The Evolution of Human Risk Tolerance Through ADHD and its Impacts on Socioeconomic Activity

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The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

Risk-tolerance is critical to economic activity, affecting numerous socioeconomic outcomes such as occupational choice and educational attainment. Individuals vary in their risk-tolerance. Neoclassical economics struggles to explain the irrational risk-taking of certain individuals, as it does not concern itself with the cause of risk-preferences. This has resulted in poor analytical tractability for economic activities, such as entrepreneurship. Entrepreneurship is a key occupational choice for economic growth. From an expected utility hypothesis perspective, entrepreneurship is irrational. Using ADHD-like behaviours, this thesis argues for the integration of biology into economics to demonstrate that irrational behaviours are rational and beneficial from an evolutionary perspective.

Risk-tolerance has an evolutionary basis and evolutionary evidence indicates that ADHD-like behaviours provided greater risk-tolerance; assisting humans in exiting the single point of origin, migrating to new lands and relaying this information to the risk-averse population. Thus, what appears to be irrational risk-taking in the modern concept is rational behaviour through the lens of evolutionary biology. As such, one is able to see that excess risk-tolerance maximises the individuals' utility through high risk activities and benefits society, if risk-tolerance is beneficial in the economic climate. In the modern economy, ADHD is a disorder and the evolutionary basis is overlooked in the discipline of economics.

This thesis contributes to the understanding of risk-preferences in economics by adapting the unified growth theory, to show that ADHD behaviours increase risk-tolerance and these behaviours have positive and negative effects. Empirical evidence in the thesis shows the behaviours increase selection into entrepreneurship, providing greater analytical tractability for an economic activity that has previously eluded it. At the same time, the thesis shows that mitigating the negative effects of ADHD are contingent upon its interaction with the environment, for instance, ADHD symptoms interact with socioeconomic background to reduce educational attainment in certain groups in society. The results lead to policy recommendations that may increase economic activity and GDP.

Introduction

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Risk-tolerance is critical to economic activity and has a biological component. Risk is studied in multiple disciplines, such as psychology and biology. The biological component of risk-tolerance is often overlooked in economic discussions of risk-tolerance. Insights from biology may help to explain the cause of heterogeneity in risk-preferences and understanding this may help to explain better those factors in economics that are affected by variations in risk-preferences, such as occupational choice and education.

A key strand of literature at the intersection of biology and economics is evolutionary economics. One key argument of evolutionary economics, which is indisputable but overlooked in economics, is that human behaviours are shaped by genetics and those genes were determined a long time ago; as such, the determinants of economic activity were determined in the distant past (Spolaore and Wacziarc, 2013). This argument applies to human risk-tolerance; i.e., risk-preferences, including utility functions, have an evolutionary basis (Robson, 1996). One possible source of the evolutionary basis of risk-tolerance is attention deficit hyperactivity disorder like behaviours (ADHD) (Gören, 2017)[1].

ADHD by definition of its acronym is considered to be a disorder. Yet, genetic evidence suggests that ADHD-like behaviours have been useful in past environments, assisting humans in exiting the single point of origin, migrating to new lands and relaying this information to the largely risk-averse population (Chen et al., 1999; Ding et al., 2002; Jensen et al., 1997; Williams and Taylor, 2005). As such, there is a mismatch, between the original environment of the behaviour and the one it currently occupies. In this current environ-

[1]From herein attention deficit hyperactivity disorder is referred to as ADHD.

ment, the behaviour produces non-optimal outcomes. However, if an activity represents something akin to the environment in which it was selected for, the behaviour can produce optimal outcomes. To understand this concept, one needs to integrate ADHD into evolutionary economics, which is a process of intimately tying theories from economics with biology. This has not yet been attempted[2].

