicates the error term, μ_1 is the intercept before the structural break, μ_2 is the change in the intercept at the time of the shift and $\varphi_{t\tau}$ represents the dummy variable.

The case of a structural break in levels with trend is represented when the time trend is introduced into the previous model, represented in the level shift with trend model given in equation (C/T):

$$y_{1t} = \mu_1 + \mu_2\varphi_{t\tau} + \beta t + \alpha^{\mathrm{T}}y_{2t} + e_t \qquad t = 1, \dots, n. \quad \text{(C/T)}$$

where βt indicates the time trend.

The third case that Gregory and Hansen (1996) discuss is a structural change where the slope vector shifts, also called regime shift. This case is represented as follows:

$$y_{1t} = \mu_1 + \mu_2\varphi_{t\tau} + \alpha_1^{\mathrm{T}}y_{2t} + \alpha_2^{\mathrm{T}}y_{2t}\varphi_{t\tau} + e_t \qquad t = 1, \dots, n. \quad \text{(C/S)}$$

where α_1^{T} represents the slope before the structural break and α_2^{T} indicates the slope at the time of the shift.

In order to control for potential structural breaks, a two steps procedure will be used. In the first approach structural break points are identified for each region by applying the Zivot and Andrews (1992) unit-root test to the residuals of a VAR model. Then, additional variables, such as a dummy or trend variable, will be introduced into the estimations in order to control for the identified structural break.

Therefore, the timing of these variables would correspond to each region's exact timing of the structural break points identified by the Zivot and Andrews (1992) test.

Since the VECM has been identified as the preferred estimation strategy, the VECM containing dummy variables can be presented as follows:

$$\Delta y_{R,t} = c_{y_R} + \sum_{i=1}^{k} \beta_{y_{R,i}} \Delta y_{R,t-i} + \sum_{i=1}^{k} \theta_{y_{R,i}} \Delta x_{t-i} + \gamma_{y_R} Z_{R,t-1} + \sum_{i=1}^{k} \delta_{y_{R,i}} \Delta D_{R,t} + \varepsilon_{y_{R,t}} \quad (2.13)$$

$$\Delta x_t = c_x + \sum_{i=1}^{k} \beta_{x_i} \Delta y_{R,t-i} + \sum_{i=1}^{k} \theta_{x_i} \Delta x_{t-i} + \gamma_x Z_{R,t-1} + \sum_{i=1}^{k} \delta_{x_i} \Delta D_{R,t} + \varepsilon_{x,t}, \quad (2.14)$$

For the case of a shift identification, $D_{R,t}$ is defined as:

$$D_{R,t} = \begin{cases} 1 & t \geq t_0 \\ 0 & t < t_0 \end{cases} \quad (2.15)$$

which takes the value of 1 from the quarter when the structural break is identified in region R until the end of the series and otherwise 0.

In the estimation process only one dummy variable is implemented at a time. The cointegration regression per region containing a dummy variable is then represented as follows:

$$Z_{t-1} = y_{R,t-1} - C_R - \alpha_R x_{t-1} + \delta_R D_{R,t-1}, \quad (2.16)$$

where $D_{R,t-1}$ is the regional dummy variable of the previous quarter and δ_R is the dummy variable coefficient of a particular region.

Since VECM is a computationally rather involved estimation procedure, an ARDL model can be used as an alternative specification in this thesis. Equation (2.17) provides an ARDL-EC model with a dummy for a potential structural break:

$$\Delta y_t = \alpha + \sum_{i=1}^{k} \beta_i \Delta y_{t-i} + \sum_{i=1}^{k} \gamma_i \Delta x_{t-i} + \sum_{i=1}^{k} \delta_{y_{R,i}} \Delta D_{R,t} - \pi \hat{e}_{t-1} + \varepsilon_t, \quad (2.17)$$

where $D_{R,t}$ is the dummy variable indicating when the structural break occurred in a particular region.

In the presence of a cointegrated relationship different tests are applied to identify structural breaks. Similarly, to the VECM case, to examine the impact of the Financial Crisis, a Zivot and Andrews (1992) unit-root test is used to identify the structural break point. Once the exact timing of the structural break per region is identified, dummy and trend variables for the exact timing of the structural break per region are included in the VECM and ARDL estimation procedure. Detailed information on the Financial Crisis control is provided in Sections 3.4.4, 4.4.2 and 5.4.3.

2.4 Conclusion

The objective of this thesis is to investigate the extent of the heterogeneity in the European monetary policy after 20 years of being in operation. The MPTM in this thesis is examined through three sub-mechanisms, namely the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment. To achieve this objective, this Chapter discussed data sources and a variety of methodological approaches to estimate MPTM proxies.

In Section 2.2 the obtained data for this thesis was presented. More precisely, since this thesis is based on a NUTS2 regional analysis, in this section the 20 NUTS2 regions across Italy were defined. Furthermore, the MRO rate was identified as the monetary policy interest rate of relevance for this thesis as it is set by the ECB. In order to evaluate the impact of the monetary policy change on Italian intra-national level, revocable loan interest rates across Italian NUTS2 regions were presented as the selected variable. Finally, the research period of this thesis was defined as 1999q4 – 2017q1, in order to eliminate national monetary policy influences in early 1999 (Angeloni et al., 2003).

To show the motivation for this thesis, figures were provided in Section 2.2.3 showing the change of the spread across Italian NUTS2 regions and time. In addition, a detailed spread analysis was undertaken, defined as the difference between each regional revocable loan time observation and the MRO time observation. The spread was also treated as an indicator of the commercial bank mark-up.

The graphs and the descriptive statistics analysis showed varying differences across all NUTS2 regions in relation to the ECB determined rates. A fundamental finding of the visual and statistical investigation was that mark-up levels and hence interest rates differed between rich and poor regions but also across rich regions of different industrial structure. In particular, in the Italian case, richer regions are exposed to lower mark-up levels than poorer regions. But also, it was found that regions where the banking sector is the main industry experienced lower commercial bank mark-up levels and hence lower interest rates in comparison to rich regions of different, non-financial, industrial structure.

In Section 2.3 various estimation models and methods were discussed in order to identify an appropriate strategy which could provide reliable estimation results considering the data characteristics. Frist, static models, such as the OLS, were explored, finding that only two of the three MPTM sub-mechanisms can be estimated and data must be stationary. The panel data discussion showed that this specification could provide region specific intercepts. However, stationary data was also required for this estimation strategy. Furthermore, the discussion showed that in the OLS and panel data cases, no long- and short-run coefficients can be obtained. The time factor, however, is important in this thesis due to two reasons: First, this thesis's objective is to examine the MPTM throughout the last 20 years. Second, to identify the impact and the adjustment process following the 2007 -2008 Financial Crisis. This led to a discussion on dynamic models which can provide long- and short-run coefficients. In addition, stationary and non-stationary data as well as the cointegration concept were presented since some of the dynamic models require these characteristics. This section concluded by identifying the VECM as the preferred estimation method and model because all three MPTM sub-mechanism can be estimated within one estimation step. The ARDL model is also considered as a potential estimation strategy in this thesis because it provides consistent long- and short-run coefficients in a single equation even for small sample sizes.

In detail, a VECM and a ARDL approach based on the MRO rate and a revocable loan rate of a particular region can provide outputs on commercial bank mark-up, long- and short-run pass-through and speed of adjustment in one estimation step for a particular NUTS2 region. Furthermore, it was shown how controls can be implanted into the models in order to control for the 2007 – 2008 Financial Crisis.

The following chapters present the computed results on the three MPTM sub-mechanisms, namely Chapter 3 presents the commercial bank mark-up, Chapter 4 shows findings in relation to long- and short-run pass-through and Chapter 5 discusses speed of adjustment results. Chapter 6 concludes this thesis.

Chapter 3
The Commercial Bank Mark-Up

3.1 Introduction

This Chapter examines the first mechanism of the Euro Zone Monetary Policy Transmission Mechanism (MPTM) indicated by commercial bank mark-up across the Italian NUTS2 regions for the period 1999q4 – 2017q1. The objective of the commercial bank mark-up analysis is to understand the interest rate channel between commercial banks and households and firms across regions. Commercial banks typically add a mark-up to the central bank interest rate when determining interest rates for their products, namely loans for a particular price. As shown in Chapter 2.2.3, interest rates vary across regions due to different risk perception, industrial structure and liquidity preference across regions. In order to examine these differences and provide insight on the MPTM, the research question of this Chapter is how the mark-up levels differ across the Italian NUTS2 regions. This research question is analysed through an empirical investigation based on the relationship between the ECB-set MRO rate and the revocable loan interest rates for each Italian NUTS2 region.

The analysis of this Chapter is based on the Optimum Currency Area (OCA) theory and official European Commission documentation. More precisely, this research provides insights on the MPTM, a mechanism through which the ECB tries to achieve its objective of price stability in the Euro Zone that, in turn, supports the objective of the European Commission to stimulate the economy and foster employment across the Euro Zone. Since the monetary policy is set for each country of the Euro Zone, prior to the introduction of the European Monetary Union (EMU), it was expected that monetary policy would transmit similarly across the Euro Zone regions. This assumption was based on the OCA theory (Mundell, 1961) and the European Commission stance of similarities across all EMU members (Treaty on European Union 1992; Commission of the European Communities, 1990). However, Montagnoli et al. (2016), Gambacorta (2008) and Angelini and Cetorelli (2000) have found heterogeneity among commercial bank mark-up levels in Italy.

This Chapter is mainly motivated by the work of Gambacorta (2008) and Montagnoli et al. (2016). The inspiring facts are: the application of econometrical strategies for the estimation of commercial bank mark-up proxies, the interpretation of the model constant as mark-up proxies and the wide variety of data available for this type of estimation.

Therefore, in this Chapter, mark-up levels are estimated per NUTS2 region by means of a vector error correction model (VECM) estimation strategy. To do so, the constant of the cointegrating equation is interpreted as a proxy for the average regional mark-up indicated in percentages, following Montagnoli et al. (2016) and Gambacorta (2008). The higher the constant of the cointegrating equation, the higher the mark-up level.

To examine mark-up proxies from a different perspective, the Cointegrated Regression (CR) will be estimated using the VECM approach. These estimations are showing similar results, namely a persistence of heterogeneity across regions. Since the 2007 – 2008 Financial Crisis as well as the Sovereign Debt Crisis are within the research period, additional estimations including event-dummy variables are conducted to examine the impact of the crisis in more detail.

The contribution of this Chapter is the unique mark-up investigation analysis from a supra (ECB) to an intra-national (NUTS2) level. Literature based on macro and micro data begins the commercial bank mark-up analysis at the market level because of the application of the money market interest rates. Therefore, these studies are examining mark-up proxies between the inter-bank money market and the loan interest rates. This Chapter, on the other hand, estimates the mark-up levels between the monetary policy interest rate, the Main Refinancing Operation (MRO) rate set by the ECB, and the observed interest rates on revocable loans across Italian NUTS2 regions set by local commercial banks. Therefore, the MPTM between the ECB and a particular Italian NUTS2 region is researched from the supra level to an intra-national level.

In this way, this Chapter contributes to the literature of regional monetary policy transmission mechanisms through an original research on the mark-up from the ECB levels across Italian NUTS2 regions for the period 1999q4 – 2017q1 and controlling for the 2007 – 2008 Financial Crisis.

Results based on VECM and CR estimation strategy show regional clusters due to the pattern of low mark-up levels in the north and high mark-up levels in the southern regions and Sicilia. These results indicate that monetary policy could transmit heterogeneously across the NUTS2 regions in Italy, indicating that commercial banks have some market power, in line with findings from Montagnoli et al. (2016), Gambacorta (2008) and Angelini and Cetorelli (2000).

More precisely, mark-up levels in the north-west and north-east are lower than in the southern and central regions as well as in Sicilia. This means that debtors on average pay more for commercial bank loans in the south and central regions as well as in Sicilia than debtors in the northern regions of Italy. A particular finding in this Chapter is that the lowest mark-up level is found in Lombardia, the region where the national financial sector is located. Heterogeneity across mark-up levels is also found when controlling for the 2007-2008 Financial Crisis.

The heterogeneity in mark-up results across NUTS2 regions indicates varying degrees of monetary policy effectiveness across the analysed regions. Furthermore, this variation in monetary policy effectiveness across regions could have contributed to convergence across the northern regions but it could have also contributed to further increase the divergence between the north and south.

Different schools of economic thought identify potential contributors explaining mark-up differentials. According to Neo-Classical literature, commercial banks' perception of risk differs across regions and is a potential explanation for mark-up heterogeneity. New-Keynesians argue that, in addition to risk perception, competition within the banking sector leads to heterogeneous mark-up levels. Finally, Post-Keynesians argue that liquidity preference yields to varying interest rates and hence mark-up levels.

This Chapter is divided in five sections. The next section presents a review of the related literature based on various mark-up estimation strategies as well as an elaboration on mark-up results found in literature. Section three discusses the empirical implementation of this Chapter. Section four presents the results of this Chapter and section five concludes this Chapter.

3.2 Literature Review

In this section, the commercial bank mark-up is defined and the existing literature around this topic is discussed. The reason for selecting the discussed papers is to show which data and estimation strategies (via estimation models and methods) are employed in order to study commercial bank mark-up levels. The following sections discuss the theoretical and empirical literature on mark-up estimation.

3.2.1 Theoretical Foundation on Mark-Up Estimation

Fontana and Setterfield (2009) defined the commercial bank mark-up as the difference between the real short-run interest rate (determined by the central bank) and the bank loan rate (charged by commercial banks for loans). A similar definition of the commercial bank mark-up was followed in Chapter 2.2.3, Figures 2.2 to 2.6, which visualised the difference between the ECB-set interest rate and the revocable loan interest rate for each NUTS2 region across time.

Rousseas (1985) identified the banking sector as oligopolistic and applied the manufacturing sector mark-up theory in order to define the commercial bank mark-up. Based on the oligopolistic price setting approach, a firm determines a product’s price by adding a mark-up to the product’s cost. More precisely, in an oligopolistic environment, firms provide the quantity of goods where marginal cost (MC) equals marginal revenue (MR) and where the price is higher than the experienced marginal cost, if firms face a downward-sloping demand function or if firms have some degree of market power. This means that an oligopolistic firm has the power to charge a higher price for a good than its cost experienced and supplies a lower quantity than in the perfectly competitive situation. As the firm sets the price, demand then follows as consumers decide how much to buy based on that price. As a result, a firm’s market power is shown by the mark-up level: the higher the mark-up, the higher the market power and the higher the profits (Rousseas, 1985).

Applying Rousseas's (1985) theoretical model to the context of this thesis, the monetary policy interest rate set by the central bank would be interpreted as the commercial bank marginal costs, whereas the interest rate charged by commercial banks for loans would be defined as the market price to households and firms for a loan. Then, following the oligopolistic price setting approach, a commercial bank determines the interest rate on the loan by adding a commercial bank mark-up to the central bank interest rate. The higher the mark-up, the higher the market power of the commercial bank.

Rousseas (1985) employed the oligopolistic mark-up theory to the financial sector because this market is characterised by having few large banks, but also because the main aim of commercial banks is to maxims their profits. In this context, financial services, such as the supply of loans, are defined as the products and the interest rate charged for a commercial bank loan is the price for providing this service (Rousseas, 1985).

Moreover, because the banking sector is characterised as oligopolistic, the supply-demand framework based on perfect competition does not apply. If demand increases in an oligopolistic market, excess capacity is utilised, and prices change in order to maintain the mark-up when labour and input commodity costs increase. Therefore, an equilibrium market analysis should not be applied to the banking sector.

In a more recent case study, Das and Kumbhakar (2016) provide empirical evidence that the Indian banking sector is oligopolistic in nature. Their results show that this sector is concentrated, indicating that large banks have significant market power especially at price setting.

Empirical studies showed that commercial bank mark-up results can vary across regions. In the case of Italy, commercial bank mark-up results indicate a north-south divide (Montagnoli et al., 2016; Gambacorta, 2008; Angelini and Cetorelli, 2000). Figures 2.2 to 2.6 in Chapter 2.2.3 also showed a north-south Italian regional divide. Therefore, the remaining of this section provides information on potential drivers leading to the commercial bank mark-up differences.

3.2.2 Theoretical Background on Regional Differences

According to an oligopolistic price setting approach, varying commercial bank mark-up levels may exist due to the market power of commercial banks. The higher the mark-up, the more market power a commercial bank has. However, Carbó et al. (2009) argue that country specific factors, such as real output growth and inflation, have a significant impact on cross-country mark-up proxies and lead to weakest cross-country mark-up measures.

Moreover, differences in commercial bank mark-up levels can also be driven by higher production efficiency, marginal organisation, changes in consumer banking habits and technological development (Carbó et al., 2009). Further elaboration on these drivers is discussed in the following sections of this Chapter.

Dow and Rodriguez-Fuentes (1997) provide explanations for differentials in the interest rate based on a theoretical revision of the Neo-Classical, New-Keynesian and Post-Keynesian schools of thought. Their arguments are as follows:

Neo-Classical

As per Dow and Rodriguez-Fuentes (1997), from the Neo-Classical point of view, regional interest rate differences exist due to the malfunctioning of regional financial markets. The functioning of regional financial markets is based on a general equilibrium model assuming an efficient allocation of resources through perfect financial flows across regions - hence, through a perfectly functioning financial market. Based on the Neo-Classical argument, regional interest rate differentials exist if credit markets do not equilibrate interregional financial flows, meaning that imperfect financial flows exist.

Such disequilibrium can occur due to supply- and demand-side arguments. From the supply-side perspective, differentials exist due to information asymmetries between lenders in credit abundant regions and borrowers of peripheral regions. The more isolated the borrower from the lender, the more difficult and costlier is the risk assessment for the lender and, therefore, the higher is the level of inelastic supply of loans to remote regions. Hence, an inelastic supply of loans may indicate a bank’s higher risk perception (Dow and Rodriguez-Fuentes, 1997). In the context of this thesis this would mean that the further the borrower lives from the lender, the higher the mark-up.

The demand-side argument is based on the fact that demand for credit by small businesses and households of remote regions is not served by their local banks and those have no access to national credit markets in order to satisfy their unserved demand for credit. Hence, the supply and demand for credits is not in equilibrium and interest rate differentials may exist (Dow and Rodriguez-Fuentes, 1997).

New-Keynesian

The New Keynesian school of thought explains regional interest rate differentials as the Neo-Classical school of thought, namely through the asymmetric information argument (Dow and Rodriguez-Fuentes,1997). However, the New-Keynesians provide further reasoning for asymmetric information by researching the cause for low regional capital mobility leading to financial resource misallocation, credit rationing and hence interest rate differentials (Dow and Rodriguez-Fuentes,1997).

One of the key factors explaining regional credit rationing is the regional banks' wealth, as it determines the extension of regional banks' lending (Dow and Rodriguez-Fuentes, 1997). In other words, banks wealth variation across regions is the source of regional segmentation in credit markets. In this thesis's context, this would mean that regions with wealthy regional banks would be able to provide more lending without relying on capital mobility from outside the region. Put it differently, the poorer a regional bank is the more it relies on capital mobility from outside the region, and the higher credit rationing through higher mark-up levels (Dow and Rodriguez-Fuentes, 1997).

From a cost perspective, local banks obtain information on regional investment opportunities as well as on standard loans and monitor them at lower cost than banks from distant regions. This point makes regional banks more competitive in comparison to banks from other, distant regions (Dow and Rodriguez-Fuentes,1997). Furthermore, information cost can lead to credit constraints, especially in financially distressed regions and is therefore understood as an additional reason for information asymmetries (Dow and Rodriguez-Fuentes, 1997).

According to Samolyk (1994), regions with a poor quality of bank loans are influenced to a higher extent by conditions of the regional banking sector than regions with a relatively healthy banking sector. This shows that in financially segmented regions, local bank' market power has a higher impact on local economies and competition between regional and non-regional banks in terms of information, which causes interest rate differentials. In this thesis's context, this means that in regions characterised by poorer quality of bank loans, regional banks play a more important role. Therefore, it is likely to conclude that regions of poor loan quality have also a poor regional banking sector. Then, if information asymmetries exist across commercial banks from different regions and capital flow is restricted, mark-up levels in this region of poorer banking sector are even higher (Samolyk, 1994).

Post-Keynesian

From a Post-Keynesian perspective, market imperfections are a norm and are influenced by the different stages of the banking development and liquidity preference (Dow and Rodriguez-Fuentes, 1997). More precisely, the Post-Keynesian literature states that the ability of regional banks in an underdeveloped banking system to supply credit is restricted by regional deposits (Dow and Rodriguez-Fuentes,1997). This issue is overcome by a more developed system, i.e., a branch banking system. Regions with branch banking can provide credit beyond the regional deposit base and the information asymmetry issue is also overcome. In this case credit supply is perfectly elastic and should not cause any restrictions (Dow and Rodriguez-Fuentes, 1997).

However, Dow (1987) argues that a perfectly elastic supply of funds should not be assumed despite the existence of a branch banking system; the reason being the impact of liquidity preference on credit supply. Low confidence of a national bank in the economic performance of a peripheral region increases the national bank's liquidity preference and hence decreases the national bank's willingness to provide funds to this peripheral region. This means that liquidity preference of national banks is high if those banks perceive a high-risk level in relation to regions or if risk assessment of particular regions is difficult. As a result, risk is associated with uncertainty. For example, the more geographically distant the borrower from the lender, the higher the uncertainty. On the other hand, borrowers' low regional economic expectations indicate borrowers' high liquidity preferences and lead to decreases in loan demand, as borrowers perceive loan repayments as obligations in a more uncertain environment (Dow, 1987).

Moreover, according to Dow and Rodriguez-Fuentes (1997), loan supply and demand are interdependent. Uncertain expectations increase liquidity preferences among lenders and borrowers and lead to a decrease in the supply and demand for loans (Dow and Rodriguez-Fuentes,1997). The result is a gap between supply and demand leading to regional credit variation and hence to interest rate differentials. Then, higher interest rates can be expected in regions of higher uncertainty, which in turn can be indicated by higher volatility in economic performance and unemployment.

The Post-Keynesian school of thought does not elaborate directly on the interest rate differentials but rather on the differences in credit creation across regions, which result in different interest rates (Dow and Rodriguez-Fuentes,1997). Liquidity preference impacts credit supply and demand and hence the interaction between both components determine the level of credit created across regions. Liquidity preference is influenced by economic expectations of each party. The more uncertain the economic situation of a region, the higher is the liquidity preference and the higher the interest rate differentials (Dow and Rodriguez-Fuentes,1997).

3.2.3 Review of Estimation Approaches in Literature for Mark-Up Proxies

In general, estimation of the commercial bank mark-up is a well-established topic in the literature. The data used to study commercial bank mark-up levels can be grouped into two categories: micro and macro data. Micro data is grounded on bank-balance sheet data for individual banks and macro data uses interest rate data on loans. Because micro data is based on bank-balance sheet data of a particular bank within a country, the sub-regional aspect is not considered within this category. Macro data, on the other hand, can be obtained sub-segmented to a particular region or country.

Furthermore, empirical studies are diverse due to the wide variety of data available and different mark-up proxies. Based on the nature of the data used in an analysis, estimation strategies differ widely. Thus, studies can be categorised according to several factors, such as data employed and estimation strategies.

The remainder of this section will provide an overview of micro and macro data and the different estimation approaches used in order to estimate commercial bank mark-up proxies.

3.2.3.1 Data

Carbó et al. (2009) researched interest rate margins by applying several market power indicators, concluding that there is no consensus in terms of the best method of how to measure commercial bank mark-up levels.

One branch of the related literature utilises banking sector micro data, taken from publicly available bank-balance sheets. The data used within this approach is, for example, revenues, profits and/or marginal costs to first calculate commercial mark-up levels and then to examine them. In this line of the literature, mark-up proxies are calculated through simple mathematical operations which require several estimation steps (Das and Kumbhakar, 2016; Carbó et al., 2009; Angelini and Cetorelli, 2000; Rousseas, 1985).

Bank-balance sheet data is usually publicly available. The gain from this approach is that it allows to control for different characteristics in the calculation process, such as different bank types (commercial banks, cooperative credit banks, saving banks) and banks which underwent mergers and acquisitions (Rousseas, 1985). However, bank-balance sheet data does not contain information on the mark-up levels directly. The challenge here is: first, to know which variables to consider within the calculation; second, to obtain the required micro data of a particular bank. By following this approach, the researcher is then replicating a commercial bank’s process of price setting.

The application of this type of micro data could lead to misleading mark-up results since revenues, profits and/or marginal costs are also influenced by other factors which are not relevant for the mark-up determination. Profits, for example, are positively influenced by higher production efficiency, managerial organisation, changes in consumer banking habits and technological development.

One example of technological development and transformation is the introduction of ATMs and online banking. This innovation could lead to a reduced number of branches, which in turn reduces the operating costs and hence lowers marginal costs (Carbó et al., 2009). Commercial banks may also increase their incomes through other off-balance-sheet activities, such as fund management, underwriting, derivative trading, insurance and other commission- or fee-based services, which in turn inflate returns on assets (Carbó et al., 2009). If these types of data are used for the mark-up calculation, results may indicate a ratio between the individual components. However, it is questionable if this ratio is a good indicator for a mark-up.

On the other hand, a different branch of literature examines commercial bank mark-up levels by utilising publicly available macro data on interest rates. The advantage of applying this type of data is that the mark-up is already a component of each interest rate observed. Then, the research is based on first, extracting this mark-up from the interest rate, through identifying a parameter in an econometric model as an appropriate proxy, and then analysing the mark-up indicators (for instance: Gambacorta, 2008; Montagnoli et al., 2016).

The disadvantage of this type of data of particular characteristics, is its availability. Common issues are, for example, to find interest rate data across different geographical areas, the sample size and to find comparable interest rate data sets, especially across the Euro Zone countries. When econometrically estimating mark-up proxies, a further challenge is based on the nature of the data and hence on determining the estimation models and methods. Supplementary discussion on the latter was provided in Chapter 2.

A further important aspect to consider when using macro data is the representation of the employed interest rate by itself. For example, which interest rate data are most suitable to demonstrate the cost of funds rate. Is it the monetary policy interest rate or a money market rate? For instance, Gambacorta and Iannotti (2007) used the repurchase interest rate, Gambacorta (2008) applied the interest rate on the repurchase agreements between the Italian central bank and credit institutions as the monetary policy indictor, Montagnoli et al. (2016) employed the three-month interbank rate of Italy and de Bondt (2002) exploited several indicators to represent the money market interest rate: the money market rates, overnight market interest rate at 1, 3, 6 and 12 months maturities, and government bond yields at 2, 3, 5 and 10 years maturities.

Another consideration is which kind of bank lending rate is the most appropriate to represent the loan interest rate. Loan interest rates are categorised according to a particular banking product and, hence, can be segmented according to regions, maturity lengths, loan values, etc. Therefore, when estimating a mark-up proxy, data selection, for the dependent and independent variables, determine which mark-up is estimated. For example, following Montagnoli et al. (2016), when using a three-month interbank rate in Italy and a commercial bank interest rate for a loan greater than EUR 75,000, a mark-up between a particular cost rate and this banking product is estimated.

Overall, this differentiation between micro and macro data leads to a potential classification of data into ex-post and ex-ante variables. Mark-up values derived from micro data could be interpreted as an ex-ante variable because of its missing mark-up component in the data. Mark-up values derived from macro data, on the other hand, could be interpreted as an ex-post variable because of the present mark-up component in interest rate data.

3.2.3.2 Empirical Studies

Three approaches have been identified in the literature on the commercial bank mark-up estimation, based on the nature of the data and estimation models and methods. These approaches are the micro, the macro and the hybrid. This section will provide a survey of the estimations found across these studies, which employed different micro and macro data as well as estimation strategies

The Micro Approach

The micro approach is defined as the estimation of commercial bank mark-up proxies using data from banks' balance sheets. The estimation strategies within this approach are based on mathematical operations. In this section some empirical studies using this approach are revised.

Das and Kumbhakar (2016) applied the micro approach when studying the characteristics of the Indian banking sector for the period 1991 – 2010 on a national level. The authors used the cost function approach and the Input Distance Function (IDF) approach to estimate mark-up proxies. When using the cost function approach, the mark-up is defined as:

$$M = \frac{p - MgC}{MgC} \tag{3.1}$$

where M is the mark-up, p are the observed prices and MgC represents the marginal cost. Equation (3.1) also defines a general expression of the Lerner index, widely used in this literature.

According to the IDF approach, the process starts by estimating a transformation function for multiple inputs and outputs. Based on this function a production function and an input distance functions are obtained. Outputs of the latter, such as total cost and total revenue, are sufficient to estimate a Lerner index which provides the mark-up level and, hence, market power. In order to undertake calculations based on the IDF approach bank micro data such as input, and output of banking information is required.

Results from the Das and Kumbhakar study show that the banking sector in India is concentrated and, therefore, large banks have significant market power, especially at price setting. Furthermore, the mark-up is mostly influenced by the bank size. A bank's higher market power was associated with higher profits. Hence, the relationship between a commercial bank's market power and mark-up level is positive: The higher the mark-up, the higher is the market power. Overall, these results show that the Indian banking sector is of oligopolistic nature.

The authors' preferred approach is the IDF due to data, and especially price variability problem, in the cost function approach. A drawback of this study relates to data requirement, namely the number of banks in the sample varies across the research period due to the consolidation of the Indian banking sector and the introduction of new private banks.

Carbó et al. (2009) researched competition in the banking sector across 14 European countries for the timeframe 1995 – 2001. The authors estimated five indicators which are widely used in the European banking industry to infer competition levels, namely the net interest margin/total asset ratio, the Lerner index, the ratio of bank net income to the value of total assets, the reduced-form revenue equation and Hirschman-Herfindahl index.

Results across those competition indicators are conflicting across countries, within countries and over time. Hence, Carbó et al. (2009) conclude that cross-country comparisons of the competition in the European banking sector lack consistency. This outcome may be due to the point that competition indicators may measure different factors and may be influenced by cross-country differences, such as economic growth, inflation, cost efficiency and fee income levels. Additionally, when the authors remove the country-specific factors, results indicate much more similar levels of competition across the countries. This may indicate that the banking markets across the 14 European countries may not be as different as initially suggested.

Finally, Angelini and Cetorelli (2000) employed price-deposit margins and the Lerner index in order to examine competitive conditions in the Italian banking sector for the period 1983 – 1997. The authors used the price deposit margin as a competition indicator, defined as a ratio of total interest paid on deposits over total assets. This approach is based on the assumption that high deposits indicate a high level of market power. This assumption is based on the people's trust: The more people trust a particular bank the higher is the deposit level of the commercial bank.

Using bank balance sheet data on all Italian banks, Angelini and Cetorelli's findings highlight four main points. First, until 1992 margins are constant across all regions but decreased afterwards, indicating an increase in competition. Second, based on commercial bank results, mark-up indicators are lower in the north than in the south, suggesting higher concentration in the north and hence a lower degree of market power in the north. This finding also indicates a north-south divide. Third, there is no evidence that mark-ups, and hence market power, increased after commercial banks experienced a merger or acquisition. Finally, the price deposit margin increased significantly after the implementation of the Second Banking Directive regulation. The analysis of Lerner indices provided comparable results.

Overall, the estimation strategies employed when using micro data are simple mathematical operations, such as calculating ratios to find proportions. The drawback of these approaches is that several estimation steps are required in order to obtain a mark-up proxy. This, in turn, introduces room for measurement errors. A further area of criticism is based on the selection of an appropriate cost function.

On the other hand, methods utilising micro data, such as profits, in order to estimate commercial bank mark-up levels are ambiguous in the context of MPTM. For instance, technological development as the introduction of ATMs and online banking, or decreasing the number of branches, lead to declining operating cost and hence lower the marginal cost. As a result, commercial banks may also increase their incomes through other off-balance-sheet activities, such as fund management, underwriting, derivative trading, insurance and other commission- or fee-based services, which in turn inflate returns on assets (Carbó et al., 2009).

The Macro Approach

The macro approach uses publicly available data on interest rates for areas such as regions or countries. The literature shows that, for this approach, econometrical estimation strategies are used to determine proxies of the commercial bank mark-up. In this section, estimation strategies of the macro approach are presented.

Rousseas' (1985) paper on the mark-up theory of bank loans is fundamental in terms of theoretical mark-up determination. Rousseas (1985) mathematical expression of the pricing model has been enhanced by de Bondt et al. (2005)

to represent the empirical retail interest rate setting equation as shown by the following equation:

$$i = \beta_1 + \beta_2 u, \tag{3.2}$$

where i indicates the commercial banks' average interest rate, u denotes the cost of funds interest rate, β_1 presents the commercial bank mark-up proxy and β_2 is the pass-through coefficient. A common finding in the literature is that the constant of any empirical model is interpreted as a mark-up proxy (Montagnoli et al., 2016; Tai et al., 2012; Gambacorta, 2008; de Bondt, 2002).

Over time, different estimation techniques have been employed to estimate proxies for the commercial bank mark-up. In particular, ordinary least squares (OLS) and dynamic estimation strategies such as error correction models (ECM) and vector error correction models (VECM) are found as popular econometric techniques in this filed.

Montagnoli et al. (2016) determine empirically mark-up levels for 20 Italian regions using the money market rate as well as short- and long-term business loan rates for the period 1998q1 – 2009q4. This interest rate data is based on revocable loans of value €75,000 and above. The short-term aspect of the interest rate is captured by different loan maturity. For example, the short-term interest rate refers to loans of maturity up to 12 months, whereas the long-term is based on a maturity longer than 12 months.

Results show that mark-ups for short-term loans are higher in comparison to mark-ups for long-term loans. This mirrors customers' reasons for taking out short-term versus long-term loans. Short-term loans are mainly taken out due to liquidity issues and have no collateral requirement. Hence, due to the higher risk taken by the commercial bank, the interest rate on short-term loans is higher. Taking the regional aspect into consideration, Calabria showed the highest mark-up levels for short- and long-term loans. The lowest mark-ups were identified in Lombardia for long-term loans and in Trentino-Alto Adige for short-term loans. Those results also support the north-south divide, with lower mark-up levels in the north and high mark-up levels in the south.

The Hybrid Approach

The hybrid approach employs econometric estimation strategies on bank balance-sheet data, linking the micro and macro approaches described before. An example of this approach is Gambacorta (2008), who uses an ECM in order to estimate commercial bank mark-up proxies.

This study is interesting as the author had to overcome the shortage of data on interest rates in order to implement an econometrical estimation. The author examined the relationship between monetary policy7 and the interest rates of 73 Italian banks for the period 1993q3 – 2001q3. Since data on short-term interest rates was not available for each of the 73 Italian banks, proxies were created through interaction terms between short-term interest rates8 and bank-level data, such as size, liquidity and capitalisation. Finally, an ECM was estimated with the help of Generalised Method of Moments (GMM). As a result, Gambacorta (2008) provides a solution for data availability issues when investigating the commercial bank mark-up.

Gambacorta (2008) examined empirically how Italian commercial banks set short-term interest rates and deposit interest rates. Results of this study indicate heterogeneity of mark-up levels across the banking sector. Moreover, Gambacorta finds evidence that competition is influenced by capitalisation, liquidity and relationship lending.

3.2.4 Literature Review Discussion

This review of the literature shows that mark-up proxies could be determined based on micro or macro data. Estimation methods based on micro data follow simple mathematical operations, such as ratios. The disadvantage of the micro approach is that several estimation steps are required, which may leave

[7] The author utilised data on repurchase agreements between the Bank of Italy and credit institutions for the period 1993 – 1998, and the interest rates on main refinancing operations of the ECB for the period 1999 – 2001 as proxies for monetary policy indicators.

[8] This study used weighted average of lending rates as a proxy for the short-term interest rate

room for errors as the researcher is replicating a commercial bank's mark-up setting process.

In terms of the macro approach, econometrical estimation methods are mainly used to calculate mark-up proxies. The advantage of this approach is that the mark-up is incorporated in each interest rate observation. Often market and particular bank loan interest rate data is employed in this estimation process. The disadvantage of the macro approach is the interest rates data availability.

Based on the literature review, this Chapter is mainly motivated by the work of Gambacorta (2008) and Montagnoli et al. (2016). The inspiring facts were: The application of econometrical estimation strategies and interpreting the model constant as mark-up proxies; how Gambacorta (2008) has overcome the lack of macro data; and how Montagnoli et al. (2016) segmented the analysis across Italian NUTS2 regions.

Since bank loan interest rate data have been found, the estimation process of commercial bank mark-up in this Chapter follows the macro approach by estimating mark-up proxies via econometrical estimation strategies. More precisely, commercial bank mark-up proxies are estimated between the ECB and Italian NUTS2 regions for the period 1999q4 – 2017q1. Therefore, the relationship between the ECB and a particular Italian NUTS2 region is researched, from the supra level to an intra-national level.

In Chapter 2, the VECM was identified as the preferred estimation strategy. Building on this discussion, the mark-up proxies are calculated based on regional VECMs, where the constant of the cointegration equation is interpreted as the mark-up.

Further differences between this Chapter in comparison to Montagnoli et al. (2016) is that, in this Chapter, interest rate data and estimation methods employed are different to Montagnoli et al. (2016). More precisely, the authors employed money market rates and interest rate loans of value €75,000 and above, whereas in this Chapter commercial bank interest rate data relates to revocable loan interest rates segmented accordingly to NUTS2 regions. No differentiation is used in terms of loan values in this Chapter because its motivation is to investigate the overall relationship between the ECB-set interest rate and the overall interest rates observed in regional loans.

Another difference between the Montagnoli et al. (2016) paper and this Chapter are the definitions of long- and short-term aspects. Montagnoli et al. (2016) captures the long- and short-term aspect based on different maturity of a loan. More precisely, the short term is defined by a loan maturity up to 12 months whilst long-term is defined by a loan maturity of more than 12 months. In this Chapter the long- and short-term relate to the point of how econometrically determined long- and short-term variables influence the current regional loan interest rate. This is a different concept of long- and short-term based on an econometrical estimation strategy.

Furthermore, Montagnoli et al. (2016) as well as Gambacorta (2008) have used money market interest rates as their cost of funds. This means that in both papers the mark-up is determined between the inter-bank market interest rate and a loan interest rates. In this Chapter the motivation is to investigate the mark-up between the ECB-set interest rate, the MRO, and the observed regional interest rates on loans, providing insight on the MPTM as discussed in Chapter 1.

There are other factors which differentiate this Chapter from the existing literature. These are as follows:

- Studies researching commercial bank mark-up based on the micro approach do not take the money market or monetary policy interest rates into consideration during the estimation process, this Chapter does. Most of the literature based on the macro approach begins the commercial bank mark-up analysis at the market level because of the application of the money market interest rates. In other words, the macro approach researches different mark-up proxies than the commercial bank mark-up of this Chapter. Therefore, with the purpose to examine the commercial bank mark-up from the ECB across Italian NUTS2 regions, the micro approach or the selection of money market rate is not appropriate.
- Empirical studies do not control by structural breaks related to the two phases of the 2007 – 2008 Financial Crisis, whereas in this Chapter those are determined endogenously. During the estimation process of this Chapter, the structural breaks are controlled via a dummy variable

or trend variable, as discussed in Chapter 2.3.8. This approach leads to more representative results of the mark-up proxies.

The originality of this Chapter's contribution is based on the combination of three elements leading to a specific commercial bank mark-up investigation. The first element is based on data selection, namely the MRO and revocable loan interest rates observed in each of the 20 Italian NUTS2 regions. Therefore, the commercial bank mark-up proxies are estimated between the ECB and each of the 20 Italian NUTS2 regions, leading to a mark-up investigation from a supra to an intra-national level. The second element is that proxies are estimated based on regional VECMs. For instance, Montagnoli et al. (2016) estimated the mark-up proxies via an OLS whilst Gambacorta (2008) used the GMM. The advantage of VECM is that long- and short-run parameters can be obtained but also lagged variables are employed as independent variables. This provides a more holistic view on the MPTM. The regional aspect is accredited to the point that optimal lag-length and rank are built-in for each regional VECM. For comparative purposes mark-up proxies were also estimated via CR. Finally, the method used for the structural break identification and control for the 2007 – 2008 Financial Crisis in each regional estimation also add to the contribution of this Chapter.

Overall, the combination of the above-mentioned elements leads to a unique mark-up investigation, analysing the mark-up from a supra to an intra-national level, through deriving regional models, studying the extent of the pass-through and controlling endogenously for the Financial Crisis of 2007 – 2008.

3.3 Empirical Implementation

The overall objective of this Chapter is to empirically investigate the first sub-mechanism of the MPTM and to research how the mark-up levels differ across the Italian NUTS2 regions. Therefore, commercial bank mark-up proxies per Italian NUTS2 region must be calculated.

The purpose of this section is to draw out the methodology employed in this Chapter to estimate regional commercial bank mark-up indicators for the Italian NUTS2 regions. This section builds on Chapter 2, which presented the data employed in this thesis and discussed various commercial bank mark-up estimation strategies.

The mark-up proxies for each of the Italian NUTS2 regions will be calculated by using an econometric estimation strategy due to the availability of data on interest rates, such as the revocable loan interest rates across the Italian NUTS2 regions and the MRO interest rate.

As discussed in Chapter 2, the VECM estimation model and method was identified as providing the richest number of MPTM coefficients in a single step, when combining time-series of a regional revocable loan interest rate and the MRO rate. The following VECM is estimated as shown in equations (3.3) and (3.4):

$$\Delta RL_{R,t} = c_{RL_R} + \sum_{R=1}^{k} \beta_{RL_{R,i}} \Delta RL_{R,t-i} + \sum_{R=1}^{k} \theta_{RL_{R,i}} \Delta MRO_{t-i} + \gamma_{RL_R} Z_{t-1} + \varepsilon_{RL_{R,t}} \quad (3.3)$$

$$\Delta MRO_t = c_{MRO} + \sum_{R=1}^{k} \beta_{MRO_i} \Delta RL_{R,t-i} + \sum_{R=1}^{k} \theta_{MRO_i} \Delta MRO_{t-i} + \gamma_{MRO_i} Z_{t-1} + \varepsilon_{MRO_t} \quad (3.4)$$

where $RL_{R,t}$ represents the regional revocable loan interest rate time-series ($RL_{R,t}$) for region R and quarter t, MRO_t is the MRO interest rate time-series for each t quarter, and C_{RL} and C_{MRO} are the model constants for revocable loan and MRO interest rates respectively. Equations (3.3) and (3.4) are adapted versions of the VECM model presented in equations (2.10) and (2.11) of Chapter 2, where the interpretation of each estimation parameter is discussed.

Since the commercial bank mark-up proxies are indicated by the constant of the cointegration equation Z_{t-1}, equation (3.3) is considered as the most important equation for this Chapter. This cointegrated equation is defined from the VECM (equation (3.3)) as:

$$Z_{t-1} = RL_{R,t-1} - C_R - \alpha_R MRO_{t-1} \quad (3.5)$$

where Z_{t-1} represents the cointegrated equation. In this context, C_R is interpreted as the commercial bank mark-up proxy per Italian NUTS2 region given in percentages (Gambacorta, 2008; Montagnoli et al., 2016). Please note that the estimation of the commercial bank mark-up proxies is at the

NUTS2 level, but the regional pattern identification is conducted at NUTS1 level.

Before estimating regional VECMs, preconditions of non-stationary and cointegrated data must be satisfied. Tests for these preconditions consist of a stationarity analysis and the Johansen cointegration test. Stationarity is examined through the Augmented Dickey Fuller (ADF) unit-root test (Dickey and Fuller, 1979) per NUTS2 area. Each regional time-series is assessed for unit-roots in levels and first differences. For completeness the test examines stationarity in the intercept, in both intercept and trend, as well as no intercept and no trend. The ADF null hypothesis assumes a unit-root (non-stationarity), whereas the alternative hypothesis assumes that there is no unit-root (stationarity).

The Johansen test for cointegration is employed in order to identify the rank of each time-series (Johansen, 1995). This test begins with examining the null hypothesis of no cointegration at zero maximum rank, following by the null hypothesis of one or fewer cointegrating equations at one maximum rank. Cointegration is determined by the first null hypothesis which is not rejected.

To support the analysis of the mark-up based on the constant of the VECM cointegration equation per region, equation (3.5) is estimated independently for each cointegrated region via the Cointegration Regression (CR). This approach allows for a comparison between the VECM and the CR approach.

Since the Financial Crisis of 2007 – 2008 is within this researched period, it needs to be accounted for in the regional estimations. This is undertaken in two ways: First, structural break points per regional time-series are endogenously determined by applying the Zivot and Andrews (1992) unit-root test. Further information on the Zivot and Andrews (1992) unit-root test and the estimation procedures are provided in Section 3.4.

In order to verify the obtained results, post-estimation tests are undertaken for each regional VECM estimation. In particular, the Chi-squared values from a Wald test are calculated per regional model. These indicators provide insight about model specification; whether the selected lag-length of the MRO rate is statistically significant within the regional VECM model, respectively.

Furthermore, following each regional VECM calculation each estimated residual is tested for the presence of serial correlation.

In conclusion, by applying a VECM estimation on data of the regionally interest rate on revocable loans and the European MRO rate, the mark-up estimator is obtained per Italian NUTS2 region. Moreover, mark-up results are compared across the geographical areas where trends and patterns can be identified. As the 2007 – 2008 Financial Crisis is within the researched timeframe of the data set employed in this analysis, it is important to test for structural breaks. The reasoning for this approach was discussed in Section 2.3.8.