The original environment and purpose of ADHD as a behaviour is argued to be for risk and novelty seeking. In the Unified Growth Theory (UGT) of Galor and Michalopoulos (2012), the authors propose that in past environments the gene associated with ADHD provided risk and novelty seeking, leading to entrepreneurship. The theory further states that risk-aversion, not risk-tolerance, is favoured as the economy matures. It is difficult to dispute this when one considers that ADHD is a behavioural disorder. Yet, the mature economy still holds pockets of risk-tolerance; that is, activities in which risk-tolerance is still required. Unsurprisingly, one of these activities is entrepreneurship and a small number of studies have found a positive relationship between ADHD and entrepreneurship[3]. Whilst these studies have certainly furthered knowledge, they have fallen short in a number of theoretical and empirical components[4].

Theoretically, extant studies investigating entrepreneurship and ADHD have overlooked the evolutionary basis of the behaviour, leading to that described above, an incomplete picture of the relationship between ADHD and entrepreneurship. One of the key components resulting from the extant viewpoints is the presumed simplicity of the relationship between ADHD and entrepreneurship. ADHD does not exist or effect only one outcome (i.e., entrepreneurship) and the behaviour interacts with the environment. The latter part of the previous sentence is critical, particularly in regard to entrepreneurship. Entrepreneurship has barriers; not every individual who is capable of undertaking entrepreneurship is able

[2]Notable exceptions include Galor and Michalopoulos (2012) and Gören (2017). However, these two studies fall short in that there is little discussion of placing ADHD into the discussion of evolutionary economics and developing a framework. Further, both Galor and Michalopoulos (2012) and Gören (2017) provide a macroeconomic argument.

[3]See Antshel(2018) for meta-review or chapter two of this thesis.

[4]Empirical shortcomings of existing studies and how they are addressed by this thesis are discussed below and at length in chapter two.

to, due to educational or financial constraints, for example. These two factors, educational and financial, influence entry into entrepreneurship in adulthood but also influence the later socioeconomic outcomes of ADHD at an early age.

In the above discussion the importance of biology in providing insight into economic outcomes is highlighted. More importantly, the need to produce a better theory of the integration of ADHD into evolutionary economics is stressed and found to be lacking in the current literature. To address this gap in the literature and provide a theoretical contribution, chapter one of this thesis expounds a theoretical argument integrating ADHD into evolutionary economics.

Studies that have investigated the relationship between ADHD and entrepreneurship have fallen short theoretically, as discussed above, and empirically. Existing studies focus on cross-sectional analysis, which in itself does not capture the individual's employment activity across a prolonged period nor does it accurately capture ADHD-like symptoms in childhood; the latter being a key clinical prerequisite for the diagnosis of ADHD (Faraone et al., 2009; Nigg, 2001). Third, little attention has been paid to business performance in relation to ADHD-like symptoms, as such the understanding of business performance and ADHD remains unclear.

Chapter two addresses the aforementioned limitations by delving deeper into the relationship between ADHD and entrepreneurship by analysing data from the British Cohort Study, which has around 12,000 eligible cohort members. First, ADHD-like symptoms are analysed at age 10. Second analysis of labour market outcomes and business performance are taken across and within a twelve-year period (age 30 to age 42). Third, business performance is analysed alongside selection into entrepreneurship and a range of business performance indicators are used. The key findings of chapter two include a positive relationship between ADHD-like symptoms in childhood and later entrepreneurial activity. This is the case across and within a twelve-year period, though it is slightly stronger across the twelve-year period, suggesting a complex relationship which is highlighted further with

results for the relationship between ADHD and business performance. Indicators for business performance include business longevity, earnings growth and take-home income; all of which have a negative relationship with ADHD-like symptoms in childhood. It is concluded in the chapter that whilst selection into entrepreneurship is greater, individuals with high ADHD-like symptoms in childhood may struggle with the operating of a business, likely due to an inability to conduct administrative tasks.