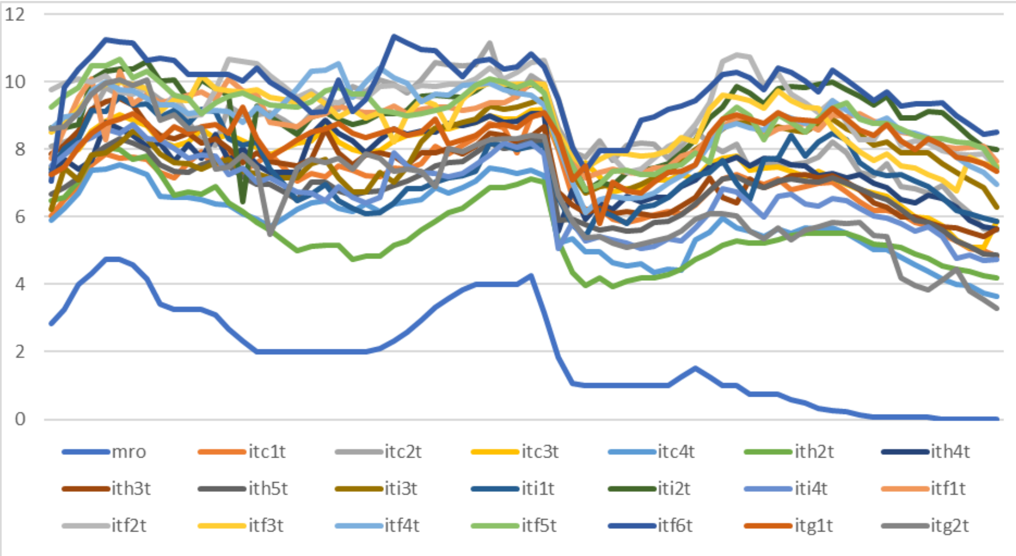
3.4 Results

This section examines the commercial bank mark-ups across the Italian NUTS2 regions, following different estimation strategies and model specifications. This section is divided into five sub-sections: First, pre-estimation results for stationarity on the time-series are discussed, which are required to set a VECM for each region. Second, VECM results are examined. Third, post estimation results are summarised providing information on model specification. The fourth section discusses results of estimations which control for the 2007 – 2008 Financial Crisis.

3.4.1 Pre-Estimation Results

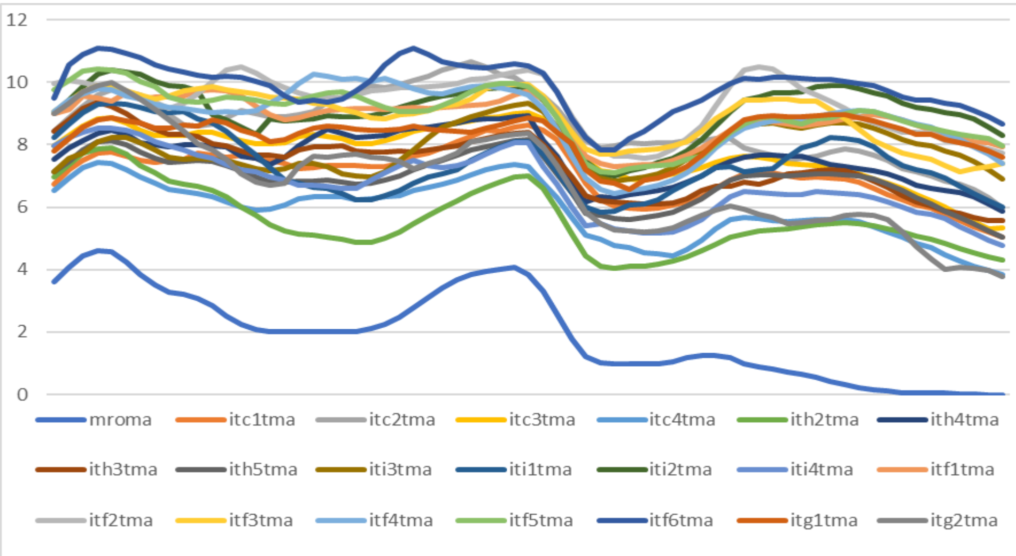
Before estimating the regional VECMs, pre-estimation tests have been conducted in order to examine stationarity of the data and to determine the rank and lag-length of the appropriate model specification. Since all pre- and post-estimation tests for a VECM apply to Chapter 3 and 4 of this thesis, detailed results are presented in Appendix B. Following ECB (2013), to account for quarterly volatility, the level data were transformed to annual moving averages. This can be seen when comparing Figures 3.1 and 3.2.

Figure 3.1 MRO and Interest Rate per NUTS2 Region (levels)



Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d)

Figure 3.2 MRO and Interest Rate per NUTS2 Region (moving average)



Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d)

The Augmented Dickey Fuller (ADF) unit-root test was applied to check the stationarity of the employed time-series (Asteriou and Hall, 2016). For completeness, each regional time-series was tested in levels and first differences in the constant, trend, as well as no constant and no trend. Therefore, each time-series was tested for six different cases per NUTS2 region. Appendix B.1 summarises the six different test cases. The first three tests refer to a stationarity analysis on data in levels for the intercept, the trend and no trend and no intercept. Tests 4 to 6 refer to the same specification with the difference that data is considered in first differences.

The null hypothesis of the ADF unit-root test states that a time-series has a unit-root, which means that the time series is not stationary versus the alternative of stationarity, shown in Appendix B.2. The t-statistics of the first three tests, as shown in columns ‘constant’, ‘trend’ and ‘no constant no trend’ under the classification ‘level’ of Appendix B.2, indicate that each regional time-series is non-stationary in levels at a 1% significance level; t-statistic results of tests 4 to 6 show stationarity of the time-series in first differences at 10% significance levels. For detailed information please see Appendix B.2.

Since the time-series were found to be non-stationary in levels and stationary in first differences the next step is to identify whether each regional revocable loan time-series is cointegrated with the MRO rate, meaning whether a long-run relationship exists between the variables. There are different tests to analyse cointegration. Following Asteriou and Hall (2016) the Johansen (1995) test for cointegration is applied.

To determine the optimal lag-length for the Johansen (1995) cointegration test, the final prediction error (FPE), the Akaike information criterion (AIC), the Schwarz Bayesian information criterion (SBIC) and the Hannan and Quinn information criterion (HQIC) were estimated. These criteria were estimated by applying the maximum lag-length selection as identified by Schwert (1989):

$$\text{Lag} - \text{Length} = \left[12 * \left(\frac{T}{100}\right)^{0.25}\right] \quad (3.6)$$

where T represent the number of time periods in the sample, which is 67 per time-series in this thesis. By computing this formula, the max lag-length is 10.

The optimal lag length for the Johansen (1995) cointegration test was then selected based on the HQIC. Table 3.1 summarises the optimal lag-length for the NUTS2 regions. Detailed results of the lag-length for each of the four information criteria can be found in Appendix B.3.

The Johansen (1995) test for cointegration is used to identify the cointegration of two time-series. This test begins with examining the null hypothesis of no cointegration at zero maximum rank followed by the null hypothesis of one or fewer cointegrating equations at one maximum rank, etc. Cointegration between a particular regional time-series and the MRO is based on the eigenvalue or trace statistics and the 5% critical value, given in the respective column of Table 3.1. The asterisks indicate the max rank of cointegration.

Table 3.1 Johansen (1995) Cointegration Test per NUTS2 region

NUTS1	NUTS2	Lag Length	Maximum rank	Eigenvalues	Trace Statistic	5% Critical value	Cointegrated
North West	Piemonte	7	0	.	27.302	15.41	Cointegrated
			1	0.36198	0.3386*	3.76	
	Valle d'Aosta/Vallée	7	0	.	7.1933*	15.41	No cointegrated
	d'Aoste		1	0.08303	1.992	3.76	
	Liguria	10	0	.	20.2382	15.41	Cointegrated
			1	0.28534	1.0887*	3.76	
	Lombardia	9	0	.	24.7896	15.41	Cointegrated
			1	0.34776	0.0033*	3.76	
North East	Provincia Autonoma	10	0	.	19.609	15.41	No cointegrated
	di Trento		1	0.22316	5.215	3.76	
	Veneto	4	0	.	20.442	15.41	Cointegrated
			1	0.24872	2.4257*	3.76	
	Friuli-Venezia Giulia	9	0	.	9.0195*	15.41	No cointegrated
			1	0.14304	0.067	3.76	
	Emilia-Romagna	9	0	.	22.991	15.41	Cointegrated
			1	0.31116	1.3718*	3.76	
Centre	Toscana	3	0	.	8.8803*	15.41	No cointegrated
			1	0.09527	2.472	3.76	
	Umbria	8	0	.	19.496	15.41	Cointegrated
			1	0.27277	0.7031*	3.76	
	Marche	7	0	.	12.5796*	15.41	No cointegrated
			1	0.14313	3.311	3.76	
	Lazio (Roma)	9	0	.	13.1730*	15.41	No cointegrated
			1	0.19543	0.561	3.76	
South	Abruzzo	7	0	.	10.3646*	15.41	No cointegrated
			1	0.15468	0.282	3.76	
	Molise	3	0	.	15.3423*	15.41	No cointegrated
			1	0.18282	2.421	3.76	
	Campania	7	0	.	24.535	15.41	Cointegrated
			1	0.33563	0.0004*	3.76	
	Puglia	7	0	.	16.389	15.41	Cointegrated
			1	0.23877	0.0193*	3.76	
	Basilicata	7	0	.	11.7693*	15.41	No cointegrated
			1	0.17420	0.285	3.76	
	Calabria	7	0	.	7.6605*	15.41	No cointegrated
			1	0.11378	0.413	3.76	
The Islands	Sicilia	7	0	.	18.486	15.41	Cointegrated
			1	0.26407	0.0882*	3.76	
	Sardegna	3	0	.	9.0325*	15.41	No cointegrated
			1	0.10720	1.775	3.76	

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: * indicates the maximum rank of cointegration.

Based on the Johansen (1995) cointegration test nine out of 20 NUTS2 regions are cointegrated with the MRO, which indicates that nine time-series have a long-run association with the MRO. In detail, three north-western regions are cointegrated with the MRO, namely Piemonte, Liguria and Lombardia. Two regions of the north-east are cointegrated with the MRO, namely Veneto and Emilia-Romagna. From the central regions only Umbria is cointegrated with the MRO, whilst two southern regions are cointegrated with the MRO: Campania and Puglia. Finally, from the islands only Sicilia is cointegrated with the MRO. This finding provides first insights with respect to the regional pattern, namely five of the richer northern regions indicate a long-run relationship with the ECB-set interest rate whilst only two southern, poorer regions are cointegrated with the ECB-set interest rate. Based on the cointegration results VECM estimations for the nine cointegrated regional time-series will be undertaken.

3.4.2 Standard Estimations

Regional average commercial bank mark-up proxies were estimated based on the VECM estimation strategy defined in Section 3.3 and following the model specification of equations (3.3) and (3.5). The mark-up proxies were calculated for the period 1999q4 – 2017q1 for the nine Italian NUTS2 regions for which cointegration was confirmed. The constant of the cointegrated equation is interpreted as the commercial bank mark-up in percentages. Table 3.2 shows results of the resulting commercial bank mark-up proxies. The last two columns of Table 3.2 show results of the mark-up proxies obtained by VECM and CR per Italian NUTS2 region. As discussed in Section 3.3, CR results are calculated to support the long-run VECM estimations.

The coefficient estimates of all specifications (VECM and CR) indicate that mark-up levels in all northern regions are lower than in the southern regions. This finding is in line with the macro approach shown by Montagnoli et al. (2016), the hybrid approach shown by Gambacorta (2008) and the micro approach shown by Angelini and Cetorelli (2000). These results indicate that, despite different estimation strategies (VECM and CR) and estimation approaches (micro, macro and hybrid approaches), the overall findings are consistent. They indicate that commercial bank mark-ups are lower in the northern regions compared to the southern regions. Moreover, CR estimations in Table 3.2 provide standard errors, which allow to make inference regarding the levels of statistical significance of the VECM mark-up values.

Table 3.2 NUTS2 Commercial Bank Mark-Up Estimations across Nine Italian NUTS2 Regions

NUTS1	NUTS2	Lag	VECM	CR
North West	Piemonte	7	6.021	6.005***
				(0.189)
	Liguria	10	6.419	6.480***
				(0.168)
	Lombardia	9	4.508	4.620***
				(0.163)
North East	Veneto	4	6.045	6.101***
				(0.166)
	Emilia-Romagna	9	5.966	5.959***
				(0.198)
Centre	Umbria	8	8.752	8.592***
				(0.280)
South	Campania	7	8.157	7.988***
				(0.216)
	Puglia	7	7.140	8.056***
				(0.336)
The Islands	Sicilia	7	8.185	8.037***
				(0.226)

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Standard errors in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

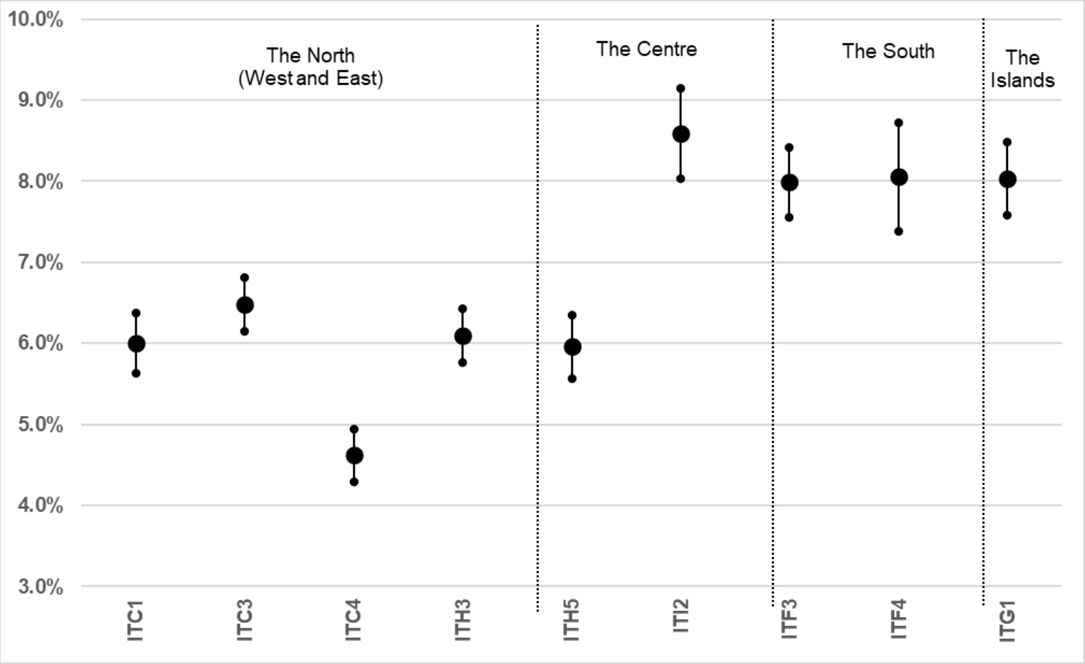
Following the literature presented in Section 3.2, these commercial bank mark-ups could be interpreted in the following way: The higher the mark-up, the higher the price for a loan and the higher the market power commercial banks have in a particular region.

Overall, as shown in Table 3.2, lowest commercial bank mark-up levels are observed across the richer north-western and north-eastern regions, whilst highest commercial mark-up levels are observed across the poorer regions of the centre, south and the islands. In detail, according to the VECM mark-up results, the lowest commercial bank mark-up is observed in Lombardia (4.508%), a north-western region, whereas the highest commercial bank mark-up level is denoted in Umbria (8.752%) a region in the centre of Italy. This means that mark-up levels are the lowest in the region where the financial sector is the key industry and where the Italian Stock Market is based.

Following the CR results as reported in the last column of Table 3.2, it can be seen that the estimates are generally similar to the VECM results. The same regional pattern is observed, namely low mark-up levels in the north and high mark-up levels in the south and the centre of Italy. These results confirm the heterogeneity in mark-up levels across the NUTS2 regions, where mark-ups are lower in the north than in the south. All mark-up results obtained through the CR are statistically significant at a 1% level.

In order to investigate the obtained mark-up results further Figure 3.3 presents the coefficient estimates for the commercial bank mark-up by regions as well as the coefficients' 95% confidence intervals. The vertical lines represent the separation between the northern, central, southern and the islands. Regions are presented in geographical order starting from northern to southern regions.

Figure 3.3 Commercial Bank Mark-Up and Confidence Intervals by NUTS2 Region



Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Note: Confidence intervals at 95% significance level. NUTS2 regional abbreviations are provided in Table 2.1 of Chapter 2.2.

When considering the mark-up levels of the northern regions, except for Lombardia (ITC4), quite homogenous mark-up levels are observed. Mark-up levels in Lombardia tend to be comparatively lower in comparison to other NUTS2 regions. When considering the mark-up levels of the southern regions a homogenously high mark-up level is observed. The mark-up levels of the central regions are heterogeneous. Therefore, Figure 3.3 shows that mark-up levels in northern NUTS2 regions are lower than in southern regions at 95% confidence interval.

Moreover, the mark-up level in Lombardia is found to be the lowest, a well-developed region of Italy, where the banking sector is a significant contributor to the economy respectively. Therefore, this finding of Lombardia supports the earlier discussed result and positions this finding as unique of this thesis.

Figure 3.3 also shows that the variability of mark-up levels differs across the NUTS2 regions. Commercial bank mark-ups show greater variability in the south, centre and Sicilia than in the north, implying that mark-up levels in Lombardia were not only low but also remained low over time.

Overall, the presented commercial bank mark-up levels show that on average consumers are paying more for revocable loans in the southern Italian regions than consumers in the northern regions of Italy, which follows results of Montagnoli et al. (2016), Gambacorta (2008) and Angelini and Cetorelli (2000). Moreover, these results indicate that monetary policy transmits heterogeneously across the Italian NUTS2 regions. Therefore, this analysis shows that the first MPTM functions more effectively in the northern regions than in the south and in most central regions.

In Chapter 1 it was discussed that the ECB is using monetary policy to support the EC's objective to enhance economic growth and employment across the Euro Area leading to convergence across regions (ECB, 2019b; EC, 2019a; Commission of the European Communities, 1990). However, results of this analysis indicate that between 1999q4 and 2017q1 the ECB's monetary policy was more effective in the northern regions of Italy than in the south, the centre and Sicilia, meaning that convergence across northern regions was more likely to take place than in the south and centre. This means that the uneven effectiveness of monetary policy across Italian NUTS2 regions could have contributed to a divergence between the north and the south.

Furthermore, following the literature, the obtained results in this section indicate that risk, competition, liquidity preference, wealth of the banking sector and/or quality of the banking sector could contribute to the regional differences of commercial bank mark-up.

3.4.3 Post-Estimation Results of Standard Estimations

To examine the lag-length selection of the MRO rate in relation to each regional revocable loan interest rate, the Chi-square of the Wald test are used for each regional VECM estimation. The Wald test is conducted for all cointegrated time-series per regional VECM estimation and assesses the impact of the independent variable(s) on the dependent variable. In the case of this thesis' regional VECM estimations, the test determines the MRO and the impact of its lags on each regional revocable loan interest rates. The hypothesis of the Wald test states that all coefficients of the independent variables are zero versus the alternative that the coefficients do not equal to zero (Asteriou and Hall, 2016). Results of this test, summarised in Appendix C.4, show that all selected lag-lengths between the time-series have a significant effect at 1% level. Hence, those results are supporting the lag length selection.

Furthermore, following each regional VECM calculation, each estimated residual was tested for the presence of serial correlation. Appendix C.5 shows that no serial correlation in the estimated residuals was found with potentially some exception in lag 8 for Sicilia.

3.4.4 Financial Crisis

The 2007 – 2008 Financial Crisis had a significant impact on the Italian economy; therefore, it is possible that it may have led to a structural break in the regional time series. As discussed in Chapter 2.3.8, Italy was affected by two phases of the Crisis: Phase 1 (denoted as FCP1) related to the Lehman Brothers fall in September 2008, and phase 2 (denoted as FCP2) related to the Italian Sovereign Debt Crisis beginning in late 2010. Figures 2.2 to 2.6 of Chapter 2 highlighted the presence of potential economic shocks to the Italian economy. Furthermore, the mean revocable interest rates were found to significantly differ before and after the Financial Crisis as shown in Section 2.2.4. Therefore, it is important to account for this crisis in the regression analysis.

There are different ways to investigate an endogenous structural break, which potentially could have been caused by events such as the Financial Crisis.

One way is by using the Gregory and Hansen (1996) test for cointegration. The authors developed an extension of the ADF-, Z_α-, and Z_t-type tests to examine the null hypothesis of no cointegration against the alternative hypothesis of cointegration in the presence of a potential regime shift.

However, the Gregory and Hansen (1996) test for cointegration will not be used in this analysis due to the following reasons: Based on Gregory et al. (1996) in modest sample size data sets there is a substantial reduction in the ability to detect structural breaks. Furthermore, the authors argue that it is very unlikely to find a break, even if the sample observation is 500, due to the observed low rejection frequency (Gregory et al., 1996). Based on the argument above and since the used data sample in this thesis is 67 observations, a different approach will be followed.

Another way to investigate endogenous structural breaks is by using the Zivot and Andrews (1992) unit-root test. The authors developed a unit-root test procedure which allows for one structural break in the intercept, trend or both. Following Zivot and Andrews (1992), structural break points are then identified in the intercept (by following Model A), in the trend (by following Model B) and in both (by following Model C) for each region. This unit-root test is undertaken on the residuals of a VAR model. For further information on Zivot and Andrews (1992) please see Section 2.3.8.

After the structural breaks have been identified endogenously, one can control for them in two ways: Following Tai et al. (2012), the sample period can be divided into two sub-samples, a pre-crisis and a post-crisis sample; or by directly adding dummy and/or trend variables into the baseline specification. The gain from the first approach is that one could identify the impact of the crisis on each of the coefficients.

However, the overall sample size in this thesis contains 67 observations. Moreover, a VECM estimation procedure is applied in this Chapter and Chapter 4, which consists of the estimation of two equations and would require an optimal lag-length selection9. If the sample is divided into two subsamples

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[9] Details on the VECM estimation are discussed in Section 2.3.7.

following Tai et al. (2012), the number of observations as well as the degrees of freedom will be significantly reduced. This is likely to compromise the reliability of the resulting coefficient estimates as this approach is highly sensitive to outliers.

As a result, to control for the Financial Crisis structural break, a dummy variable and/or a trend variable will be used in this thesis. In detail, to integrate the structural break in the VECM model, as identified by the Zivot and Andrews (1992) unit-root test, two models are used: Model A to control for a structural break in the intercept and Model B to control for a structural break in the trend. Therefore, by following this approach the analysis controls for the Financial Crisis in two ways. Following Model A per cointegrated region, a dummy variable is added and is set at the identified structural break date following Zivot and Andrews (1992). According to Model B, a trend variable is added to the baseline specification and is set at the different structural break dates following Zivot and Andrews (1992). Finally, a VECM with either a dummy variable or trend variable is re-estimated in order to control for the structural break.

To estimated commercial bank mark-up proxies whilst controlling for structural breaks the estimation procedure is as follows.

First, the optimal lag-length for the Johansen (1995) cointegration test was determined as explained in Section 3.4.1, namely by estimating FPE, AIC, SBIC and HQIC. These four information criteria were estimated by applying the maximum lag-length selection following Schwert (1989). Please see Section 3.4.1, for detailed information on Schwert (1989) estimated maximum lag-length for this thesis.

Second, the optimal lag length for the Johansen (1995) cointegration test was then selected based on the minimum observed of the HQ information criterion. Table 3.1 summarises the optimal lag-length across the regions. Detailed results of the lag-length for each of the four information criteria can be found in Appendix B.3.

Third, the Johansen (1995) test for cointegration was used to identify the cointegration between a regional interest rate and the MRO. For detailed information on the Johansen (1995) cointegration test please see Section

3.4.1. Based on the Johansen (1995) cointegration test, nine out of 20 NUTS2 regions are cointegrated with the MRO. In detail, three north-western regions are cointegrated with the MRO, namely Piemonte, Liguria and Lombardia. Two regions of the north-east are cointegrated with the MRO, namely Veneto and Emilia-Romagna. From the central regions only Umbria is cointegrated with the MRO, whilst two southern regions are cointegrated with the MRO: Campania and Puglia. Finally, from the islands only Sicilia is cointegrated with the MRO.

Fourth, a VAR was estimated for each cointegrated region and each regional VAR residual was saved. The first three columns of Table 3.3 provide information on the identified optimal lag-length, the number of observations, and the log likelihood of each regional VAR estimation. Columns 4 – 7 provide information on the VAR residuals per region, such as the mean, standard deviation, minima and maxima. This table shows that across the cointegrated regions the residuals are normally distributed with mean of 0, as expected.

Table 3.3 VAR Estimations per Region, Statistics and Residuals

NUTS2	VAR estimation			VAR residual			
	Lag	Obs	Log likelihood	Mean	Standard Deviation	Minimum	Maximum
Piemonte	7	60	173.41	0.000	0.067	-0.144	0.166
Liguria	10	57	185.77	0.000	0.052	-0.100	0.144
Lombardia	9	58	184.32	0.000	0.049	-0.139	0.108
Veneto	4	63	159.43	0.000	0.074	-0.161	0.240
Emilia-Romagna	9	58	185.79	0.000	0.050	-0.124	0.102
Umbria	8	59	131.56	0.000	0.113	-0.447	0.276
Campania	7	60	162.28	0.000	0.075	-0.162	0.201
Puglia	7	60	162.65	0.000	0.074	-0.242	0.153
Sicilia	7	60	151.29	0.000	0.093	-0.265	0.186

Source: Author’s estimation using Bank of Italy (2017b) and ECB (2019d).

Fifth, based on the ADF test the residuals are investigated for stationarity. Results of this investigation are shown in Table 3.4.

Table 3.4 ADF Unit-Root Test for Stationarity on VAR Residuals per Region

NUTS2	Test statistic	Critical values		
		1%	5%	10%
Piemonte	-7.503***	-3.567	-2.923	-2.596
Liguria	-7.219***	-3.572	-2.925	-2.598
Lombardia	-8.234***	-3.570	-2.924	-2.597
Veneto	-7.482***	-3.563	-2.920	-2.595
Emilia-Romagna	-7.745***	-3.570	-2.924	-2.597
Umbria	-7.22***	-3.569	-2.924	-2.597
Campania	-7.496***	-3.567	-2.923	-2.596
Puglia	-7.709***	-3.567	-2.923	-2.596
Sicilia	-7.672***	-3.567	-2.923	-2.596

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

As stated before, the null hypothesis of the ADF unit-root test states that a time-series has a unit-root, which means that the time series is non-stationary versus the alternative of stationarity. Based on the results of the test statistic reported in Table 3.4, the null hypothesis of a unit-root is rejected meaning that the VAR residuals are stationary.

Sixth, Zivot and Andrews (1992) unit-root tests were conducted for each region based on Model A that tests for a structural break in the intercept, based on Model B that tests for a structural break in the trend and based on Model C that test for a structural break in both, the intercept and trend. The Zivot and Andrews (1992) unit-root test was conducted on the VAR residual terms for each region and is again based on the lag-length selection as suggested by Schwert (1989). Since the Zivot and Andrews (1992) unit-root test is based on a univariate case, the earlier estimated VAR residual is used for the Zivot and Andrews (1992) unit-root test in this Chapter and for Chapter 4. For further information on the applied models please see Section 2.3.8 and for further information on the max lag-length, please see Section 3.4.1. Table 3.5 summarises the results of the Zivot and Andrews (1992) unit-root test per cointegrated region, where column entitled 'Model' provides information on the particular model used, column 'Breakpoint date' provides the identified break point, column 't-statistic' provides the obtained t-statistics and the last three columns provide the critical values at 1%, 5% and 10% respectively.

Table 3.5 Zivot and Andrews (1992) Test for Endogenous Break per Cointegrated Region

NUTS2	Model	Breakpoint date	t-statistic	Critical values		
				1%	5%	10%
Piemonte	Intercept	2008q3	-8.13	-5.34	-4.80	-4.58
	Trend	2014q4	-8.95	-4.93	-4.42	-4.11
	Both	2014q2	-9.05	-5.57	-5.08	-4.82
Liguria	Intercept	2014q4	-7.92	-5.34	-4.80	-4.58
	Trend	2013q4	-7.78	-4.93	-4.42	-4.11
	Both	2013q3	-7.88	-5.57	-5.08	-4.82
Lombardia	Intercept	2012q1	-8.59	-5.34	-4.80	-4.58
	Trend	2006q1	-8.37	-4.93	-4.42	-4.11
	Both	2008q4	-8.53	-5.57	-5.08	-4.82
Veneto	Intercept	2005q2	-8.08	-5.34	-4.80	-4.58
	Trend	2009q2	-7.76	-4.93	-4.42	-4.11
	Both	2005q2	-8.19	-5.57	-5.08	-4.82
Emilia-Romagna	Intercept	2007q4	-7.77	-5.34	-4.80	-4.58
	Trend	2005q1	-7.76	-4.93	-4.42	-4.11
	Both	2014q3	-8.00	-5.57	-5.08	-4.82
Umbria	Intercept	2005q3	-7.83	-5.34	-4.80	-4.58
	Trend	2007q1	-7.17	-4.93	-4.42	-4.11
	Both	2005q3	-8.16	-5.57	-5.08	-4.82
Campania	Intercept	2011q4	-8.56	-5.34	-4.80	-4.58
	Trend	2009q2	-8.14	-4.93	-4.42	-4.11
	Both	2012q1	-8.44	-5.57	-5.08	-4.82
Puglia	Intercept	2005q2	-8.47	-5.34	-4.80	-4.58
	Trend	2006q4	-7.80	-4.93	-4.42	-4.11
	Both	2005q2	-8.64	-5.57	-5.08	-4.82
Sicilia	Intercept	2005q2	-8.41	-5.34	-4.80	-4.58
	Trend	2007q2	-8.02	-4.93	-4.42	-4.11
	Both	2005q2	-8.43	-5.57	-5.08	-4.82

Source: Author’s estimation using Bank of Italy (2017b) and ECB (2019d).

The null hypothesis of the Zivot and Andrews (1992) unit-root is that a time-series is non-stationary against the alternative hypothesis of stationarity (Gregory and Hansen, 1996).

Based on the t-statistics in Table 3.5, the null hypothesis of a unit-root with a single structural break can be rejected at a 1% level for the three models and for all regions. This indicates that the obtained VAR residuals are stationary.

The results of the Zivot and Andrews (1992) test find break-points that are consistent with the Financial Crisis in the following regions: Piemonte (intercept) Lombardia (both), Veneto (trend) and Campania (trend) for Financial Crisis Phase 1 (FCP1) as discussed in Section 2.3.8. Financial Crisis break points that are consistent with the Financial Crisis Phase 2 (FCP2) are identified in Piemonte (trend and both) Liguria (intercept, trend and both), Lombardia (intercept), Emilia-Romagna (both) and Campania (intercept and both). In the remaining regions the structural breaks identified by the Zivot and Andrews (1992) test were before the 2007-2008 Financial Crisis.

The impact of the crisis on NUTS2 regions at different points in time is due to the varying economic structures of the regions. Calabria's economy, for example, depends strongly on the public budget and a considerable proportion of the population is employed in the public sector. Furthermore, this region has a weak industrial structure and an economy mainly characterised by agro-food production, chemistry, textile, wood and steal (EC, 2019b). Therefore, an early impact of FCP1, the Sovereign Debt Crisis, on this region is plausible.

Emilia-Romagna, is a relatively rich region in the north-east of Italy. Nevertheless, the Crisis impacted this region due to their economic structure and their contributions to exports. The region contributes largely to the national export and are mainly characterised by small- and medium-sized enterprises (SME). The economy of Emilia-Romagna is characterised by groups that are interrelated to automotive and mechanical engineering, medical equipment, precision farming, agro-food and construction materials (EC, 2019b). As a result, due to its export exposure it is likely that FPC2 impacted this region at an earlier stage.

Late structural break points reveal that the banking system in those regions experienced an increased existence of non-performing loans first. Due to changes in economic and financial circumstances, debtors were unable to meet their financial obligations with their lenders leading to non-performing loans (Bank of Italy, 2017a).

NUTS2 areas which were influenced at a later stage by FCP2 are Lombardia, Piemonte and Liguria. In those regions the increase of non-performing loans grew at a later stage of the Italian Sovereign Crisis. Figures 2.2 to 2.6 of Chapter 2.2.3 also illustrate these findings. The reason for the late Crisis impact is probably due to the fact that these three north-eastern regions belong to the richest of Italy (EC, 2019b).

Lombardia, for example, is not only one of the richest regions in Italy but also in Europe, driven by the financial sector and the Italian Stock Exchange that is located in Milano, the capital of Lombardia (EC, 2019b). Piemonte is mainly characterised by a traditional industry, such as the automotive industry (FIAT), agro-industry and the recently emerged information and communication technology industry (EC, 2019b). Liguria's economy is different to most of the northern and central regions of Italy and specialised in the service (tourism) sector (EC, 2019b). The three regions are relatively rich and, in the case of Liguria its economy is different to most of the country, may have contributed to a late impact of the FCP2.

Seven, to control for the structural break on the mark-up, dummy and trend variables were computed for each breakpoint date taken from the Zivot and Andrews (1992) unit-root test and were added to the respective VECM. This allows for an analysis of a structural break in the constant. A dummy variable was generated which takes the value of 1 from the quarter when the structural break is identified in region R until the end of the series and otherwise 0. For example, the dummy variable for Piemonte would start at 2008Q3 for the intercept case (Model A). (For further information on Models A, B and C, please see Section 2.3.8.)

To analyse a structural break in the trend, a trend variable was set which takes the value 1 from the quarter when the structural break was identified in region R and increases by 1 for each quarter until the end of the series and is 0 otherwise. In case of Piemonte the trend variable would be set to 1 at 2014q4.

Eight, VECMs are calculated for each model including the structural break dummy or the trend variable. Perron (1989) argues that time-series can be sufficiently modelled by applying either model A (mean shift) or model C (mean and trend shift). (For further information on Models A, B and C, please see Section 2.3.8.) However, estimations have been conducted following Model A and Model B as defined in Section 2.3.8. The reason for this approach is that it allows for a control of the structural break in the intercept and trend separately per regional mark-up. In contrast, Model C (mean and intercept shift) does not provide the constant of the cointegrating equation, which is interpreted as the commercial bank mark-up in this Chapter. Therefore, a VECM was estimated per region with a dummy to represent Model A or a trend variable to represent Model B only. Results of these estimations are summarised in Table 3.6.

Table 3.6 Commercial Bank Mark-Up Levels for Model A and Model B per Region

NUTS1	NUTS2	Lag	Intercept	Trend
North West	Piemonte	7	4.968	6.305
	Liguria	10	6.751	6.650
	Lombardia	9	3.597	2.569
North East	Veneto	4	6.666	5.501
	Emilia-Romagna	9	4.049	1.730
Centre	Umbria	8	9.730	11.715
South	Campania	7	6.229	8.688
	Puglia	7	7.496	4.028
The Islands	Sicilia	7	9.051	10.788

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).

Based on the VECM results provided in Table 3.6 allowing for a structural break in the intercept, given in column 'Intercept' the lowest mark-up level is observed in Lombardia (3.597%), whilst the highest mark-up level is observed in Umbria (9.730%). By following Model A in the VECM estimations the north-south divide is identified and Lombardia is again identified as a region with the lowest mark-up. This is also confirmed when the average of the northern regions is compared with the remaining regions. The average mark-up for the northern regions is 5.206% whilst the average mark-up for the remaining regions is 8.127%.

Based on the VECM results allowing for a structural break in the trend, given in column 'Trend', the lowest mark-up levels are observed in Emilia-Romagna (1.730%), whilst the highest mark-up level is observed in Umbria (11.715%). In this case, Lombardia does not have the lowest mark-up level but the second lowest. By following Model B in the VECM estimations the north-south divide is also identified. This is also confirmed when the average of the northern regions is considered versus the remaining regions. The average mark-up for the northern regions is 4.551% whilst the average mark-up for the remaining regions is 8.805%.

Results of the Wald test for Model A and Model B, summarised in Appendix C.6, show that all selected lag-lengths per regional time-series are significant at a 1% level. Hence, those results are supporting the lag length selection.

Furthermore, following each regional VECM calculation, each estimated residual was tested for the presence of serial correlation. Appendix C.7

provides results on serial error correlation for the VECM estimations following Model A. Appendix C.7 shows no presence of serial correlation in the residual term at 5% with the exception of some potential correlation in lag1 for Liguria.

Appendix C.8 provides results on serial error correlation for the VECM estimations following Model B. Appendix C.8 shows no presence of serial correlation in the error term at 5%

Table 3.7 summarises all the mark-up across the three different estimated models (Standard VECM, as well as VECMs accounting for structural breaks). Column 'Standard' provides mark-up levels of the baseline VECM estimations. Column 'Intercept' provides mark-up levels of estimations where a structural break was allowed in the intercept. Column 'Trend' provides mark-up levels of estimations where a structural break was allowed in the trend.

Table 3.7 Commercial Bank Mark-Up Levels for Standard Estimation, Model A and Model B per Region

NUTS1	NUTS2	Lag	Standard	Intercept	Trend
North West	Piemonte	7	6.021	4.968	6.305
	Liguria	10	6.419	6.751	6.650
	Lombardia	9	4.508	3.597	2.569
North East	Veneto	4	6.045	6.666	5.501
	Emilia-Romagna	9	5.966	4.049	1.730
Centre	Umbria	8	8.752	9.730	11.715
South	Campania	7	8.157	6.229	8.688
	Puglia	7	7.140	7.496	4.028
The Islands	Sicilia	7	8.185	9.051	10.788

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).

When comparing the mark-up levels across the three specifications no particular pattern is identified. For example, based on Piemonte, mark-up levels computed using Model B are not always the highest and mark-up levels based on Model A are not always the lowest across the models.

One common factor across the three models is that Umbria is the region with the highest mark-up levels. Lombardia has the lowest mark-up levels for the standard VECM estimation and Model A. Another common factor is that the north-south divide is observed across the three models.

In Chapter 1 it was discussed that the ECB is using monetary policy to support the EC's objective to enhance economic growth and employment across the

Euro Area leading to convergence across regions (ECB, 2019b; EC, 2019a; Commission of the European Communities, 1990). However, results of this analysis indicate that between 1999q4 and 2017q1 the ECB's monetary policy was more effective in the northern regions of Italy than in the south, the centre and Sicilia, meaning that convergence across northern regions was more likely to take place than in the south, centre and Sicilia. This means that the uneven effectiveness of monetary policy across Italian NUTS2 regions could have contributed to a divergence between the north and the south.

3.4.5 Additional Explanations

In Section 3.2.2 various reasons have been discussed which may lead to differences in mark-up levels. The purpose of this section is to examine potential explanations and provide more detail for the regional differences across mark-up levels. The discussion in Section 3.2.2 showed that risk, competition and liquidity preference could be important drivers for mark-up heterogeneity.

From a Neo-Classical perspective, risk is a key driver for interest rate differential: If levels of risk differ by region then varying mark-up levels would be expected (Dow and Rodriguez-Fuentes, 1997). Interest rates tend to be higher as more risk is involved. Therefore, in regions with a higher aggregate risk, higher interest rates on average would be expected (Dow and Rodriguez-Fuentes, 1997). As a result, a positive relationship between mark-up and risk proxies is expected.

In addition to risk, the New-Keynesian school of thought considers that the level of competition in the banking sector explaining differences in interest rates and hence mark-up levels across regions. More precisely, competition in the banking sector contributes to varying degrees of capital mobility across regions, leading to regional interest rate differentials.

As discussed in Section 3.2.2, regional banks are more competitive as they have cheaper access to information about regional investment opportunities and their monitoring. Therefore, the higher the level of information flow between regions, the more loans are approved leading to more capital mobility across regions (Dow and Rodriguez-Fuentes, 1997). Hence, low capital mobility may be due to low level of information flow across regions (Dow and Rodriguez-Fuentes, 1997). High levels of competition may indicate high levels of information flow. As a result, high capital mobility leads to lower interest rate variability and mark-up level differentials. Therefore, from a theoretical point of view, a negative relationship between mark-up and competition is expected.

Another potential driver of differentials on interest rates, from the Post-Keynesian perspective, is the liquidity preference (Dow and Rodriguez-Fuentes, 1997). Liquidity preference is defined as the 'preference [of firms and individuals] for holding a proportion of a given stock of wealth in liquid form' (Fuentes and Dow, 2010, p. 973). Liquidity preference increases when expectations of capital loss from alternative assets increases or when uncertainty in forecasting asset prices arise (Dow and Rodriguez-Fuentes, 1997). Changes in liquidity preference affect a bank's willingness to lend and borrowers' demand for loans. For instance, when liquidity preference increases, the willingness of banks to grant loans decreases, but also the willingness of borrowers to take out loans reduces as borrowers identify the responsibility of paying back loans as a burden (Fuentes and Dow, 2010). Therefore, in regions with high liquidity preference, higher interest rates and higher mark-up levels are expected on average.

3.5 Conclusion

This Chapter examined the first mechanism of the Euro Zone MPTM, indicated by the commercial bank mark-up, across the Italian NUTS2 regions for the period 1999q4 – 2017q1. The objective of the commercial bank mark-up analysis was to understand the interest rate channel between commercial banks and households and firms across Italian regions.

This analysis is important because it provides insights on the MPTM, as a mechanism through which the ECB tries to achieve its objective of price stability in the Euro Zone, and this, in turn, supports the objective of the European Commission to stimulate the economy and foster employment across the Euro Zone. Since the monetary policy is set for each country of the Euro Zone, it was expected that monetary policy transmits similarly across regions of the Euro Zone. Moreover, findings in the literature show that mark-up levels across Italian regions are heterogeneous, with low mark-up levels in the north and high mark-up levels in the south (Montagnoli et al., 2016; Gambacorta, 2008).

In this Chapter the mark-up was defined as the difference between the price of a product, in this case the interest rate for a loan, and the cost commercial banks are bearing for borrowing funds from the central bank. Mark-up levels per NUTS2 region were estimated via a VECM. Following Montagnoli et al. (2016) and Gambacorta (2008), the constant of the cointegrating equation was interpreted as the mark-up.

Results show that commercial bank mark-up levels differ considerably across Italian NUTS2 regions, which indicates that monetary policy could transmit heterogeneously across regions in Italy. This finding is in line with the literature, Montagnoli et al. (2016), Gambacorta (2008) and Angelini and Cetorelli (2000), for instance.

Low commercial bank mark-up levels were observed across northern regions, with Lombardia being the region with the lowest mark-up. High commercial bank mark-up levels were observed across central, southern and the islands regions, with Umbria being the region with the highest mark-up. This means that mark-up levels are the lowest in richer regions, particularly in regions where the financial sector is a key industry. Moreover, mark-up levels in poor regions are high, in particular in regions where the dependence on the public budget is strong and where a large proportion of the workforce is employed in the public sector.

The finding of Lombardia having the lowest mark-up levels is original to this thesis and was not discussed in the previous literature, indicating that the presence of the financial sector and the Italian Stock Exchange in a region has a considerable impact on its mark-up levels. Commercial bank mark-ups show greater variability in the south and centre than in the north. This implies that mark-up levels in Lombardia were not only low but also remained low over time.

Moreover, regional groupings were identified based on the pattern of low mark-up levels in northern and high mark-up levels in southern regions when controlling endogenously for the 2007 – 2008 Financial Crisis. These results are consistent with previous VECM estimations. It was observed that in Umbria the mark-up levels were higher on average throughout the research period.

The heterogeneity in mark-up results across NUTS2 regions indicates varying monetary policy effectiveness across the analysed regions. Furthermore, variation in monetary policy effectiveness across regions could have contributed to some convergence across the northern regions but it could have also contributed to divergence between the north and south.

The literature provides some explanations for the heterogeneity across commercial bank mark-up levels. According to the Neo-Classical school of thought, commercial bank mark-up levels vary due to differing perceptions of risk across regions. New-Keynesian argue that in addition to risk perception, competition within the banking market is an important contributor to heterogeneous results. Finally, Post-Keynesians argue that liquidity preference leads to varying interest rates and hence mark-up levels.

Overall, the lessons learned from this Chapter are that mark-up levels differ across Italian NUTS2 regions, which is in line with the literature. This means that the MPTM differs across regions and could reinforce the north-south divide. Other factors, such as risk, competition in the banking sector and liquidity preference are potential contributors to the varying mark-up levels.

Therefore, in light of the argument that the ECB tries to achieve its objective of price stability in the Euro Zone that, in turn, supports the objective of the European Commission to stimulate the economy and foster employment across the Euro Zone, this Chapter concludes that the MPTM, indicated by the mark-up proxy, works for some regions rather better than for others. As a result, other supporting mechanisms to foster economic growth and employment should be introduced especially for the ‘poorer’ regions where risk, competition level in the banking sector influences the interest rate on loans.

The next chapter examines the monetary policy pass-through, the second MPTM sub-mechanism.

Chapter 4
The Monetary Policy Pass-Through

4.1 Introduction

This Chapter examines the second sub-mechanism of the Euro Zone Monetary Policy Transmission Mechanism (MPTM) indicated by monetary policy pass-through across 17 Italian NUTS2 regions for the period 1999q4 – 2017q1. The objective of this Chapter is to understand how the monetary policy pass-through, transmitted to the commercial bank lending rates, differs across the Italian NUTS2 regions in the long- and short-run.

Therefore, the research question of this Chapter is how the level of monetary policy pass-through differ across regions. This research question is analysed through an empirical investigation based on the relationship between the ECB-set MRO rate and the revocable loan interest rates, as defined in Chapter 2, for each of the cointegrated Italian NUTS2 regions.

The analysis of this Chapter follows the Optimum Currency Area (OCA) theory and official European Commission documentation. More precisely, this research provides insights on the MPTM, a mechanism through which the ECB tries to achieve its objective of price stability in the Euro Zone that, in turn, supports the objective of the European Commission to stimulate the economy and foster employment across the Euro Zone. Since the monetary policy is set for each country of the Euro Zone, prior the introduction of the European Monetary Union (EMU), it was expected that monetary policy would transmit similarly across the Euro Zone regions. This assumption was based on the OCA theory (Mundell, 1961) and the European Commission stance of similarities across all EMU members (Treaty on European Union 1992; Commission of the European Communities, 1990). However, studies of the monetary policy pass-through on a national level by Montagnoli et al. (2016), Leroy and Lucotte (2016), Bogoev and Petrevski (2012), ECB (2013), Gambacorta (2008) and de Bondt et al. (2005) find heterogeneity among pass-through levels for the Euro Zone and across Italian NUTS2 regions.