Chapter three identifies key labour market outcomes, but highlights the importance of factors such as education, which are established early in childhood and in and of themselves have complex developments. The purpose of chapter three is to delve deeper into the economic development of individuals and empirically test the theory presented in chapter one and the UGT, that risk-tolerance will have large and negative socioeconomic outcomes. Whilst research has been conducted on the negative outcomes of ADHD, the effects of family socioeconomic status on labour market success in ADHD individuals have been under-researched. In an attempt to address the aforementioned limitation and understand the economics of human development, chapter three utilises human capital theory and identifies key determinants of human capital development. An empirical investigation of these determinants is undertaken with the British Cohort Study, with variables including the ADHD-like behaviours, taken from age 10, labour market outcomes and success taken from age 30 and data on parents and grandparents taken as early as birth (1970). The findings from the chapter indicate that high ADHD-like symptoms in childhood have a delicate relationship with the socio-economic background of parents, more so than low ADHD-like symptoms in childhood. For instance, one key finding is that higher educational attainment can reduce unemployment in those with high ADHD-like symptoms, but educational attainment itself is contingent upon parent's socio-economic background. Thus, the chapter highlights and produces key policy recommendations that have the possibility to reduce unemployment in the economy and possibly increase gross domestic product (GDP).

The culmination of results from the three chapters presented in the thesis suggest that early childhood interventions can dramatically alter outcomes; interventions potentially

move from those outcomes that are costly to the state to those that improve the nation's economy through entrepreneurship.

As discussed above, the thesis is presented in three chapters. The chapters are interrelated and underpinned by the common theme of ADHD-like behaviours providing increased risk-tolerance. At the same time, the chapters may be read independently of one another. The following chapter, 'Evolutionary Basis of Economic Risk-Tolerance Through ADHD', lays the base discussion of ADHD as providing an increase in risk-tolerance, which subsequently has effects on economic activity.

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1 Chapter 1 - Evolutionary Basis of Economic Risk-Tolerance Through ADHD

"*The Mecca of the economist lies in economic biology rather than in economic dynamics.*"

Alfred Marshall (1898)

Risk preferences are critical to human behaviour. All decisions made by humans carry some element of risk (Trepel et al., 2005). Many of these decisions occur every day and receive little attention. Some occur infrequently and require considerable deliberation, such as occupational choice. Individuals vary in their willingness to take risk; i.e., to opt for the risk-laden choice. The cause of variation in individual risk-preferences is of great interest to economics (Starmer, 2000), as it effects various outcomes, such as education, investment and occupational choice (Burnham et al., 2015; Friedman and Savage, 1948). Human behaviour (including risk preferences) is rooted in biology and influenced by the evolutionary past of humans (Hirshleifer, 1978; Robson, 1996). It thus seems logical to expect that the human behaviour studied in economics, specifically risk preference, has an evolutionary past (Robson, 2001; Robson and Samuelson, 2011).

1.1 Theories of Risk in Economics

In the discipline of economics, the concept of risk is often understood through the basis of decision-making (Mishra, 2014; Starmer, 2000); wherein, risk is defined as the option with higher outcome variance (Mishra, 2014; Schonberg et al., 2011). To understand human risk-tolerance, economics proposes two broad theoretical approaches; i.e., normative theories and descriptive theories.

1.1.1 Expected Utility Theory

Normative theories attempt to explain behaviour through a top-down approach, indicating how a decision should be made (Mishra, 2014; Thaler, 2000). The most prominent normative theory is expected utility theory (EUT) (Starmer, 2000).

Expected utility theory was conceived by Daniel Bernoulli to address the shortcomings of the then prevalent expected value theory (Mishra, 2014; Starmer, 2000)[5]. Expected value theory assumed that risk is measured by the expected value multiplied by the probability of the outcome occurring. Take for example a lottery that has a 50% chance of winning $10,000 and a 50% chance of winning $0; the expected value of this lottery is $5,000. However, Bernoulli noted that this theory is inherently flawed, as individuals and their situations alter the approaches to gambles. For instance, according to Bernoulli a poor man would be ill-advised to not sell the lottery for $4,000, and a rich man would be ill-advised not to buy the ticket for $4,000 (Mishra, 2014).