In this Chapter, long- and short-run monetary policy pass-through proxies are estimated per NUTS2 region via a VECM estimation strategy and are interpreted in percentage points. The VECM coefficient of the cointegrating equation represents a long-run monetary policy pass-through proxy, and the short-run MRO coefficient denotes the short-run monetary policy pass-through, following Montagnoli et al. (2016), ECB (2013) and Gambacorta (2008), de Bondt et al. (2005). Cointegrated Regression (CR) estimations are also undertaken for comparative purposes. Additional estimations are performed to control for the 2007 – 2008 Financial Crisis.

Hence, the contribution of this Chapter is grounded on a unique long- and short-run monetary policy pass-through investigation from a supra (ECB) to an intra-national (NUTS2) level. In this way, this Chapter contributes to the literature of regional monetary policy transmission mechanisms through an original research on the long- and short-run pass-through from the ECB level across Italian NUTS2 regions for the period 1999q4 – 2017q1 and controlling for the 2007 – 2008 Financial Crisis.

Results for long-run monetary policy pass-through show that pass-through levels differ across Italian NUTS2 regions, which indicates that monetary policy could transmit heterogeneously across the NUTS2 regions in Italy, in line with the literature (Montagnoli et al., 2016; Gambacorta, 2008, for instance).

More precisely, long-run pass-through levels in the north-west and the north-east, are higher than in the southern and central regions as well as in Sicilia. These results imply that regions with a higher pass-through tend to be more industrialised and less dependent on public expenditure. Note that Lombardia has complete monetary policy pass-through in comparison to the other central regions across all estimation methods. This finding indicates that in Lombardia, where the financial sector is the key industry, has an optimal monetary policy effectiveness. This finding has not been discussed in the literature.

The pass-through can be also defined as a measurement of monetary policy effectiveness (Gambacorta, 2008). Therefore, the identified heterogeneous long-run pass-through across Italy could be interpreted as follows: The Euro Zone monetary policy in northern NUTS2 regions is more effective than in the southern regions and Sicilia. In addition, the heterogeneity of the pass-through results imply that other factors could be influencing the regional interest rates in less developed regions. Furthermore, variation in monetary policy effectiveness across regions could have contributed to some convergence across the northern regions but it could have also contributed to some divergence between the north and south.

The analysis on short-run pass-through provides the same regional pattern as found for the long-run case. However, in the short-run monetary policy seems to be more effective in comparison to the long-run, in particular in Veneto and Emilia-Romagna. This means that in the short-run a higher proportion of a change in the MRO rate was transmitted to the north-eastern regions implying a more effective monetary policy and different dynamics between the long- and short-term.

As the Financial Crisis is part of the sample time frame, it could have resulted in a structural break. To examine this, two versions of the Zivot and Andrews test on residuals were estimated to determine the existence as well as the timing of regional structural breaks. More precisely, Model A allows for a structural break in the intercept and Model B for a structural break in the trend were examined. Long-run pass-through and speed of adjustment results across both models are mixed in relation to the regional pattern of high and low long-run pass-through and speed of adjustments. Meaning that these results provide mixed information in relation to the monetary policy effectiveness. This indicates an uneven effectiveness of monetary policy across Italian NUTS2 regions, which could have contributed to a divergence between the north and the south.

This Chapter is divided in five sections. The next section presents a review of the related literature based on pass-through as well as an elaboration on pass-through results found in literature. Section three discusses the empirical implementation of this Chapter. Section four presents the empirical results of this Chapter and section five concludes this Chapter.

4.2 Literature Review

The purpose of this literature review is to define the monetary policy pass-through, to discuss the existing literature around this topic, as well as to analyse the data employed in the literature in order to study monetary policy pass-through. Furthermore, controls for crises are presented.

4.2.1 Definition of the Pass-Through

Monetary policy pass-through can be defined as the influence of changes in the policy or market rates on the retail commercial bank interest rate (Rehman, 2009; in Tai et al. 2012). In other words, the interest rate pass-through is the extent of the policy change that is transmitted to the banking lending rates.

Three possible outcomes can be found in terms of monetary policy pass-through, namely a complete, incomplete and overshooting pass-through:

- A complete monetary policy pass-through case is indicated by a pass-through value being one and meaning that commercial banks adjust their interest rates by the same extent that the monetary policy interest rate is changed (Sander and Kleimeier, 2004).
- An incomplete monetary policy pass-through case is indicated by a pass-through value between 0 and 1 meaning that the implemented change in the bank lending rates is smaller than the initial change in the monetary policy rate. Furthermore, according to Marotta (2009), a low level of interest rate pass-through leads monetary policy to fail to stabilise shocks in an economy (Sander and Kleimeier, 2004).
- An overshooting pass-through is indicated by a pass-through value greater than one implying that the change in the bank lending rate is a multiple of the change in the policy interest rate. An overshooting pass-through occurs when commercial banks increase interest rates to compensate for high credit risk. This means that commercial banks do not ration credit supply when credit risk is high but increase interest rates for more risky loans (Sander and Kleimeier, 2004).

4.2.2 Reasons for Pass-Through Heterogeneity across Estimations

As mentioned in the introduction of this Chapter, the literature provides examples of heterogeneity in pass-through. In the remainder of this section, potential explanations are provided under the light of the three possible outcomes which can be found in terms of monetary policy pass-through mentioned before.

De Bondt et al. (2005) showed that market power and loan demand elasticity influence commercial bank pass-through. If commercial banks have some market power, and if the demand for loans is not fully elastic, then in both cases the pass-through coefficient is expected to be less than one. The less competitive the banking sector, the more incomplete is the adjustment process of policy/market rates to retail banking rates. In this case, commercial banks do not pass through fully the monetary policy interest rate changes to costumers' lending rates because commercial banks do not have to fight for market share by competing on prices for loans and hence the monetary policy is less effective (de Bondt et al., 2005; Sander and Kleimeier, 2004).

For instance, Bogoev and Petrevski (2012) found that high market power of banks in Bulgaria, Croatia and Macedonia could prevent a smooth pass-through from the money market rates to the bank lending rates, leading to stickiness in bank lending interest rates.

Factors influencing market power in the banking sector and demand elasticity for loans are regulatory restrictions to access the market and the access to alternative sources of finance. If borrowers do not have access to alternative sources of funding, then the demand elasticity for loans is more inelastic and the pass-through indicator is expected to be less than one (Bogoev and Petrevski, 2012; de Bondt et al., 2005). Inelastic demand for commercial bank products and market power may also be influenced by asymmetric information costs (for acquiring information) and switching costs (administrative). If switching costs are accredited to the borrower, it is less likely that the borrower will refinance a loan or undertake a product transfer to a different bank, influencing inelasticity on demand (Montagnoli et al., 2016; de Bondt et al., 2005).

Underdeveloped capital markets could also lead to incomplete pass-through. If alternative sources are not available for the private sector to obtain external financing, this may lead to inelastic demand for bank loans, which in turn increases commercial bank market power (Bogoev and Petrevski, 2012).

Credit risk can influence commercial bank pass-through negatively. The higher the risk perception, the lower is the pass-through response. The regional view on credit risk among national and regional commercial banks may differ. For example, nationally operating banks may have different risk perspectives than regional banks, meaning that the former might perceive a region of higher risk in comparison to banks of that particular region. (ECB, 2013; Montagnoli et al. (2016).

From a supply-side perspective, liquidity of bank balance-sheets influences commercial bank pass-through. For example, the less liquid a bank's balance sheet is, the more sensitive this bank is to interest rate changes, leading to higher levels of pass-through (ECB, 2013; Montagnoli et al., 2016). In a modern financial system, the interbank market could increase the level of liquidity of commercial banks. However, Mistrulli (2005) argues that in Italy the relevance of the interbank market is not clear. Hence, interbank markets are less influential in the commercial bank sector.

More broadly speaking, heterogeneity in pass-through is explained by differences in characteristics of national financial markets and macroeconomic factors, for instance inflation, interest rate volatility, the amount of bank deposits and the concentration of bank branches (Montagnoli et al., 2016; Sander and Kleimeier, 2004).

Therefore, considering the European Commission and ECB objectives after the 2007 – 2008 Financial Crisis, it would have been expected that the pass-through from the ECB-set interest rate to regional lending rates would increases in order to enhance the economy and employment. However, according to the ECB (2013) the transmission heterogeneity was low due to the persistent Sovereign Debt Crisis, weak capital positions, fragile economic activity and high level of uncertainty.

4.2.3 Estimation Approaches for Pass-Through Proxies

The theoretical and empirical analysis of the monetary policy pass-through is a well-established topic in the monetary policy area. A common empirical approach found in the literature is to analyse the relationship between a cost of fund interest rate (any interest rates which commercial banks are exposed to when borrowing funds) and interest rates on loans or deposits (Leroy and Lucotte, 2016; Montagnoli et al., 2016; ECB, 2013; Bogoev and Petrevski, 2012; Tai et al., 2012; Gambacorta, 2008; Kleimeier and Sander, 2006; de Bondt et al., 2005; Sander and Kleimeier, 2004).

Empirical studies, however, are diverse due to the wide variety of interest rate data available. A comparison between different papers may therefore be difficult because each analysis examines a different aspect of the monetary policy pass-through. Models and methods are subject to the data used in the analysis. In this way, studies can be categorised according to the data employed.

Therefore, the remainder of this section discusses data, estimation strategies and results found in the literature in relation to monetary policy pass-through. Moreover, since the 2007 – 2008 Financial Crisis was a significant event, a section on identification methods and controls in the pass-through literature is presented.

4.2.3.1 Data Employed in the Literature

When investigating the monetary policy pass-through, most empirical studies utilise money market interest rates (Sander and Kleimeier, 2004; de Bondt et al., 2005; ECB, 2013; Montagnoli et al., 2016). A common proxy for the European money market rate is the Euro Interbank Offered Rate (EURIBOR), presented in Chapter 2, calculated as an average of the interest rates which European banks pay when borrowing funds from each other (ECB, 2019). The EURIBOR rate is calculated daily for interbank deposits and is differentiated by maturity. On the other hand, Leroy and Lucotte (2016) utilised the Euro Overnight Index Average (EONIA) rate as a money market interest rate. EONIA is calculated based on daily over-night bank lending interest rate on unsecured lending of EU banks (ECB, 2019; European Money Markets

Institute, 2018). The difference between EONIA and EURIBOR is that EONIA is an index for the Euro overnight market whereas the EURIBOR is a rate for inter-bank lending of a maturity either of one week or of 12 months. Therefore, by utilising the money market rates, the analysis begins at the money market level.

One of the reasons for employing EURIBOR or EONIA in the pass-through estimation process is that both are more volatile in comparison to the MRO rate, making trends easier to identify in comparison to less volatile time-series. The volatility of EURIBOR or EONIA is mainly driven by liquidity concerns (Gaspar et al., 2001; in de Bondt et al., 2005).

The impact of changes in the money market rate is then studied on a variety of interest rates, loans and deposits, for instance. Interest rates on loans are often differentiated across commercial bank products. For example, consumer loans to households (ECB, 2013; Kleimeier and Sander, 2006), interest rates on mortgages (Leroy and Lucotte, 2016; ECB, 2013; Kleimeier and Sander, 2006) and interest rates on short-, medium- and long-term loans to enterprises. Further categories are maturity of loans, loan-size, geographical areas, expected and unexpected monetary policy changes (Sander and Kleimeier, 2004; Kleimeier and Sander, 2006; Montagnoli et al., 2016;).

Kleimeier and Sander (2006) showed how data on futures could be interpreted in the pass-through context. The authors researched the interest rate pass-through between expected and unexpected monetary policy changes in the Euro Zone. One-month futures denote the expected monetary policy rate (MPE), whereas the unexpected monetary policy rate (MPU) is calculated through the difference between the actual monetary policy rate (MP) and the MPE.

In summary, data selection is crucial when investigating monetary policy pass-through. The above-mentioned studies examine the monetary policy pass-through from the money market to bank lending and/or deposit rate. Thus, characteristics of the employed bank lending and/or deposit rates determine the point of the investigation.

4.2.3.2 The pass-through in the Literature

This section summarises results on monetary policy pass-through found in the literature. Tai et al. (2012) researched the pass-through between the money market rate and the retail banking rate for Korea, Indonesia, Singapore, Hong Kong, Malaysia, Philippines, and Thailand for the periods pre- and post-1997 Asian Financial Crisis. The author's applied the Seemingly Unrelated Regression (SUR) equations, finding a sluggish and slow pass-through across these countries. More precisely, before the Crisis the pass-through to the lending rate was slightly lower than to the deposit rate. The pass-through in Hong Kong, Singapore and Malaysia seems to be slightly higher than in Korea, Thailand, Indonesia and the Philippines. Moreover, after the 1997 Asian Financial Crisis the adjustment rates are slower across the researched countries except for Malaysia. Higher pass-through, in turn, indicates higher level of competition in the financial sector and a more integrated financial sector. Then, the implication of these results is that policy rates of some Asian countries influence the lending rates to a lower extent and the central banks are unable to lead the economy to its policy target. Then, the pass-through can be improved through higher competition and higher integration of the financial sector (Tai et al., 2012).

Bogoev and Petrevski (2012) studied the money market pass-through to lending rates for three South-Eastern European small open economies with fixed exchange rates, namely Bulgaria, Macedonia and Croatia, for the period 2000 – 2010. Currently, these three countries do not belong to the European Area and Macedonia has an EU candidate country status. Results of this study show that long-run pass-through is relatively complete for Macedonia but not for Bulgaria and Croatia. Furthermore, short-run pass-through to lending rates is sluggish and suggests a limited influence from the national central bank on bank lending rates.

Because these three countries are influenced by substantial foreign ownership in the banking sector and currency substitutions, further analysis on the relationship between the EURIBOR (as the foreign impact) and the domestic money market rates and bank lending rates was undertaken. For Macedonia and Croatia, no relationship was found between the EURIBOR and their domestic money market rates and bank lending rates, indicating that banks in

Macedonia and Croatia depend on domestic deposits as a source of finance and the EURIBOR is not treated as a cost of funds. Results for Bulgaria, on the other hand, indicate that the EURIBOR influences the pass-through impact on their bank lending rates. Hence, these results may indicate an ongoing integration of Bulgaria in the EU. Moreover, the short-run pass-through analysis between domestic money market interest rates and the bank lending rates showed an incomplete pass-through for most of the cases.

Sander and Kleimeier (2004) estimate the interest rate pass-through in the Euro Zone for Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain between January 1993 and October 2002, by using VAR and cointegration methods. The authors used the over-night money market interest rate and six bank lending interest rates based on different bank products[10]. Results of this study indicate heterogeneous pass-through across countries, as for most retail rates an incomplete long- and short-run pass-through was found. Sander and Kleimeier (2004) argue that this may be due to an imperfectly competitive market. In addition, the shorter the maturity of the loan, the higher is the pass-through level. However, according to these results, the market for short-term corporate lending seems to have become more homogenous. Overall, these heterogeneous pass-through results across the Euro Zone imply that the European banking market may be still fragmented.

Similarly, de Bondt et al. (2005) researched the pass-through for all Euro Area member states, except Greece and Luxembourg, for the period April 1994 to December 2002. The study is based on an analysis between money market rates, such as the three-month money market rate, the 10-year government bond yields and the three-month EURIBOR, and various retail interest rates, such as long- and short-term loans to enterprises, household mortgages, time deposits and consumer credits.

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10 The interest rate on the 12-month rate for consumer loans, the 10-year rate for mortgages, the 6-month rate for medium- and long-term corporate loans, the 1-month rate for short-term corporate loans, and the 3-months rate for time deposits and savings accounts.

De Bondt et al. (2005) found that short-term pass-through from market to retail bank interest rates are incomplete, which is in line with Sander and Kleimeier (2004). However, since January 1999 the pass-through from the central bank to money market interest rates has become more complete in the Euro Area, hence quicker. De Bondt et al. (2005) conclude that the sluggish retail interest rates were influenced by different maturities of bank products and money market rates. Therefore, short-term movements in market interest rates are not fully transferred to lending interest rates for loans with longer maturities, hence the incomplete pass-through. However, the introduction of the Euro led to higher integration of the European banking sector, leading to an enhancement of the bank interest rate pass-through.

Kleimeier and Sander (2006) researched the interest rate pass-through between expected and unexpected monetary policy changes on a national level for Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain, in the period January 1999 to May 2003. Results show that interest rate anticipation has a significant positive influence on the pass-through to loan interest rates.

The interesting point of this paper is the data selection to define future proxies: The one-month EURIBOR deposits interest rate was defined as the observed monetary policy rate (MP), whereas the one-month futures traded at Eurex Exchange denotes the expected monetary policy rate (MPE). Then, the unexpected monetary rate (MPU) is calculated as the difference between the MP and the MPE. The findings of this study imply that the anticipation of interest rates has a significant positive influence on the pass-through. Therefore, Kleimeier and Sander (2006) conclude that speeding up the pass-through can be achieved through transparent central bank policy and a good central bank communication.

The ECB (2013) studied the bank lending pass-through in the euro zone for Finland, Greece, Italy, Portugal, Austria, Luxembourg, Spain, Ireland, Netherlands, Belgium, Germany and France for the period January 2003 to April 2013. The cost of funds was denoted by the Monetary Financial Institutions (MFI) interest rate statistics, which covers all interest rates that monetary financial institutions resident in the Euro Area (except central banks and money market funds) apply to euro-dominated deposits and loans to households and non-financial corporations (ECB, 2019l). Commercial bank rates were indicated by long- and short-term lending rates both to households for house purchase and to non-financial corporations. The computation of the national pass-through indicators is based on a single equation ECM.

Results show that the pass-through to interest rate on loans to non-financial corporations was found to be incomplete for Italy and Spain, whereas the interest rate pass-through for loans to non-financial corporations in Germany and France was much more complete since late 2011. Due to decreasing cost of funds interest rates following the 2007-2008 Financial Crisis, these results imply that interest rates on loans to non-financial corporations in Germany and France were much more responsive to cost of funds changes (hence reduced to a higher extent), in comparison to interest rate changes on loans to non-financial corporations in Italy and Spain.

Furthermore, results on loans to households for house purchases differ slightly. Bank lending rates to households for house purchases in Italy and Spain reacted strongly to the decreases in policy interest rates at the end of 2008 and 2009. This implies that a higher proportion of mortgages in Italy and Spain are on short-term fixed interest rates than in other large Euro Area economies. This intense reaction of mortgage interest rates experienced largely in Italy and Spain than in Germany and France may be relate to the fact that Italy and Spain were hit more severely by the Crisis than France and Germany.

Another finding of this analysis is that mortgage interest rates in Italy and Spain increased more sharply after the beginning of the Sovereign Debt Crisis than in France and Germany. This could imply that interest rates in Italy and Spain adjusted accordingly to higher risk perceptions in comparison to Germany and France. Overall, this study emphasises that, despite record low monetary policy interest rates in the Euro Area, interest rates on mortgages in Italy and Spain remain above the levels experienced in 2010 (ECB, 2013).

Leroy and Lucotte (2016) undertook a similar pass-through analysis, in terms of countries and period, compared to ECB (2013). The distinguishing feature of Leroy and Lucotte (2016) is their focus on the impact of the Financial Crisis on the pass-through. The authors found evidence that large cross-country and -time differences exist in the EMU transmission mechanism. The MPTM effectiveness has reduced after the Financial Crisis due to fragmented financial markets and higher credit risk perception.

Gambacorta (2008) examined the relationship between monetary policy[11] and the interest rate of 73 Italian banks, constituting more than 70% of the Italian banking sector, for the period 1993q3 – 2001q3. Since data on short-term interest rates was not available for each of the 73 Italian banks at the point in time of this investigation, proxies were created through interaction terms between short-term interest rates[12] and bank-level data, such as size, liquidity and capitalisation.

The purpose of this study was to investigate how Italian commercial banks set interest rates, showing that bank characteristics such as size, liquidity and capitalisation, have only short-term effects on the heterogeneity in the lending rates pass-through. Moreover, well-capitalised and liquid banks respond less to official rate changes, especially on short-term lending. These findings imply that wealthy and liquid banks do not change their interest rates for their products as quickly as less capitalised, liquid, banks. This argument is similar to the one presented in Chapter 3 in relation to explanations of differences across varying commercial bank mark-up levels.

Montagnoli et al. (2016) estimated long- and short-term pass-through across 20 Italian NUTS2 regions for the period 1998q1 – 2009q4. The pass-through analysis is based on the relationship between money market rates and loan and deposit rates. The money market rate is defined by the three-months interbank rate in Italy. Interest rates on loans are differentiated between short- and long-term maturities, namely a maturity less than one year and more than

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11 Gambacorta (2008) utilised data on repurchase agreements between the Bank of Italy and credit institutions in the period 1993 – 1998, and the interest rates on main refinancing operations of the ECB for the period 1999 – 2001 as proxies for monetary policy indicators.

12 This study used weighted average of lending rates as a proxy for the short-term interest rate.

one year respectively. Furthermore, the employed interest rate data refers to loans that equal to or exceed €75,000.

Results show a heterogeneous regional lending rate pass-through. The pass-through in the northern regions is quicker than in the southern regions. More precisely, in terms of long-term lending rates, it takes approximately two months to accommodate the full change of the money market rate in a northern region whilst it takes three months to accommodate the same change in a southern region. A similar pattern is observed in the short-term lending: The average adjustment time in the south is higher than in central regions. These results imply that it takes longer for the southern regions than for the northern region to experience changes in the money market rate.

In terms of short-term lending, Montagnoli et al. (2016) found a complete pass-through for Piedmont, Trentino-Alto Adige, Valle d'Aosta, Basilicata, Sardinia and Sicily, whereas for long-term lending rates a complete pass-through was found in Valle d'Aosta, Campania, Sardinia and Sicily. These results on complete pass-through do not indicate a north-south divide.

4.2.3.3 Controls for the Financial Crisis

As discussed in Chapter 2.3.7, when undertaking empirical analysis, the identification and control of structural breaks is significant especially when events such as the Financial Crisis are within the period of analysis. Then, there are different approaches to identify and control for structural breaks when estimating pass-through proxies.

Gambacorta (2008) identified the structural break exogenously, defined as the introduction of the Consolidated Law on Banking in Italy, and selected the research period after the event avoiding the structural break point. Tai et al. (2012) defined the structural break relating to the Asian Financial Crisis exogenously, dividing the data sample into a pre- and post-break period, and estimating the pass-through for both sub-periods separately. Leroy and Lucotte (2016) controlled for the 2007 – 2008 Financial Crisis in a similar way by using a pre- and a Crisis data sub-samples.

Sander and Kleimeier (2004) determined the structural breaks endogenously by estimating a supremum-F test in order to control for structural changes caused by the 1992-1993 European Exchange Rates crisis, the EU regulatory changes including the Second Banking Directive, and the introduction of the single currency. Results of the long-run relationship between the retail rate and the market rate in this paper show that structural breaks occurred before the single currency introduction in January 1999. Furthermore, this study found different breakpoints across countries in different banking market segments. In general, after the structural break the monetary policy pass-through has improved in terms of lending rates but not in relation to deposit rates.

4.2.4 Literature Review Discussion

This Chapter researches the monetary policy pass-through between the ECB and a particular Italian NUTS2 region, the second mechanism of the MPTM. Following Chapter 2, the VECM was identified as the preferred estimation strategy for MPTM. Furthermore, in Chapter 2 the MRO interest rate and the revocable loan interest rates per Italian NUTS2 region were defined as the cost of funds and the bank lending interest rates respectively. Therefore, pass-through proxies are estimated between the ECB and Italian NUTS2 regions for the period 1999q4 – 2017q1 leading to a pass-through examination form the supra to the intra-national level.

Based on the above presented literature review, a key motivation for this Chapter is grounded on de Bondt et al. (2005) findings which state that across the Euro Area the pass-through from the central bank to the money market rates became more complete; however, the pass-through from the market rates to bank lending rates was incomplete. This finding motivated this Chapter to research the pass-through from the ECB-set rate across lending rates. Montagnoli et al. (2016) motivated this Chapter through the analysis on NUTS2 level.

Further inspiring characteristics of the presented papers are the differentiation between long- and short-run pass-through (Bogoev and Petrevski, 2012;

Montagnoli et al., 2016), and the endogenous determination of structural breaks (Sander and Kleimeier, 2004).

However, there are crucial differences between this Chapter and the existing literature, on which will be elaborated as next: Much of the presented literature in this Chapter is based on cross-country comparisons. However, national factors could contribute to the heterogeneity of pass-through proxies (Sander and Kleimeier, 2004). In order to keep national influences constant and to examine the monetary policy pass-through methodically, this analysis starts at the ECB level and concludes across the Italian NUT2 regions.

Furthermore, most of the literature investigates the pass-through between the money market level and some lending or deposit interest rates. This approach shortens the investigated MPTM outreach. In order to examine the complete MPTM from the ECB across Italian NUTS2 regions, an interest rate that is determined by the ECB, as the monetary policy is selected instead of money market interest rates in this Chapter. The reason being that any money market rate is already influenced by the money market and is not the 'pure' rate set by the ECB. Therefore, with the intention to study the 'complete' monetary policy pass-through from the supra (ECB) level to the intra-national (Italian NUTS2) level, the empirical investigation of this Chapter is based on the MRO rate and a revocable loan interest rate per Italian NUTS2 region.

A further factor that differentiates the empirical analysis in this Chapter from the literature is that structural breaks related to the two phases of the 2007 – 2008 Financial Crisis are determined endogenously. As presented in section 4.2.3.3, different methods are employed in the literature in order to detect structural breaks. In the estimation process, structural breaks are controlled for by a dummy variable or trend variable. This approach leads to robust monetary policy pass-through proxies.

Since Montagnoli et al. (2016) was one of the key inspirations for this Chapter the differences between this study and this Chapter are as follows: One key difference is that interest rate data and estimation methods employed in this study are different in comparison to Montagnoli et al. (2016). For example, Montagnoli et al. (2016) employed the interest rate on loans of value €75,000 and above as the bank loan lending rate. Furthermore, the long- and short-term aspects in Montagnoli et al. (2016) are captured by the loan maturity, namely by 12 months or more than 12 months respectively.

In this Chapter, commercial bank interest rate data relates to total revocable loan interest rates segmented according to NUTS2 regions, without differentiation in terms of loan value and/or maturity. In this Chapter the long- and short-term differentiation is based on the applied estimation strategy and not data. Furthermore, Montagnoli et al. (2016) have used money market interest rates as the cost of fund interest rate, whereas in this Chapter the MRO interest rate indicates cost of funds interest rate. Therefore, in this Chapter the monetary policy pass-through proxies are estimated for the 'complete' pass-through mechanism.

Furthermore, this Chapter not only identifies which of the NUTS2 regions has a full monetary policy pass-through, but it also evaluates the influence from the ECB-set MRO rate to the regional revocable loan interest rates.

Finally, Montagnoli et al. (2016) used a mathematically rearranged ECM and estimated the pass-through proxies through OLS. This Chapter, in contrast, is based on regional VECM, including pre- and post-estimations. As a result, characteristics of each regional time-series are incorporated in each regional model. Additionally, this Chapter controls for the two phases of the 2007 – 2008 Financial Crisis.

Considering all the differences between the literature and, in particular in comparison to Montagnoli et al. (2016), the contributions of this Chapter are as follows: The originality of this Chapter's contribution comes from the combination of four elements leading to a specific monetary policy pass-through investigation. The first element is based on data selection, namely the MRO and revocable loan interest rates observed in each of the 20 Italian NUTS2 regions. Therefore, the pass-through proxies are estimated from the ECB across the 20 Italian NUTS2 regions leading to a pass-through investigation from a supra to a micro level.

The second element is that through the data selection, the influence of national characteristics is kept constant, because pass-through proxies are computed in an environment of uniform national characteristics on an intra-national level. As a result, the heterogeneity in results should not be influenced by national factors.

The third element is that proxies are estimated based on regional VECMs. The regional aspect is accredited to the point that optimal lag-length and rank are built in in each regional VECM. For comparative purposes, pass-through proxies are also estimated via CR. Finally, the method used for the structural break identification and the control for the 2007 – 2008 Financial Crisis in each regional estimation also add to the contribution of this Chapter.

Overall, the combination of the above-mentioned four elements leads to a unique pass-through investigation from a supra to an intro-national level, through deriving regional models, studying the extent of the pass-through and controlling endogenously for the Financial Crisis of 2007 – 2008.

4.3 Empirical Implementation

The overall objective of this Chapter is to investigate empirically the second sub-mechanism of the MPTM, the pass-through, and to examine the extent of the monetary policy change that is transmitted to the bank lending rates in the long- and short-run. Since the speed of adjustment is an accelerator of the long-run pass-through, the monetary policy speed of adjustment is also analysed in this Chapter. To examine how the monetary policy pass-through and speed of adjustment differ across regions, proxies are calculated per Italian NUTS2 region. This section draws out the methodology employed in this Chapter in order to estimate regional monetary policy pass-through and speed of adjustment indicators for the Italian NUTS2 regions. It builds on Chapter 2, which presented the data employed in this thesis and discussed various estimation strategies.

The monetary policy pass-through and speed of adjustment proxies for each Italian NUTS2 region will be calculated by using an econometric estimation strategy due to the availability of data on interest rates, such as the revocable loan interest rates across the Italian NUTS2 regions and the MRO interest rate. As discussed in Chapter 2, the VECM was identified as providing the richest number of MPTM coefficients in a single step, when implemented on time-series of a regional revocable loan interest rate and the MRO rate. The VECM is estimated as follows:

$$\Delta RL_{R,t} = c_{RL_R} + \sum_{R=1}^{k} \beta_{RL_{R,i}} \Delta RL_{R,t-i} + \sum_{R=1}^{k} \theta_{RL_{R,i}} \Delta MRO_{t-i} + \gamma_{RL_R} Z_{t-1} + \varepsilon_{RL_{R,t}} \tag{4.1}$$

$$\Delta MRO_t = c_{MRO} + \sum_{R=1}^{k} \beta_{MRO_i} \Delta RL_{R,t-i} + \sum_{R=1}^{k} \theta_{MRO_i} \Delta MRO_{t-i} + \gamma_{MRO_i} Z_{t-1} + \varepsilon_{MRO_t} \tag{4.2}$$

where $RL_{R,t}$ represents the regional revocable loan interest rate time-series ($RL_{R,t}$) for region R, quarter t and lag-length i, MRO_t is the MRO interest rate time-series for each t quarter, and C_{RL} and c_{MRO} are the model constants for revocable loan and MRO interest rates respectively. Equations (4.1) and (4.2) are adapted versions of the VECM model presented in equations (2.10) and (2.11) in Chapter 2.3.6, where the interpretation of each estimation parameter is discussed.

The regional short-run monetary policy pass-through is denoted by $\theta_{RL_{R,i}}$ in equation (4.1), whereas the regional long-run monetary policy pass-through is indicated by α_R from the cointegrated equation (4.3), which is defined as:

$$Z_{t-1} = RL_{R,t-1} - C_R - \alpha_R MRO_{t-1} \tag{4.3}$$

Both proxies are given in percentage points.

The regional monetary policy speed of adjustment coefficient is indicated by γ_{RL_R} in equation (4.1). This coefficient is given in percentages and is a short-run parameter which measures how quickly the deviations “from the long-run relationship observed in the previous period are corrected in period t” (Montagnoli et al., 2016, p. 1409).

In conclusion, by applying a VECM estimation to the regional revocable loan interest rates and the European MRO rate, the long- and short-run monetary policy pass-through and speed of adjustment estimates are obtained for each Italian NUTS2 region. Moreover, long- and short-run monetary policy pass-through and speed of adjustment results are compared across geographical NUTS1 areas where trends and patterns can be identified.

Since the Financial Crisis of 2007 – 2008 is within this researched period, it is possible that it has led to structural breaks in the time series and need to be accounted for. This will be undertaken in the same way as in the previous chapter: First, by determining the breakpoint date using the Zivot and Andrews test and then adding dummy variables and/or trends based on the timing of the regional structural break as identified using the Zivot and Andrews (1992) test. The VECM specification containing a dummy variable was presented in Section 2.3.8. The structural break point per regional time-series in the presence of cointegration is endogenously determined by applying the Zivot and Andrews (1992) test.

4.4 Results

The purpose of this section is to examine the long-run and short-run pass-through results as well as VECM speed of adjustment results across the Italian NUTS2 regions. This section is divided into two further sections; first general VECM estimations for the whole period are provided and the second section controls for the 2007 – 2008 Financial Crisis.

4.4.1 Standard Estimations

Pass-through proxies were estimated following the VECM estimation strategy as defined in Section 4.3 and are interpreted in percentage points. As the speed of adjustment proxies can be understood as an acceleration or deceleration of the pass-through, these proxies are also reported in this section.

The pass-through and the speed of adjustment proxies were calculated based on the relationship between the ECB-set MRO rate, defined as the independent variable, and the revocable loan interest rate for each region, defined as the dependent variable. Thus, the empirical approximations of the pass-through and the speed of adjustment are defined as the influence of the MRO rate on the regional revocable loan interest rate.

Table 4.1 shows results for the pass-through and the speed of adjustment proxies. The ‘LR PT VECM’ column contains results of the long-run pass-through proxy obtained via VECM estimation per Italian NUTS2 region. The 'SoA' column provides results for the speed of adjustment proxies obtained from the same estimations. As discussed in Chapter 3.4.2, the cointegrated equation CR from equation (4.3), was computed for comparative purposes. Results on CR are shown in column LR PT CR. In addition to long-run proxies, short-run pass-through proxies were estimated as discussed in Section 4.3 and are reported in the last column. Due to the negative pass-through results of Marche and Umbria within the VECM estimations, both regions are not considered in the analysis of results.

In this Chapter, the monetary policy pass-through is given in percentage points. Following the literature presented in Section 4.2.1, pass-through coefficients are interpreted in the following way:

- A pass-through of one (equivalent to 100 percentage points) indicates a complete pass-through, meaning that the same change is observed in the regional lending rate than in the change of the monetary policy rate. This result signals an effective monetary policy (Gambacorta, 2008).
- A pass-through level of less than one (equivalent to less than 100 percentage points) indicates an incomplete pass-through, suggesting that a smaller extent of the ECB monetary policy change is filtering through to the regional lending rates. The closer the pass-through value to zero, the more incomplete is the pass-through, signalising a sluggish pass-through adjustment. In this case, lending rates are interpreted as sticky and monetary policy is categorised as less effective (Gambacorta, 2008).
- A pass-through coefficient of more than one (equivalent to more than 100 percentage points) is interpreted as overshooting, indicating that the change in the regional lending rate is stronger than the undertaken change in the monetary policy. This result implies an 'over-effective' monetary policy with commercial bank interest rates being sensitive to monetary policy changes. In this case, a change in the monetary policy has a multiplicative impact on the bank lending rate (Gambacorta, 2008).

Moreover, the speed of adjustment in this Chapter is computed as the rate of change (given in percent) by which the revocable loan interest rate in each NUTS2 region adjusts back to its long-run path. This proxy denotes the extent at which shocks are essentially absorbed in the regional interest rates and allows to draw conclusions about the effectiveness of monetary policy.

A speed of adjustment coefficient close to 0 implies that the correction towards equilibrium during the last period is minimal. As a result, the speed of adjustment is sluggish, and the monetary policy transmits slowly to a particular region’s bank lending rate. Equivalently, a high level of speed of adjustment (a speed of adjustment close to 1) implies that the correction towards equilibrium during the last period is high. Therefore, a high level of speed of adjustment is interpreted as more effective monetary policy (Gambacorta, 2008).

Following ECB (2013), to avoid quarterly volatility, level data were transformed to annual moving averages. As discussed in Chapter 3.4.1, before estimating the regional VECMs, pre-estimation tests have been conducted in order to examine non-stationarity/stationarity of the data, to determine the optimal lag-length for the Johansen (1995) test for cointegration and to determine the rank for each regional VECM. All these tests and results were discussed in detail in Chapter 3.4.1.

In summary, the ADF test showed that the employed time-series are stationary in first differences. The optimal lag-length for each regional VECM was determined by first, estimating information criteria (FPE, the AIC, the SBIC and the HQIC) and restricting the maximum lag-length following Schwert (1989). Then, the optimal lag-length for the Johansen (1995) test for cointegration was chosen based on the minimum observed HQ information criterion. As next the Johansen (1995) test for cointegration was conducted for each NUTS2 region, including the identified optimal lag-length and rank. The Johansen (1995) cointegration results show that nine Italian NUTS2 regions are cointegrated with the MRO. The cointegrated regions are: Piemonte, Liguria and Lombardia of the north- west; Veneto and Emilia-Romagna of the north-east; Umbria of the centre, Campania and Puglia of the south and Sicilia, of the islands. The optimal lag-length selection for the

Johansen (1995) test for cointegration and the results on cointegration are found in Table 3.1 of Chapter 3.4.1.

Finally, regional VECMs were estimated for the nine cointegrated regions. Table 4.1 provides the optimal lag-length (given in column 'lag'), the results on the long-run pass-through (given in column LR PT), the results on the short-run pass-through (given in column SR PT) and the results on the speed of adjustment (given in column SoA) of each regional VECM. In addition, the long-run pass-through taken from CR is reported in column LR PT CR. Column 1 of Table 4.1 (labelled 'LR PT') reports the results of the long-run pass-through per cointegrated region.

A regional pattern of high levels of long-run pass-through is observed in the southern NUTS2 region Puglia (75.9 percentage points), followed by the northern NUTS2 regions of Lombardia (69.7 percentage points) and Veneto (69.7 percentage points). Low levels of long-run pass-through are denoted in southern regions, such as in Campania (42.6 percentage points), for instance.

With the exception of Puglia, a regional pattern of high levels of long-run pass-through is observed in the northern NUTS2 regions whereas low levels of long-run pass-through are observed in the southern and central regions.

Also, the results of Table 4.1 indicate that in the long-run 75.9 percentage points of the MRO change filters through to the regional interest rates in Puglia. In terms of Lombardia and Veneto, 69.7 percentage points of the MRO change filters through to the regional interest rates. These results indicate relatively effective monetary policy in these regions. Since the long-run pass-through in Campania is 42.6 percentage points, this signalises a sluggish pass-through adjustment as only a fraction of the MRO interest rate change flows through to interest rates in Campania.

Table 4.1 Long- and Short-run Pass-Through and Speed of Adjustment Estimations across Nine Italian NUTS2 Regions

NUTS1	NUTS2	Lag	LR PT	SR PT	SoA
North West	Piemonte	7	0.578***	0.650***	-0.184***
			(0.051)	(0.160)	(0.036)
	Liguria	10	0.684***	0.575***	-0.158***
			(0.054)	(0.176)	(0.048)
	Lombardia	9	0.697***	0.939***	-0.158***
			(0.042)	(0.147)	(0.040)
North East	Veneto	4	0.697***	1.204***	-0.082***
			(0.073)	(0.141)	(0.026)
	Emilia-Romagna	9	0.433***	1.216***	-0.189***
			(0.044)	(0.155)	(0.045)
Centre	Umbria	8	0.123	0.818***	-0.160***
			(0.104)	(0.295)	(0.041)
South	Campania	7	0.426***	0.832***	-0.178***
			(0.053)	(0.173)	(0.041)
	Puglia	7	0.759***	0.490**	-0.102***
			(0.119)	(0.236)	(0.027)
The Islands	Sicilia	7	0.095	0.453**	-0.140***
			(0.090)	(0.210)	(0.036)

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Standard errors in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

The long-run pass-through process in the remaining central and southern regions as well as Sicilia is found to be small and insignificantly estimated which suggests that in these regions the MRO change is also only partially transmitted to the regional interest rates. This analysis shows a substantial cross-NUTS2 heterogeneity in the pass-through of the MRO interest rate.

To identify regional patterns of high or low proxies, Table 4.2 provides calculated regional averages for long-run pass-through (LR PT), short-run pass-through (SR PT) and speed of adjustment (SoA) based on Model A/Intercept and Model B/Trend. For example, the average long-run pass-through for the northern regions, based on Model A/Intercept is 89.2 percentage points. Column 'North' encompasses the cointegrated regions of north-west and north-east. Column 'Rest encompasses the cointegrated regions of the centre, south and Sicilia.

Table 4.2 Average Long- and Short-run Pass-Through and Speed of Adjustment between the North and the Rest

	LR PT		SR PT		SoA	
	North	Rest	North	Rest	North	Rest
Standard VECM average	0.6178	0.593	0.917	0.648	0.154	0.145
Model A/Intercept	0.892	0.985	0.848	0.949	0.157	0.177
Model B/Trend	1.069	1.687	0.902	0.729	0.181	0.141

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Average of the estimators for the North and the Rest of Italy

This regional split between the north and south is confirmed when considering average long-run pass-through for the northern regions (north-west and north-south) versus the average long-run pass-through of the remaining regions (the centre, the south and Sicilia). The average long-run pass-through for the northern regions is 61.78 percentage points whilst the average long-run pass-through for the remaining regions is 59.3 percentage points. Note that the average long-run pass-through consists only of two regions, namely Campania and Puglia as the proxies are statistically significant. Furthermore, as per Table 4.1, Lombardia indicates the second largest long-run pass-through, a result similar to the commercial bank mark-up discussed in Chapter 3. With the exception of Umbria and Sicilia, all pass-through indicators are statistically significant at the 1% level.

Column 2 of Table 4.1 (labelled 'SoA') reports the estimated regional speed of adjustment. The highest speed of adjustment is observed in Emilia-Romagna (18.9%), whereas lowest speeds of adjustment are observed in Veneto (8.2%), both north-east regions. The obtained results for Emilia-Romagna indicate that in the next quarter 18.9% of an exogenous variation from the equilibrium of the employed time-series is adjusted, on average, back towards the equilibrium. In terms of Veneto only 8.2% of an exogenous shock would be adjusted towards the long-run trend in the next period.

However, when considering the regional average between the northern regions (north-west and north-east) and the remaining regions (the centre, south and Sicilia) as shown in Table 4.2, some north-south divide indication is found. The average speed of adjustment for the northern regions is 15.4% and the average speed of adjustment for the remaining regions is 14.5%. As required, all the speed of adjustment proxies are statistically significant at 1% and have a negative sign.

Overall, the regional split of the speed of adjustment results reinforces the previous findings for the monetary policy pass-through. When combining the speed of adjustment results with the pass-through, it can be concluded that in the northern NUTS2 regions the higher speeds of adjustment accelerate the monetary policy pass-through, leading to an even higher monetary policy effectiveness. The reason for this interpretation is based on econometrics grounds, namely the speed of adjustment is indicated by the coefficient of the error correction term of which the pass-through is a component (Asteriou and Hall, 2016). Therefore, the pass-through and speed of adjustment are influencing the regional revocable loan interest rate in a combined effect.

When considering the economic structure of the northern versus the southern regions, it can be argued that the long-run pass-through is ‘more complete’ across the economically more developed regions but also where the banking sector plays a crucial role in the regional economy such as in Lombardia (EC, 2019b). A similar result was found by Tai et al. (2012) where a higher pass-through was identified for countries where the financial sector contributes significantly to the economy (Hong Kong and Singapore) and a lower level of pass-through was found in countries where other sectors, such as manufacturing, contribute mainly to the economy (Korea, Thailand, Indonesia, and the Philippines).

The qualitatively same finding applies to the speed of adjustment results, namely that more economically developed regions, the northern regions of Italy such as Piemonte or Lombardia, react more quickly to adjust the lending rates towards the equilibrium if the ECB changes the MRO rate. On the other hand, in Puglia, a less developed region, the speed of adjustment was found to be much lower. It has to be noted that agriculture is the key sector in this region and especially since the Financial Crisis unemployment is high (EC, 2019b). In other words, regions which are considered as riskier, see fewer changes of the interest rates on average.

The statistical significance of the VECM long-run pass-through results, also shown in Figure 4.1, highlight an interesting pattern, namely results of northern regions are statistically significant at 1% whereas results of central and Sicilia are not statistically significant. This means that in the long-run the extent of a change in the MRO rate has limited impact on revocable loan interest rates in the centre and in Sicilia.

Overall, the regional differences in the long-run pass-through and speed of adjustment results show different levels in monetary policy effectiveness across regions.

To examine the long-run pass-through further, the CR was calculated as an alternative estimation method which provides further insight on the proxy and hence MPTM. The CR long-run pass-through results are reported in column 4 of Table 4.1, which indicate a similar north-south divide as found in the long-run pass-through proxies estimated via VECM. All CR results are statistically significant at the 5% level with the exception of Marche and Sicilia, which are not statistically significant.

The analysis on the short-run pass-through, as reported in the last column of Table 4.1, provides a similar regional pattern. The highest short-run pass-through was found in Emilia-Romagna (121.6 percentage points), whereas the lowest level was found in Sicilia (45.3 percentage points). Moreover, a complete short-run pass-through was found in Lombardia (93.9 percentage points). Overshooting short-run pass-through was identified in Emilia-Romagna (121.6 percentage points), Veneto (120.4 percentage points). In terms of statistical significance, short-run results for all regions are significant at 1%.

Results in Chapter 3 indicated low commercial bank mark-up levels in the northern regions and high mark-up levels in the central, southern regions and Sicilia. As found in the same Chapter, those regional differences can be explained by other influences such as risk, competition in the banking sector and liquidity preferences. Since similar regional patterns across the pass-through and speed of adjustment results have been found in comparison to mark-up, it is likely that risk, competition and liquidity preference may also contribute to the differences in the pass-through and speed of adjustment results.