The theory can be broadly understood as the utility of any decision outcome multiplied by its probability (Kahneman and Tversky, 1979; Mishra, 2014). Utility here refers to the currency to be obtained by the decision; e.g., happiness or gratification. The premise of expected utility theory is that utility is a more accurate assessment of risk. Utility differs according to an individual's circumstances. For instance, the expected utility decreases over wealth, in a concave function (Okasha, 2011); i.e., as wealth increases the utility derived

[5]EUT also addressed the St Petersburg Paradox (Starmer, 2000).

from money diminishes, as more money has less impact on the individual's happiness. The equation for expected utility is given by the following:

$$E(u) = (p * u) \tag{1}$$

Expected utility theory predicts that decision makers are rational and seek to maximise utility in all decisions (Brennan and Lo, 2013; Mishra 2014; Friedman and Savage, 1948). Further, EUT proposes that there are three types of utility functions; risk averse (concave-down), risk neutral (linear) and risk seeking (convex-up) (Starmer, 2000). Consider this in the context of marginal utility; i.e., the effect of a unit change in reward (x axis) on utility (y axis) (Mishra, 2014). For risk aversion, every increase on the x axis has a smaller effect on utility than the previous unit. In contrast, for risk seeking every unit increase on the x axis has a greater effect than the last.

Over time the EUT has proposed specific axioms that must be satisfied in order for the predictions of the theory to hold (Mishra, 2014 p282; von Neumann and Morgernstern, 1944)[6]. Only if these axioms are satisfied can a (numerical) value be placed on the utility and the agent considered to be rational. However, the axioms have been criticised as unrealistic and many real-world examples of violations of these examples (Mishra, 2014). Perhaps the most famous of these violations is the Allais Paradox, which violates the independence axiom (Machina, 1982). The violations and contradictory empirical findings have given rise to adaptations of the expected utility theory, such as prospect theory.

1.1.2 Prospect Theory

Prospect theory is a descriptive theory of human decision making. Descriptive theories attempt to explain actual human behaviour through a bottom-up approach; i.e., why humans make decisions in the manner that they do (Mishra, 2014; Thaler, 2000). Prospect theory developed from expected utility theory but replaces the utility function with a value

[6](1) Completeness – Preferences over outcomes can be ranked; (2) Transitivity – The preferences over outcomes are consistent (i.e., completeness does not change) (3) Continuity – There is a probability that decision makers are indifferent between the most preferred and least preferred outcomes; (4) Independence – Adding a third outcome does not impact on the independence of preferences.

function that is based around a particular reference point (Trepel et al., 2005). The basic formula for prospect theory is given by the following equation:

$$V(x,p) = v(x)w(p) \tag{2}$$

Where V is the value function, given by v, the subjective value of consequence x, and w, the impact of probability p on the attractiveness of the prospect (Trepel et al., 2005).

One of the misgivings of EUT tackled by prospect theory is the framing effect. Kahneman and Tversky (1979) found through observations of actual human behaviour that the framing of a decision altered the option and thus the risk participants would take. Consider the example of the Asian disease problem in the footnote (Tversky and Kahneman, 1981 p453)[7].

In the example, both options A & B have the same expected value. However, option B is riskier as it has higher outcome variance. Thus, the majority of respondents choose the risk-averse option. However, when the decision is framed differently, there is a marked shift in responses In options C and D, both have the same expected value as one another and with options A and B. Yet, when the decision is framed as a loss in options C and D, the majority of individuals chose option D, the riskier option. This shift from risk-aversion when the prospect is framed as a gain to risk-acceptance when the prospect is framed as a loss explains some of the anomalies of decision making under EUT. This is often referred to as loss aversion (Kahneman and Tversky, 1979).