Montagnoli et al. (2016) also found heterogeneous long-run pass-throughs across regions. Moreover, Montagnoli et al. (2016) found a complete pass-through in Campania, Sardinia and Sicily, namely in the south and the islands.

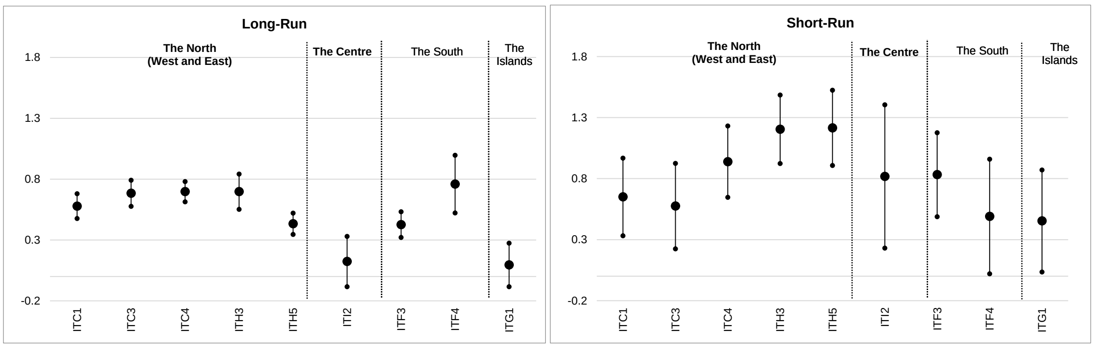
In this Chapter, in contrast, a relatively complete pass-through was found in Puglia. This discrepancy in results between this Chapter and Montagnoli et al. (2016) may be due to the different data and the estimation strategies employed.

As discussed in Section 4.2.2, further reasons for regional differences in monetary policy pass-through may be due to market power/competition in the banking sector, loan demand elasticity, credit risk, liquidity of bank balance-sheets, bank deposits and the concentration of bank branches (ECB, 2013; Bogoev and Petrevski, 2012; de Bondt et al., 2005; Sander and Kleimeier, 2004). Following the literature discussed in Section 4.2.2, this would mean that commercial banks have some level of market power, which would also be in line with the discussion on oligopolistic banking market structure as suggested by Rousseas (1985) and Das and Kumbhakar (2016) in Chapter 3. Furthermore, the results obtained in this Chapter imply that the demand for loans is more inelastic, the credit risk perspective is higher and the liquidity of bank balance sheets is lower, in particular across the central and southern regions as well as in Sicilia.

When comparing the long-run with the short-run proxies, differences occur in their levels, in particular due to the occurrence of short-run pass-through proxies close to, and greater than one, 100 percentage points, as observed in Lombardia, Veneto and Emilia-Romagna. These differences suggest that in the short-run commercial bank interest rates are more responsive to MRO interest rate changes than in the long-run. Figure 4.1 presents the long- and short-run pass-through estimations and their confidence intervals.

In order to investigate the obtained long-run and short-run pass-through results further, Figure 4.1 presents the coefficient estimates for the long- and short-run pass-through by regions as well as the coefficients' 95% confidence interval. The vertical lines represent the separation between the northern, central, southern and the islands NUTS2 regions. Regions are presented in geographical order starting from northern to southern regions.

Figure 4.1 VECM Long- and Short-Run Pass-Through and Confidence Intervals by NUTS2 Region



Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Note: Left panel presents long-run estimations, right panel presents short-run estimations. Confidence intervals at 95% significance level. NUTS2 regional abbreviations are provided in Table 2.1 of Chapter 2.2.

The left panel of Figure 4.1 also shows that the long-run variability of southern regions is higher than in norther regions. This implies that during the sample period on average the long-run pass-through varied more in southern regions than in northern regions (indicating a north-south divide). The right-hand panel shows similar variability in the short-run across all regions (indicating no north-south divide). This implies that, in the long-run, the pass-through varied in southern regions more than in northern regions however, in the short-run the variability across all regions is similar.

Following the literature presented in Section 4.2.1, these results show that in the short-run Umbria is more sensitive to monetary policy interest rate changes, indicating over-effective monetary policy in the short-run compared to other NUTS2 regions and to the long-term pass-through. These results are in line with Kleimeier and Sander (2005). The reasons for this finding could be that market power/competition and loan demand elasticity, credit risk and/or liquidity of bank balance-sheets have more relevance in the short-run than in the long-run.

Post-estimation tests were undertaken in order to obtain Chi-square statistics for each regional VECM and to research serial correlation of the error term. Results of Chi-square statistics, summarised in Appendix C.4, show that all selected lag-lengths between the time-series have a significant effect at 1% level. Hence, those results are supporting the lag length selection.

Furthermore, following each regional VECM calculation, each estimated residual was tested for the presence of serial correlation. Appendix C.5 shows that no serial correlation in the estimated residuals was found with potentially some exception in lag 8 for Sicilia.

Overall, the heterogeneity across pass-through and speed of adjustment results indicate that between 1999q4 and 2017q1 the effectiveness of monetary policy was higher in the northern regions than in most central and southern regions as well as in Sicilia. These results indicate that there seems to be a clear north-south divide and potential evidence of convergence between the northern parts of the country, which contrasts with ECB policy. This indicates that trying to achieve these goals such as convergence by means of a simple monetary policy may not be enough to do so or may take a while to achieve. This research shows that it is more likely that northern regions converged between 1999q4 and 2017q1, whilst southern and central regions diverged from the north.

4.4.2 Financial Crisis

As discussed in Section 2.3.8 Italy was impacted by the 2007-2208 Financial Crisis and because the crisis is part of the sample period, it is possible that it has led to a structural break in the regional time series. It is therefore important to test for endogenous structural breaks.

The purpose of this section is to examine the long- and the short-run pass-through based on two models for the Italian NUTS2 regions as described in Section 4.1, whilst controlling for structural breaks.

The estimation procedure for this Chapter follows the same argument and steps as provided in Section 3.4.4. Therefore, for detailed information on the applied estimation procedure, please see Section 3.4.4.

Table 4.3 summarises the long- and short-term pass-through results as well as the speed of adjustments based on Model A and Model B. For further information on Models A and B please see discussion in Section 2.3.8 and Section 3.4.4.

Table 4.3 Long- and Short-Run Pass-Through and Speed of Adjustment for Model A and Model B per Region

			Intercept			Trend		
NUTS1	**NUTS2**	**Lag**	**LR PT**	**SR PT**	**SoA**	**LR PT**	**SR PT**	**SoA**
North West	Piemonte	7	0.972***	0.720***	-0.137***	0.466***	0.500***	-0.259***
			(0.140)	(0.241)	(0.028)	(0.040)	(0.147)	(0.040)
	Liguria	10	0.565***	0.521***	-0.296***	0.599***	0.575***	-0.302***
			(0.026)	(0.141)	(0.073)	(0.038)	(0.167)	(0.070)
	Lombardia	9	1.020***	1.155***	-0.151***	1.249***	0.910***	-0.090**
			(0.084)	(0.167)	(0.046)	(0.248)	(0.178)	(0.035)
North East	Veneto	4	0.568***	1.220***	-0.112***	0.912***	1.175***	-0.072**
			(0.066)	(0.134)	(0.029)	(0.135)	(0.155)	(0.030)
	Emilia-Romagna	9	1.336***	0.623***	-0.090***	1.650***	1.349***	-0.057
			(0.197)	(0.214)	(0.020)	(0.261)	(0.210)	(0.037)
Centre	Umbria	8	0.030	0.840***	-0.278***	1.153***	0.663	-0.033
			(0.069)	(0.289)	(0.052)	(0.381)	(0.407)	(0.032)
South	Campania	7	1.094***	1.195***	-0.195***	0.263**	0.718***	-0.212***
			(0.125)	(0.211)	(0.047)	(0.120)	(0.192)	(0.049)
	Puglia	7	0.876***	0.811***	-0.049***	4.384***	0.740***	-0.013
			(0.190)	(0.191)	(0.017)	(0.991)	(0.230)	(0.010)
The Islands	Sicilia	7	0.074	0.294	-0.186***	0.949***	0.311	-0.070**
			(0.083)	(0.220)	(0.041)	(0.260)	(0.297)	(0.034)

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Standard errors in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

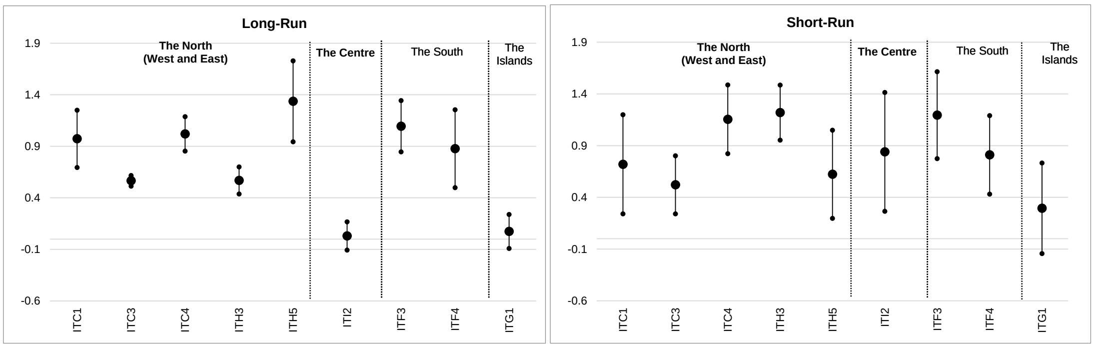
First, the long-run pass-through, short-run pass-through and speed of adjustment based on Model A are discussed. Model A accounts for a structural break in the intercept. Then the same analysis is provided based on Model B estimations. Model B allowed for structural breaks in the trend.

Based on Table 4.3 'Intercept' results, high long-run pass-through are observed in Emilia-Romagna (133.6 percentage points) and low long-run pass-through are observed in Liguria (56.5 percentage points), a north-western and a north-eastern region respectively. As Table 4.2 shows, the average long-run pass-through, based on 'Model A' for the northern regions is 89.2 percentage points and the average long-run pass-through for the remaining regions (the centre, south and Sicily) is 98.5 percentage points. Note that for the average calculations only statistically significant values have been taken into consideration. Therefore, a north-south divide in Model A is the reverse of the overall findings of Section 4.4.1. With the exception of Umbria and Sicilia all estimates are statistically significant at 1%.

Based on Table 4.3 'Intercept' outputs, high short-run pass-through results are observed in Veneto (122.0 percentage points) and low short-run pass-throughs are observed in Liguria (52.1 percentage points), a north-western and a north-eastern region respectively. As Table 4.2 shows, the average short-run pass-through for the northern regions is 84.8 percentage points and the average short-run pass-through for the remaining regions is 94.9 percentage points. Therefore, a north-south divide in Model A is the reverse of the overall findings of Section 4.4.1. With the exception of Sicilia all estimates are statistically significant at 1%.

Based on Table 4.2 'Intercept' outputs, high speeds of adjustment results are observed in Liguria (29.6%) and low speed of adjustment estimates are observed in Emilia-Romagna (9%), a north-western and north-eastern region respectively. As Table 4.2 shows, the average speed of adjustment for the northern regions is 15.7% and the average speed of adjustment for the remaining regions is 17.7%. Therefore, a north-south divide in Model A is also the reverse of the overall findings of Section 4.4.1. All coefficient estimates have the required negative sign and are statistically significant at 1%. This shows that there exist a long-run association between the employed variables. Figure 4.2 presents the long- and short-run pass-through and their confidence intervals by region based on Model A.

Figure 4.2 VECM Long- and Short-Run Pass-Through and Confidence Intervals by NUTS2 Region, Model A



Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Note: Left panel presents Model A long-run estimations, right panel presents Model A short-run estimations. Confidence intervals at 95% significance level. NUTS2 regional abbreviations are provided in Table 2.1 of Chapter 2.2.

Figure 4.2 indicates that the long-run pass-through estimates observed in northern regions (except Emilia-Romagna) show low variability. Furthermore, these results indicate that in the short-run north-eastern regions are much more sensitive to monetary policy interest rate changes than in the long-run. This pattern is in line with Kleimeier and Sander (2005) indicating that monetary policy is more effective in the short-run than in the long-run across the regions. One potential explanation is that market power/competition and loan demand elasticity, credit risk and/or liquidity of bank balance-sheets are more important in the short-term than in the long-run (ECB, 2013; Bogoev and Petrevski, 2012; de Bondt et al., 2005; Sander and Kleimeier, 2004). Furthermore, the variability in the short-run is higher than in the long-run.

Overall, findings from Model A estimations are that Lombardia indicates a long- and short-run pass-through over but close to one. This indicates effective monetary policy. Moreover, Model A provides three long-run pass-throughs over, but close to, 1. This is observed in Lombardia, Emilia-Romagna and Campania. In terms of the short-run speed of adjustment two regions have a value over, but close to, 1, namely Lombardia and Campania. In summary, Lombardia seems to indicate the most effective monetary policy. The regional pattern of high pass-through and speed of adjustments found in Section 4.4.1 is reversed across outputs based on Model A.

Following regional VECM calculations, each estimated residual was tested for the presence of serial correlation. Appendix C.7 summarises the error serial correlation results for Model A/Intercept. At 5% significance level, these results show that no serial correlation in the estimated residuals was found with potentially some exception in lag 1 for Liguria.

Appendix C.8 summarises the error serial correlation results for Model B/Trend. At 5% significance level these results show that no serial correlation in the estimated residuals was found.

Based on Table 4.3 ‘Trend’ outputs, high long-run pass-through are observed in Puglia (438.4 percentage points) and low long-run pass-through are observed in Campania (26.3 percentage points), both southern regions. Since the estimate of Liguria is negative, this region is omitted from this analysis. As Table 4.2 shows, the average long-run pass-through for the northern regions is 106.9 percentage points and the average long-run pass-through for the centre, south and Sicilia is 168.7 percentage points. Therefore, a north-south divide in Model B is also the reverse of the overall findings of Section 4.4.1. All estimates are statistically significant at 1% with the exception of Campania, which is statistically significant at 5%.

This means that by controlling for a structural break in the trend, in the long run the change in the revocable loan interest rate in Puglia is much more sensitive than in any other region. The result for Puglia is statistically significant. One reason for these high long-run coefficient estimates may be that commercial banks may have adjusted their interest rates due to their changes in risk perception. Therefore, the risk perception in Umbria may have increased to a much higher extent than the risk perception in any other region and therefore the higher coefficient of long-run pass-through.

Based on Table 4.3 'Trend' outputs, high short-run pass-through estimates are observed in Emilia-Romagna (134.9 percentage points) and low short-run pass-through outputs are observed in Piemonte (50.0 percentage points), a north-eastern and north-western region respectively. As Table 4.2 shows, the average short-run pass-through for the northern regions is 90.2 percentage points and the average short-run pass-through for the remaining regions is 72.9 percentage points. The north-south divide for short-run pass-through in Model B is similar to the overall findings of Section 4.4.1. With the exception of Umbria and Sicilia all results are statistically significant at 1%. Umbria and Sicilia are not statistically significant.

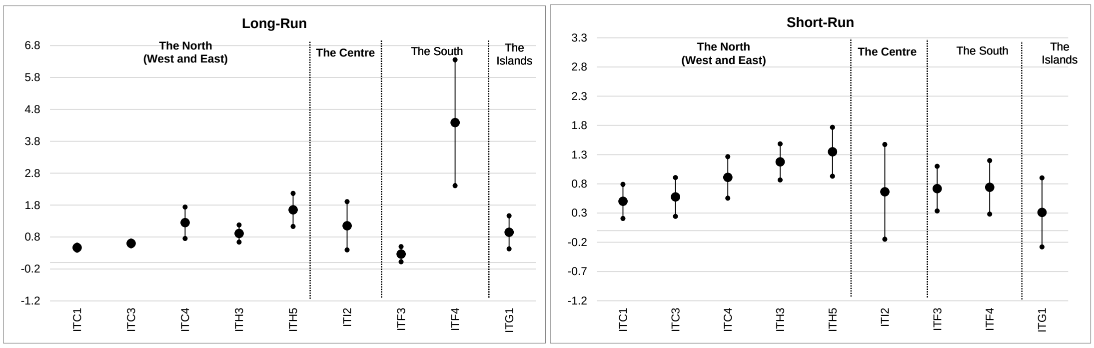
Based on Table 4.3 'Trend' outputs, high speeds of adjustments estimates are observed in Liguria (30.2%) and low speeds of adjustment are observed in Sicilia (7.0%) a north-western region and one of the islands respectively. The average speed of adjustment for the northern regions is 18.1% and the average speed of adjustment for the centre, south and Sicily is 14.1%. Therefore, a north-south divide in Model B for speed of adjustment is similar to the one of the overall findings of Section 4.4.1. Emilia-Romagna, Umbria and Puglia have statistically insignificant results. Otherwise, the speed of adjustments is statistically significant at 5% level and have the required negative sign.

Overall, findings from Model B estimations are that Lombardia indicates a long- and short-run pass-through estimates around one. This indicates relatively effective monetary policy. Moreover, Model B provides four long-run pass-through over one. These regions are: Lombardia, Emilia-Romagna, Umbria and Puglia. The long-run pass-through for Puglia is 438. 4 percentage points and is the highest value for long-run pass-through overall. In terms of short-run speed of adjustment two regions have a value over, but close to, 1, namely Veneto and Emilia-Romagna. In summary, Lombardia seems to indicate the most effective monetary policy.

Following regional VECM calculations, each estimated residual was tested for the presence of serial correlation. Appendix C.7 summarises the error serial correlation results for Model A/Intercept. At 5% significance level, these results show that no serial correlation in the estimated residuals was found with potentially some exception in lag 1 for Liguria.

Appendix C.8 summarises the error serial correlation results for Model B/Trend. At 5% significance level these results show that no serial correlation in the estimated residuals was found. Figure 4.3 shows the long- and short-run pass-through based on Model B and their confidence intervals by region.

Figure 4.3 VECM Long- and Short-Run Pass-Through and Confidence Intervals by NUTS2 Region, Model B



Source: Author’s estimation using Bank of Italy (2017b) and ECB (2019d).
Note: Left panel presents Model B long-run estimations, right panel presents Model B short-run estimations. Confidence intervals at 95% significance level. NUTS2 regional abbreviations are provided in Table 2.1 of Chapter 2.2. Umbria (ITI2) has been removed due to its extreme estimate.

Figure 4.3 indicates that short-run pass-throughs show a higher variability than the long-run pass-through estimates. Please consider that the long-run pass-through for Puglia is an outlier. In terms of short-run pass-through, variability across all regions is stable, with exception of Umbria.

In summary, when comparing the average long-run pass-through and average speed of adjustment results of Table 4.2 for the three models estimated in this Chapter, namely the standard VECM, Model A and Model B which account for structural breaks, then the regional pattern of high proxies in the north and low proxies in the south, centre and Sicilia is not identified for each model. In short, the results are mixed.

In detail, high average long-run pass-throughs and high average speeds of adjustment are identified in the standard VECM estimations. This result indicates that monetary policy is more effective in the northern regions than in the other regions.

However, the revers applies for estimations of Model A. When structural breaks are controlled for, then higher average long-run pass-throughs and average speed of adjustment proxies are observed in the centre, south and Sicilia. This would indicate that monetary policy is more effective in the south, centre and Sicilia.

When looking at Model B results, the average long-run pass-through is higher in the centre, south and Sicilia but the average speed of adjustments is higher in the northern regions. These results provide mixed information in relation to the monetary policy effectiveness.

However, the common result across the different models and indicators is that heterogeneity across regions exists and that there seems to be a divide within the country. The heterogeneity of the proxies becomes apparent across the different estimation models and controls for the 2007-2008 Financial Crisis.

This structural break analysis shows that a substantial cross-NUTS2 heterogeneity in the pass-through and speed of adjustment of the MRO interest rate exists when controlling for structural breaks. This identified heterogeneity is in line with the mark-up results discussed in Chapter 3 and the standard VECM estimations for the monetary policy pass-through. Therefore, based on the findings of Chapter 3, it is likely that risk, competition and liquidity preference may contribute to explain the differences in the pass-through results when controlling for structural breaks.

Moreover, as argued in Section 4.2.2, banking sector competition, credit risk, switching costs, information asymmetries and demand elasticity could explain the regional heterogeneity in the long-run pass-through (ECB, 2013; Bogoev and Petrevski, 2012; de Bondt et al., 2005; Sander and Kleimeier, 2004). Similar to the baseline VECM results, the ECB’s objective of achieving inflation of 2%, or close to 2%, via monetary policy is more likely to be achieved in the northern regions than in the centre, south and Sicilia.

Another finding is that short-run pass-through for Model A and Model B have short-run pass-through greater than one. In terms of Model A, short-run pass-through greater than one is found in Lombardia, Veneto and Campania. In terms of Model B, short-run pass-through greater than one is found in Veneto and Emilia-Romagna.

These results indicate that in the short-run interest rates in these regions are much more sensitive to monetary policy interest rate changes than in the long-run. This pattern is in line with Kleimeier and Sander (2005). Monetary policy is more effective in the short-run than in the long-run across these regions. One potential explanation is that market power/competition and loan demand elasticity, credit risk and/or liquidity of bank balance-sheets are more important in the short-run than in the long-run (ECB, 2013; Bogoev and Petrevski, 2012; de Bondt et al., 2005; Sander and Kleimeier, 2004). Overall, Figure 4.2 shows similar patterns than Figure 4.1.

In Chapter 1 it was discussed that the ECB is using monetary policy to support the EC’s objective to enhance economic growth and employment across the Euro Area leading to convergence across regions (ECB, 2019b; EC, 2019a; Commission of the European Communities, 1990).

However, results of this analysis indicate that between 1999q4 and 2017q1 the ECB’s monetary policy effected regions of Italy differently. This means that the uneven effectiveness of monetary policy across Italian NUTS2 regions could have contributed to a divergence between the north and the south. This indicates that trying to achieve goals such as convergence by means of a simple monetary policy may not be enough to do so or may take a while to achieve.

4.5 Conclusion

This Chapter examined the second mechanism of the Euro Zone MPTM, indicated by the monetary policy pass-through, across the Italian NUTS2 regions for the period 1999q4 – 2017q1. The objective of this Chapter was to understand how the monetary policy pass-through differs across the NUTS2 regions in long-, short-run and speed of adjustment. This research question was analysed through an empirical investigation based on the relationship between the ECB-set MRO rate and the revocable loan interest rates for each of the cointegrated Italian NUTS2 regions separately for the period 1999q4 – 2017q1.

The relevance of this analysis is to provide insights on the MPTM, as a mechanism through which the ECB tries to achieve its objective of price stability in the Euro Zone, and this, in turn, supports the objective of the European Commission to stimulate the economy and foster employment across the Euro Zone. Since the monetary policy is set for each country of the Euro Zone, it was expected that monetary policy transmits homogenously across its regions. Moreover, findings in the literature show that pass-through levels across Italian regions are heterogeneous, with high pass-through levels in the north and low pass-through levels in the south.

Following the literature, the monetary policy pass-through was defined as the influence of changes in the monetary policy interest rate on regional revocable interest rates (Rehman, 2009; in Tai et al. 2012). In this Chapter, the long-run monetary policy pass-through was defined as the long-run MRO coefficient of the cointegrated equation, whilst the short-run monetary pass-through was given by the short-run MRO coefficient of the VECM estimation.

Long- and short-run monetary policy pass-through proxies per NUTS2 region were estimated via a VECM. Regional CR estimations were also undertaken for comparative purposes. Since the 2007 – 2008 Financial Crisis is within the researched period, additional estimations were undertaken to control for structural breaks. Results show that monetary policy pass-through levels differ across Italian NUTS2 regions, which indicates that monetary policy could transmit heterogeneously across regions in Italy. This finding is in line with the literature (Montagnoli et al., 2016; and Gambacorta, 2008, for instance). More precisely, long-run pass-through levels in the north-west and north-east were higher than in the southern and central regions as well as in Sicilia. Furthermore, the long-run variability in the pass-through of southern regions is higher than in norther regions. This implies that during the sample period, on average, the long-run pass-through varied more in southern regions than in northern regions, suggesting a north-south divide.

These results imply that regions with a higher pass-through tend to be more developed in economic and industrial terms. Note that Lombardia has complete monetary policy pass-through in comparison to the other central regions across all estimation methods. This finding indicates that in Lombardia, where the financial sector is the key industry, has an optimal monetary policy effectiveness. This finding has not been discussed in the literature.

The long-run monetary policy pass-through results imply that, in economically more developed regions and in regions where the financial sector is a key contributor to the economy, higher percentage points of the change in the MRO rate is transmitted to the regional interest rates. In less economically developed regions, the transmitted proportion of the MRO rate change is lower. The identified heterogeneous long-run pass-through across Italy could be interpreted as the Euro Zone monetary policy in the northern NUTS2 regions is more effective than in the centre, south and Sicilia.

A similar result was found by Tai et al. (2012), namely a higher pass-through was identified in countries such as Hong Kong and Singapore in comparison to the pass-through in the Philippines, Korea, Thailand and Indonesia.

The analysis on short-run pass-through provided the same regional pattern as the one found in the long-run pass-through case. However, the short-run monetary policy seems to be more effective in comparison to the long-run, in particular in Veneto and Emilia-Romagna.

Structural breaks were tested and accounted for through the application of two models; Model A, where a structural break was allowed to occur in the intercept and Model B, where the structural break was allowed in the trend. Long-run pass-through and speed of adjustment results across both models are mixed, meaning that these results provide mixed information in relation to the monetary policy effectiveness. This indicates an uneven effectiveness of monetary policy across Italian NUTS2 regions, which could have contributed to a divergence between the north and the south.

Overall, the lessons learned from this Chapter are that regions in which the financial sector is a key industry show a higher monetary policy effectiveness. In this Chapter, Lombardia has been identified as the region with the most complete monetary policy pass-through leading to optimal monetary policy effectiveness. This result is in line with Tai et al. (2012). Furthermore, long- and short-term monetary policy pass-through levels differ across Italian NUTS2 regions, which is in line with the literature (Montagnoli et al., 2016; Gambacorta, 2008). This means that the MPTM differs across regions and could reinforce the north-south divide. Moreover, other factors, such as risk, competition in the banking sector, may contribute to the varying regional monetary policy pass-through in Italy, as shown through the pass-through results when controlling for the crisis.

Therefore, considering the argument that the ECB tries to achieve its objective of price stability in the Euro Zone that, in turn, supports the objective of the European Commission to stimulate the economy and foster employment across the Euro Zone, this Chapter concludes that the MPTM works for some regions rather better than for others. As a result, other supporting mechanisms to foster economic growth and employment should be introduced, especially for the ‘poorer’ regions where risk and competition level in the banking sector influences the interest rate on loans.

The next chapter examines the speed of adjustment, the third MPTM sub-mechanism.

Chapter 5
The Speed of Adjustment

5.1 Introduction

This Chapter examines the third sub-mechanism of the Euro Zone Monetary Policy Transmission Mechanism (MPTM), indicated by the monetary policy speed of adjustment, across 11 Italian NUTS2 regions for the period 1999q4 – 2017q1. The objective of this Chapter is to understand how the regional interest rates adjust towards an equilibrium with the ECB-set rate within a quarter. The equilibrium is defined as the steady state between two cointegrated time-series (Asteriou and Hall, 2016).

Therefore, the research question of this Chapter is how the speeds of adjustment differ across regions and therefore indicates the effect of the ECB monetary policy. This research question is analysed through an empirical investigation based on the relationship between the ECB-set MRO rate and the revocable loan interest rates for each of the 11 Italian NUTS2 regions.

The analysis of this Chapter is based on the Optimum Currency Area (OCA) theory and the view and expectations of the European Commission before the introduction of the European Monetary Union (EMU). More precisely, this research provides insights on the MPTM, a mechanism through which the ECB tries to achieve its objective of price stability in the Euro Zone that, in turn, supports the objective of the European Commission to stimulate the economy and foster employment across the Zone. Since monetary policy is set for each country of the Euro Zone, prior the introduction of the EMU, it was expected that monetary policy would transmit similarly across EMU regions. This assumption was based on the OCA theory (Mundell, 1961) and the European Commission stance of similarities across all EMU members (Treaty on European Union 1992; Commission of the European Communities, 1990).

However, Montagnoli et al. (2016), ECB (2013), Karagiannis et al. (2011), and de Bondt et al. (2005) studied the speed of adjustment on a national level, for the Euro Zone and across Italian NUTS2 regions respectively, finding heterogeneity among pass-through levels.

Following Montagnoli et al. (2016), ECB (2013), and de Bondt et al. (2005), in this Chapter the speed of adjustment proxies is estimated per NUTS2 region using an ARDL estimation strategy, where the coefficient of the lagged error correction term is interpreted as the speed of adjustment proxy given in percentages. More detailed, the speed of adjustment in this Chapter signalises the correction in the regional interest rate towards the equilibrium during the last quarter, indicated by a proportion given in percent. The higher the proportion the larger is the extent which is adjusted in the regional interest rate towards the equilibrium during the last period.

Following Gambacorta (2008) and similarly to the long- and short-run pass-through the speed of adjustment proxy is a further measure of monetary policy effectiveness. In both cases, the higher the proportion of the long- and short-run pass-through and speed of adjustment, the higher is the extent of the monetary policy effectiveness.

The difference between this Chapter and the previous one is as follows: The long- and short-run pass-through provides information to which extent (expressed in percentage points) the change in the MRO rate is transmitted to regional interest rates in the long- and short-run. The speed of adjustment indicates the extent which is adjusted in the regional interest rate towards the equilibrium during the last period, indicated in percent points (Asteriou and Hall, 2016).

This Chapter contributes to the analysis of MPTM in two ways: First, the speed of adjustment is an additional measure of monetary policy effectiveness. Second, Lombardia, has been identified as the region with effective speed of adjustment, a region where the financial sector is the main contributor to regional GDP.

In order to estimate the speed of adjustment, a particular model specification is required which the Cointegrated Regression (CR) estimations cannot provide. Therefore, CR estimations are not undertaken for this Chapter as in the previous ones. Since the 2007 – 2008 Financial Crisis is within the researched period, additional estimations are conducted including event-dummy variables and trend variables in order to control endogenously for the Crisis.

Hence, the contribution of this Chapter is grounded on a unique monetary policy speed of adjustment investigation from a supra (ECB) to an intra-national (NUTS2) level. In this way, this Chapter contributes to the literature of regional MPTM through an original research on the monetary policy speed of adjustment from the ECB level across Italian NUTS2 regions for the period 1999q4 – 2017q1, as well as controlling for the 2007 – 2008 Financial Crisis.

Based on regional ARDL estimations, the speed of adjustment results differ across Italian NUTS2 regions, which indicates that monetary policy may transmit heterogeneously across the NUTS2 regions in Italy. Montagnoli et al. (2016), ECB (2013) Karagiannis et al. (2011), de Bondt et al. (2005), Kleimeier and Sander (2006), for instance, also found heterogeneous results in speeds of adjustment across the Euro Zone and Italy. Therefore, the findings of this Chapter are in line with the literature.

More precisely, speed of adjustment levels in some northern regions are higher than in some southern and central regions. This means that in the northern regions the interest rates adjust towards the equilibrium to a higher extent within one quarter than in southern and central regions. The implication of these results is that, through investigating a further monetary policy sub-mechanism, namely the speed of adjustment, it is identified that monetary policy is more effective in the northern regions of Italy than across central and southern regions, which is similar to the findings of Chapter 4. Moreover, when controlling for the Financial Crisis, regional heterogeneity is identified and the north-south divide is found in based on cointegration results across the regions.

This Chapter is divided in five sections. The next section presents a review of the speed of adjustment literature and its findings. Section three discusses the empirical implementation of this Chapter. Section four shows the empirical findings of this Chapter and section five concludes this Chapter with a discussion of the findings.

5.2 Literature Review

The purpose of this literature review is to define the speed of adjustment, to discuss the existing literature around this topic, as well as to analyse the data employed in the literature, in order to understand the study of the speed of adjustment under different contexts. Furthermore, methods to control for economic and Financial Crises are discussed as well.

5.2.1 Definitions of the Speed of Adjustment

Based on an error correction model (ECM) specification, the speed of adjustment could be defined as the coefficient of the error correction term. This coefficient provides information on the extent of the correction process in the dependent variable towards equilibrium in the last period. In this case the concept of equilibrium is based on econometric theory, namely as an equilibrium between two time-series, if the time-series share a common trend (Asteriou and Hall, 2016).

Gambacorta (2008) refers to the speed of adjustment coefficient as the “loading coefficient”, which is defined as the “percentage of an exogenous variation from the steady state between the rates which are brought back towards equilibrium in the next period” (Gambacorta, 2008 p. 801).

Havranek et al. (2016) interpreted the error correction term as the speed of adjustment proxy and interpreted this coefficient as the speed of adjustment parameter “between short-term reaction and long-term equilibrium” (Havranek et al., 2016, p. 157). De Bondt et al. (2005) understood the speed of adjustment as an adjustment “towards the equilibrium price of retail bank products” (de Bondt et al., 2005, p. 18).

Karagiannis et al. (2011) suggested to use the speed of adjustment proxy as commercial bank manager’s power to transfer any changes in the wholesale interest rate to consumers. This managers’ power is influenced by the competition in the banking sector. Therefore, speed of adjustment can be used as a competition indicator in the banking sector.

The definition for the speed of adjustment this Chapter follows is the one provided by Gambacorta (2008), but the suggestion of Karagiannis et al.

(2011) to use speed of adjustment as competition indicator is also further analysed and implemented.

5.2.2 Influences on the Speed of Adjustment

Empirical studies show that the speed of adjustment differs across the Euro Area (de Bondt, 2005), across countries (Havranek et al., 2016; Bogoev and Petrevski, 2012; Karagiannis et al., 2011) and between different bank products (Montagnoli et al., 2016; Horváth and Podpiera, 2012). This section discusses the reasons which could explain these variations.

A further influence on the speed of adjustment is the level of competition in the banking sector, which may also differ across countries (Karagiannis et al., 2011; Leuvensteijn et al., 2008; de Bondt, 2005). The higher the level of competition in the banking sector, the quicker the response of a bank in reacting to wholesale rate changes (Leuvensteijn et al., 2008). Conversely, the more concentrated the banking sector the slower the response of a bank to wholesale rate changes, and the more powerful is the banking sector. Therefore, Karagiannis et al. (2011) proposed to interpret the speed of retail adjustment as an indicator for competition in the banking sector.

Horváth and Podpiera (2012) came to a similar conclusion by arguing that speed of adjustment coefficients can be influenced by the degree of competition and financial innovations. Increased levels in financial innovation lead to higher levels in the speed of adjustment (Gropp et al., 2007).

According to the ECB (2013) lending rates across countries show varying speeds of adjustment because of the influence of different national market rates and risk factors across the Euro Zone countries (ECB, 2013). This implies that if risk perception for a particular region is high, the speed of adjustment may be low especially in an environment of low policy interest rates. This divergence in speed of adjustment reflects different risk perception and partially asynchronous business cycles (ECB, 2013). The ECB (2013) concludes that the bank resilience and the fragmentation in the Euro Area credit market influences heterogeneous MPTM in the Euro Area.

Bogoev and Petrevski (2012) analysed the speed of adjustment in Macedonia and found a slow speed of adjustment due to the presence of structural breaks in the time-series. In this case, structural breaks could have been caused by the introduction of new financial instruments through treasury bills and/or the 2008 Financial Crisis.

De Bondt et al. (2005) argue that the speed of adjustment may have increased in the Euro Area since January 1999 due to changes in the banking sector behaviour: Banks started innovating by using more market-based instruments for raising capital rather than using traditional methods, namely short-term deposits for long-term loan funding.

Furthermore, de Bondt et al. (2005) argue that volatility in the market interest rate could be another factor which influences the lending rate changes and hence the speed of adjustment. Because the banking behaviour changed in terms of capital raising, volatility in the market interest rate represents uncertainty of the market-based refinancing conditions. De Bondt et al. (2005) mentioned that since the introduction of the EMU the volatility in the Italian long- and short-term market interest rate has decreased leading to a slowdown in the speed of adjustment in Italy overall.

Montagnoli et al. (2016), on the other hand, find that asymmetries in the speed of adjustment across Italian regions are plausible and depend on whether the whole sale market interest rates are decreasing or increasing. If the market interest rates are increasing, then the speed of adjustment is larger than when market interest rates are decreasing.

Following this literature, the implication of these findings on the MPTM is that competition, financial innovations, risk, the presence of structural breaks in the data set and whether a rise or a fall in the whole sale interest rate, may influence the speed of adjustment.

5.2.3 Literature Review on the Speed of Adjustment

Empirical studies are diverse because of the wide variety of interest rates data available. Therefore, each analysis is examining a different monetary policy speed of adjustment. Estimation strategies, implied by models and methods, are subject to the data used in the analysis. Thus, studies can be categorised according to several factors such as data employed, estimation model and method.

When examining the monetary policy speed of adjustment, a common empirical approach found in the literature is to analyse the relationship between a cost of fund interest rate (any interest rates which commercial banks are exposed to when borrowing funds) and interest rates on loans or deposits (Havranek et al., 2016; Montagnoli et al., 2016; Bogoev and Petrevski, 2012; Karagiannis et al., 2011;)

The remaining of this section discusses data, estimation strategies and results found in literature in relation to the monetary policy speed of adjustment. Moreover, since the 2007 – 2008 Financial Crisis was a significant event within the last decade, a section on identification methods and controls for the Crisis in the speed of adjustment literature is presented.

5.2.3.1 Data Employed in the Literature

Many empirical studies are estimating the speed of adjustment between money market data and interest rates on loans and/or deposits. More precisely, when analysing the speed of adjustment, the money market, or market interest rate, is often utilised. The reason for this data selection is based on the investigated research question and data availability (Havranek et al., 2016; Montagnoli et al., 2016; Bogoev and Petrevski, 2012; Horváth and Podpiera, 2012; Karagiannis et al., 2011; de Bondt, 2005; Gambacorta, 2008).

Interest rates on loans are often represented, for example, by retail bank interest rates across the Euro Area (de Bondt, 2005), bank lending rates on a national level (Bogoev and Petrevski, 2012; Karagiannis et al., 2011; Gambacorta, 2008), lending interest on small and large loans for household and non-financial corporations (ECB, 2013; Horváth and Podpiera, 2012), interest rates on particular bank products (Havranek et al., 2016) and long- and short-term business loan rates (excluding mortgages) across Italian NUTS2 regions (Montagnoli et al., 2016). Deposit rates were also employed by Montagnoli et al. (2016) and Karagiannis et al. (2011).

Therefore, when calculating speed-of adjustment proxies, a specific speed of adjustment is estimated for the specific interest rate analysed, mostly between money market rates and various bank lending rates.

5.2.3.2 Results Found in the Literature

De Bondt (2005) studied the speed of adjustment for the Euro Area for the period January 1996 – May 2001 for ten Euro Area countries. Results show that the speed of adjustment from market rates to bank lending rates differ across countries. However, the speed of adjustment increased since the introduction of the Euro. Therefore, the introduction of the Euro may be understood as a stimulus to the competition in the banking sector.

Gambacorta (2008) estimated the average speed of adjustment for lending rates between 1993Q1 – 2001q1 in Italy to be around 0.4, which means that 40% of the deviation of the exogenous shock is adjusted for in the bank rate during the first quarter. Following Asteriou and Hall (2016), this is a relatively low speed of adjustment level.

Horváth and Podpiera (2012) estimated the speed of adjustment for the Czech Republic for the period January 2004 – December 2008. Results of this study show a faster speed of adjustment for loans to non-financial corporations than to loans for households. The implication of this study is that the speed of adjustment differs between banking products. Hence, data selection is crucial for speed of adjustment studies, as these results provide interesting insights on the speed of adjustment to particular agents in an economy.

Havranek et al. (2016) analysed the speed of adjustment based on Czech bank product-level data and money market rates between January 2004 – December 2013. Overall, results show homogenous speeds of adjustment across bank products, with household-related products having slightly a slower speed of adjustment than business related products. This result is in line with Horváth and Podpiera (2012).

The key difference between Horváth and Podpiera (2012) and Havranek et al. (2016) is two different time frames of analysis. Furthermore, Horváth and Podpiera (2012) used loan interest rates to households and non-financial sector whilst Havranek et al. (2016) used product and bank level data.

Karagiannis et al. (2011) examined the speed of adjustment for Greece, Bulgaria and Slovenia, between January 1999 – April 2004 for the Greek case, whilst January 1999 – August 2007 for the Bulgarian and Slovenian cases. Results for Greece indicate that commercial banks transmit changes in the central bank and money market rates (interest rate in- and decreases) to borrowers and depositors. Hence, symmetry exist across changes in policy-controlled interest rates and commercial bank lending and borrowing rates. This result, in turn, indicates an effective monetary policy conduct.

In terms of Bulgaria, the speed of adjustment coefficients is only statistically significant for the relationship between policy-controlled variables and loan interest rates, indicating that reductions in policy-controlled variables are passed to borrower rates. These results suggest a less effective monetary policy conduct. Results for Slovenia, on the other hand, show that the speed of adjustment coefficient is statistically significant for the relationship between money market rates and either lending or deposit interest rates. This indicates that commercial banks transmit decreases in the money market rates to borrowers and depositors and not the changes in the central bank interest rates. Hence, the conduct of monetary policy in Slovenia is less effective. Overall, the authors suggest using the asymmetric behaviour in the response to wholesale rate changes observed as an indicator for competition in the banking sector. Therefore, the speed of adjustment can be interpreted as an indicator for competition level in the banking sector.

Bogoev and Petrevski (2012) researched the speed of adjustment in Macedonia, a small open transition economy with fixed exchange rates, between bank lending and money market rates for the time period 2002 – 2010. Results show that the speed of adjustment is slow in the case of Macedonia. This may be due to the presence of structural breaks, such as the introduction of new financial instruments through treasury bills and/or the 2008 Financial Crisis. Bogoev and Petrevski (2012) employed structural break tests, such as the Chows’ breakpoint and forecasting test and the Quandt-Andrews test. Despite these results were inconclusive, this study shows the relevance of controlling for structural breaks.

Montagnoli et al. (2016) estimated the speed of adjustment for 20 Italian NUTS2 regions for the period 1998q1 – 2009q4, using a two-step approach. The authors employed long- and short-term business loan rates (excluding mortgages) and deposit rates as prevailing interest rates across regions.

Results show that the speed of adjustment for long-term rates are high, however no regional pattern was found in their results.

5.2.3.3 Control for the Financial Crisis

The discussion in the second chapter of this thesis demonstrated that it is important to account for the presence of, and then to control for, structural breaks in empirical analysis. Furthermore, it was shown that there are different approaches how to control for structural breaks, especially when an event such as the recent Financial Crisis lies within the data set.

Horváth and Podpiera (2012), for example, deal with the impact of the 2007 – 2008 Financial Crisis by dividing the data into pre- and Crisis-periods. The authors then estimated speed of adjustment coefficients for both periods independently. Then, the authors compared the speed of adjustment results between the two periods across different products. Findings of this analysis show that during 2008 the speed of adjustment decreased slightly for corporate loans in comparison to household related products (Horváth and Podpiera, 2012). Moreover, the ECB (2013) argues that bank lending rates, especially after the 2007 – 2008 Financial Crisis, react slowly to the reduction of the monetary policy rate due to varying credit risk perceptions and asynchronous business cycles across countries.

5.2.4 Literature Review Discussion

The literature review in this Chapter presented various papers which analysed empirically the speed of adjustment under different contexts. The key motivation of this Chapter is grounded on some inspiring characteristics found in the presented papers. For example: The differentiation between countries, or sub-national regions when estimating speed of adjustment proxies (Montagnoli et al., 2016; Bogoev and Petrevski, 2012; Horváth and Podpiera, 2012; Karagiannis et al., 2011; de Bondt, 2005); the differentiation between banking products, such as interest rates on loans for households and non-financial corporations (Havranek et al., 2016; Montagnoli et al., 2016; Horváth and Podpiera, 2012); adjustments in the speed of adjustment to changes in monetary policy and/or money market rates (in- or decreases) (Karagiannis et al., 2011); and the impact that shocks, like the 2007 – 2008 Financial Crisis, have on speed of adjustment proxies.

However, some shortcomings in the literature have also been identified. For example, the discussion provided in Section 5.2.2 emphasised several factors influencing speed of adjustment proxies. Similar to Chapter 4, the pass-through chapter, one of the shortcomings in the literature is that the monetary policy speed of adjustment is examined either across the whole Euro Zone or across member countries of the Euro Zone (de Bondt, 2005; Karagiannis et al., 2011; Gambacorta, 2008). The disadvantage of a national monetary policy speed of adjustment analysis across Euro Zone countries is that national factors could contribute to the heterogeneity of speed of adjustment coefficients (Sander and Kleimeier, 2004). Also, according to the ECB (2013), national factors, such as different national market rates and risk perceptions, can contribute to heterogeneity across speed of adjustment proxies. Therefore, in order to control for national factors within speed of adjustment proxies, and for easier comparison and analysis of results, those proxies could be estimated on a sub-national level within one country.

Moreover, as stated by Granger (1980) and Zaffaroni (2004), the speed of adjustment may be distorted by the aggregation bias. Under this bias, idiosyncratic shocks can disappear when a significant number of time-series are aggregated in the estimation process (Altissimo et al., 2009). Therefore, it is likely that speed of adjustment estimates may be underestimated if calculated on an aggregated level.

In order to control for these issues and to examine the monetary policy speed of adjustment, this Chapter controls for both: Any national macroeconomic factor, and the aggregation bias by analysing the monetary policy speed of adjustment across different NUTS2 regions in one country. More precisely, this analysis starts at the ECB level and concludes across the NUT2 regions of one country, namely Italy.

Furthermore, most of the literature investigates the speed of adjustment between a money market interest rate and any bank lending interest rate. This approach shortens the investigated MPTM due to the selection of the money market interest rate as a proxy for the monetary policy. The main interest of this Chapter is to examine the whole transmission mechanism from the ECB across Italian NUTS2 regions. Therefore, with the intention to study the 'complete' monetary policy pass-through from the supra (the ECB) level to the Italian intra-national (NUTS2) level, the empirical estimations of this Chapter are based on the MRO rate, implying the monetary policy interest rate, and regional revocable loan interest rates for Italy. As explained in Chapter 2, the MRO rate is set by the central bank, which establishes this rate as the monetary policy interest rate.

A further factor which differentiates the empirical analysis in this Chapter from the literature is that structural breaks related to the 2007 – 2008 Financial Crisis are determined endogenously. As presented in Section 5.2.3.3, different methods are employed in the literature to detect and control for the timing of the Crisis and its resulting structural breaks. In this Chapter, structural breaks are controlled by adding a dummy variable or trend variable into the model specification. This approach leads to more robust speed of adjustment proxies.

This Chapter was inspired by Montagnoli et al. (2016) to a high extent. However, there are some key differences between this Chapter and Montagnoli et al. (2016). Montagnoli et al. (2016) investigated the speed of adjustment between a money market interest rate and an interest rate on loans of €75,000 and above per Italian NUTS2 region. In this Chapter, the speed of adjustment is analysed between the MRO interest rate and revocable loan interest rates per Italian NUTS2 region. Therefore, the analysis of this Chapter is based on an investigation from the European supra level across intra-national regions. Furthermore, the regional interest rates in this Chapter are based on revocable loans.

In Montagnoli et al. (2016) the short-term aspect is captured through the maturity of loans up to 12 months. In this Chapter no differentiation is used in terms of loan value and/or maturity. Finally, Montagnoli et al. (2016) used an ECM which was mathematically rearranged and the speed of adjustment proxies were then estimated by OLS, whereas this Chapter's estimations are based on regional ARDL models and the necessary pre-estimations. In this way, the data characteristics of each regional time-series are incorporated in each regional model. Furthermore, this Chapter controls for the 2007 – 2008 Financial Crisis.

The contributions of this Chapter are based on the combination of four elements leading to a specific monetary policy speed of adjustment investigation. These elements are:

- Data selection, namely the MRO and revocable loan interest rates observed in each of the 20 Italian NUTS2 regions.
- The influence of national characteristics is kept constant through the data selection, as speed of adjustment proxies are computed in an environment of uniform national characteristics on an intra-national level. As a result, the heterogeneity in results should not be influenced by any national macroeconomic factor.
- Proxies are estimated based on regional ARDL models. The regional aspect is accredited to the point that optimal lag-length and rank are built in each regional ARDL model.
- The method used for the structural break identification and control for the 2007 – 2008 Financial Crisis in each regional estimation also adds to the contribution of this Chapter.

Overall, the combination of the above-mentioned contributions leads to an original speed of adjustment investigation, analysing the speed of adjustment from a supra- to an intra-national level, through deriving regional models, studying the extent of the speed of adjustment and controlling endogenously for the 2007 – 2008 Financial Crisis.

5.3 Empirical Implementation

The overall objective of this Chapter is to empirically investigate the third sub-mechanism of the MPTM, namely the speed of adjustment, from the ECB across Italian NUTS2 regions, for the period 1999q4 – 2017q1. Furthermore, the interest is to identify how the speed of adjustment differs across regions. Therefore, speed of adjustment proxies per Italian NUTS2 region must be calculated.

The purpose of this section is to draw out the methodology employed in this Chapter in order to estimate speed of adjustment indicators for each Italian NUTS2 region. This section builds on Chapter 2, which presented the data employed in this thesis and discussed various estimation strategies, including pre-estimation procedures.

The speed of adjustment in this Chapter is computed as the rate (given in percent) by which the revocable loan interest rate in each NUTS2 region adjusts back to its equilibrium path. This proxy denotes the extent at which shocks are absorbed in the regional interest rate and hence to understand differences in the effectiveness of the monetary policy across Italian regions. For this purpose, an ARDL model is estimated, as introduced and discussed in Section 2.3.5. This approach also controls for the effects of any national macroeconomic factors which may influence the speed of adjustment of monetary policy (Sander and Kleimeier, 2004; Zaffaroni, 2004; Granger, 1980).

Since the pre-estimation tests have identified that the employed data is cointegrated of rank I(1), the long-run solution of an ARDL model, also called the EC version of an ARDL model, is estimated in this Chapter. Following Asteriou and Hall (2016), an ARDL model in its long-run solution is represented as follows:

$$\Delta RL_{R,t} = C_{RL_R} + \sum_{R=1}^{k} \beta_{RL_{R,i}} \Delta RL_{R,t-i} + \sum_{R=1}^{k} \gamma_{RL_{R,i}} \Delta MRO_{t-i} - \pi_{RL_{R,i}} \hat{e}_{R,t-i} + \varepsilon_{RL_{R,t}} \quad (5.1)$$

where $RL_{R,t}$ represents the regional revocable loan interest rate time-series ($RL_{R,t}$) for region R at quarter t and lag length i, MRO_t is the MRO interest rate time-series for each t quarter, and C_{RL_R} is the model constant for the revocable loan interest rate. Equation (5.1) is the adapted version of the ARDL model presented in equation (2.9) of Chapter 2.3.5, where the interpretation of each estimation parameter is discussed.

The main variable of interest in this Chapter is the coefficient of the error correction term, $\pi_{RL_{R,i}}$, in equation (5.1). This coefficient can be interpreted as a measure of the regional monetary policy speed of adjustment and is given in percentages. This coefficient is a short-run parameter which measures how quickly the deviations “from the long-run relationship observed in the previous period are corrected in period t” (Montagnoli et al., 2016, p. 1409).

Speed of adjustment values are expected to lie between 0 and 1. A speed of adjustment of 1 is interpreted as 100 percent of the adjustment towards an equilibrium within a given time. A speed of adjustment close to 0 represents a minimal adjustment towards the equilibrium within a given time period. Equilibrium is defined as the steady state of two cointegrated time-series.

Based on the monetary policy context and the data employed in this thesis, the speed of adjustment is understood in the following way: In an econometric specification, a long-run trend is estimated from the time-series, namely the MRO interest rate and the revocable loan interest rate of a region. Once the quarterly observation deviates from this long-run trend, the speed of adjustment coefficient determines the proportion (given in percent) which is adjusted to get back to the equilibrium path per region.

A large value on the speed of adjustment indicates that the deviation from the long-run growth path in the period t-1 will be corrected quickly in period t. Therefore, this Chapter follows the coefficient interpretation of Gambacorta (2008), where a high level of speed of adjustment indicates that shocks are absorbed quickly by the regional interest rates and these rates do not seem to deviate from its equilibrium and vice versa. As a result, a high level of speed of adjustment indicates an effective monetary policy whilst a low level of speed of adjustment may indicate a less effective monetary policy.

Thus, the empirical approximation of the speed of adjustment is defined as the correction process in the dependent variable towards equilibrium in the last period.

5.4 Results

The purpose of this section is to examine the speed of adjustment results across the Italian NUTS2 regions, following the ARDL estimation strategy and model specifications. This section is divided into two further sections: First, results for the general ARDL estimations are discussed; the second section presents results for ARDL estimations which control for the Financial Crisis.

5.4.1 Pre-Estimation Results

As discussed in Chapter 2, the ARDL estimation approach was identified as appropriate estimation strategy for this Chapter as it provides the monetary policy speed of adjustment proxy when combining time-series of a regional revocable loan interest rate and the MRO rate. Following ECB (2013), to avoid quarterly volatility, level data were transformed to annual moving averages.

To identify the most appropriate model specification, three pre-estimation tests have to be conducted. The pre-estimation tests consist of investigations for data stationarity, identifying cointegration between regional interest rates and the MRO, applying the maximal lag-length based on the employed sample and selecting the optimal lag-length.

First, the Augmented Dickey Fuller (ADF) unit-root test was applied to test the stationarity of the employed time-series (Asteriou and Hall, 2016). For further information on the ADF unit-root test, please see Section 3.4.1. In summary, results for the six cases investigated by the ADF unit-root test are presented in Appendix Tables B.1 and B.2 and show that each regional time-series is non-stationary in levels but is stationary in first differences. This finding infers that the time-series are non-stationary.

Second, an ARDL-ECM model per cointegrated region is estimated, incorporating the max lag-length of 10, as suggested by Schwert (1989). This is shown in column ‘Maxlag’ of Table 5.1. For further information on the lag-length selection please see Section 3.4.1. In each regional ARDL the optimal lag-length is based on the Bayesian Information Criteria (BIC). Table 5.1 summarises the optimal lag-length for y, the regional interest rate, (given by p) in column ‘Optimum p-lag’ and x, the MRO, (given by q) in column ‘Optimum q-lag’, where the error term has no serial correlation. Column ‘BIC’ provides the lowest BIC value per region, estimated by the Bayesian Information Criteria (BIC)13.

[13] Full list of BIC values per region are available on request.

Table 5.1 Optimal Lag-Length Selection Based on BIC

NUTS2	Maxlag	Optimum p-lag	Optimum q-lag	BIC
Piemonte	10	2	1	-99.846
Valle d'Aosta/Vallée d'Aoste	10	2	4	-69.223
Liguria	10	2	3	-113.936
Lombardia	10	6	9	-114.228
Provincia Autonoma di Trento	10	2	3	-167.646
Veneto	10	4	3	-106.645
Friuli-Venezia Giulia	10	6	9	-49.874
Emilia-Romagna	10	6	9	-112.935
Toscana	10	2	2	-65.013
Umbria	10	3	1	-32.131
Marche	10	2	3	-111.129
Lazio (Roma)	10	2	2	-46.730
Abruzzo	10	6	1	-109.853
Molise	10	2	1	-76.184
Campania	10	6	3	-87.460
Puglia	10	2	3	-90.464
Basilicata	10	3	1	-87.684
Calabria	10	6	1	-67.526
Sicilia	10	7	3	-58.876
Sardegna	10	2	1	-48.246

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).

Based on the undertaken pre-estimation tests, the most appropriate model specifications per region were identified. The following section presents the speed of adjustment results estimated with the identified regional ARDLs.

Third, in order to estimate the ARDL the cointegration of each regional time-series with the MRO is tested by the bounds testing procedure suggested by Pesaran et al. (2001). This bounce test is based on the above discussed ARDL model specification. The reason for the application of the bounce test is that in this thesis only two variables are considered per estimation, namely an interest rate per region and the MRO. This means that the case is bivariate and hence at most only one cointegrating relationship is expected. Therefore, in this thesis the identification of the number of cointegrating vectors is not pivotal. Following Pesaran et al. (2001) and Narayan (2005), a bounds testing procedure, is conducted to examine whether a long-run relationship exists between each regional time-series and the MRO. The null hypothesis of this test assumes no long-run relationship between the employed variables whilst the alternative hypothesis assumes the presence of a long-run relationship ($H_0 = \beta_{RL_{R,i}} = \gamma_{RL_{R,i}} = 0$, versus $H_A \neq \beta_{RL_{R,i}} \neq \gamma_{RL_{R,i}} \neq 0$).

The bounce testing procedure provides an F- and t-statistic for the hypothesis testing. “If the computed F-statistics is higher than the upper bound of the critical values then the null hypothesis of no cointegration is rejected” (Narayan, 2005, p. 1981). The t-statistics is rejected if the test statistic is smaller than the critical value. In both cases (F- and t-statistics), the result is inconclusive if the critical value falls within the upper and lower bound. The asymptotic distribution of the critical values is provided for cases where all regressors are I(1), I(0) or mutually cointegrated (Pesaran et al., 2001; Narayan, 2005).

The upper panel of Table 5.2 provides the F-statistics, the upper and lower bound critical values of the bounds test, the decision and statistical significance. The lower panel of Table 5.2 provides the t-statistics, the upper and lower bound critical values of the bounds test, the test decision and statistical significance. In this Chapter regions are identified as being cointegrated if the null hypothesis using the F-statistics or the t-statistics, or both are rejected.

Based on the F- and t-statistics shown in Table 5.2, interest rates of 11 NUTS2 regions are cointegrated with the MRO. These are the regions where the null hypothesis is rejected in column ‘Test Decision’. In detail cointegration was found in one north-western region (Lombardia), three north-eastern regions (Veneto, Friuli-Venezia Giulia, Emilia-Romagna), one central region (Umbria), five southern regions (Abruzzo, Molise, Campania, Puglia and Calabria) and one of the islands (Sicilia). In summary, based on the bounds test, a north-south divide was found in terms of cointegration. In this case nearly all southern regions, one island and one central region are cointegrated.

Table 5.2 F-Statistics of the Bounds Test per NUTS2 region

NUTS2	Statistic	Critical values								Test	Level
		10%		5%		2.5%		1%			
		I [0]	I [1]	I [0]	I [1]	I [0]	I [1]	I [0]	I [1]		
F-statistic											
Piemonte	2.378	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Fail to reject	-
Valle d'Aosta/Vallée d'Aoste	3.614	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Fail to reject	-
Liguria	2.290	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Fail to reject	-
Lombardia	7.047	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Reject	2.5%
Provincia Autonoma di Trento	3.814	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Fail to reject	-
Veneto	8.819	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Reject	1%
Friuli-Venezia Giulia	5.229	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Reject	10%
Emilia-Romagna	6.943	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Reject	2.5%
Toscana	2.691	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Fail to reject	-
Umbria	5.686	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Reject	10%
Marche	1.673	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Fail to reject	-
Lazio (Roma)	2.055	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Fail to reject	-
Abruzzo	5.395	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Reject	10%
Molise	11.371	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Reject	1%
Campania	11.586	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Reject	1%
Puglia	5.009	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Reject	10%
Basilicata	2.421	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Fail to reject	-
Calabria	4.474	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Inconclusive	10%
Sicilia	7.808	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Reject	2.5%
Sardegna	1.989	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	Fail to reject	-
t-statistic											
Piemonte	-2.009	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Fail to reject	-
Valle d'Aosta/Vallée d'Aoste	-1.857	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Fail to reject	-
Liguria	-1.866	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Fail to reject	-
Lombardia	-2.895	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Inconclusive	10%
Provincia Autonoma di Trento	-2.705	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Inconclusive	10%
Veneto	-4.174	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Reject	1%
Friuli-Venezia Giulia	-2.708	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Inconclusive	10%
Emilia-Romagna	-3.166	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Reject	10%
Toscana	-2.306	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Fail to reject	-
Umbria	-3.253	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Reject	5%
Marche	-1.257	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Fail to reject	-
Lazio (Roma)	-1.961	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Fail to reject	-
Abruzzo	-3.222	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Reject	5%
Molise	-4.759	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Reject	1%
Campania	-4.813	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Reject	1%
Puglia	-3.081	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Reject	10%
Basilicata	-2.162	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Fail to reject	-
Calabria	-2.917	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Reject	10%
Sicilia	-3.952	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Reject	1%
Sardegna	-1.994	-2.57	-2.91	-2.86	-3.22	-3.13	-3.5	-3.43	-3.82	Fail to reject	-

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: accept if F < critical value for $I(0)$ regressors, reject if F > critical value for $I(1)$ regressors; accept if t > critical value for $I(0)$ regressors, reject if t < critical value for $I(1)$ regressors.

Based on the analysis in this section, speed of adjustment proxies are estimated only for regions that are cointegrated with the MRO-rate. Furthermore, the speed of adjustments is estimated following the regional specifications as discussed in this section.

5.4.2 Estimation Results

In this section, first the speed of adjustment results are presented based on a simple ARDL-ECM model. As defined in Section 5.3, the speed of adjustment proxies were estimated following the ARDL estimation strategy in its long-run solution. A speed of adjustment coefficient close to 0 implies that the correction towards equilibrium during the last period is only minimal. As a result, the speed of adjustment is sluggish and monetary policy transmits slowly to a particular region's bank lending rate. Equivalently, high levels of speed of adjustment (a speed of adjustment close to 1) imply that the correction towards equilibrium during the last period is fast. Therefore, a high level of speed of adjustment is interpreted as more effective monetary policy (Gambacorta, 2008). Table 5.3 shows results of the speed of adjustment proxies based on regional ARDL-EC models. Column 'SoA' summarises the baseline speed of adjustment results.

Table 5.3 Speed of Adjustment Estimations per NUTS2 Region

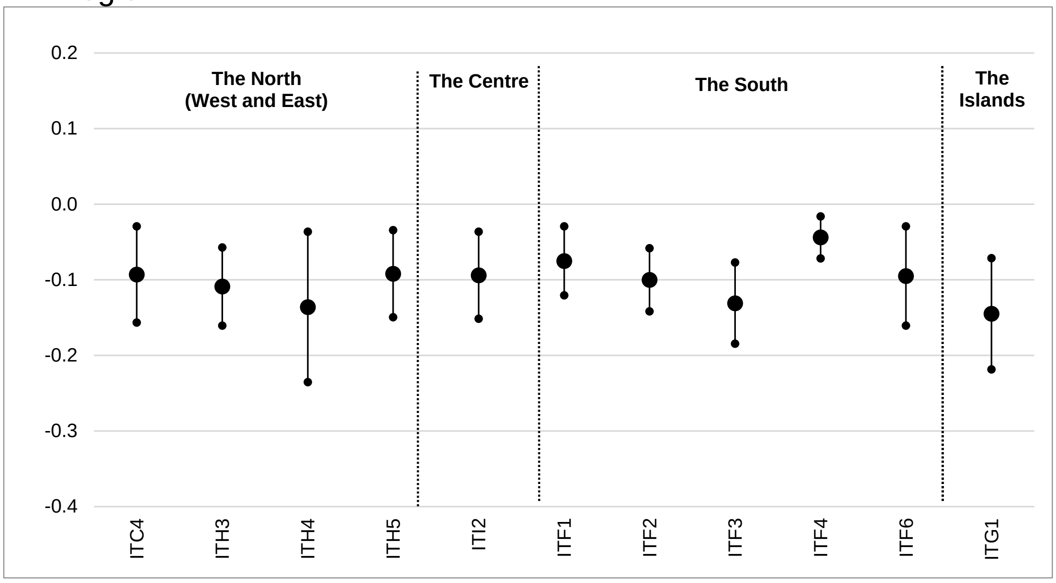
NUTS1	NUTS2	SoA
North West	Lombardia	-0.093***
		(0.032)
North East	Veneto	-0.109***
		(0.026)
	Friuli-Venezia Giulia	-0.136***
		(0.050)
	Emilia-Romagna	-0.092***
		(0.029)
Centre	Umbria	-0.094***
		(0.029)
South	Abruzzo	-0.075***
		(0.023)
	Molise	-0.100***
		(0.021)
	Campania	-0.131***
		(0.027)
	Puglia	-0.044***
		(0.014)
	Calabria	-0.095***
		(0.033)
The Islands	Sicilia	-0.145***
		(0.037)

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Standard errors in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively. For full results, please see Appendix D.1.

The baseline results presented in the 'SoA' column of Table 5.3 show a mixed regional pattern of levels of speed of adjustment. The highest speed of adjustment was observed in Sicilia (14.5%) whilst the lowest level of speed of adjustment was observed in Puglia (4.4%). Both regions belong to the south NUTS2 classification. The coefficient estimate for Sicilia indicates that in the next quarter 14.5% of an exogenous variation from the equilibrium path of the employed time-series is adjusted, on average, back towards equilibrium. This result indicates that it takes less than seven quarters for the interest rate in Sicilia to get back onto the long-run path. In terms of Puglia only 4.4% of an exogenous shock would be adjusted towards the equilibrium in the next period, which means that it takes less than 25 quarters for the interest rate to get back onto the long-run path. The discussed results are statistically significant at 1% and have the required negative sign. Table 5.3 shows that speed of adjustment is much more clustered than in previous cases. This finding is also visible in Figure 5.1.

Figure 5.1 illustrates the estimates speed of adjustment coefficient estimates as well as their confidence intervals based on the ARDL estimation approach. The Figure confirms that speeds of adjustment are more similar across the regions than any other proxy. Although the southern regions indicate a slightly lower level of the speed of adjustment.

Figure 5.1 ARDL Speed of Adjustment and Confidence Intervals per NUTS2 Region



Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Note: Confidence intervals at 95% significance level. NUTS2 regional abbreviations are provided in Table 2.1 of Chapter 2.2.

A further finding obtained from Figure 5.1 is that, on average, the variability of the speed of adjustment tends to be slightly higher across northern regions than the centre and the south. This implies that the speed of adjustment varied across norther regions during the sample period slightly more than across the central and southern regions.

The north-south divide found in previous chapters is confirmed across the speed of adjustment results. This north-shout divide is based on the average speed of adjustment for the northern regions and the centre, south and Sicilia presented in Table 5.3. The average speed of adjustment for the northern regions is 10.75% whilst the average speed of adjustment for the centre, south and Sicilia is 8.48%. Based on the speed of adjustment results, the effectiveness of the ECB monetary policy seems to be higher in some northern regions, which is in line with speed of adjustment results found in the literature (Havranek et al., 2016; Montagnoli et al., 2016; Bogoev and Petrevski, 2012; Horváth and Podpiera, 2012; Karagiannis et al., 2011; de Bondt, 2005). It should also be noted that the north-south divide in the speed of adjustment estimates is found across the two estimation strategies applied in this thesis, namely the VECM and the ARDL approaches.

Considering the industrial characterisation of the NUTS2 regions, as discussed in Chapter 2.2.3 and Chapter 3.4.4, the obtained speed of adjustment results show that in more economically developed regions, the northern regions of Italy, the speed of adjustment is relatively high and it is more aligned across the regions. On average, these regions react more quickly to adjust the lending rates towards the equilibrium if the ECB changes the MRO rate. On the other hand, in Puglia, a less developed region where agriculture is a substantial sector of the economy and unemployment is high especially following the crisis (EC, 2019b), the speed of adjustment was found to be much lower.

Furthermore, based on ARDL-ECM estimations presented in Table 5.3, the national speed of adjustment is 10.1% Considering the regional VECM speed of adjustment results reported in Table 4.1 of the previous Chapter, an average speed of adjustment rate of 15% is obtained. Gambacorta (2008) obtained a national average of 40% for Italy based on the period 1993q3 –

2001q3. In qualitative terms, both strategies provide similar patterns even if the magnitude of the estimates differs. This difference in magnitude is due to the different estimation strategies. Gambacorta (2008) uses different data, a different research period and estimation strategy. The average national level estimates of ARDL-ECM and VECM speed of adjustments for the period 1999q – 2017q1 of this thesis were calculated using a simple average of the observed regional ARDL-ECM and VECM speed of adjustment proxies. In contrast, the average speed of adjustment obtained by Gambacorta (2008) for the time period of 1999q3 – 2001q3 is based on bank balance sheet data. When comparing the average VECM speed of adjustment estimate with Gambacorta's result it becomes apparent that the speed of adjustment between 1999q3 and 2001q3 was slightly higher than during the period 1999q – 2017q1.

Karagiannis et al. (2011) note that the speed of adjustment can be interpreted as an indicator for the level of competition in the banking sector. Therefore, based on the VECM and ARDL-ECM results presented in Table 4.1 and Table 5.1, it can be concluded that the competition level in the northern regions of Italy may be higher than in the central and southern regions. Furthermore, the different levels of competition in the Italian banking sector during the research period used in the work by Gambacorta (2008) and this thesis may have also contributed to the deviation in the speed of adjustment results. At the beginning of 2000, the competition level in the Italian banking sector was higher than during the last ten years but it then fell again since the 2007 – 2008 Financial Crisis due to the subsequent mergers and acquisitions in this sector (Marchionne and Zazzaro, 2018; Visco, 2018). In this case, the theoretical argument of high competition levels leading to higher speed of adjustment would hold (Karagiannis et al., 2011; Leuvensteijn et al., 2008; de Bondt, 2005).

Bogoev and Petrevski (2012) calculated a speed of adjustment of 5% for Macedonia for the period 2002 – 2010. The reason for this finding may be that Macedonia is an open economy with a relatively high level of currency substitution; furthermore, the research period encompasses a time of financial, economic, political and institutional reforms and changes in

Macedonia which may have contributed to the observed low level of speed of adjustment (Bogoev and Petrevski, 2012).

5.4.3 Financial Crisis

The purpose of this section is to examine the speed of adjustment for the 11 cointegrated Italian NUTS2 regions, as identified in Section 5.2.4, whilst controlling for the 2007 – 2008 Financial Crisis. In other words, in this section the 11 cointegrated regions that were found in Section 5.2.4 are analysed for structural breaks.

5.4.3.1 Pre-Estimation Tests and the Financial Crisis Control

In order to control for the Financial Crisis within an ARDL estimation approach, an ARDL-ECM model per region was estimated. Therefore, the same procedure was undertaken as explained in Section 5.4.1, meaning pre-estimation tests have been conducted as for a standard ARDL estimation approach, discussed in Section 5.4.1. This means that first, the non-stationarity of the time-series was identified. For further explanation please see Section 3.4.1.

Second, following Pesaran et al. (2001) and Narayan (2005), a bounds testing procedure was conducted to examine whether a long-run relationship exists between the each regional time-series and the MRO. In this Chapter regions are identified as being cointegrated if the null hypothesis using the F-statistics or the t-statistics, or both is rejected. Based on the bounds testing procedure 11 cointegrated regions were identified. For detailed bounds test results please see Section 5.4.1.

Third, a regional ARDL model was estimated for each of the 11 cointegrated regions, incorporating the maximum lag-length, as suggested by Schwert (1989). For further information on Schwert (1989) please see Section 3.4.1. The 11 cointegrated regions were found in Section 5.4.1. The optimal lag-length was determined by the BIC. In the left panel under the classification ‘ARDL estimation’, Table 5.4 summarises ARDL-ECM specifications for each cointegrated region. Column ‘Maxlag’ provides the applied maximal lag-length, as followed by Schwert (1989). Column ‘Optimum p-lag’ provides the optimal lag-length of the dependent variable, namely the regional interest rate. Column, ‘Optimum q-lag’ provides the optimal lag-length of the independent variable, namely the MRO-rate. Column ‘Obs’ indicates the number of observations per regional ARDL. The left panel of Table 5.4 shows the optimal lag-length per region.

Table 5.4 Regional ARDL specifications and ARDL Residual Statistics

NUTS2	ARDL estimation				ARDL residual			
	Maxlag	Optimum p-lag	Optimum q-lag	Obs	Mean	Standard Deviation	Minimum	Maximum
Lombardia	10	6	9	58	0.000	0.049	-0.112	0.105
Veneto	10	4	3	63	0.003	0.073	-0.159	0.243
Friuli-Venezia Giulia	10	6	9	58	-0.005	0.093	-0.272	0.206
Emilia-Romagna	10	6	9	58	0.000	0.049	-0.130	0.104
Umbria	10	3	1	64	0.013	0.147	-0.538	0.600
Abruzzo	10	6	1	61	0.001	0.082	-0.295	0.190
Molise	10	2	1	65	-0.005	0.118	-0.270	0.272
Campania	10	6	3	61	0.004	0.078	-0.141	0.213
Puglia	10	2	3	64	0.002	0.087	-0.266	0.209
Calabria	10	6	1	61	-0.001	0.098	-0.311	0.216
Sicilia	10	7	3	60	0.005	0.096	-0.253	0.207

Source: Author’s estimation using Bank of Italy (2017b) and ECB (2019d).

Four, after estimating each regional ARDL the residual was saved and some diagnostic statistics were conducted. In the right panel, under the classification ‘ARDL residual’, Table 5.4 summarises diagnostic statistics for each ARDL residual term for a cointegrated region. In detail column ‘Mean’ provides the mean of each regional residual. Column ‘Standard Deviation’ provides the standard deviation of that ARDL residual. Columns ‘Minimum’ and ‘Maximum’ provide the minima and maxima of each regional residual, respectively. The right panel of Table 5.4 shows that errors are normally distributed with mean of 0, as expected.

Five, the stationarity of each ARDL residual is then tested using the ADF unit-root test (Dickey and Fuller, 1979). Table 5.5 summaries the ADF unit-root tests on the regional ARDL predicted residuals. The ADF null hypothesis assumes a unit-root (non-stationarity), whereas the alternative hypothesis assumes no unit-root presence (stationarity). Based on Table 5.5 the null hypothesis of non-stationarity is rejected for each cointegrated region. This means that the ARDL residuals are stationary.

Table 5.5 ADF Unit-Root Test for Stationarity on ARDL Residuals on Each Cointegrated Region

NUTS2	Test statistic	Critical values		
		1%	5%	10%
Lombardia	-8.826***	-3.570	-2.924	-2.597
Veneto	-6.618***	-3.563	-2.920	-2.595
Friuli-Venezia Giulia	-8.771***	-3.570	-2.924	-2.597
Emilia-Romagna	-8.184***	-3.570	-2.924	-2.597
Umbria	-7.817***	-3.562	-2.920	-2.595
Abruzzo	-8.925***	-3.566	-2.922	-2.596
Molise	-7.128***	-3.560	-2.919	-2.594
Campania	-8.031***	-3.566	-2.922	-2.596
Puglia	-8.283***	-3.562	-2.920	-2.595
Calabria	-7.700***	-3.566	-2.922	-2.596
Sicilia	-7.774***	-3.567	-2.923	-2.596

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

Six, the Zivot and Andrews (1992) unit-root test is conducted on each earlier predicted ARDL residual for Models A, B and C, applying the maximum lag-length as suggested by Schwert (1989) to identify the appropriate specification. For further information on the Zivot and Andrews (1992) unit-root test and the three models please see Section 2.3.8. In short, Model A tests for unit-root and allows for a structural break in the intercept. Model B tests for unit-root and allows for a structural break in the trend. Model C tests for unit-root and allows for a structural break in both, intercept and trend.

The null hypothesis of the Zivot and Andrews (1992) unit-root is that the time-series is non-stationary against the alternative hypothesis of stationarity in a univariate time-series. Therefore, in this Chapter the Zivot and Andrews (1992) unit-root test is undertaken based on the earlier estimated ARDL residuals of the cointegrated regions. Table 5.6 summarises the Zivot and Andrews (1992) unit-root results. Column 'Model' provides the three estimated models. Column 'Breakpoint data' provides the identified break points. Column 't-statistic' provides the obtained t-statistics of the test per region. The last three columns provide the critical values of the test.

Table 5.6 Zivot and Andrews (1992) Unit-Root test for Cointegrated Regions

NUTS2	Model	Breakpoint date	t-statistic	Critical values		
				1%	5%	10%
Lombardia	Intercept	2013q2	-4.14	-5.34	-4.80	-4.58
	Trend	2014q4	-3.94	-4.93	-4.42	-4.11
	Both	2013q2	-4.57	-5.57	-5.08	-4.82
Veneto	Intercept	2005q2	-7.68***	-5.34	-4.80	-4.58
	Trend	2009q2	-7.095***	-4.93	-4.42	-4.11
	Both	2005q2	-7.652***	-5.57	-5.08	-4.82
Friuli-Venezia Giulia	Intercept	2005q3	-8.855***	-5.34	-4.80	-4.58
	Trend	2014q4	-8.965***	-4.93	-4.42	-4.11
	Both	2014q1	-9.398***	-5.57	-5.08	-4.82
Emilia-Romagna	Intercept	2007q4	-8.529***	-5.34	-4.80	-4.58
	Trend	2014q4	-8.263***	-4.93	-4.42	-4.11
	Both	2007q4	-8.640***	-5.57	-5.08	-4.82
Umbria	Intercept	2011q4	-8.768***	-5.34	-4.80	-4.58
	Trend	2014q3	-8.224***	-4.93	-4.42	-4.11
	Both	2011q4	-9.233***	-5.57	-5.08	-4.82
Abruzzo	Intercept	2011q1	-10.486***	-5.34	-4.80	-4.58
	Trend	2007q2	-10.324***	-4.93	-4.42	-4.11
	Both	2008q2	-10.514***	-5.57	-5.08	-4.82
Molise	Intercept	2009q4	-7.389***	-5.34	-4.80	-4.58
	Trend	2014q3	-7.305***	-4.93	-4.42	-4.11
	Both	2003q4	-7.949***	-5.57	-5.08	-4.82
Campania	Intercept	2011q4	-8.825***	-5.34	-4.80	-4.58
	Trend	2007q2	-8.554***	-4.93	-4.42	-4.11
	Both	2009q4	-8.871***	-5.57	-5.08	-4.82
Puglia	Intercept	2005q2	-8.699***	-5.34	-4.80	-4.58
	Trend	2006q4	-8.327***	-4.93	-4.42	-4.11
	Both	2005q2	-8.708***	-5.57	-5.08	-4.82
Calabria	Intercept	2011q1	-8.27***	-5.34	-4.80	-4.58
	Trend	2014q4	-8.004***	-4.93	-4.42	-4.11
	Both	2013q1	-8.471***	-5.57	-5.08	-4.82
Sicilia	Intercept	2005q2	-8.961***	-5.34	-4.80	-4.58
	Trend	2007q2	-8.593***	-4.93	-4.42	-4.11
	Both	2005q2	-8.918***	-5.57	-5.08	-4.82

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

Based on the t-statistics shown in Table 5.6, the null hypothesis of unit-root with a single structural break can be rejected at 1% for the three models, for all regions with the exception of Lombardia. This indicates again that the residuals are stationary and structural breaks have been identified in all regions and across the three models with the exception of Lombardia. Since the null hypothesis for Lombardia cannot be rejected this means that the ARDL residual is non-stationary and no structural breaks are found across the three models. Therefore, Lombardia is excluded from the structural break analysis.

The structural breaks associated with FCP1 are observed in Veneto (Trend), Molise (Intercept) and Campania (Both) and occur in 2009. This, in turn, reveals that the banking system in these regions experienced an increased occurrence of non-performing loans before the other regions. Due to changes in economic and financial circumstances, debtors were unable to meet their financial obligations with their lenders leading to non-performing loans (Bank of Italy, 2017a). Structural breaks associated with FCP2 are observed in Friuli-Venezia Giulia (Trend and Both), Emilia-Romagna (Trend), Umbria (Intercept, Trend, Both), Abruzzo (Intercept), Molise (Trend), and Campania (Intercept, Trend and Both). It follows that Umbria and Calabria were impacted by the FCP2 and indicate that an increase in non-performing loans occurred late.

Seven, for consistency following Chapter 3 and 4, Model A and Model B were estimated when controlling for structural breaks which means that structural breaks in the intercept or trend are accounted for. To control for the structural break in the ARDL-ECM speed of adjustment, a dummy and a trend variable were generated for each breakpoint date. The dummy and trend variables were set at the break point identified via Zivot and Andrews (1992) unit-root test. Depending on the estimated model, these were then added to the respective ARDL-ECM estimations. This approach allows for an analysis of the speed of adjustment whilst controlling for a structural break.

In detail, a dummy variable was generated which takes the value of 1 from the quarter when the structural break is identified in region R until the end of the series and otherwise 0. For example, the dummy variable for Veneto would start at 2005Q2 for the intercept case (Model A). (For further information on Models A, B and C, please see Section 2.3.8.)

To analyse a structural break in the trend, a trend variable was set which takes the value 1 from the quarter when the structural break was identified in region R and increases by 1 for each quarter until the end of the series and is 0 otherwise. In case of Veneto the trend variable would be set to 1 at 2009q2.

Eight, an ARDL-ECM was calculated for each model and region including the structural break dummy or trend variable. ARDL estimations have been conducted following Model A and Model B as defined in Section 2.3.8. The reason for this approach is that in this way structural break estimations follow a consistent approach across the chapters. Therefore, two ARDL-ECMs per region were estimated: one with a dummy to represent Model A and one with a trend variable to represent Model B.

Furthermore, each regional ARDL model was estimated with maximal lag-length as suggested by Schwert (1989). The optimal lag-length was then identified by the BIC. Table 5.7 provides details regarding the appropriate specifications for each region for Model A and Model B. In detail, the left panel entitled 'Intercept' provides ARDL-ECM specifications for Model A and the right panel denoted as 'Trend' provides ARDL-ECM specifications for Model B. Column 'Maxlag' shows the applied max lag-length. Column 'Optimum p-lag' provides the optimal lag-length of the dependent variable, the regional interest rate in this Chapter. Column 'Optimum q1-lag' provides the optimal lag-length of the independent variable, the MRO-rate in this case. 'Optimum q2-lag' provides the optimal lag-length of the dummy variable. Column 'BIC' provides the lowest BIC value per region, estimated by the Bayesian Information Criteria (BIC)14.

The right panel with the title 'Trend' provides information based on Model B. Furthermore, column 'Optimum q2-lag' provides the optimal lag-length of the trend variable.

Table 5.7 ARDL Specifications of Model A/Intercept and Model B/Trend

NUTS2	Intercept					Trend				
	Maxlag	Optimum p-lag	Optimum q1-lag	Optimum q2-lag	BIC	Maxlag	Optimum p-lag	Optimum q1-lag	Optimum q2-lag	BIC
Veneto	10	4	3	0	-114.159	10	4	3	0	-102.604
Friuli-Venezia Giulia	10	6	9	0	-48.041	10	6	9	0	-50.578
Emilia-Romagna	10	6	9	10	-132.252	10	6	9	0	-110.851
Umbria	10	2	1	0	-35.911	10	2	2	0	-34.907
Abruzzo	10	6	2	0	-108.463	10	6	1	0	-107.415
Molise	10	3	1	0	-73.374	10	2	1	0	-78.008
Campania	10	6	7	0	-85.403	10	6	3	0	-86.880
Puglia	10	6	2	6	-109.487	10	2	1	0	-87.041
Calabria	10	6	1	0	-64.412	10	6	1	0	-69.010
Sicilia	10	8	2	0	-66.125	10	7	2	0	-57.396

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).

14 Full list of BIC values per region are available on request.

Nine, for Model A and Model B for each originally cointegrated region (as discussed in Section 5.4.2) a bounds test was conducted to re-examine cointegration of the modified specification using the above discussed ARDL specification. Table 5.8 summarises the bounds test results for Model A.

The bounds testing procedure provides an F- and t-statistic for the hypothesis testing. "If the computed F-statistics is higher than the upper bound of the critical values then the null hypothesis of no cointegration is rejected" (Narayan, 2005, p. 1981). The t-statistics is rejected if it is smaller than the critical value. In both cases (F- and t-statistics), the result is inconclusive if the critical value falls within the upper and lower bound (Pesaran et al., 2001; Narayan, 2005).

The upper panel of Table 5.8 provides the F-statistics, the upper and lower bound critical values, the decision and statistical significance. The lower panel of Table 5.8 provides the t-statistics, the upper and lower bound critical values, the test decision and statistical significance. In this Chapter regions are identifies as being cointegrated if the null hypothesis using the F-statistics or the t-statistics, or both is rejected.

Table 5.8 Bounds Test for Model A/Intercept

NUTS2	Statistic	Critical values								Test Decision	Level
		10%		5%		2.5%		1%			
		I [0]	I [1]	I [0]	I [1]	I [0]	I [1]	I [0]	I [1]		
F-statistic											
Veneto	10.572	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	1%
Friuli-Venezia Giulia	4.047	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Inconclusive	10%
Emilia-Romagna	3.174	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Inconclusive	10%
Umbria	5.624	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	2.5%
Abruzzo	4.631	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	10%
Molise	3.194	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Fail to reject	-
Campania	12.577	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	1%
Puglia	7.749	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	1%
Calabria	3.226	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Fail to reject	-
Sicilia	12.271	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	1%
t-statistic											
Veneto	-5.494	-2.57	-3.21	-2.86	-3.53	-3.13	-3.8	-3.43	-4.10	Reject	1%
Friuli-Venezia Giulia	-2.894	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Inconclusive	10%
Emilia-Romagna	-2.606	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Inconclusive	10%
Umbria	-4.022	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Reject	2.5%
Abruzzo	-1.472	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Fail to reject	-
Molise	-2.420	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Fail to reject	-
Campania	-6.006	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Reject	1%
Puglia	-4.408	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Reject	1%
Calabria	-2.962	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Fail to reject	-
Sicilia	-5.820	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Reject	1%

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).

Based on the F- and t-statistics shown in Table 5.8, interest rates of six NUTS2 regions are cointegrated with the MRO when controlling for a structural break in the intercept. These are the regions where the null hypothesis is rejected in column ‘Test Decision’. In detail cointegration was found in one north-eastern region (Veneto), one central region (Umbria), three southern regions (Abruzzo, Campania and Puglia) and one of the islands (Sicilia).

In summary, based on the bounds test on Model A, a north-south divide was found in terms of cointegration. No north-western region is cointegrated. Only one north-eastern region is cointegrated but the majority of southern regions, including Umbria and Sicily are cointegrated. This means that on average interest rates of the southern regions, Umbria and Sicilia have a long-run relationship with the MRO-rate. Interest rates in north-western and most north-eastern regions do not indicate a long-run relationship with the MRO-rate based on this estimation approach.

Table 5.9 summarises the bounds test results for Model B. In this case, regions are identified as being cointegrated if the null hypothesis using the F-statistics or the t-statistics, or both can be rejected.

Table 5.9 Bounds Test for Model B/Trend

NUTS2	Statistic	Critical values								Test Decision	Level
		10%		5%		2.5%		1%			
		I [0]	I [1]	I [0]	I [1]	I [0]	I [1]	I [0]	I [1]		
F-statistic											
Veneto	5.758	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	1%
Friuli-Venezia Giulia	4.824	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	10%
Emilia-Romagna	5.125	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	5%
Umbria	6.638	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	1%
Abruzzo	4.070	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Inconclusive	10%
Molise	10.084	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	1%
Campania	8.969	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	1%
Puglia	8.780	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	1%
Calabria	4.813	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	10%
Sicilia	7.611	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	Reject	1%
t-statistic											
Veneto	-4.122	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Reject	1%
Friuli-Venezia Giulia	-3.185	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Inconclusive	10%
Emilia-Romagna	-3.286	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Reject	10%
Umbria	-2.398	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Inconclusive	10%
Abruzzo	-3.366	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Reject	10%
Molise	-5.371	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Reject	1%
Campania	-5.105	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Reject	1%
Puglia	-4.163	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Reject	1%
Calabria	-2.562	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Fail to reject	-
Sicilia	-4.525	-2.57	-3.21	-2.86	-3.53	-3.13	-3.80	-3.43	-4.10	Reject	1%

Source: Author’s estimation using Bank of Italy (2017b) and ECB (2019d).

Based on the F- and t-statistics shown in Table 5.9, interest rates of ten NUTS2 regions are cointegrated with the MRO when controlling for a structural break in the trend. These are the regions where the null hypothesis is rejected in column 'Test Decision'. In detail cointegration was found in three north-eastern regions (Veneto, Friuli-Venezia Giulia and Emilia-Romagna), one central region (Umbria), five southern regions (Abruzzo, Molise, Campania, Puglia and Calabria) and one of the islands (Sicilia).

In summary, based on the bounds test for Model B, a north-south divide was also found in terms of cointegration. Again, no north-western region is cointegrated. Only two north-eastern regions are cointegrated but the majority of southern regions, including Umbria and Sicily are cointegrated. The difference to Model A is that three north-eastern regions are cointegrated with the MRO-rate, meaning that when controlling for a structural break via a trend variable most north-eastern regions indicate a long-run relationship with the MRO-rate.

Based on the analysis in this section, the speed of adjustment proxies are estimated for regions that are cointegrated with the MRO-rate. Furthermore, the speed of adjustment proxies are estimated following the regional specifications as discussed in this section. The results are discussed in the next section.

5.4.3.2 Structural Break Control Speed of Adjustment

The purpose of this section is to examine the speed of adjustment whilst controlling for a structural break. This is undertaken by re-estimating the baseline ARDL-ECM based on the two models; Model A/Intercept and Model B/Trend. These calculations were undertaken for regions that were identified as cointegrated by estimating an ARDL-ECM containing a dummy variable and an ARDL-ECM model containing a trend variable.

Table 5.10 shows results of the speed of adjustment proxies based on regional ARDL-ECM following Model A and Model B. In detail, Column 'SoA intercept' provides speed of adjustment proxies which were estimated by an ARDL-ECM following Model A; incorporating a dummy variable to control for a structural break in the intercept. Column 'SoA trend' provides speed of adjustment proxies which were estimated by an ARDL-ECM following Model B; incorporating a trend variable to control for a structural break in the trend. Please note that all speed of adjustment coefficients presented in Table 5.10 are below 1.

The Model A speed of adjustment results, presented in the ‘SoA intercept’ column of Table 5.3, show a mixed regional pattern. The highest speed of adjustment was observed in Sicilia (23.4%) whilst the lowest level of speed of adjustment was observed in Puglia (7.3%). When controlling for the structural break in the intercept, the coefficient estimate for Sicilia indicates that in the next quarter 23.4% of an exogenous variation from the equilibrium path of the employed time-series is adjusted, on average, back towards equilibrium. In terms of Puglia, 7.3% of an exogenous variation from the equilibrium path of the employed time-series is adjusted, on average, back towards equilibrium. Following Gambacorta (2008), these results indicate that in Puglia the speed of adjustment is sluggish and monetary policy transmits slowly in comparison to Sicilia. Please note that both regions are in the south.

As only six regions were identified as being cointegrated, the regional pattern of the cointegration results should be taken into consideration in the overall result discussion. When controlling for the structural break by following Model A, no north-western region was found to be cointegrated. In terms of north-eastern regions, only one region is cointegrated. Cointegration was mainly found across the southern regions, Umbria and Sicilia. Therefore, a north-south divide is found. With the exception of Abruzzo, all results are statistically significant at the 1% level and have the required negative sign.

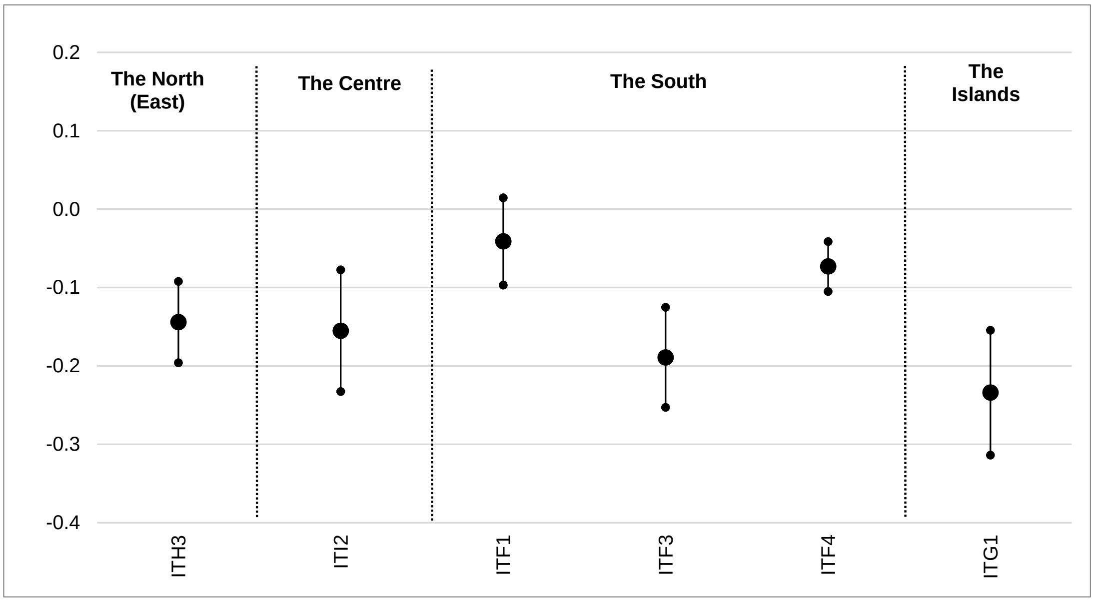
Table 5.10 Speed of Adjustment Estimations for Model A and Model B

NUTS1	NUTS2	SoA intercept	SoA trend
North East	Veneto	-0.144***	-0.110***
		(0.026)	(0.027)
	Friuli-Venezia Giulia		-0.162***
			(0.051)
	Emilia-Romagna		-0.096***
			(0.029)
Centre	Umbria	-0.155***	-0.067**
		(0.039)	(0.028)
South	Abruzzo	-0.041	-0.079***
		(0.028)	(0.023)
	Molise		-0.111***
			(0.021)
	Campania	-0.189***	-0.156***
		(0.032)	(0.031)
	Puglia	-0.073***	-0.060***
		(0.016)	(0.014)
	Calabria		-0.082**
			(0.032)
The Islands	Sicilia	-0.234***	-0.163***
		(0.040)	(0.036)

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Standard errors in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively. For full results, please see Appendix D.2 and D3.

Figure 5.2 confirms this finding when showing the obtained speed of adjustment results graphically as well as the estimated confidence intervals when accounting for the structural break in the intercept.

Figure 5.2 ARDL-ECM Speed of Adjustment and Confidence Intervals per NUTS2 Region, Model A



Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Note: Confidence intervals at 95% significance level. NUTS2 regional abbreviations are provided in Table 2.1 of Chapter 2.2.

Based on Model A estimations, no clear pattern in variability of the speed of adjustment proxies across regions can be found. This indicates that the speed of adjustment varied across all regions between 1999q4 and 2017q1.

The Model B speed of adjustment results, presented in the 'SoA trend' column of Table 5.3, show a mixed regional pattern. The highest speed of adjustment was observed in Sicilia (16.3%) whilst the lowest level of speed of adjustment was observed in Puglia (6.0%). When controlling for the structural break in the trend, the coefficient estimate for Sicilia indicates that in the next quarter 16.3% of an exogenous variation from the equilibrium path of the employed time-series is adjusted, on average, back towards equilibrium. In terms of Puglia 6.0% of an exogenous variation from the equilibrium path of the employed time-series is adjusted, on average, back towards equilibrium. Following Gambacorta (2008), these results indicate that in Puglia the speed of adjustment is sluggish and monetary policy transmits slowly in comparison to Sicilia, when controlling for a structural break in the trend.

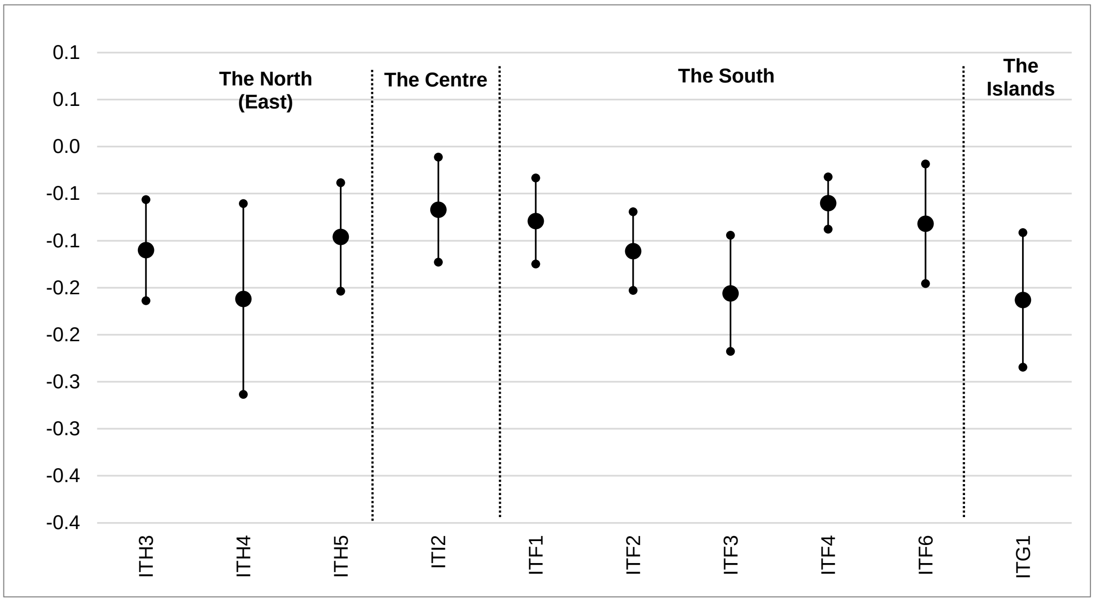
In case of Model B estimations, 10 regions are cointegrated. Therefore, when controlling for a structural break in the trend, three north-eastern regions are cointegrated with the MRO-rate.

The regional pattern of the cointegration results should also be taken into consideration in the overall result discussion. In detail, when controlling for the structural break by following Model B, three north-eastern regions are cointegrated. With the exception of Umbria and Calabria, all results are statistically significant at 1%. Speed of adjustment proxies for Umbria and Calabria are statistically significant at the 5% level. All speed of adjustment proxies have the required negative sign.

There was no cointegration found for interest rates in Lombardia and the MRO-rate when controlling for structural breaks in the trend. Therefore, no speed of adjustment estimations were performed for this region.

Figure 5.2 shows the obtained speed of adjustment results in the context of their confidence interval based on Model B.

Figure 5.3 ARDL Speed of Adjustment and Confidence Intervals per NUTS2 Region, Model B



Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Note: Confidence intervals at 95% significance level. NUTS2 regional abbreviations are provided in Table 2.1 of Chapter 2.2.

Figure 5.1 shows that, on average, the variability of the speed of adjustment tends to be slightly higher across northern regions than across the centre and the south. This implies that the speed of adjustment varied across northern regions during the sample period slightly more than across the central and southern regions. Note, variability in Sicily is high.

Overall, when controlling for structural breaks in the intercept or trend the highest speed of adjustment was found in Sicilia and the lowest speed of adjustment was found in Puglia, both southern regions. This identified regional pattern indicates that in Sicilia the deviation from the long-run growth path in the previous quarter was corrected more quickly in the current period than in Puglia. Following Gambacorta (2008), in Sicilia shocks are absorbed quickly by the regional interest rates and these rates do not seem to deviate from its equilibrium and vice versa. Moreover, the higher level of speed of adjustments in Sicilia indicates a more effective monetary policy in comparison to Puglia.

It has to be noted that in both regions agriculture and non-market services, are key sectors and especially since the Financial Crisis unemployment is high (EC, 2019b). Therefore, both regions are considered as riskier regions. Linking this background information with the speed of adjustment findings, it can be interpreted that in Sicilia shocks are absorbed quickly, however in Puglia not. This in turn, leads to the finding that in terms of speed of adjustment other factors should be considered within the analysis.

Coefficient estimates for the speed of adjustment accounting for structural breaks are mixed in absolute magnitude in comparison to the VECM speed of adjustment proxies discussed in Chapter 4. This may be due to the application of two different estimation strategies. Moreover, the identified regional pattern varies as well to the one found across the standard ARDL-ECM and standard VECM results.

An interesting pattern is found when comparing the baseline results with those controlling for structural breaks, as presented in columns ‘SoA’ of Table 5.3, ‘SoA intercept’ and ‘SoA trend’ of Table 5.10, when controlling for structural breaks, in some regions the speed of adjustment increased and in some regions the speed of adjustment decreased. In Umbria and Abruzzo, the speed of adjustment decreased, which implies that in these regions shocks are absorbed less quickly by the regional interest rates and these rates do seem to deviate from its equilibrium more. Following Gambacorta (2008) these results indicate that less developed regions tend to be worse at adjusting to the monetary policy after the crisis.

Across the other regions speeds of adjustment increased when controlling for the crisis. This regionally varying impact of structural breaks implies that other factors, such as competition level in the banking sector, financial innovation, risk factors, may contribute to the speed of adjustment (ECB, 2013; Karagiannis et al., 2011; Leuvensteijn et al., 2008; Gropp et al., 2007; de Bondt, 2005).

In Friuli-Venezia Giulia, for example, the speed of adjustment towards the long-run equilibrium increased by 2.6 percentage points when controlling for the structural break. As discussed in Chapter 3, Friuli-Venezia Giulia belongs to the richer regions in the north of Italy, however this region was severely impacted by the Financial Crisis. Unemployment increased from 4.3% in 2008 to 6.8% in 2016 (EC, 2019b). This is due to the economic structure of the region. Friuli-Venezia Giulia is mainly dominated by SMEs and is characterised by manufacturing, producing wood-furniture, electrical and non-electric household appliances and metal products. The food and beverage industry are also important in this region (EC, 2019b). Then, it can be concluded that because this region was highly impacted by the crisis, banks needed to react quickly to monetary policy changes leading to the increase in speed of adjustment when controlling for the crisis.

5.5 Conclusion

This Chapter studied the third mechanism of the Euro Zone MPTM, indicted by the speed of adjustment, across Italian NUTS2 regions for the period 1999q4 – 2017q1. The objective of this Chapter was to understand how regional interest rates adjust towards the long-run equilibrium with the ECB-set rate within a quarter.

Therefore, the research question of this Chapter was how the speed of adjustment differs across regions and, therefore, indicates the effectiveness of the ECB monetary policy. This research question was analysed through an empirical investigation based on the relationship between the ECB-set MRO rate and the revocable loan interest rates for each of the 11 Italian NUTS2 regions.

This analysis is important to the literature because it provides insights on the MPTM, as a mechanism through which the ECB tries to achieve its objective of price stability in the Euro Zone and this, in turn, supports the objective of the European Commission to stimulate the economy and foster employment across the Euro Zone. Since the monetary policy is set for each country of the Euro Zone, it was expected that monetary policy transmits homogenously across Euro Zone regions and, therefore, the speed of adjustment would be homogenous across regions (Commission of the European Communities, 1990; Mundell, 1961). However, Montagnoli et al. (2016), ECB (2013); Karagiannis et al. (2011) and de Bondt et al. (2005) studied the speed of adjustment in the Euro Zone on a national level and across Italian NUTS2 regions, finding heterogeneity among pass-through levels.

As per Gambacorta (2008), similarly to the long- and short-run pass-through, the speed of adjustment proxy is a further measure of monetary policy effectiveness. In both cases, the higher the proportion of the long- and short-run pass-through or speed of adjustment, the higher is the extent of the monetary policy effectiveness.

Following Montagnoli et al. (2016), ECB (2013) and, de Bondt et al. (2005), in this Chapter speed of adjustment proxies were estimated per NUTS2 region, via an ARDL-ECM estimation strategy where the coefficient of the lagged error correction term was interpreted as the speed of adjustment proxy. More detailed, the speed of adjustment in this Chapter denotes the correction in the regional interest rate towards equilibrium during the last quarter, given in percent units. The higher the proportion the larger is the extent with which the regional interest rate is adjusted towards equilibrium during the last period. Equilibrium was defined as the steady state of two cointegrated time-series. Moreover, since the 2007 – 2008 Financial Crisis is within the researched period, additional estimations were undertaken in order to control for potential structural breaks in the time series.

Overall, results based on ARDL-ECM estimations show that speeds of adjustment differ across Italian NUTS2 regions. This finding is in line with Montagnoli et al. (2016) and Sander and Kleimeier (2006), for instance. Higher levels of the speed of adjustment were observed in some northern NUTS2 regions, whereas lower levels of speed of adjustment were denoted in some southern regions. This suggested that, across northern regions, a higher proportion of the adjustment towards the long-run equilibrium is taking place within one quarter than across southern regions, implying a higher level of monetary policy effectiveness in northern than in southern regions.

When controlling for the Financial Crisis, an interesting pattern is observed when comparing standard speed of adjustments and Financial Crisis speed of adjustments. The comparison shows that, when controlling for the structural breaks, in some regions the speed of adjustment increased and in some regions the speed of adjustment decreased compared to the baseline findings.

This varying impact of the crisis on regions implies that other factors, such as competition level in the banking sector, financial innovation, risk factors, may contribute to the speed of adjustment (ECB, 2013; Karagiannis et al., 2011; Leuvensteijn et al., 2008; Gropp et al., 2007; de Bondt, 2005). Furthermore, it was found that the variability of the speed of adjustment was higher across northern regions than across central and southern regions.

Overall, the lesson learned from this Chapter is that the speed of adjustments differs from the ECB across Italian NUTS2 regions, which is in line with Montagnoli et al. (2016), ECB (2013); Karagiannis et al. (2011) and de Bondt et al. (2005). The Financial Crisis influenced Italian regions in different ways. In some regions the speed of adjustment increased and in some regions the speed of adjustment decreased. Even though the European monetary policy has been in operation for the last 20 years, it appears that other factors influence the speed of adjustment.

The next chapter concludes on the overall findings of this thesis and discuses on the findings of these three MPTM sub-mechanisms.

Chapter 6
Conclusions

6.1 Introduction

The ECB conducts the European monetary policy for the whole Euro Area by setting the monetary policy interest rate and hence securing price stability (ECB, 2019). This monetary policy interest rate, in turn, is the key interest rate influencing all Euro Area interest rates and its economies, flowing through the monetary policy transmission mechanism (MPTM). The MPTM can be analysed through different channels.

The interest rate channel examines how changes in the ECB monetary policy are transmitted to commercial bank lending interest rates across regions. In particular, the ECB-set interest rate transmits through the MPTM influencing the inter-bank rates and commercial bank interest rates and therefore impacting interest rates on loans for households and firms. The interest rate channel can be approached empirically through three sub-mechanisms of the MPTM: the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment.

The main objective of this thesis was to investigate the monetary policy operations of the European Monetary Union (EMU) from the ECB across the Euro Area within its 20 years of operations through the MPTM. Since the ECB sets the monetary policy interest rate for all Euro Zone countries and based on the EMU structure and history, it was anticipated that the monetary policy operations would transmit homogenously across regions. However, previous empirical studies had found heterogeneity in monetary policy operations when analysing the MPTM through mark-up, monetary policy pass-through and speed of adjustment across the Euro Area countries and on intra-national levels (Leroy and Lucotte, 2016; Montagnoli et al., 2016; ECB, 2013; Bogoev and Petrevski, 2012; Karagiannis et al., 2011; Gambacorta, 2008; de Bondt et al., 2005; Sander and Kleimeier, 2004; Angelini and Cetorelli, 2000).

Therefore, this discrepancy between theory and empirical findings was the motivation for this thesis, which contributes to the academic literature by researching three sub-mechanism of the MPTM as suggested by the literature, namely the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment.

In this thesis the MPTM was examined from the ECB across the Euro Area regions, by beginning the analysis at the ECB level (the supra level) and concluding at the Italian NUTS2 regions (the intra-national level). To capture the MPTM across the different levels each of the sub-mechanisms was empirically estimated by employing the ECB-set Main Refinancing Operation (MRO) rate and bank lending rates observed across the Italian NUTS2 regions. Hence, the MPTM was investigated from the monetary policy level across sub-national levels of Italy. This particular characteristic differentiates this thesis from other work done in this field. Moreover, based on the data selection the influence of national characteristics is kept constant and the estimated proxies are computed in an environment of uniform national characteristics. Therefore, the influence of macroeconomic factors on the estimations is constant. A further factor which differentiates the empirical analysis in this thesis from the literature is that structural breaks related to the 2007-2008 Financial Crisis, are determined endogenously and are controlled for by adding a dummy and a trend variable into the model specification.

This approach leads to more robust MPTM proxies. Italy was chosen as a case study due to its north-south regional divide which mirrors the division across the Euro Area countries.

Chapter 2 provided a discussion on data and different empirical estimation strategies. This Chapter concluded by identifying the MRO rate as the monetary policy interest rate because in 1999, the ECB Governing Council began to conduct the European monetary policy by formulating the monetary policy for the Euro Area by setting the rate of MRO. A further key finding of Chapter 2 was that the VECM was identified as the preferred estimation model and method. One of the key reasons for choosing the VECM was the advantage of estimating all three sub-mechanisms analysed in this thesis in one estimation step and therefore eliminating room for error within the calculation process. Furthermore, the ARDL model was identified as an appropriate alternative estimation strategy for the speed of adjustment proxy.

Chapter 3 examines the first sub-mechanism of the MPTM, namely the commercial bank mark-up calculated between the MRO interest rate and observed revocable loan interest rates for each Italian NUTS2 region. Low commercial bank mark-up levels were found across northern regions, with Lombardia being the region with the lowest mark-up. High commercial bank mark-up levels were found across central and southern regions and Sicily, with Umbria being the region with the highest mark-up. Moreover, Lombardia the region with the lowest mark-up levels is also the region where the Italian stock exchange and the financial sector are located. This finding is unique in this thesis because it has been not discussed in literature.

Chapter 4 analyses the second sub-mechanism of the MPTM, the long- and short-run monetary policy pass-through, in conjunction with the speed of adjustment. The VECM speed of adjustment proxy was reported in Chapter 4 because it operates as an acceleration of the long-run pass-through. All proxies were computed with VECMs between the MRO interest rate and revocable loan interest rates. Findings of this Chapter show that long-run pass-through levels in the north-west and the north-east, were higher than in southern and central regions, as well as in Sicilia.

The analysis on short-run pass-through provided the same regional pattern as the one found in the long-run pass-through case. However, the short-run monetary policy pass-through seems to be more effective in comparison to the long-run, in particular in Veneto and Emilia-Romagna. The speed of adjustment results show the same regional pattern as the long- and short-run pass-throughs and therefore the speed of adjustment reinforces the regional heterogeneity in the monetary policy long-run pass-through.

Chapter 5 investigates the third sub-mechanism of the MPTM, namely the speed of adjustment. This proxy was calculated between the MRO interest rate and the regional revocable loan interest rates. Results of this Chapter also indicate a regional split showing high levels of speed of adjustment in the northern NUTS2 regions, whereas low levels of speed of adjustment were found in southern regions.

Based on the results of Chapters 3, 4 and 5 on the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment respectively, regional heterogeneity has been identified leading to the conclusion that the effectiveness of the ECB monetary policy varies across regions. Higher monetary policy effectiveness was identified across the northern NUTS2 regions whilst lower monetary policy effectiveness was identified across the southern and central NUTS2 regions and Sicilia.

This finding in relation to Lombardia is original to this thesis and was not discussed in the literature, indicating that the presence of the financial sector in a region has a considerable impact on monetary policy effectiveness. Based on this result, it would be interesting to see how the presence of financial sectors influences the MPTM and therefore regional development from a monetary policy angle. Moreover, when controlling for the 2007 – 2008 Financial Crisis similar regional clusters have been identified.

To obtain more insight on reasons for regional diversion across commercial bank mark-up levels and therefore differentiation in monetary policy effectiveness the relationship between the estimated mark-up levels and risk, competition in the banking sector and liquidity preference have been investigated. Results are in line with the theoretical arguments implying that risk, banking sector competition and liquidity preference could contribute to the observed heterogeneity of the commercial bank mark-up.

This Chapter is divided in seven sections: the next section provides more detail on the commercial bank mark-up chapter, whilst section three elaborates on the monetary policy pass-through and speed of adjustment from VECM estimations. Section four investigates the speed of adjustment further based on the findings from an ARDL-ECM estimation strategy. Section five presents a discussion of the findings. Section six denotes the limitations of this thesis and finally section seven highlights the future agenda.

6.2 The Commercial Bank Mark-Up

The third chapter examined the first mechanism of the Euro Zone MPTM indicated by commercial bank mark-up across 9 Italian NUTS2 regions for the period 1999q4 – 2017q1. The objective of the commercial bank mark-up investigation was to understand the interest rate channel between commercial banks and households and firms across regions.

The commercial bank mark-up was defined as the difference between the interest rates commercial banks charge for loans (the bank lending rate) and the cost of funds rate defined as the rate commercial banks must bear when borrowing money (Fontana and Setterfield, 2009). The higher the mark-up the more power a commercial bank has and the more borrowers must pay for borrowing.

A further approach to the mark-up definition is based on the literature relating to oligopolistic price setting due to the oligopolistic market structure in the banking sector and because commercial banks behave like oligopolistic firms. This means that oligopolistic firms have power to charge a higher price for services than cost experienced (Rousseas, 1985). A commercial bank's market power may be indicated by high mark-up level (Das and Kumbhakar, 2016).

Interest rates vary across regions in Italy. In order to examine these differences and provide insights on the MPTM, the research question of Chapter 3 is to examine differences in the mark-up levels across the Italian NUTS2 regions. This research question was analysed through an empirical investigation based on the relationship between the ECB-set MRO rate and the revocable loan interest rate for each Italian NUTS2 region.

Therefore, in this Chapter, mark-up levels were estimated per NUTS2 region using a vector error correction model (VECM). The constant of the cointegrating equation was then interpreted as a proxy for the average regional mark-up following Montagnoli et al. (2016) and Gambacorta (2008). To test for the validity of these results, Cointegrated Regressions (CR) were also estimated. Since the 2007 – 2008 Financial Crisis was within the researched period, additional estimations including a dummy variable and trend variable were conducted to account for structural breaks.

The contribution of this Chapter is based on the unique mark-up investigation analysis from a supra (ECB) to an intra-national (NUTS2) level. In the literature, the commercial bank mark-up analysis starts at the market level because of the application of the money market interest rates. Therefore, these studies are examining particular mark-up proxies between the inter-bank money market and the loan interest rates. This Chapter, on the other hand, estimated the mark-up levels between the monetary policy interest rate, the MRO rate set by the ECB, and the observed interest rates on revocable loans across Italian NUTS2 regions set by local commercial banks. Therefore, the MPTM between the ECB and a particular Italian NUTS2 region is researched from the supra level to an intra-national level.

In this way, this Chapter contributes to the literature of regional monetary policy transmission mechanisms through an original research on the mark-up from the ECB levels across Italian NUTS2 regions for the period 1999q4 – 2017q1 and controlling for structural breaks, for example those caused by the 2007 – 2008 Financial Crisis.

Overall, the results were qualitatively showing similar results, namely a persistence of heterogeneity across regions. These findings were consistent across estimation strategies showing low mark-up levels in the north and high mark-up levels in southern regions and Sicilia. More precisely, the lowest commercial bank mark-up was observed in Lombardia, a north-western region, whereas the highest commercial bank mark-up level was denoted in Umbria, a region in the south of Italy.

Commercial bank mark-ups show greater variability in the south and centre than in the north. This implies that mark-up levels in Lombardia were not only low but also remained low over time. These results indicate that monetary policy may transmit heterogeneously across the NUTS2 regions in Italy, which may be explained, for example, by a higher degree of market power by commercial banks. These results are in line with findings from Montagnoli et al. (2016), Gambacorta (2008) and Angelini and Cetorelli (2000).

Lombardia, the NUTS2 region where the hub of the national financial sector is located, has significantly lower mark-up values in comparison to the other regions across all estimation methods. This particular finding is original of this thesis and was not found in the literature. This result indicates that the presence of the financial sector in a region has a considerable impact on its mark-up levels.

Italy was affected by two phases of the Crisis: Phase 1 (denoted as FCP1) related to the Lehman Brothers fall in September 2008, and phase 2 (denoted as FCP2) related to the Italian Sovereign Debt Crisis beginning in late 2010. A structural break per regional was identified via the Zivot and Andrews (1992) unit-root test.

When controlling for the crisis, regional mark-ups were found to be similar compared to the baseline findings. The lowest commercial bank mark-up level has been found in Lombardia a north-western region and Emilia-Romagna north-eastern region, whereas the highest mark-up level has been found in Umbria, a southern region.

Different schools of economic thought identified potential contributors explaining mark-up differentials. According to Neo-Classical literature, commercial banks' perception of risk differs across regions and is a potential explanation for mark-up heterogeneity. New-Keynesians argue that, in addition to risk perception, competition within the banking sector leads to heterogeneous mark-up levels. Finally, Post-Keynesians argue that liquidity preference leads to varying interest rates and hence mark-up levels.

6.3 The Monetary Policy Pass-Through

The fourth chapter researched the second sub-mechanism of the Euro Zone MPTM indicated by the monetary policy pass-through across 9 Italian NUTS2 regions for the period 1999q4 – 2017q1. Since the estimation method of the pass-through in this Chapter is the VECM, its speed of adjustment is also presented in this Chapter. This is due to the fact that the speed of adjustment proxy is an accelerator of the pass-through proxy.

The monetary policy pass-through is defined as the extent of the policy change that is transmitted to the bank lending rates. Three possible outcomes can be found in terms of monetary policy pass-through, namely a complete, incomplete and overshooting pass-through: A complete monetary policy pass-through case occurs if the pass-through value is one meaning that commercial banks adjust their interest rates by the same extent that the monetary policy interest rate is changed. An incomplete monetary policy pass-through case is indicated by a pass-through value between 0 and 1 meaning that the implemented change in bank lending rates is smaller than the initial change in the monetary policy rate. Overshooting pass-through, on the other hand, is indicated by a pass-through value of greater than one implying that the change in the bank lending rate is a multiple of the change in the policy interest rate.

The objective of this Chapter was to understand how the monetary policy pass-through, transmitted to the commercial bank lending rates, differed across the Italian NUTS2 regions in the long- and short-run. Therefore, the research question of this Chapter was how the extent of monetary policy pass-through differed across regions in the long- and short-run. This research question was analysed through an empirical investigation based on the relationship between the ECB-set MRO rate and the revocable loan interest rates for each of the 9 Italian NUTS2 regions.

In this Chapter, long- and short-run monetary policy pass-through proxies were estimated per NUTS2 region via a VECM estimation strategy. The VECM coefficient of the cointegrating equation represented a long-run monetary policy pass-through proxy, and the short-run MRO coefficient denoted the short-run monetary policy pass-through, following Montagnoli et al. (2016), ECB (2013) and Gambacorta (2008), de Bondt et al. (2005). Cointegrated Regression (CR) estimations were also undertaken for validity purposes, as well as additional estimations including a dummy variable and a trend variable in order to control endogenously for structural breaks such as the 2007 – 2008 Financial Crisis.

To support the pass-through results the VECM speed of adjustment results were also reported. The reason for this approach is that the speed of adjustment works as an accelerator for the pass-through proxy.

Hence, the contribution of this Chapter was grounded in a unique long- and short-run monetary policy pass-through investigation from a supra (ECB) to an intra-national (NUTS2) level. In this way, this Chapter contributes to the literature of regional MPTM through an original research on the long- and short-run pass-through from the ECB level across Italian NUTS2 regions for the period 1999q4 – 2017q1 and controlling for the 2007 – 2008 Financial Crisis.

Results for long-run monetary policy pass-through, based on VECM showed that pass-through levels differed across Italian NUTS2 regions, which indicated that monetary policy may transmit heterogeneously across the NUTS2 regions in Italy. This finding was in line with the literature (Montagnoli et al., 2016; Gambacorta, 2008, for instance).

More precisely, a regional pattern of high levels of long-run pass-through was observed in the northern NUTS2 regions, such as in Lombardia and Veneto, whereas low levels of long-run pass-through were denoted in southern regions, such as in Campania, for instance. Similarly, to the results obtained in the mark-up chapter, Lombardia, the region where the hub of the national financial sector is located, was found to have the highest monetary policy pass-through. Moreover, long-run variability in southern regions is higher than in northern regions. This implies that during the sample period, on average, the long-run pass-through varied more in southern regions than in northern regions.

These results indicated a north-south divide and implied that regions with a higher pass-through tend to be more industrialised and less dependent on public expenditure. Following Gambacorta (2008), the pass-through can also be defined as a measurement of monetary policy effectiveness. Therefore, the identified heterogeneous long-run pass-through across Italy could be interpreted as follows: The Euro Zone monetary policy in northern NUTS2 regions is more effective than in the central and southern regions and Sicilia. In addition, the heterogeneity of the pass-through results imply that other factors could be influencing the regional interest rates in less developed regions.

The analysis on short-run pass-through provided the same regional pattern as the one found in the long-run case. However, in the short-run monetary policy seems to be more effective in comparison to the long-run, in particular in Veneto and Emilia-Romagna. This means that in the short-run a higher extent of the MRO rate change was transmitted to Veneto and Emilia-Romagna, implying different dynamics between the long- and short-term.

The speed of adjustment results show the same regional pattern as the long- and short-run pass-throughs and therefore the speed of adjustment reinforces the regional heterogeneity in the monetary policy long-run pass-through.

This identified regional pattern across the long- and short-run monetary policy pass-through and speed of adjustment is in line with the mark-up results discussed in Chapter 3. Therefore, it is likely that risk, competition and liquidity preference may have also contributed to the differences in the pass-through results. Moreover, banking sector competition, credit risk, switching costs, information asymmetries and demand elasticity could explain the regional heterogeneity in the long-run pass-through (ECB, 2013; Bogoev and Petrevski, 2012; de Bondt et al., 2005; Sander and Kleimeier, 2004). In general, based on the obtained results, the ECB's objective of achieving inflation of 2%, or close to 2%, via monetary policy is more likely to be achieved in the northern regions than in the centre, south and Sicilia.

When controlling for structural breaks, the heterogeneity in monetary policy effectiveness persisted. However, in some cases the regional pattern of high pass-through levels in the north and low pass-through levels in the centre, south and Sicilia was reversed. More precisely, when controlling for the Financial Crisis in the intercept the highest long-run pass-through was identified in Emilia-Romagna, and the lowest long-run pass-through was observed in Liguria both northern regions. When controlling for the Financial Crisis in the trend the highest long-run pass-through was identified in Puglia, and the lowest long-run pass-through was observed in Campania, both southern regions. This indicates high level of heterogeneity.

This finding implies that other factors influenced the regional interest rates and suggests that the crisis may have influenced the monetary policy pass-through across regions in different ways.

The analysis on short-run pass-through also provided a north-south divide. The highest short-run pass-through was found in Emilia-Romagna whereas the lowest level was found in Sicilia. This shows that, in the short-run, interest rates in Emilia-Romagna changed to a higher extent than the MRO change. When controlling for the crisis, short-run pass-through indicted a mixed north-south divide.

One implication of these results could be that commercial banks may have adjusted their risk perceptions across regions leading to a reversed north-south divide pattern (Sander and Kleimeier, 2004).

6.4 Speed of Adjustment

The fifth chapter examined the third sub-mechanism of the Euro Zone MPTM indicated by the monetary policy speed of adjustment across 11 Italian NUTS2 regions for the period 1999q4 – 2017q1. The objective of this Chapter was to understand how the regional interest rates adjust towards a long-run equilibrium with the ECB-set rate within one quarter.

In general, the speed of adjustment was defined as the coefficient of the error correction term which provides information on the extent of the correction process in the dependent variable towards an equilibrium in the next period. In this case the concept of equilibrium was based on econometric grounds in that an equilibrium between two time-series exists, if the time-series share a common trend (Asteriou and Hall, 2016).

Speed of adjustment values were expected to lie between 1 and 0. A speed of adjustment coefficient of 1 was interpreted that 100 percent of the adjustment towards the equilibrium path has taken place within a given time. A speed of adjustment close to 0 has been interpreted as a minimal adjustment towards the equilibrium within a given time. Moreover, as per Gambacorta (2008), similarly to the long- and short-run pass-through, the speed of adjustment proxy is a further measure of monetary policy effectiveness. Therefore, the closer the speed of adjustment value is to one, the higher is the extent of the monetary policy effectiveness.

The research question of this Chapter was how the speed of adjustment differed across regions and therefore indicated the effect of the ECB monetary policy on regional interest rates. This research question was analysed through an empirical investigation based on the relationship between the ECB-set MRO rate and the revocable loan interest rates for each of the 11 Italian NUTS2 regions.

Following Montagnoli et al. (2016), ECB (2013) and de Bondt et al. (2005), in this Chapter, the speed of adjustment proxies were estimated per NUTS2 region via an ARDL-ECM estimation strategy, where the coefficient of the error correction term was interpreted as the speed of adjustment proxy. The Cointegrated Regression (CR) estimations were unable to provide proxies for the speed of adjustment therefore, CR estimations were not undertaken for this Chapter. Since the 2007 – 2008 Financial Crisis is within the researched period, additional estimations including a dummy variable and a trend variable were conducted in order to control endogenously for the crisis.

The contribution of this Chapter was grounded in a unique monetary policy speed of adjustment investigation from a supra (ECB) to an intra-national (NUTS2) level. In this way, this Chapter contributed to the literature of regional MPTM through an original research on the monetary policy speed of adjustment from the ECB levels across Italian NUTS2 regions for the period 1999q4 – 2017q1 and controlling for the 2007 – 2008 Financial Crisis. Therefore, a further measure of the monetary policy effectiveness was estimated.

The difference between the monetary policy pass-through and the speed of adjustment was as follows: The long- and short pass-through provided information on the extent to which (expressed in percentage points) the change in the MRO rate was transmitted to regional interest rates in the long- and short-run. The speed of adjustment indicated the extent (expressed in percent) to which changes in the regional interest rate adjusted towards equilibrium during the next period. However, when combining the result of the speed of adjustment with the pass-through, the speed of adjustment can accelerate the pass-through and therefore the monetary policy effectiveness.

Based on regional ARDL-ECM models, the speed of adjustment results differed across Italian NUTS2 regions, which implies that monetary policy could have been transmitted heterogeneously across the NUTS2 regions in Italy. Montagnoli et al. (2016), ECB (2013) Karagiannis et al. (2011), de Bondt et al. (2005). Kleimeier and Sander (2006), for instance, also found heterogeneous results in speed of adjustments across the Euro Zone and Italy, therefore, the findings of this Chapter are in line with the literature.

More precisely, speed of adjustment levels in the north were higher than in the south, centre and Sicilia. These results imply that in the northern regions the interest rates adjusted towards the equilibrium to a higher extent within one quarter than in Sicilia, the southern and central regions. Moreover, the variability of the speed of adjustment is slightly higher across northern regions than across the centre, south and Sicily. This implies that the speed of adjustment varied across the norther regions during the sample period slightly more than across the central and southern regions.

Therefore, through investigating a further monetary policy sub-mechanism, namely the speed of adjustment, it was identified that the monetary policy is more effective in the northern regions of Italy than across central and southern regions, which is similar to the findings of Chapter 4.

Considering the industrial characterisation of the NUTS2 regions, the obtained speed of adjustment results showed that in more developed regions, the northern regions of Italy, such as in Friuli-Venezia Giulia or Lombardia where the banking sector constitutes a significant proportion of the overall industry, reacted more quickly to adjust the lending rates towards the equilibrium when the ECB changed the MRO rate.

When controlling for the Financial Crisis, a mixed regional pattern has been found in terms of regional groupings in comparison to the baseline ARDL case. High levels and low speeds of adjustment were observed in the southern NUTS2 regions. However, a north-south south divide was identified across the cointegration results, namely, most of the northern regions were not cointegrated whilst most southern regions were found to be cointegrated. Moreover, in some regions the speed of adjustment increased and in some regions the speed of adjustment decreased. In Umbria and Abruzzo, the speed of adjustment decreased, which implies that in these regions shocks are absorbed less quickly by the regional interest rates and these rates do seem to deviate from its equilibrium more. In the other regions the speed of adjustment increased which indicates that in these regions shocks are absorbed more quickly by the regional interest rates and these rates do seem to deviate from its equilibrium less.

This varying impact of the crisis on regions implied that the Financial Crisis may have impacted regions in different ways and other factors, such as competition levels in the banking sector, financial innovation and other risk factors may also contribute to the speed of adjustment results (ECB, 2013; Karagiannis et al., 2011; Leuvensteijn et al., 2008; Gropp et al., 2007; de Bondt, 2005).

6.5 Lessons Learned from this Thesis

The motivation for this thesis was to research how monetary policy transmitted from the ECB across the Euro Area after being in operation for 20 years. The analysis of this thesis was based on the Optimum Currency Area (OCA) theory and the European Commission view before 1999. More precisely, this research provided insights on the MPTM, a mechanism through which the ECB tries to achieve its objective of price stability in the Euro Zone that, in turn, supports the objective of the European Commission to stimulate the economy and foster employment across the Euro Zone. Since the monetary policy is set for each country of the Euro Zone, prior the introduction of the EMU, it was expected that monetary policy would transmit similarly across the Euro Zone regions. This assumption was based on the OCA theory (Mundell, 1961) and the European Commission stance of similarities across all EMU members (Treaty on European Union 1992; Commission of the European Communities, 1990).

However, empirical studies found heterogeneity in monetary policy operations when analysing the MPTM through mark-up, monetary policy pass-through and speed of adjustment across the Euro Area countries and on intra-national levels (Leroy and Lucotte, 2016; Montagnoli et al., 2016; ECB, 2013; Bogoev and Petrevski, 2012; Karagiannis et al., 2011; Gambacorta, 2008; de Bondt et al., 2005; Sander and Kleimeier, 2004; Angelini and Cetorelli, 2000).

Overall, results of Chapters 3, 4 and 5 on the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment respectively indicated regional heterogeneity.

Commercial bank mark-up results showed that mark-up levels differ considerably across Italian NUTS2 regions, which indicates that monetary policy may transmit heterogeneously across regions in Italy. This finding is in line with the literature, Montagnoli et al. (2016), Gambacorta (2008) and Angelini and Cetorelli (2000), for instance. More precisely, low commercial bank mark-up levels were observed across northern regions, with Lombardia being the region with the lowest mark-up. High commercial bank mark-up levels were observed in Sicilia and across central and southern regions, with Umbria being the region with the highest mark-up. This means that mark-up levels are lowest in richer regions, particularly in regions where the financial sector is a key industry. Moreover, mark-up levels in poorer regions tend to be high, particularly in regions where the dependence on the public budget is strong and where a large proportion of the workforce is employed in the public sector. These results imply that Italians in the north pay less for borrowing than Italians in the south.

Even though Lombardia, the NUTS2 region with the lowest mark-up levels is also the region where the Italian stock exchange and the financial sector are located. This finding is original to this thesis and was not discussed in the previous literature on Italy, indicating that the presence of the financial sector in a region has a considerable impact on its mark-up levels. When controlling for both phases of the global Financial Crisis similar regional clusters have been identified.

According to the Neo-Classical school of thought, commercial bank mark-up levels vary due to differing perceptions of risk across regions. New-Keynesian argue that in addition to risk perception, competition within the banking sector is an important contributor to heterogeneous results. Finally, Post-Keynesians argue that liquidity preference leads to varying interest rates and hence mark-up levels.

Overall, the lessons learned from Chapter 3 are that mark-up levels differ across Italian NUTS2 regions, which is in line with the literature. This means that the MPTM differs across regions and reinforces the north-south divide argument. Other factors, such as risk, competition in the banking sector and liquidity preference are potential contributors to the varying mark-up levels.

Therefore, in light of the argument that the ECB tries to achieve its objective of price stability in the Euro Zone that, in turn, supports the objective of the European Commission to stimulate the economy and foster employment across the Euro Zone, this Chapter concludes that the MPTM works for some regions rather better than for others.

In Chapter 1 it was discussed that the ECB is using monetary policy to support the EC's objective of enhancing economic growth and employment across the Euro Area leading to convergence across regions (ECB, 2019b; EC, 2019a; Commission of the European Communities, 1990). However, results of this analysis indicate that between 1999q4 and 2017q1 the ECB's monetary policy was more effective in the northern regions of Italy than in the south and in most of central regions and Sicily, meaning that convergence across northern regions was more likely to take place than in the south and centre. This means that the uneven effectiveness of monetary policy across Italian NUTS2 regions could have contributed to a divergence between the north and the south.

The monetary policy pass-through research showed that long-run pass-through levels in the north-west and north-east, were higher than in the southern and central regions as well as in Sicilia. These results imply that regions with a higher pass-through tend to be more developed in economic and industrial terms. Note that Lombardia is the region where the Italian stock exchange and the financial sector are located and has the lowest long-run pass-through. This finding in terms of Italy has been not discussed in literature.

The long-run monetary policy pass-through results imply that, in economically more developed regions and in regions where the financial sector is a key contributor to the economy, higher percentage points of the change in the MRO rate is transmitted to the regional interest rates. In less economically developed regions, the transmitted proportion of the MRO rate change is lower. The identified heterogeneous long-run pass-through across Italy could be interpreted as the Euro Zone monetary policy in the northern NUTS2 regions is more effective than in the southern regions and Sicilia.

The analysis on short-run pass-through provided the same regional pattern as the one found in the long-run pass-through case. However, the short-run monetary policy seems to be more effective in comparison to the long-run, in particular in Veneto and Emilia-Romagna.

A regional pattern of high levels of VECM speed of adjustment are observed in the northern NUTS2 regions, whereas low levels of VECM speeds of adjustment are denoted in southern regions. As a result, the regional split of the VECM speed of adjustment results reinforces the previous findings for the monetary policy long-run pass-through. When combining the VECM speed of adjustment results with the long-run pass-through, it can be concluded that in the northern NUTS2 regions the higher levels in VECM speed of adjustment accelerate the monetary policy long-run pass-through, leading to an even higher monetary policy effectiveness, meaning that convergence, as anticipated by the ECB and CEC across northern regions was more likely to take place than in the south and centre (ECB, 2019b; EC, 2019a; Commission of the European Communities, 1990).

Overall, the lessons learned from Chapter 4 are that long- and short-term monetary policy pass-through levels differ across Italian NUTS2 regions, which is in line with the literature (Montagnoli et al., 2016; Gambacorta, 2008). This means that the MPTM differs across regions and reinforces the north-south divide argument. Moreover, other factors, such as risk, competition in the banking sector, may contribute to the varying regional monetary policy pass-through in Italy, especially as shown through the pass-through results when controlling for structural breaks.

Therefore, in light of the argument that the ECB tries to achieve its objective of price stability in the Euro Zone that, in turn, supports the objective of the European Commission to stimulate the economy and foster employment across the Euro Zone, this Chapter concludes that the MPTM works for some regions rather better than for others and can initiate divergence across the NUTS2 regions.

The research on the speed of adjustment showed that across northern regions, on average, a higher proportion of the adjustment towards the long-run equilibrium is taking place within one quarter than across southern regions, implying a higher level of monetary policy effectiveness in the northern regions than in the southern regions.

Based on econometric grounds, when combining the speed of adjustment results with the monetary policy pass-through it can be concluded that in the northern NUTS2 regions the higher levels in the speed of adjustment accelerate the monetary policy pass-through leading to an even higher monetary policy effectiveness. Therefore, this mechanism can also contribute to a divergence across the Italian NUTS2 regions.

When controlling for the Financial Crisis, mixed results in terms of regional groupings have been found than in the baseline ARDL case, namely high and low levels of speed of adjustment were observed in the southern NUTS2 regions.

An overall lesson learned from Chapter 5 is that the speed of adjustment differs across Italian NUTS2 regions, which is in line with Montagnoli et al. (2016), ECB (2013), Karagiannis et al. (2011) and de Bondt et al. (2005), even after 20 years of the European monetary policy being in operation.

Investigation on all MPTMs indicated regional differences across the Italian NUTS2 regions often in line with the north-south divide. Moreover, based on the observed variability of the confidence intervals it can be concluded that the three researched MPTMs transmit heterogeneously across regions but also the MPTM indicators reacted differently to the Financial Crisis across regions. Furthermore, it has been identified that other factors may lead to a heterogeneous transmission of the monetary policy, such as risk perceptions, competition in the lending market, financial innovation and liquidity preferences.

Based on the analysis of this thesis, it can be concluded that the MPTM works differently across regions leading to different effectiveness of monetary policy across regions. Varying effectiveness of monetary policy, in turn, can contribute to regional divergence rather than convergence. This means that the ECB’s objective of price stability in the Euro Zone, which in turn, supports to enhance economic growth and employment in the Euro Zone operates differently across regions. Furthermore, the Financial Crisis impacted regions differently which had a varying impact on the MPTMs across the Italian NUTS2 regions. As a result, other supporting mechanisms to foster economic growth and employment should be introduced, especially for the ‘poorer’ regions where risk and the level of competition in the banking sector influences the interest rate on loans.

6.6 Limitations of this Thesis

Eurostat (2011) requires a compilation and dissemination of data across regions of the European Union. However, comparable interest rate time-series data across the Euro Zone countries are not publicly available especially when considering the beginning of a research period to be 1999, the introduction of European monetary policy. The key issues are the differing definitions of interest rate data across regions and across time, if the data is comparable and the length of the time-series is short.

For instance, a similar research as the one conducted for Italy was planned for a core Euro Zone country, namely Germany. However, due to the lack of availability of comparable interest rate data for German NUTS2 regions it was not possible to conduct this analysis.

The ideal data for this type of analysis would be to be able to differentiate between secured and unsecured interest rates across NUTS2 regions for households and firms for the period 1999 to present. In this way a more detailed analysis could be undertaken on the MPTM. Furthermore, if similar interest rate data across different Euro Zone countries on NUTS2 levels would be available, a more insightful analysis of the MPTM could be conducted. Then, results not only of one country across NUTS2 regions could be undertaken but also across NUTS2 regions of other Euro Zone countries, such as Germany or France.

A limitation of using revocable loan interest rate data per Italian NUTS2 region is that the estimated MPTM proxies (the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment) are general for a particular region. No split between households and firms could have been conducted. This is a limitation because commercial banks differentiate between these agents.

6.7 Future Research

In the analysis of this thesis, it has been identified that factors, such as risk, the level of competition in the banking sector, and liquidity preference contribute to the heterogeneity of the MPTM. Based on this finding future research including these factors should be undertaken in order to understand the impacts on the MPTM in further detail.

According to the ECB (2013) bank resilience and the fragmentation in the Euro Area credit market influences the heterogeneous MPTM in the Area. Sander and Kleimeier (2004) suggest that differences in characteristics of national financial markets and macroeconomic factors, for instance structural inflation, interest rate volatility and growth, can explain a substantial part of the heterogeneity in the MPTM. Moreover, cultural and legal differences remain significant determinants of the MPTM. As a result, neither a single monetary policy regime nor convergence of financial systems across countries can lead to a homogenous MPTM in the Euro Zone in the short-term.

Based on both views mentioned above and the gained knowledge from this thesis, future research is important and could be grounded on three key areas: the context of analysis, estimation strategies and data employed.

The context of analysis could be changed by undertaking a similar empirical investigation as conducted within this thesis but on a different Euro Zone country and its NUTS2 regions, such as Germany. In this way a comparison between this thesis and a core country could be undertaken. It would be interesting to see if the results across the two countries and its regions differ and if so, how the results would differ.

In terms of estimation strategies, further research could be undertaken by calculating the mark-up indicator following the micro approach and using bank balance-sheet data or by employing panel analysis. Then the commercial bank mark-up proxies could be compared between a micro and a macro approach and/or across mark-up estimates obtained through a panel estimation approach.

Another direction of development of this thesis would be by following Arestis et al. (2016) and examining the convergence of the Italian NUTS2 regions and creating links to regional growth theories. Based on the results found in this thesis initial conclusions could be that convergence across Italian NUTS2 regions did not occur to the extent as expected by the European Commission and ECB. Furthermore, the Italian NUTS2 regions grew at different speeds over the sample period.

Furthermore, the speed of adjustment proxy could have also been examined by following Karagiannis et al. (2011). The authors used the LSE-Hendry general-to-specific approach, also known as the GETS model. The advantage of this approach is that it allows for two different speed of adjustment examinations simultaneously. The speed of adjustment could be estimated for the case when the monetary policy rate was increasing and decreasing. In this way the magnitude of positive and negative changes in the lending rate could be studied as a response to the monetary policy rate in- or decreases.

Due to the north-south divide and the different industrial structures across Italian regions the responses between monetary policy in- and decreases may vary across the NUTS2 regions. Furthermore, it would be interesting to see whether a north-south divide could be identified when analysing the MPTM and controlling for in- and decreases in the monetary policy rate. This kind of analysis would provide furthermore granulated insight on the MPTM in Italy.

Different data could also be employed in order to estimate the indicators of each MPTM. For example, the commercial bank mark-up, the monetary policy pass-through and the speed of adjustment proxies could be estimated by using interest rate data on mortgages and interest rates on loans to non-financial corporations similarly to the ECB (2013) investigation but on a NUTS2 level. Results of the ECB (2013) show a division between the core and the peripheral countries similar to the north-south divide in Italy. The pass-through to interest rates on loans to non-financial corporations of this study was found to be incomplete for Italy and Spain, whereas the interest rate pass-through for loans to non-financial corporations in Germany and France was much more complete since late 2011.

A further finding of the ECB (2013) was that bank lending rates to households for house purchases in Italy and Spain reacted strongly to the decreases in policy interest rates at the end of 2008 and 2009. This implies that a higher proportion of mortgages in Italy and Spain are on short-term fixed interest rates than in other large Euro Area economies. Based on these findings it would be interesting to see whether such a differentiation as the one found for non-financial corporations across the core and peripheral countries would be found across the NUTS2 regions in Italy. Furthermore, it would be of interest to see the response of interest rates on loans to households for house purchases to changes in the monetary policy rate and further to investigate what it means that the majority of mortgages in Italy are on short-term fixed rates.

This type of analysis would provide more detailed insight on the MPTM and how the proxies vary across the different bank lending products in Italy. By following the majority of the literature (Montagnoli et al., 2016; ECB, 2013; Kleimeier and Sander, 2006; de Bondt et al., 2005, just to name a few) another suggestion is to use the money market rate and investigate the mechanisms between the inter-bank lending market and end-consumers, the borrowers. In this way, further insight could be obtained on the relationship between the interbank market and the lending market and how changes in the influence of the inter-bank market vary in comparison to the ones identified between the monetary policy rate and the lending market. One way to access different interest rate data for the Euro Zone would be through the data from the Monetary Financial Institutions (MFI) provided by Eurostat. This data set contains information on financial institutions, which are subject to the Euro System's minimum reserve requirements (ECB, 2019l). Another data source for further research could be the Bank Lending Survey statistics published by the ECB.

A further direction of development of this thesis would be to examine the impact of the presence of the financial sector in a region on MPTMs in other countries across the Euro Zone but also on a global scale. Then, for instance, a cross Euro Zone comparison could be undertaken which could provide a deeper insight on the MPTM. Furthermore, it would be interesting to look deeper into how the presence of a financial sector influences regional development from a monetary policy angle. Hence, the relationship between monetary policy and growth theories could be established.

Furthermore, two key points need to be drawn out: First, the lessons learned from this thesis imply that the effectiveness of monetary policy varies across regions and the presence of the financial sector influences MPTM positively. Second, the current right-wing rise across Europe is due to imbalances across regions. The rise of these political views takes place in regions which were neglected and/or forgotten by globalisation and Europeanisation. By considering the findings of this thesis and the right-wing movement across Europe, this highlights the importance of regional policies and hence future regional research. Therefore, based on the current political state in Europe and the examination of this thesis it is recommended to undertake research on the regional level, such as the NUTS2 level and consider these results in regional policies.

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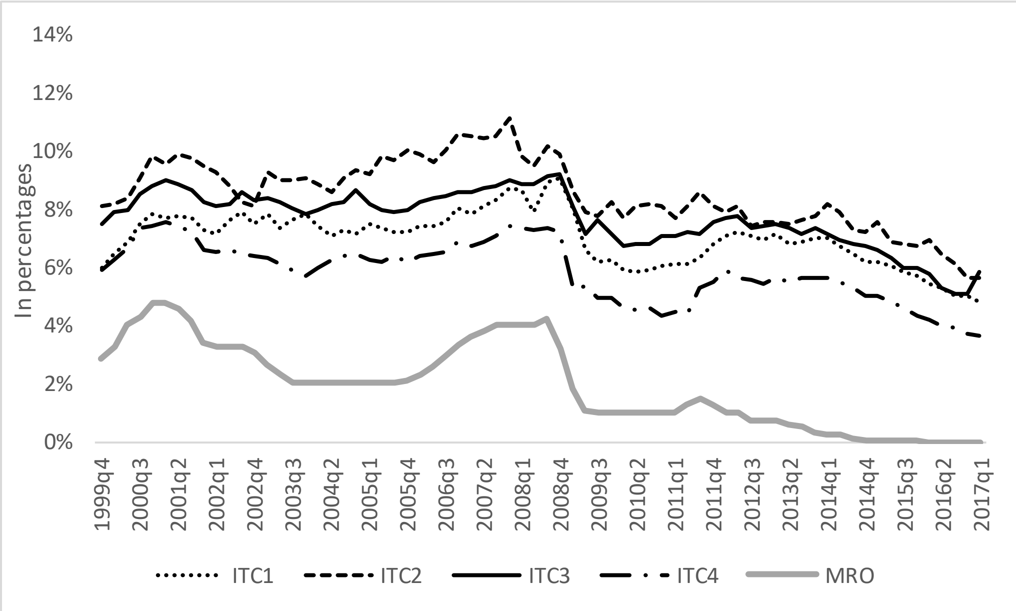
List of Abbreviations

ADF	Augmented Dickey-Fuller
$AdjR^2$	Adjusted R^2
AIC	Akaike information criterion
AR	Autoregressive
ARDL	Autoregressive Distributed Lag
ARIMA	Autoregressive Integrated Moving Average
CEC	Commission of European Communities
CLRM	Classical Linear Regression Model
CR	Cointegrated Regression
EC	European Commission
ECB	European Central Bank
ECM	Error Correction Model
EMU	European Monetary Union
EONIA	Euro Overnight Index Average
ESCB	European System of Central Banks
EURIBOR	Euro Interbank Offered Rate
FCP1	Financial Crisis Phase 1
FCP2	Financial Crisis Phase 2
GDP	Gross Domestic Product
HQIC	Hannan-Quinn Information Criterion
IO	Innovative Outlier
LR	Likelihood-ratio
MLF	Marginal Lending Facility
MP	Actual Monetary Policy
MPE	Expected Monetary Policy Rate
MPTM	Monetary Policy Transmission Mechanism
MPU	Unexpected Monetary Policy Rate
MRO	Main Refinancing Operation
NCB	National Central Banks
NUTS	Nomenclature of Territorial Units for Statistics
OCA	Optimum Currency Area
OLS	Ordinary Least Squares
SBIC	Schwarz Bayesian Information Criterion
SME	Small-and-Medium-Sized Enterprises
SUR	Seemingly Unrelated Regression
VAR	Vector Autoregressive
VECM	Vector Error Correction Model

Appendix A
Evolution of Interest and Default Rates

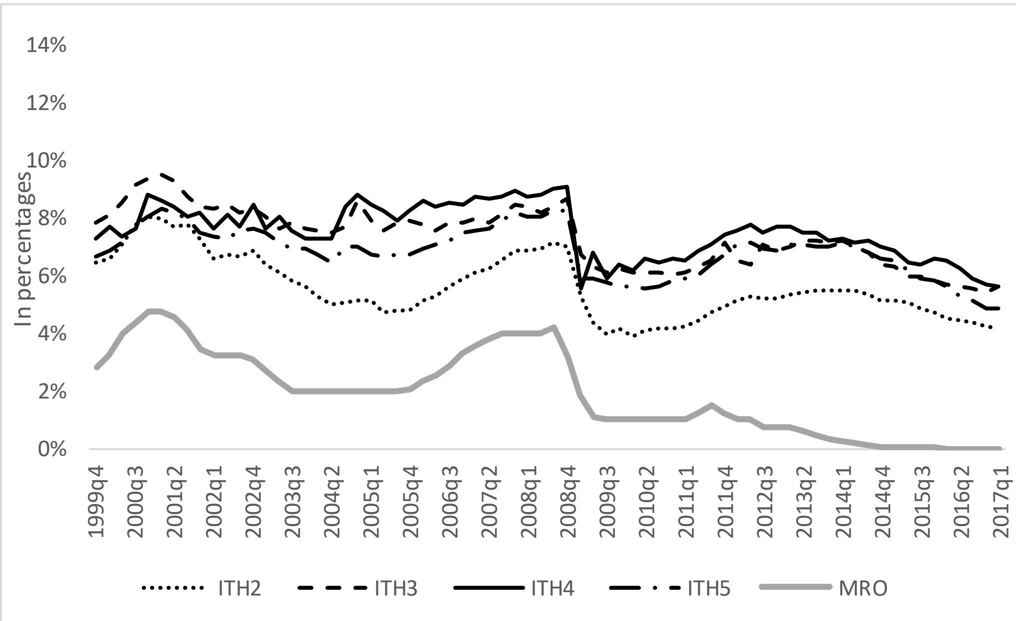
A.1 Evolution of the ECB MRO and Revocable Loan Interest Rates by Italian NUTS2 Region, 1999q4 – 2017q1

A.1.1 North-West NUTS1 region



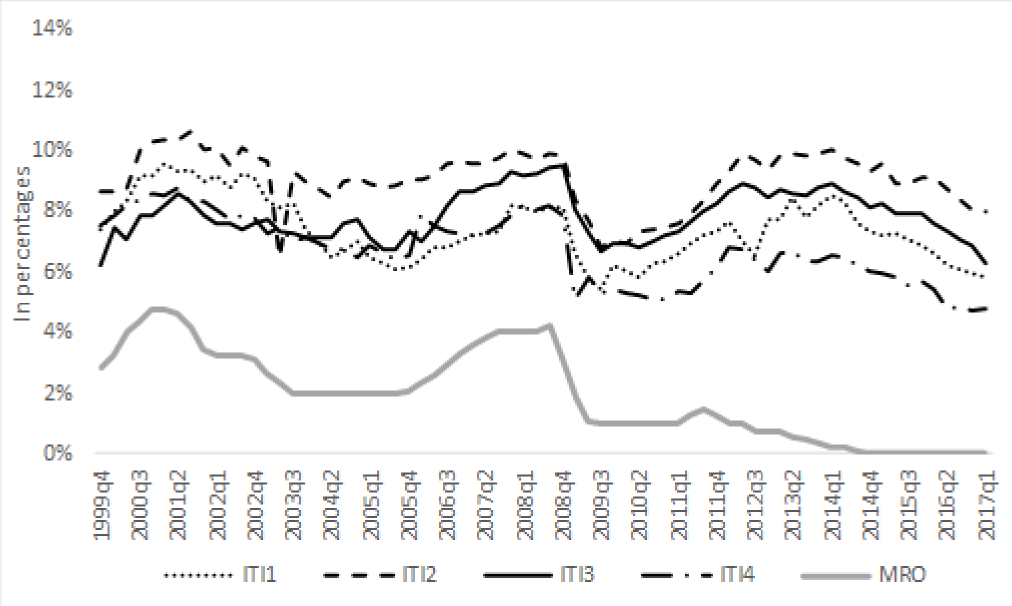
Source: Author’s calculation using Bank of Italy (2017b) and ECB (2019d)

A.1.2 North-East NUTS1 region



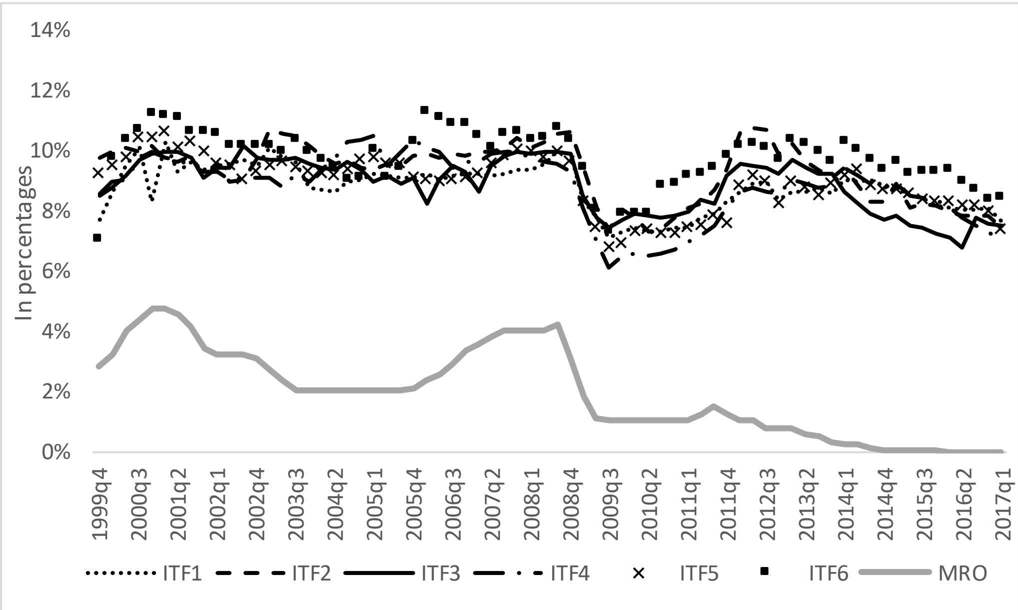
Source: Author’s calculation using Bank of Italy (2017b) and ECB (2019d)

A.1.3 Centre NUTS1 Region



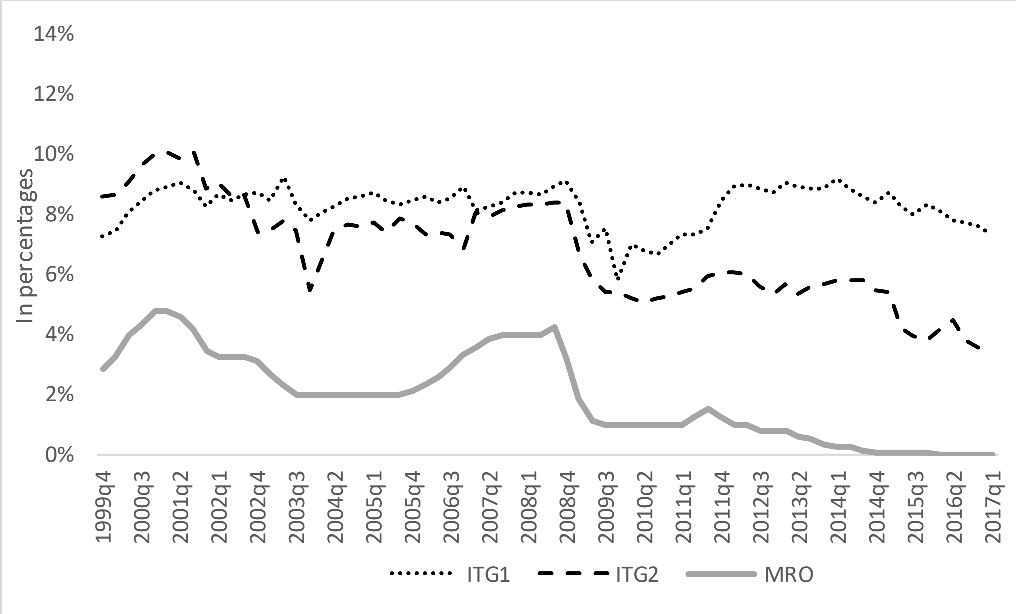
Source: Author's calculation using Bank of Italy (2017b) and ECB (2019d)

A.1.4 South NUTS1 Region



Source: Author's calculation using Bank of Italy (2017b) and ECB (2019d)

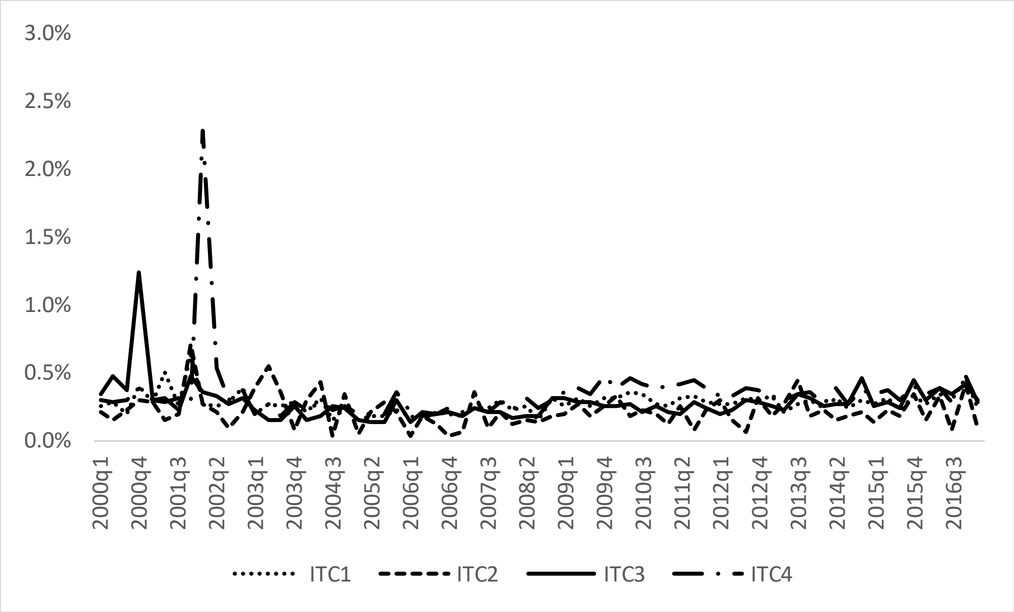
A.1.5 The Islands NUTS1 Region



Source: Author's calculation using Bank of Italy (2017b) and ECB (2019d)

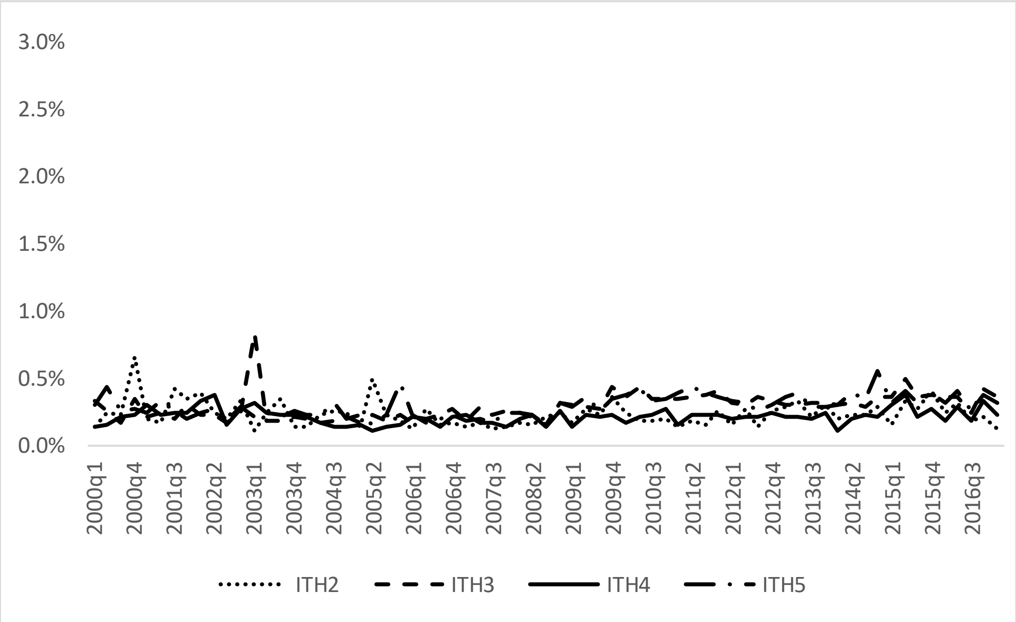
A.2 Evolution of the Default Rates by Italian NUTS2 Region, 2000q1 – 2017q1

A.2.1 North-West NUTS1 Region



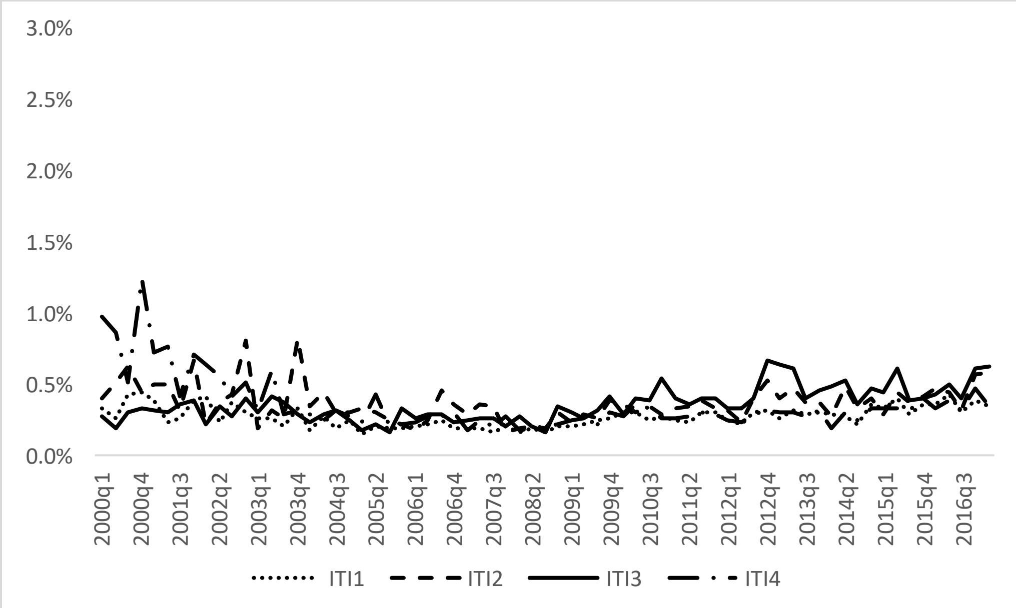
Source: Author’s calculation using Bank of Italy (2018)

A.2.2 North-East NUTS1 Region



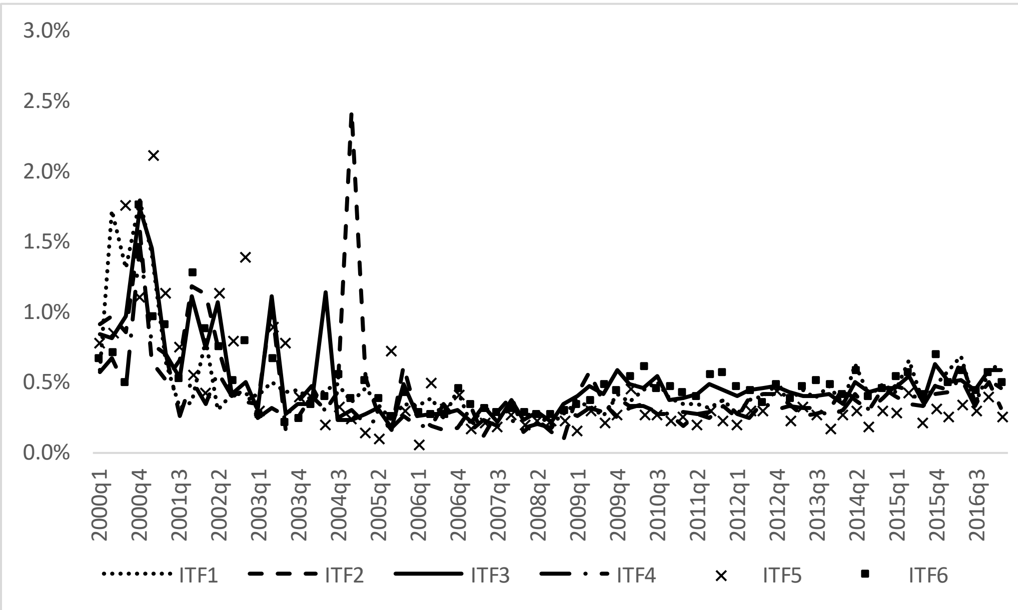
Source: Author’s calculation using Bank of Italy (2018)

A.2.3 Centre NUTS1 Region



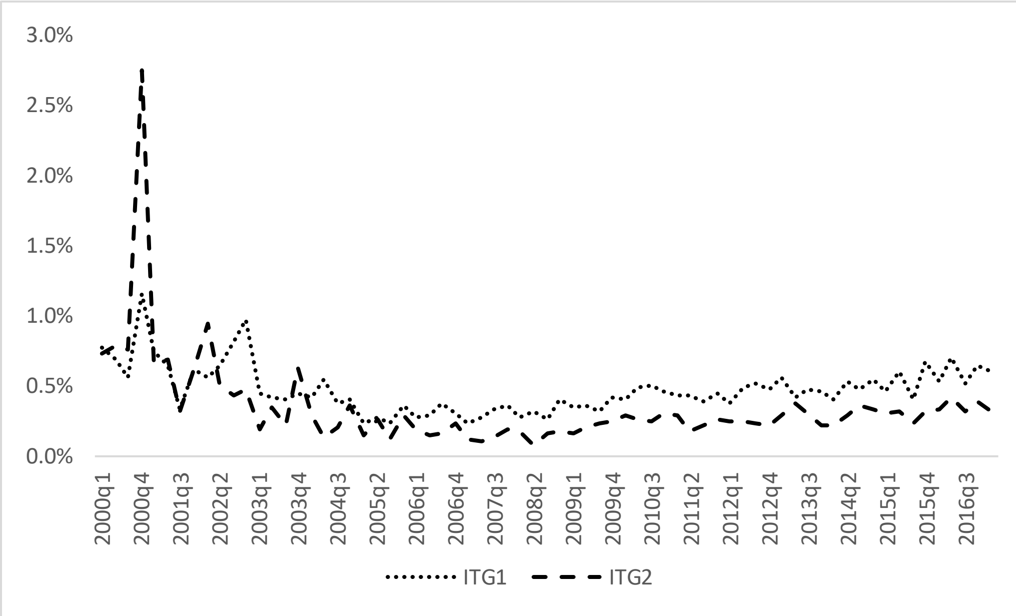
Source: Author's calculation using Bank of Italy (2018)

A.2.4 South NUTS1 Region



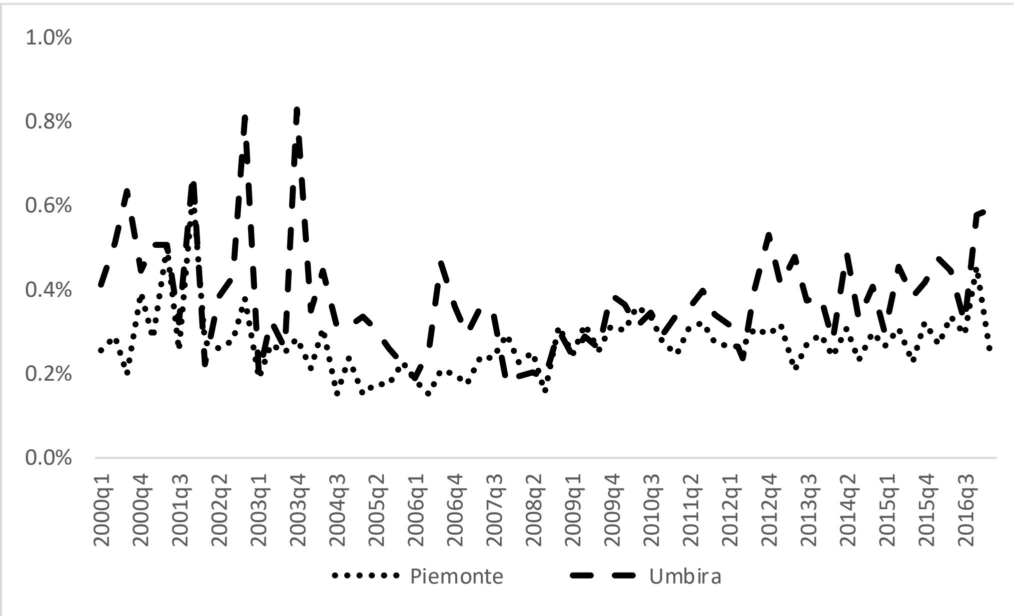
Source: Author's calculation using Bank of Italy (2018)

A.2.5 The Islands NUTS1 Region



Source: Author's calculation using Bank of Italy (2018)

A.2.6 Piemonte and Umbria



Source: Author's calculation using Bank of Italy (2018)

Appendix B
Pre-Estimation Tests

B.1 Stationarity Test, Possible Conditions/Cases

Test	Data format	Exogenous
Test 1	Level	Constant
Test 2	Level	Trend
Test 3	Level	No constant No trend
Test 4	1st difference	Constant
Test 5	1st difference	Trend
Test 6	1st difference	No constant No trend

B.2 ADF Unit Root Test, *t*-Statistics, per Italian NUTS2 Region

NUTS1	NUTS2	Level			First difference		
		Constant	Trend	No constant no trend	Constant	Trend	No constant no trend
	MRO	-0.419	-1.278	-1.819	-2.770*	-3.788**	-2.552**
North West	Piemonte	0.533	-1.395	-0.962	-3.111**	-6.670***	-3.009***
	Valle d'Aosta/Vallée d'Aoste	1.207	-1.407	-1.308	-3.247**	-3.339*	-3.076***
	Liguria	1.695	-0.949	-1.749	-3.172**	-5.784***	-2.973***
	Lombardia	0.399	-1.145	-1.580	-2.945**	-6.485***	-2.770***
North East	Provincia Autonoma di Trento	-0.953	-1.201	-1.564	-4.172***	-4.160***	-2.354**
	Veneto	-0.019	-1.490	-1.878	-3.564***	-3.468*	-3.364***
	Friuli-Venezia Giulia	-0.134	-1.525	-0.893	-3.975***	-3.980**	-3.928***
	Emilia-Romagna	0.219	-0.966	-1.191	-2.799*	-6.648***	-2.695***
Centre	Toscana	-0.672	-1.017	-1.189	-2.872*	-6.681***	-2.784***
	Umbria	-1.086	-1.259	-0.437	-3.357**	-3.326*	-3.362***
	Marche	-1.163	-0.741	-0.239	-5.677***	-5.622***	-2.442**
	Lazio (Roma)	-0.235	-1.252	-1.796	-3.446**	-3.407*	-3.296***
South	Abruzzo	-0.811	-1.602	-0.714	-3.489**	-3.468*	-3.485***
	Molise	-0.617	-1.202	-1.095	-5.785***	-5.737***	-2.441**
	Campania	-0.225	-1.664	-0.972	-2.963**	-6.841***	-2.922***
	Puglia	-0.418	-1.118	-0.901	-5.624***	-5.573***	-2.246**
	Basilicata	-0.881	-1.322	-1.106	-2.689*	-5.501***	-2.621***
	Calabria	-1.028	-1.794	-0.460	-4.542***	-4.393***	-4.486***
The Islands	Sicilia	-1.285	-1.499	-0.216	-3.684***	-3.652**	-3.705***
	Sardegna	-0.009	-1.386	-2.399	-3.036**	-6.745***	-2.779***

Notes: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

Critical values for Test1/Constant are -3.558, -2.917 and -2.594 for 1%, 5% and 10% respectively. Critical values for Test2/Trend are -4.115, -3.484 and -3.170 for 1%, 5% and 10% respectively. Critical values for Test3/No Constant, No Trend are -2.614, -1.950 and -1.610 for 1%, 5% and 10% respectively. Critical values for Test4/Constant are -3.559, -2.918 and -2.594 for 1%, 5% and 10% respectively. Critical values for Test5/Trend are -4.117, -3.485 and -3.171 for 1%, 5% and 10% respectively. Critical values for Test6/No Constant, No Trend are -2.614, -1.950 and -1.610 for 1%, 5% and 10% respectively.

B.3 Information Criteria

The Final Prediction Error (FPE), the Akaike Information Criterion (AIC), the Schwarz Bayesian Information Criterion (SBIC) and the Hannan and Quinn Information Criterion (HQIC) for Optimal Lag-Length Selection for the Full Sample Size (limited by a max lag length of 10 as defined by Schwert (1989) based on a sample size of 67 time-observations per time-series). The star (*) shows the minimum (optimum) value for each information criteria.

B.3.1: Piemonte (ITC1)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-123.1				0.27652	4.390	4.418	4.462
1	44.9	336.0	4.000	0.000	0.00088	-1.363	-1.280	-1.148
2	123.8	157.9	4.000	0.000	0.00006	-3.993	-3.854	-3.634
3	137.7	27.7	4.000	0.000	0.00005	-4.339	-4.144	-3.8372*
4	139.9	4.5	4.000	0.347	0.00005	-4.277	-4.026	-3.632
5	141.2	2.6	4.000	0.618	0.00005	-4.183	-3.877	-3.395
6	151.2	19.9	4.000	0.001	0.00004	-4.391	-4.029	-3.459
7	165.6	28.923*	4.000	0.000	.00003*	-4.75846*	-4.34056*	-3.683
8	166.2	1.2	4.000	0.877	0.00003	-4.639	-4.166	-3.421
9	170.4	8.4	4.000	0.077	0.00004	-4.647	-4.117	-3.285
10	175.0	9.2	4.000	0.056	0.00004	-4.668	-4.083	-3.163

B.3.2: Valle d'Aosta (ITC2)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-126.4				0.31045	4.506	4.534	4.578
1	43.9	340.7	4.000	0.000	0.00091	-1.330	-1.247	-1.115
2	107.3	126.8	4.000	0.000	0.00011	-3.415	-3.275	-3.056
3	124.8	34.9	4.000	0.000	0.00007	-3.887	-3.692	-3.385
4	132.9	16.3	4.000	0.003	0.00006	-4.032	-3.781	-3.38679*
5	139.6	13.4	4.000	0.010	0.00006	-4.126	-3.820	-3.338
6	145.5	11.8	4.000	0.019	0.00005	-4.194	-3.831	-3.262
7	154.8	18.6	4.000	0.001	0.00004	-4.380	-3.962*	-3.305
8	160.3	10.945*	4.000	0.027	0.00004*	-4.43157*	-3.958	-3.213
9	160.8	1.0	4.000	0.907	0.00005	-4.309	-3.780	-2.947
10	164.8	7.9	4.000	0.094	0.00005	-4.308	-3.723	-2.803

B.3.3: Liguria (ITC3)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-119.7				0.24537	4.271	4.299	4.342
1	57.7	354.9	4.000	0.000	0.00056	-1.815	-1.731	-1.600
2	127.6	139.7	4.000	0.000	0.00006	-4.125	-3.986	-3.767
3	143.3	31.6	4.000	0.000	0.00004	-4.538	-4.343	-4.03666*
4	146.0	5.2	4.000	0.266	0.00004	-4.490	-4.239	-3.844
5	147.1	2.4	4.000	0.666	0.00004	-4.391	-4.085	-3.602
6	154.7	15.1	4.000	0.005	0.00004	-4.515	-4.153	-3.583
7	169.0	28.6	4.000	0.000	0.00003	-4.876	-4.458	-3.800
8	172.6	7.4	4.000	0.118	0.00003	-4.865	-4.391	-3.646
9	175.8	6.4	4.000	0.171	0.00003	-4.837	-4.307	-3.475
10	185.8	19.854*	4.000	0.001	.000024*	-5.04462*	-4.45957*	-3.539

B.3.4: Lombardia (ITC4)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-124.3				0.28853	4.433	4.461	4.504
1	44.4	337.5	4.000	0.000	0.00089	-1.348	-1.265	-1.133
2	120.2	151.6	4.000	0.000	0.00007	-3.868	-3.729	-3.510
3	137.9	35.3	4.000	0.000	0.00005	-4.347	-4.152	-3.84486*
4	144.2	12.6	4.000	0.014	0.00004	-4.427	-4.176	-3.782
5	146.6	4.9	4.000	0.294	0.00004	-4.373	-4.067	-3.585
6	157.7	22.2	4.000	0.000	0.00003	-4.622	-4.260	-3.690
7	169.0	22.6	4.000	0.000	0.00003	-4.878	-4.460	-3.803
8	170.1	2.1	4.000	0.723	0.00003	-4.774	-4.300	-3.555
9	180.3	20.514*	4.000	0.000	0.00003*	-4.99331*	-4.46398*	-3.631
10	183.3	6.1	4.000	0.195	0.00003	-4.959	-4.374	-3.454

B.3.5: Provincia Autonoma di Trento (ITH2)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-137.7				0.46167	4.903	4.931	4.975
1	53.7	382.8	4.000	0.000	0.00064	-1.672	-1.588	-1.457
2	153.6	199.9	4.000	0.000	0.00002	-5.039	-4.900	-4.681
3	173.4	39.5	4.000	0.000	0.00001	-5.592	-5.397	-5.0898*
4	176.1	5.6	4.000	0.234	0.00001	-5.549	-5.298	-4.904
5	183.6	14.9	4.000	0.005	0.00001	-5.669	-5.363	-4.881
6	186.7	6.3	4.000	0.177	0.00001	-5.639	-5.277	-4.708
7	196.2	19.0	4.000	0.001	0.00001	-5.832	-5.414	-4.757
8	200.0	7.5	4.000	0.110	0.00001	-5.824	-5.350	-4.605
9	203.6	7.2	4.000	0.124	0.00001	-5.810	-5.281	-4.448
10	214.1	21.015*	4.000	0.000	8.8e-06*	-6.03878*	-5.45372*	-4.533

B.3.6: Veneto (ITH3)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-126.3				0.30892	4.501	4.529	4.573
1	47.0	346.7	4.000	0.000	0.00081	-1.440	-1.357	-1.225
2	110.3	126.5	4.000	0.000	0.00010	-3.520	-3.380	-3.161
3	136.4	52.2	4.000	0.000	0.00005	-4.295	-4.100	-3.793
4	148.0	23.2	4.000	0.000	0.00004	-4.562	-4.31144*	-3.917*
5	150.0	3.9	4.000	0.413	0.00004	-4.491	-4.185	-3.703
6	151.1	2.1	4.000	0.712	0.00004	-4.388	-4.026	-3.456
7	160.6	19.1	4.000	0.001	0.00004	-4.583	-4.165	-3.507
8	161.5	1.9	4.000	0.763	0.00004	-4.475	-4.001	-3.256
9	170.4	17.777*	4.000	0.001	0.00004*	-4.64617*	-4.117	-3.284
10	171.6	2.3	4.000	0.679	0.00004	-4.546	-3.961	-3.041

B.3.7: Friuli-Venezia Giulia (ITH4)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-130.8				0.36263	4.661	4.689	4.733
1	33.6	328.9	4.000	0.000	0.00130	-0.968	-0.884	-0.753
2	88.4	109.5	4.000	0.000	0.00022	-2.749	-2.610	-2.391
3	108.6	40.4	4.000	0.000	0.00012	-3.318	-3.123	-2.81617*
4	111.3	5.5	4.000	0.240	0.00013	-3.274	-3.023	-2.629
5	114.5	6.4	4.000	0.173	0.00014	-3.246	-2.939	-2.457
6	123.9	18.8	4.000	0.001	0.00011	-3.435	-3.073	-2.503
7	137.9	27.9	4.000	0.000	0.00008	-3.785	-3.367	-2.710
8	143.1	10.4	4.000	0.035	0.00008	-3.827	-3.353	-2.608
9	150.5	14.95*	4.000	0.005	0.00007*	-3.94885*	-3.41952*	-2.587
10	151.6	2.0	4.000	0.730	0.00008	-3.844	-3.259	-2.339

B.3.8: Emilia-Romagna (ITH5)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-133.4				0.39658	4.751	4.779	4.823
1	45.1	357.1	4.000	0.000	0.00087	-1.373	-1.289	-1.158
2	119.6	149.0	4.000	0.000	0.00007	-3.846	-3.707	-3.488
3	139.6	40.0	4.000	0.000	0.00004	-4.408	-4.212	-3.9057*
4	144.2	9.1	4.000	0.057	0.00004	-4.428	-4.177	-3.783
5	148.0	7.7	4.000	0.104	0.00004	-4.422	-4.116	-3.633
6	156.6	17.1	4.000	0.002	0.00004	-4.581	-4.219	-3.650
7	170.6	28.0	4.000	0.000	0.00003	-4.932	-4.514	-3.857
8	174.3	7.6	4.000	0.109	0.00003	-4.924	-4.451	-3.706
9	181.8	14.899*	4.000	0.005	0.00002*	-5.04553*	-4.5162*	-3.684
10	182.3	1.0	4.000	0.914	0.00003	-4.922	-4.337	-3.417

B.3.9: Toscana (ITI1)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-155.8				0.87039	5.537	5.565	5.609
1	29.0	369.7	4.000	0.000	0.00153	-0.808	-0.724	-0.593
2	106.9	155.7	4.000	0.000	0.00012	-3.399	-3.260	-3.041
3	121.3	29.0	4.000	0.000	0.00008	-3.767	-3.5715*	-3.26472*
4	124.9	7.0	4.000	0.135	0.00008	-3.749	-3.499	-3.104
5	126.4	3.0	4.000	0.551	0.00009	-3.662	-3.356	-2.874
6	132.1	11.4	4.000	0.023	0.00008	-3.721	-3.359	-2.789
7	141.8	19.6	4.000	0.001	0.00007*	-3.92415*	-3.506	-2.849
8	143.8	3.9	4.000	0.414	0.00008	-3.853	-3.379	-2.634
9	144.7	1.8	4.000	0.774	0.00009	-3.744	-3.215	-2.382
10	152.9	16.384*	4.000	0.003	0.00008	-3.891	-3.306	-2.386

B.3.10: Umbria (ITI2)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-158.9				0.96955	5.645	5.673	5.717
1	20.2	358.2	4.000	0.000	0.00208	-0.499	-0.416	-0.284
2	87.1	133.8	4.000	0.000	0.00023	-2.707	-2.567	-2.348
3	100.8	27.3	4.000	0.000	0.00016	-3.045	-2.850	-2.54328*
4	105.7	9.8	4.000	0.043	0.00016	-3.077	-2.827	-2.432
5	107.2	3.0	4.000	0.557	0.00017	-2.990	-2.683	-2.201
6	111.6	8.9	4.000	0.065	0.00017	-3.005	-2.643	-2.073
7	122.2	21.1	4.000	0.000	0.00014	-3.234	-2.816	-2.158
8	129.1	13.9	4.000	0.008	0.00013*	-3.33692*	-2.86331*	-2.118
9	129.7	1.3	4.000	0.862	0.00015	-3.219	-2.690	-1.857
10	135.8	12.138*	4.000	0.016	0.00014	-3.292	-2.707	-1.786

B.3.11: Marche (ITI3)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-153.6				0.80504	5.459	5.487	5.531
1	41.9	391.0	4.000	0.000	0.00097	-1.260	-1.176	-1.044
2	127.8	171.7	4.000	0.000	0.00006	-4.132	-3.992	-3.773
3	143.6	31.8	4.000	0.000	0.00004	-4.549	-4.354	-4.04705*
4	148.1	9.0	4.000	0.061	0.00004	-4.566	-4.316	-3.921
5	151.3	6.4	4.000	0.171	0.00004	-4.539	-4.232	-3.750
6	159.0	15.4	4.000	0.004	0.00003	-4.668	-4.306	-3.736
7	167.2	16.4	4.000	0.003	0.00002*	-4.81496*	-4.39707*	-3.740
8	168.3	2.2	4.000	0.700	0.00003	-4.713	-4.239	-3.494
9	173.4	10.235*	4.000	0.037	0.00003	-4.752	-4.223	-3.390
10	175.3	3.7	4.000	0.447	0.00003	-4.677	-4.092	-3.172

B.3.12: Lazio (ITI4)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-132.8				0.38872	4.731	4.759	4.803
1	30.7	327.0	4.000	0.000	0.00144	-0.866	-0.783	-0.651
2	91.9	122.5	4.000	0.000	0.00019	-2.874	-2.735	-2.516
3	107.6	31.3	4.000	0.000	0.00013	-3.283	-3.088	-2.78106*
4	114.6	14.0	4.000	0.007	0.00012	-3.388	-3.138	-2.743
5	118.5	7.8	4.000	0.098	0.00012	-3.385	-3.079	-2.597
6	124.1	11.3	4.000	0.024	0.00011	-3.443	-3.081	-2.511
7	133.5	18.7	4.000	0.001	0.00009	-3.630	-3.212	-2.555
8	135.2	3.4	4.000	0.486	0.00010	-3.550	-3.077	-2.332
9	144.9	19.489*	4.000	0.001	0.00008*	-3.75205*	-3.22271*	-2.390
10	146.4	2.9	4.000	0.570	0.00010	-3.663	-3.078	-2.158

B.3.13: Abruzzo (ITF1)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-137.0				0.44976	4.877	4.905	4.948
1	35.2	344.4	4.000	0.000	0.00123	-1.025	-0.942	-0.810
2	128.9	187.5	4.000	0.000	0.00005	-4.174	-4.034	-3.815
3	143.2	28.6	4.000	0.000	0.00004	-4.535	-4.340	-4.03278*
4	145.9	5.4	4.000	0.252	0.00004	-4.488	-4.238	-3.843
5	147.1	2.4	4.000	0.667	0.00004	-4.390	-4.083	-3.601
6	156.7	19.1	4.000	0.001	0.00004	-4.585	-4.223	-3.653
7	167.0	20.645*	4.000	0.000	0.00002*	-4.80679*	-4.38889*	-3.732
8	167.9	1.8	4.000	0.764	0.00003	-4.699	-4.225	-3.480
9	170.2	4.6	4.000	0.336	0.00004	-4.638	-4.109	-3.276
10	173.5	6.5	4.000	0.162	0.00004	-4.613	-4.028	-3.107

B.3.14: Molise (ITF2)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-153.8				0.81001	5.465	5.493	5.537
1	9.3	326.1	4.000	0.000	0.00306	-0.115	-0.031	0.100
2	106.9	195.3	4.000	0.000	0.00011	-3.401	-3.261	-3.042
3	122.6	31.4	4.000	0.000	0.00007*	-3.81144*	-3.61643*	-3.30964*
4	125.0	4.6	4.000	0.325	0.00008	-3.753	-3.502	-3.107
5	125.8	1.6	4.000	0.802	0.00009	-3.641	-3.335	-2.852
6	128.6	5.6	4.000	0.231	0.00010	-3.599	-3.237	-2.667
7	138.6	20.1	4.000	0.000	0.00008	-3.811	-3.393	-2.736
8	138.8	0.4	4.000	0.981	0.00009	-3.678	-3.205	-2.460
9	140.2	2.7	4.000	0.614	0.00010	-3.585	-3.055	-2.223
10	145.7	10.98*	4.000	0.027	0.00010	-3.637	-3.052	-2.132

B.3.15: Campania (ITF3)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-142.6				0.54804	5.074	5.102	5.146
1	33.3	351.8	4.000	0.000	0.00132	-0.958	-0.874	-0.743
2	109.5	152.3	4.000	0.000	0.00011	-3.490	-3.351	-3.132
3	128.8	38.7	4.000	0.000	0.00006	-4.028	-3.833	-3.5266*
4	132.7	7.8	4.000	0.100	0.00006	-4.025	-3.774	-3.379
5	133.4	1.3	4.000	0.856	0.00007	-3.908	-3.601	-3.119
6	143.2	19.6	4.000	0.001	0.00006	-4.111	-3.749	-3.179
7	154.7	23.121*	4.000	0.000	0.00004*	-4.37653*	-3.95863*	-3.301
8	155.5	1.5	4.000	0.825	0.00005	-4.263	-3.789	-3.044
9	156.6	2.1	4.000	0.711	0.00006	-4.160	-3.630	-2.798
10	159.6	6.1	4.000	0.190	0.00006	-4.127	-3.542	-2.621

B.3.16: Puglia (ITF4)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-168.5				1.35948	5.983	6.011	6.055
1	18.4	373.7	4.000	0.000	0.00222	-0.434	-0.350	-0.219
2	112.1	187.5	4.000	0.000	0.00010	-3.583	-3.443	-3.224
3	130.9	37.7	4.000	0.000	0.00006	-4.103	-3.908	-3.60139*
4	132.5	3.2	4.000	0.526	0.00006	-4.019	-3.768	-3.374
5	132.8	0.5	4.000	0.976	0.00007	-3.887	-3.580	-3.098
6	142.1	18.7	4.000	0.001	0.00006	-4.074	-3.712	-3.142
7	154.1	24.1	4.000	0.000	0.00004*	-4.356	-3.93787*	-3.280
8	158.3	8.2	4.000	0.083	0.00005	-4.360	-3.886	-3.141
9	161.3	6.1	4.000	0.190	0.00005	-4.327	-3.798	-2.965
10	166.7	10.695*	4.000	0.030	0.00005	-4.37423*	-3.789	-2.869

B.3.17: Basilicata (ITF5)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-147.6				0.65272	5.249	5.277	5.321
1	28.4	352.0	4.000	0.000	0.00156	-0.786	-0.702	-0.571
2	114.1	171.5	4.000	0.000	0.00009	-3.654	-3.515	-3.296
3	130.8	33.4	4.000	0.000	0.00006	-4.099	-3.904	-3.5974*
4	133.3	5.0	4.000	0.285	0.00006	-4.047	-3.796	-3.402
5	139.9	13.2	4.000	0.010	0.00006	-4.139	-3.832	-3.350
6	146.2	12.5	4.000	0.014	0.00005	-4.217	-3.855	-3.286
7	157.2	22.08*	4.000	0.000	0.00004*	-4.46448*	-4.04658*	-3.389
8	158.3	2.1	4.000	0.721	0.00005	-4.361	-3.887	-3.142
9	159.0	1.4	4.000	0.853	0.00005	-4.244	-3.715	-2.882
10	159.7	1.5	4.000	0.819	0.00006	-4.131	-3.546	-2.625

B.3.18: Calabria (ITF6)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-146.9				0.63646	5.224	5.252	5.296
1	21.0	335.8	4.000	0.000	0.00203	-0.526	-0.443	-0.311
2	100.9	159.8	4.000	0.000	0.00014	-3.189	-3.050	-2.831
3	116.0	30.3	4.000	0.000	0.00010	-3.581	-3.386	-3.07874*
4	119.2	6.3	4.000	0.175	0.00010	-3.551	-3.301	-2.906
5	121.4	4.3	4.000	0.365	0.00011	-3.487	-3.180	-2.698
6	127.4	12.1	4.000	0.017	0.00010	-3.559	-3.197	-2.627
7	139.3	23.8	4.000	0.000	0.00008	-3.836	-3.41784*	-2.760
8	142.2	5.9	4.000	0.210	0.00008	-3.798	-3.325	-2.579
9	145.9	7.3	4.000	0.121	0.00008	-3.786	-3.256	-2.424
10	153.1	14.4*	4.000	0.006	0.00007*	-3.89809*	-3.313	-2.393

B.3.19: Sicilia (ITG1)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-145.0				0.59631	5.159	5.187	5.230
1	24.5	339.0	4.000	0.000	0.00179	-0.648	-0.565	-0.433
2	101.3	153.6	4.000	0.000	0.00014	-3.202	-3.063	-2.843
3	116.3	30.1	4.000	0.000	0.00010	-3.590	-3.395	-3.0885*
4	119.6	6.6	4.000	0.159	0.00010	-3.566	-3.315	-2.920
5	122.1	5.0	4.000	0.282	0.00010	-3.514	-3.207	-2.725
6	128.0	11.7	4.000	0.019	0.00010	-3.579	-3.217	-2.648
7	144.3	32.6	4.000	0.000	0.00006	-4.010	-3.59228*	-2.935
8	148.0	7.3	4.000	0.119	0.00007	-3.999	-3.525	-2.780
9	152.9	9.9	4.000	0.043	0.00006	-4.031	-3.502	-2.669
10	158.3	10.775*	4.000	0.029	0.00006*	-4.07999*	-3.495	-2.575

B.3.20: Sardegna (ITG2)

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-134.8				0.41654	4.800	4.828	4.872
1	23.3	316.3	4.000	0.000	0.00187	-0.608	-0.525	-0.393
2	93.8	141.0	4.000	0.000	0.00018	-2.942	-2.803	-2.583
3	108.6	29.6	4.000	0.000	0.00012	-3.320	-3.12504*	-2.81826*
4	110.6	4.0	4.000	0.405	0.00013	-3.250	-2.999	-2.605
5	114.2	7.1	4.000	0.132	0.00014	-3.234	-2.927	-2.445
6	117.6	6.8	4.000	0.146	0.00014	-3.213	-2.851	-2.281
7	129.7	24.3	4.000	0.000	.000106*	-3.498	-3.081	-2.423
8	131.8	4.3	4.000	0.371	0.00012	-3.433	-2.959	-2.214
9	135.7	7.6	4.000	0.106	0.00012	-3.426	-2.897	-2.064
10	141.9	12.573*	4.000	0.014	0.00011	-3.50665*	-2.922	-2.001

Appendix C
VECM Estimations

C.1 VECM Estimations for cointegrated NUTS2 regions

Coefficient	Piemonte	Liguria	Lombardia	Veneto	Emilia-Romagna	Umbria	Campania	Puglia	Sicilia
Adjustment	-0.184***	-0.157***	-0.157***	-0.082***	-0.188***	-0.159***	-0.178***	-0.102***	-0.140***
	(0.036)	(0.047)	(0.039)	(0.026)	(0.044)	(0.040)	(0.040)	(0.027)	(0.035)
Local interest rate									
LD.	0.484***	0.753***	0.577***	0.465***	0.606***	0.325**	0.615***	0.855***	0.366***
	(0.130)	(0.162)	(0.127)	(0.120)	(0.131)	(0.127)	(0.127)	(0.147)	(0.127)
L2D.	0.213	-0.062	0.493***	0.180	0.205	0.282**	0.276*	0.111	0.504***
	(0.153)	(0.215)	(0.159)	(0.115)	(0.153)	(0.133)	(0.146)	(0.195)	(0.133)
L3D.	0.210	0.420**	-0.079	0.227*	0.310**	0.216	0.067	-0.069	0.199
	(0.144)	(0.208)	(0.165)	(0.118)	(0.154)	(0.137)	(0.140)	(0.192)	(0.128)
L4D.	-0.302**	-0.490**	-0.393**		-0.455***	-0.302**	-0.258*	-0.321*	-0.424***
	(0.143)	(0.199)	(0.162)		(0.160)	(0.127)	(0.145)	(0.186)	(0.126)
L5D.	0.485***	0.498***	0.404***		0.478***	0.103	0.465***	0.480***	0.208
	(0.148)	(0.194)	(0.152)		(0.141)	(0.134)	(0.145)	(0.186)	(0.135)
L6D.	0.162	0.034	0.154		0.153	0.287**	0.167	0.131	0.255*
	(0.136)	(0.180)	(0.149)		(0.144)	(0.131)	(0.153)	(0.190)	(0.132)
L7D.		0.300*	0.158		0.181	0.245*		-0.188	
		(0.177)	(0.141)		(0.141)	(0.132)		(0.188)	
L8D.		-0.075	0.097		0.176			-0.044	
		(0.183)	(0.133)		(0.143)			(0.188)	
L9D.		0.076						0.398**	
		(0.152)						(0.157)	
MRO									
LD.	0.649***	0.575***	0.938***	1.203***	1.216***	0.817***	0.832***	0.489**	0.453**
	(0.159)	(0.175)	(0.147)	(0.141)	(0.155)	(0.294)	(0.172)	(0.235)	(0.209)
L2D.	-0.361	-0.612*	-1.650***	-1.319***	-1.906***	-0.604	-0.687**	-0.627	0.056
	(0.294)	(0.332)	(0.278)	(0.243)	(0.304)	(0.559)	(0.302)	(0.400)	(0.388)
L3D.	-0.216	-0.241	1.144***	0.180	1.232***	0.262	-0.049	0.270	-0.389
	(0.304)	(0.364)	(0.332)	(0.173)	(0.358)	(0.552)	(0.319)	(0.423)	(0.391)
L4D.	0.322	0.693**	-0.468		-0.584*	-0.213	-0.068	-0.201	0.317
	(0.290)	(0.313)	(0.323)		(0.309)	(0.498)	(0.310)	(0.408)	(0.386)
L5D.	-0.117	-0.530*	0.227		0.594**	-0.070	0.232	0.185	-0.369
	(0.279)	(0.293)	(0.293)		(0.276)	(0.495)	(0.294)	(0.379)	(0.369)
L6D.	-0.321*	0.025	-0.623**		-1.148***	0.625	-0.334*	-0.362	0.181
	(0.186)	(0.350)	(0.293)		(0.296)	(0.496)	(0.177)	(0.367)	(0.216)
L7D.		-0.459	0.643**		0.763**	-0.720**		0.137	
		(0.370)	(0.289)		(0.306)	(0.293)		(0.364)	
L8D.		0.597*	-0.605***		-0.484***			0.146	
		(0.323)	(0.183)		(0.182)			(0.335)	
L9D.		-0.477**						-0.484**	
		(0.197)						(0.226)	
Constant	0.002	-0.003	-0.002	-0.007	0.003	0.001	-0.002	0.003	0.001
	(0.010)	(0.010)	(0.009)	(0.010)	(0.009)	(0.020)	(0.012)	(0.014)	(0.015)
Cointegrated equation									
MRO	-0.577***	-0.683***	-0.696***	-0.696***	-0.433***	-0.122	-0.426***	-0.759***	-0.095
	(0.051)	(0.053)	(0.042)	(0.073)	(0.044)	(0.104)	(0.053)	(0.119)	(0.090)
_cons	-6.020	-6.419	-4.507	-6.045	-5.965	-8.751	-8.157	-7.140	-8.185
Obs	60	57	58	63	58	59	60	57	60
R^2	0.887	0.901	0.939	0.834	0.941	0.812	0.872	0.928	0.791
Log likelihood	173.24	185.23	184.32	158.22	185.10	131.21	162.28	166.67	151.25

Source: Author’s estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Standard errors in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

C.2 VECM Estimations for cointegrated NUTS2 regions, Model A/Intercept

Coefficient	Piemonte	Liguria	Lombardia	Veneto	Emilia-Romagna	Umbria	Campania	Puglia	Sicilia
Adjustment	-0.136***	-0.295***	-0.150***	-0.112***	-0.089***	-0.277***	-0.194***	-0.048***	-0.186***
	(0.027)	(0.073)	(0.045)	(0.029)	(0.019)	(0.052)	(0.047)	(0.016)	(0.040)
Local interest rate									
LD.	0.382***	0.554***	0.754***	0.482***	0.596***	0.137	0.472***	0.951***	0.267**
	(0.148)	(0.142)	(0.138)	(0.118)	(0.139)	(0.128)	(0.145)	(0.176)	(0.134)
L2D.	0.165	-0.038	0.611***	0.144	0.008	0.339**	0.154	-0.104	0.545***
	(0.171)	(0.174)	(0.182)	(0.109)	(0.170)	(0.136)	(0.155)	(0.234)	(0.138)
L3D.	0.254	0.461***	-0.455**	0.282**	0.190	0.339**	-0.057	0.007	0.242*
	(0.157)	(0.168)	(0.183)	(0.117)	(0.169)	(0.145)	(0.155)	(0.186)	(0.135)
L4D.	-0.311**	-0.434***	-0.372*		-0.471***	-0.309***	-0.198	-0.219	-0.439***
	(0.153)	(0.165)	(0.191)		(0.151)	(0.118)	(0.159)	(0.169)	(0.132)
L5D.	0.409***	0.437***	0.576***		0.468***	-0.096	0.611***	0.252	0.108
	(0.159)	(0.160)	(0.171)		(0.133)	(0.134)	(0.159)	(0.168)	(0.147)
L6D.	0.178	0.087	0.151		0.041	0.454***	0.081	0.129	0.358**
	(0.144)	(0.144)	(0.163)		(0.141)	(0.174)	(0.151)	(0.142)	(0.141)
L7D.		0.335**	0.008		0.148	0.514***			
		(0.146)	(0.155)		(0.135)	(0.185)			
L8D.		0.044	0.176		0.039				
		(0.156)	(0.144)		(0.130)				
L9D.		0.101							
		(0.129)							
MRO									
LD.	0.719***	0.520***	1.155***	1.219***	0.622***	0.840***	1.194***	0.810***	0.294
	(0.241)	(0.141)	(0.167)	(0.133)	(0.213)	(0.289)	(0.210)	(0.191)	(0.220)
L2D.	-0.535	-0.434	-2.513***	-1.336***	-1.113***	-0.300	-0.919***	-0.708**	0.370
	(0.357)	(0.268)	(0.339)	(0.227)	(0.359)	(0.537)	(0.339)	(0.281)	(0.402)
L3D.	-0.160	-0.327	1.892***	0.206	0.989***	0.150	-0.217	0.002	-0.473
	(0.328)	(0.292)	(0.420)	(0.162)	(0.359)	(0.517)	(0.353)	(0.280)	(0.391)
L4D.	0.420	0.710***	-0.360		-0.452	-0.059	0.025	-0.200	0.387
	(0.302)	(0.249)	(0.393)		(0.289)	(0.466)	(0.322)	(0.276)	(0.384)
L5D.	-0.136	-0.432*	-0.326		0.268	0.107	0.338	0.623**	-0.388
	(0.296)	(0.236)	(0.336)		(0.262)	(0.462)	(0.310)	(0.261)	(0.368)
L6D.	-0.356	-0.002	-0.585*		-0.680**	0.637	-0.769***	-0.589***	0.300
	(0.218)	(0.288)	(0.302)		(0.294)	(0.471)	(0.243)	(0.174)	(0.218)
L7D.		-0.516*	0.988***		0.641**	-0.764***			
		(0.312)	(0.303)		(0.288)	(0.291)			
L8D.		0.637**	-0.873***		-0.463**				
		(0.278)	(0.215)		(0.185)				
L9D.		-0.546***							
		(0.166)							
Intercept dummy									
LD.	-0.180**	-0.037	-0.144**	0.025	-0.239***	-0.257	0.145	0.016	-0.033
	(0.088)	(0.057)	(0.073)	(0.079)	(0.081)	(0.169)	(0.097)	(0.095)	(0.117)
L2D.	-0.110	-0.060	-0.149**	-0.133*	-0.219***	-0.287*	0.101	0.067	0.153
	(0.108)	(0.055)	(0.076)	(0.076)	(0.082)	(0.169)	(0.099)	(0.091)	(0.116)
L3D.	-0.171	-0.133**	0.127*	0.088	-0.190**	0.081	0.152	-0.133	0.065
	(0.109)	(0.056)	(0.077)	(0.078)	(0.079)	(0.126)	(0.101)	(0.090)	(0.111)
L4D.	-0.328***	-0.161***	-0.147*		-0.263***	0.028	0.128	0.070	-0.042
	(0.106)	(0.057)	(0.084)		(0.076)	(0.124)	(0.111)	(0.097)	(0.110)
L5D.	-0.169	-0.192***	0.026		-0.548***	-0.097	0.055	-0.297***	-0.039
	(0.108)	(0.060)	(0.086)		(0.100)	(0.127)	(0.110)	(0.094)	(0.109)
L6D.	-0.135	-0.273***	0.042		-0.336***	-0.107	-0.101	-0.054	0.054
	(0.102)	(0.066)	(0.086)		(0.122)	(0.130)	(0.104)	(0.105)	(0.109)
		-0.275***	-0.233***		-0.338***	-0.044			
		(0.072)	(0.087)		(0.109)	(0.129)			
		-0.324***	-0.015		-0.189*				
		(0.079)	(0.085)		(0.104)				
		-0.111							
		(0.086)							
Constant	-0.012	-0.000	-0.001	-0.002	-0.029**	0.002	0.008	-0.004	0.005
	(0.011)	(0.008)	(0.010)	(0.010)	(0.012)	(0.021)	(0.013)	(0.011)	(0.016)
Cointegrated equation									
MRO	-0.972***	-0.564***	-1.020***	-0.568***	-1.336***	0.029	-1.093***	-0.875***	0.073
	(0.140)	(0.025)	(0.084)	(0.065)	(0.197)	(0.069)	(0.124)	(0.190)	(0.082)
_cons	-4.967	-6.750	-3.596	-6.665	-4.048	-9.730	-6.228	-7.496	-9.050
Obs	60	57	58	63	58	59	60	60	60
R^2	0.908	0.954	0.956	0.863	0.963	0.866	0.889	0.934	0.822
Log likelihood	253.01	255.99	279.45	212.27	277.37	202.84	223.78	235.45	204.74

Source: Author’s estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Standard errors in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

C.3 VECM Estimations for cointegrated NUTS2 regions, Model B/Trend

Coefficient	Piemonte	Liguria	Lombardia	Veneto	Emilia-Romagna	Umbria	Campania	Puglia	Sicilia
Adjustment	-0.259***	-0.302***	-0.089**	-0.072**	-0.056	-0.033	-0.212***	-0.013	-0.069**
	(0.039)	(0.070)	(0.035)	(0.029)	(0.037)	(0.031)	(0.048)	(0.009)	(0.034)
Local interest rate									
LD.	0.349***	0.496***	0.673***	0.503***	0.750***	0.441***	0.586***	0.991***	0.457***
	(0.122)	(0.169)	(0.142)	(0.124)	(0.163)	(0.154)	(0.139)	(0.139)	(0.143)
L2D.	0.185	0.074	0.472**	0.153	0.176	0.277*	0.312**	-0.059	0.508***
	(0.139)	(0.222)	(0.185)	(0.128)	(0.197)	(0.166)	(0.156)	(0.200)	(0.160)
L3D.	0.234*	0.432*	-0.124	0.228*	0.193	0.123	0.115	0.169	0.239
	(0.130)	(0.226)	(0.187)	(0.132)	(0.198)	(0.167)	(0.153)	(0.205)	(0.157)
L4D.	-0.282**	-0.477**	-0.512***		-0.694***	-0.312**	-0.272*	-0.522**	-0.470***
	(0.130)	(0.212)	(0.188)		(0.204)	(0.159)	(0.152)	(0.218)	(0.150)
L5D.	0.441***	0.490**	0.463***		0.631***	0.111	0.390**	0.590***	0.108
	(0.135)	(0.195)	(0.178)		(0.191)	(0.166)	(0.160)	(0.224)	(0.162)
L6D.	0.210*	0.105	0.184		0.070	0.195	0.277	-0.144	0.094
	(0.126)	(0.175)	(0.170)		(0.192)	(0.160)	(0.178)	(0.170)	(0.142)
L7D.		0.334**	0.112		0.062	0.024			
		(0.168)	(0.159)		(0.181)	(0.146)			
L8D.		0.063	-0.012		-0.021				
		(0.182)	(0.147)		(0.177)				
L9D.		0.057							
		(0.158)							
MRO									
LD.	0.500***	0.574***	0.910***	1.175***	1.348***	0.663	0.718***	0.739***	0.310
	(0.146)	(0.167)	(0.177)	(0.155)	(0.210)	(0.406)	(0.191)	(0.229)	(0.297)
L2D.	-0.084	-0.484	-1.790***	-1.367***	-2.346***	-0.709	-0.560*	-0.818**	0.067
	(0.272)	(0.318)	(0.312)	(0.253)	(0.378)	(0.707)	(0.338)	(0.346)	(0.476)
L3D.	-0.254	-0.396	1.269***	0.180	1.517***	0.420	-0.190	-0.035	-0.367
	(0.276)	(0.348)	(0.365)	(0.196)	(0.452)	(0.692)	(0.355)	(0.327)	(0.453)
L4D.	0.356	0.714**	-0.572		-0.646	-0.410	0.116	-0.283	0.215
	(0.262)	(0.307)	(0.363)		(0.401)	(0.621)	(0.378)	(0.322)	(0.447)
L5D.	-0.127	-0.244	0.282		0.659*	-0.217	0.059	0.611**	-0.563
	(0.251)	(0.304)	(0.333)		(0.359)	(0.618)	(0.346)	(0.310)	(0.429)
L6D.	-0.248	-0.282	-0.749**		-1.488***	0.880	-0.236	-0.564**	0.528*
	(0.165)	(0.392)	(0.345)		(0.387)	(0.618)	(0.192)	(0.249)	(0.288)
L7D.		-0.454	0.738**		1.134***	-0.754*			
		(0.421)	(0.340)		(0.386)	(0.387)			
L8D.		0.721**	-0.644***		-0.552**				
		(0.359)	(0.221)		(0.262)				
L9D.		-0.598***							
		(0.207)							
Intercept dummy									
LD.	-0.005	-0.040	-0.031	-0.129	0.011	0.048	-0.186	-0.023	0.097
	(0.072)	(0.073)	(0.074)	(0.099)	(0.088)	(0.177)	(0.142)	(0.118)	(0.140)
L2D.	0.045	0.029	0.003	0.033	0.039	-0.040	0.124	0.313*	0.035
	(0.097)	(0.106)	(0.098)	(0.122)	(0.113)	(0.230)	(0.154)	(0.163)	(0.177)
L3D.	0.006	0.100	0.092	0.072	-0.060	0.146	0.051	-0.217	0.106
	(0.097)	(0.105)	(0.099)	(0.098)	(0.113)	(0.230)	(0.149)	(0.162)	(0.178)
L4D.	0.035	-0.097	-0.059		0.134	-0.012	-0.128	-0.027	-0.084
	(0.097)	(0.098)	(0.098)		(0.112)	(0.231)	(0.141)	(0.151)	(0.177)
L5D.	-0.034	-0.009	0.031		-0.078	-0.046	0.039	0.044	-0.002
	(0.096)	(0.095)	(0.098)		(0.111)	(0.231)	(0.146)	(0.135)	(0.176)
L6D.	0.037	-0.017	-0.042		-0.068	0.095	0.078	-0.090	-0.216
	(0.077)	(0.093)	(0.098)		(0.110)	(0.231)	(0.120)	(0.103)	(0.147)
L7D.		-0.093	0.089		0.006	-0.246			
		(0.089)	(0.098)		(0.112)	(0.196)			
L8D.		-0.010	-0.143*		-0.043				
		(0.085)	(0.074)		(0.091)				
L9D.		-0.076							
		(0.071)							
Constant	0.011	0.006	0.023	-0.016	0.016	-0.013	-0.011	-0.021	0.001
	(0.011)	(0.010)	(0.024)	(0.015)	(0.034)	(0.048)	(0.016)	(0.026)	(0.032)
Cointegrated equation									
MRO	-0.465***	-0.598***	-1.249***	-0.911***	-1.650***	1.153***	-0.263**	-4.383***	0.949***
	(0.040)	(0.037)	(0.247)	(0.134)	(0.261)	(0.381)	(0.120)	(0.990)	(0.259)
_cons	-6.304	-6.650	-2.569	-5.500	-1.730	-11.71	-8.688	4.028	-10.78
Obs	60	57	58	63	58	59	60	60	60
R^2	0.921	0.938	0.941	0.831	0.925	0.762	0.881	0.912	0.765
Log likelihood	226.04	253.29	241.99	225.39	238.85	192.21	240.53	233.55	217.66

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Standard errors in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

C.4 VECM Post-estimation: Wald Test

NUTS1	NUTS2	Lag Length	Sample Size	Wald test (chi^2)
North West	Piemonte	7	60	1111.02***
	Valle d'Aosta/Vallée d'Aoste	-	-	-
	Liguria	10	57	958.78***
	Lombardia	9	58	1003.67***
North East	Provincia Autonoma di Trento	-	-	-
	Veneto	4	63	732.05***
	Friuli-Venezia Giulia	-	-	-
	Emilia-Romagna	9	58	1087.94***
Centre	Toscana	-	-	-
	Umbria	8	59	788.9***
	Marche	-	-	-
	Lazio (Roma)	-	-	-
South	Abruzzo	-	-	-
	Molise	-	-	-
	Campania	7	60	955.56***
	Puglia	7	57	1154.93***
	Basilicata	-	-	-
	Calabria	-	-	-
The Islands	Sicilia	7	60	1043.08***
	Sardegna	-	-	-

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

C.5 VECM Post-estimation: Serial Correlation of the Error Term

Lag	Piemonte	Liguria	Lombardia	Veneto	Emilia-Romagna	Umbria	Campania	Puglia	Sicilia
1	0.8727	0.7308	0.4071	0.6906	0.7527	0.7671	0.9630	0.7383	0.8009
2	0.9736	0.8891	0.5325	0.8485	0.5259	0.4611	0.5848	0.9453	0.8070
3	0.7460	0.9717	0.6232	0.7705	0.7273	0.3451	0.7329	0.9892	0.6566
4	0.8020	0.9740	0.2810	0.2769	0.4995	0.4393	0.8569	0.7138	0.7875
5	0.8256	0.9920	0.3888	0.1581	0.6329	0.3348	0.9208	0.8301	0.4546
6	0.8744	0.9965	0.4919	0.1530	0.7469	0.4398	0.9634	0.8455	0.4021
7	0.9310	0.9655	0.5578	0.1262	0.8217	0.4980	0.9843	0.9043	0.3346
8	0.7820	0.9297	0.5231	0.1303	0.2885	0.2543	0.9936	0.8466	0.0846
9	0.8018	0.9578	0.5148	0.1593	0.2162	0.3353	0.9974	0.8971	0.1067
10	0.8415	0.9005	0.4872	0.2162	0.1777	0.3263	0.9990	0.8852	0.1399

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

C.6 VECM Post-estimation: Wald Test on Model A/Intercept and Model B/Trend

NUTS1	NUTS2	Lag	Sample Size	Intercept	Trend
North West	Piemonte	7	60	1874.30***	1598.39***
	Liguria	10	57	1032.44***	1648.59***
	Lombardia	9	58	1465.42***	3002.33***
North East	Veneto	4	63	762.13***	3517.90***
	Emilia-Romagna	9	58	1992.77***	3166.90***
Centre	Umbria	8	59	893.42***	3483.72***
South	Campania	7	60	1089.58***	4901.15***
	Puglia	7	57	1520.18***	4633.76***
The Islands	Sicilia	7	60	1120.64***	4379.86***

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

C.7 VECM Post-estimation: Serial Correlation of the Error Term on Model A/Intercept

Lag	Piemonte	Liguria	Lombardia	Veneto	Emilia-Romagna	Umbria	Campania	Puglia	Sicilia
1	0.9151	0.0461	0.1950	0.9499	0.5355	0.4781	0.4901	0.5709	0.6857
2	0.9691	0.0621	0.4159	0.4667	0.8188	0.2994	0.5679	0.3616	0.7766
3	0.7365	0.1053	0.6243	0.4945	0.9198	0.0956	0.7111	0.5652	0.7904
4	0.6793	0.1643	0.6118	0.1399	0.9701	0.1577	0.8091	0.6010	0.7946
5	0.8011	0.2590	0.6626	0.1426	0.9903	0.1020	0.6903	0.7360	0.5372
6	0.7638	0.2350	0.7058	0.1056	0.9433	0.1631	0.7896	0.8206	0.4584
7	0.8219	0.1776	0.7992	0.0538	0.7964	0.1590	0.8142	0.8885	0.3823
8	0.7030	0.1924	0.8191	0.0810	0.4606	0.1677	0.8610	0.7964	0.1170
9	0.7798	0.2489	0.6836	0.1212	0.5445	0.2284	0.7503	0.8632	0.1546
10	0.8458	0.1519	0.7004	0.1715	0.6121	0.2939	0.5212	0.4252	0.1878

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

C.8 VECM Post-estimation: Serial Correlation of the Error Term on Model B/Trend

Lag	Piemonte	Liguria	Lombardia	Veneto	Emilia-Romagna	Umbria	Campania	Puglia	Sicilia
1	0.2748	0.0640	0.0579	0.5448	0.5641	0.9309	0.7122	0.2489	0.5748
2	0.1917	0.1002	0.0761	0.7550	0.4331	0.6683	0.5699	0.3959	0.7908
3	0.3429	0.0862	0.1598	0.8514	0.4879	0.7737	0.6824	0.4651	0.8826
4	0.3339	0.1189	0.1090	0.2942	0.4006	0.8804	0.7226	0.3371	0.8456
5	0.4512	0.1964	0.0843	0.1437	0.5225	0.6381	0.6675	0.3312	0.8350
6	0.4430	0.2693	0.1296	0.1377	0.5860	0.5019	0.7368	0.4436	0.8620
7	0.5514	0.3252	0.1667	0.1384	0.6217	0.5090	0.8292	0.5310	0.7269
8	0.5221	0.3866	0.2087	0.1519	0.6096	0.3680	0.8135	0.6388	0.4551
9	0.4407	0.4846	0.2434	0.1842	0.4842	0.4349	0.8402	0.5742	0.2755
10	0.3288	0.3856	0.2684	0.2490	0.4859	0.5025	0.8545	0.6593	0.3487

Source: Author’s estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

Appendix D
ARDL Estimations

D.1 ARDL Estimations for cointegrated NUTS2 regions

Coefficient	Lombardia	Veneto	Friuli-Venezia Giulia	Emilia-Romagna	Umbria	Abruzzo	Molise	Campania	Puglia	Calabria	Sicilia
Adjustment	-0.092***	-0.109***	-0.136***	-0.092***	-0.093***	-0.074***	-0.099***	-0.131***	-0.043***	-0.095***	-0.145***
	(0.032)	(0.026)	(0.050)	(0.029)	(0.028)	(0.023)	(0.020)	(0.027)	(0.014)	(0.032)	(0.036)
Long run	0.753***	0.607***	0.593***	0.473***	-0.018	0.231**	0.399***	0.368***	0.582**	0.211*	0.034
	(0.105)	(0.080)	(0.114)	(0.098)	(0.186)	(0.109)	(0.122)	(0.077)	(0.255)	(0.124)	(0.086)
Short run											
Local interest rate											
LD.	0.707***	0.368***	0.624***	0.740***	0.373***	0.913***	0.835***	0.644***	0.907***	0.981***	0.335**
	(0.114)	(0.101)	(0.117)	(0.114)	(0.123)	(0.118)	(0.056)	(0.111)	(0.062)	(0.125)	(0.125)
L2D.	0.407***	0.284**	0.139	0.190	0.255**	-0.060		0.210		-0.294*	0.508***
	(0.146)	(0.112)	(0.131)	(0.132)	(0.118)	(0.169)		(0.131)		(0.166)	(0.131)
L3D.	-0.264*	0.354***	0.122	0.164		-0.091		0.162		0.301*	0.146
	(0.141)	(0.098)	(0.131)	(0.134)		(0.156)		(0.132)		(0.166)	(0.115)
L4D.	-0.339**		-0.300**	-0.516***		-0.249**		-0.272*		-0.554***	-0.416***
	(0.140)		(0.128)	(0.135)		(0.123)		(0.137)		(0.161)	(0.115)
L5D.	0.539***		0.473***	0.589***		0.341***		0.376***		0.361***	0.212*
	(0.116)		(0.109)	(0.119)		(0.085)		(0.103)		(0.118)	(0.125)
L6D.											0.252**
											(0.120)
MRO											
D1.	0.311**	0.124	0.527**	0.358**	0.434***	0.219***	0.219***	0.224	0.287	0.242***	-0.315
	(0.136)	(0.142)	(0.242)	(0.141)	(0.115)	(0.054)	(0.072)	(0.166)	(0.172)	(0.079)	(0.213)
LD.	0.352	0.915***	0.808*	0.583**				0.412	0.276		1.016***
	(0.265)	(0.242)	(0.461)	(0.275)				(0.290)	(0.286)		(0.359)
L2D.	-1.466***	-1.036***	-2.738***	-1.783***				-0.561***	-0.499***		-0.437*
	(0.288)	(0.164)	(0.509)	(0.301)				(0.184)	(0.172)		(0.235)
L3D.	1.289***		2.843***	1.375***							
	(0.304)		(0.539)	(0.320)							
L4D.	-0.340		-1.839***	-0.408							
	(0.325)		(0.559)	(0.304)							
L5D.	-0.197		1.203**	0.127							
	(0.318)		(0.596)	(0.319)							
L6D.	-0.353		-1.976***	-0.931***							
	(0.299)		(0.582)	(0.316)							
L7D.	0.714***		1.948***	1.007***							
	(0.254)		(0.484)	(0.261)							
L8D.	-0.499***		-0.747***	-0.424***							
	(0.130)		(0.242)	(0.135)							
Constant	0.407**	0.675***	0.893**	0.548***	0.855***	0.627***	0.865***	1.088***	0.338***	0.902***	1.204***
	(0.158)	(0.165)	(0.353)	(0.186)	(0.253)	(0.192)	(0.180)	(0.226)	(0.118)	(0.304)	(0.306)
Obs	57	57	57	57	57	57	57	57	57	57	57
R^2	0.937	0.841	0.859	0.942	0.677	0.878	0.855	0.867	0.881	0.843	0.790
Log likelihood	91.48	71.52	59.30	90.83	28.19	73.12	48.20	65.97	59.38	51.96	53.70

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Standard errors in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

D.2 ARDL Estimations for cointegrated NUTS2 regions, Model A/Intercept

Coefficient	Veneto	Friuli-Venezia Giulia	Emilia-Romagna	Umbria	Abruzzo	Molise	Campania	Puglia	Calabria	Sicilia
Adjustment	-0.143***	-0.146***	-0.067**	-0.155***	-0.040	-0.063**	-0.189***	-0.072***	-0.097***	-0.233***
	(0.026)	(0.050)	(0.025)	(0.038)	(0.027)	(0.026)	(0.031)	(0.016)	(0.032)	(0.040)
Long run										
MRO	0.524***	0.513***	0.467	0.654***	1.428	0.789*	1.010***	0.377***	0.411	-0.043
	(0.059)	(0.110)	(0.387)	(0.174)	(1.242)	(0.458)	(0.186)	(0.117)	(0.256)	(0.052)
Local interest	-0.699***	-0.409	0.032	1.911***	2.976	1.044	1.373***	-1.501***	0.583	-0.617***
rate	(0.201)	(0.337)	(0.693)	(0.447)	(3.216)	(1.163)	(0.407)	(0.397)	(0.680)	(0.173)
Short run										
Local interest rate										
LD.	0.294***	0.593***	0.867***	0.415***	0.923***	1.018***	0.604***	1.008***	0.968***	0.167
	(0.095)	(0.119)	(0.096)	(0.102)	(0.122)	(0.114)	(0.111)	(0.112)	(0.126)	(0.124)
L2D.	0.309***	0.131	-0.014		-0.034	-0.238*	0.069	-0.157	-0.310*	0.449***
	(0.103)	(0.130)	(0.108)		(0.165)	(0.121)	(0.129)	(0.149)	(0.167)	(0.119)
L3D.	0.433***	0.134	0.032		-0.118		0.131	0.026	0.291*	0.354**
	(0.093)	(0.131)	(0.113)		(0.150)		(0.135)	(0.132)	(0.166)	(0.138)
L4D.		-0.285**	-0.155		-0.359***		-0.203	-0.218	-0.557***	-0.331***
		(0.128)	(0.112)		(0.129)		(0.135)	(0.135)	(0.161)	(0.109)
L5D.		0.446***	0.406***		0.309***		0.545***	0.330***	0.338***	0.139
		(0.111)	(0.089)		(0.085)		(0.118)	(0.093)	(0.121)	(0.120)
L6D.										0.249**
										(0.117)
L7D.										0.209*
										(0.115)
MRO										
D1.	0.163	0.548**	0.223	0.434***	0.499***	0.198***	0.240	0.583***	0.242***	-0.295*
	(0.131)	(0.241)	(0.171)	(0.112)	(0.139)	(0.071)	(0.186)	(0.103)	(0.079)	(0.175)
LD.	0.873***	0.813*	-0.064		-0.380**		0.388	-0.319**		0.783***
	(0.221)	(0.458)	(0.304)		(0.171)		(0.329)	(0.127)		(0.208)
L2D.	-0.984***	-2.670***	-0.237				-0.685**			
	(0.151)	(0.508)	(0.308)				(0.338)			
L3D.		2.781***	0.505*				0.134			
		(0.538)	(0.268)				(0.331)			
L4D.		-1.797***	-0.204				-0.249			
		(0.556)	(0.229)				(0.330)			
L5D.		1.226**	-0.313				0.184			
		(0.592)	(0.253)				(0.325)			
L6D.		-1.938***	-0.181				-0.480**			
		(0.579)	(0.246)				(0.202)			
L7D.		1.914***	0.457**							
		(0.481)	(0.207)							
L8D.		-0.704***	-0.322***							
		(0.243)	(0.107)							
L9D.										
Constant	0.997***	1.038***	0.384*	1.121***	0.203	0.474*	1.227***	0.700***	0.862***	2.095***
	(0.180)	(0.370)	(0.195)	(0.278)	(0.278)	(0.256)	(0.244)	(0.157)	(0.309)	(0.349)
Obs	57	57	57	57	57	57	57	57	57	57
R^2	0.870	0.865	0.981	0.698	0.892	0.868	0.904	0.958	0.846	0.827
Log likelihood	77.29	60.41	122.73	30.08	76.47	50.84	75.05	89.11	52.42	59.34

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Standard errors in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.

D.3 ARDL Estimations for cointegrated NUTS2 regions, Model B/Trend

Coefficient	Veneto	Friuli-Venezia Giulia	Emilia-Romagna	Umbria	Abruzzo	Molise	Campania	Puglia	Calabria	Sicilia
Adjustment	-0.109***	-0.161***	-0.096***	-0.067**	-0.078***	-0.110***	-0.156***	-0.060***	-0.081**	-0.163***
	(0.026)	(0.050)	(0.029)	(0.028)	(0.023)	(0.020)	(0.030)	(0.014)	(0.031)	(0.036)
Long run										
MRO	0.601***	0.419***	0.340**	-0.959	0.029	0.241*	0.115	-0.473	0.005	-0.228
	(0.213)	(0.111)	(0.136)	(0.590)	(0.210)	(0.126)	(0.148)	(0.377)	(0.205)	(0.191)
Local interest rate	-0.000	-0.102*	-0.092	-0.518*	-0.021	-0.132**	-0.023*	-0.077**	-0.190	-0.022
	(0.022)	(0.056)	(0.081)	(0.287)	(0.018)	(0.055)	(0.012)	(0.032)	(0.124)	(0.016)
Short run										
Local interest rate										
LD.	0.368***	0.561***	0.685***	0.277**	0.929***	0.836***	0.648***	0.797***	0.903***	0.287**
	(0.104)	(0.119)	(0.123)	(0.124)	(0.118)	(0.054)	(0.109)	(0.058)	(0.125)	(0.130)
L2D.	0.284**	0.133	0.177		-0.050		0.222*		-0.268	0.454***
	(0.114)	(0.127)	(0.132)		(0.168)		(0.128)		(0.160)	(0.130)
L3D.	0.354***	0.123	0.153		-0.095		0.142		0.298*	0.137
	(0.099)	(0.127)	(0.133)		(0.155)		(0.130)		(0.160)	(0.117)
L4D.		-0.305**	-0.525***		-0.246*		-0.253*		-0.552***	-0.396***
		(0.125)	(0.135)		(0.123)		(0.135)		(0.155)	(0.117)
L5D.		0.422***	0.536***		0.360***		0.432***		0.316***	0.214*
		(0.110)	(0.127)		(0.086)		(0.107)		(0.115)	(0.127)
										0.307**
MRO										
D1.	0.123	0.496**	0.322**	0.069	0.216***	0.233***	0.108	0.289***	0.301***	-0.281
	(0.149)	(0.235)	(0.144)	(0.238)	(0.054)	(0.070)	(0.177)	(0.066)	(0.081)	(0.218)
LD.	0.916***	0.884*	0.644**	0.682**			0.511*			0.687***
	(0.247)	(0.450)	(0.278)	(0.301)			(0.290)			(0.255)
L2D.	-1.034***	-2.610***	-1.716***				-0.520***			
	(0.175)	(0.499)	(0.306)				(0.183)			
L3D.		2.701***	1.322***							
		(0.529)	(0.322)							
L4D.		-1.701***	-0.362							
		(0.548)	(0.305)							
L5D.		1.204**	0.168							
		(0.579)	(0.319)							
L6D.		-1.886***	-0.890***							
		(0.568)	(0.317)							
L7D.		1.826***	0.952***							
		(0.474)	(0.264)							
L8D.		-0.650***	-0.380***							
		(0.241)	(0.140)							
Constant	0.677***	1.135***	0.604***	0.770***	0.710***	1.008***	1.415***	0.654***	0.820***	1.481***
	(0.181)	(0.367)	(0.191)	(0.249)	(0.204)	(0.183)	(0.295)	(0.130)	(0.295)	(0.309)
Obs	57	57	57	57	57	57	57	57	57	57
R^2	0.841	0.871	0.943	0.714	0.882	0.869	0.875	0.865	0.858	0.784
Log likelihood	71.52	61.68	91.81	31.60	73.92	51.13	67.70	55.65	54.72	52.96

Source: Author's estimation using Bank of Italy (2017b) and ECB (2019d).
Notes: Standard errors in parentheses. ***, ** and * indicate statistical significance at 1%, 5% and 10% levels respectively.