In prospect theory, decisions of gains and losses are made around a reference point, given the value of zero. Tversky and Kahneman (1981) note that the subjective value

[7]There is an epidemic that is expected to kill 600 people. Two alternative programs have been created to combat the disease. Assume that the exact scientific estimate of the consequences of the programs are as follows: [Option A] If program A is adopted, 200 people will be saved [72% of respondents chose this option]. [Option B] If program B is adopted, there is a 1/3 probability that 600 people will be saved and 2/3 probability that no people will be saved [28% of respondents chose this option]. [Option C] If program C is adopted, 400 people will die [22% of respondents chose this option]. [Option D] If program D is adopted, there is a 1/3 probability that nobody will die, and 2/3 probability that 600 people will die [78% of respondents chose this option].

differs among individuals and attributes. An important question is what differentiates risk-taking amongst individuals? Mishra (2014) highlights that personality traits can play a critical role in altering the decision making and risk-taking amongst individuals. In particular, impulsivity is noted as a stable personality trait that is consistently found to lead to higher risk-seeking (Mishra, 2014).

From the above discussion, the importance of risk-taking in the discipline of economics is highlighted and the difficulties in generalising from this concept.

1.1.3 Limitations of Neoclassical Approach

Risk preferences in neoclassical economics enter exogenously (Burnham et al., 2015). That is, risk preferences are allowed to vary, but the preferences are implicitly assumed as being influenced by some biological process (ibid). Neoclassical economics does not concern itself with the ultimate cause of risk-preferences (Becker, 1976; Robson and Samuelson, 2010). Yet, what if the ultimate cause of risk preferences has profound impacts on neoclassical economic assumptions? It is almost certain that risk-preferences have an evolutionary basis (Netzer, 2009; Robson, 1996; Robson and Samuelson, 2010). According to the unified growth theory of Galor and Michalopoulos (2012), risk-tolerance is not adapted to the modern environment and this may have profound negative consequences not predicted by neoclassical economics.

If it is the case that the utility oft-cited in understanding risk economics may have a biological and evolutionary component, then it is necessary to understand the evolutionary basis of it. Neoclassical economics considers such discussion to be outside of the realm of economic interest. Heterogeneity in preferences, especially in risk-preferences is likely to be important in the composition of the economy. Thus, in the section that follows, we review literature on the ultimate causes of economic preferences, with a particular focus on the ultimate cause of risk preferences.

1.2 Using the Evolutionary Approach To Understand Economic Behaviour

The central question in the discussion thus far is how deep-rooted are economic preferences (Spolaore and Wacziarc, 2013)? Can one understand the complexities of economic activity brought about by economic preferences through proximate inferences alone? Recently, scholars have begun to move the field of economics to incorporate the deep-rooted history of economic preferences in search of these answers (Spolaore and Wacziarc, 2013)[8].

1.2.1 Overview of Evolutionary Economics

Evolutionary economics can be understood in two forms and it is important to make this distinction. The first approach considers evolution in the context of evolution of firms or the economy. The second considers evolution from a biological perspective and its effects on various economic phenomena. The latter is the approach to be taken here.

Biological evolutionary economics, as with economics, can be further divided into different levels of analysis. These include the genetic basis of economic activities (i.e., entrepreneurship) (e.g., Galor and Michalopoulos, 2012 ; Guedes et al., 2019; Nicolaou et al., 2011), evolution of economic preferences (e.g., Becker, 1976; Robson and Samuelson, 2011), interaction of evolutionary and economic dynamics (e.g., Spolaore and Wacziarc, 2009) and the genetic foundations of economic development (e.g., Gören, 2017; Spolaore and Wacziarc, 2009). In this discussion, we are concerned with the evolution of economic preferences, given the aim of the chapter is to understand heterogeneity in risk preferences.

Evolutionary economics sits on the periphery of discussions in economics. This arguably stands at odds with the fact that economic behaviour (i.e., preferences) are based in an evolutionary past (Becker, 1976; Robson and Samuelson, 2011). For instance, the utility function in much economic discussion of risk-taking (see earlier sections) is likely to have an evolutionary basis (Netzer, 2009; Robson, 1996; Robson and Samuelson, 2011). One cannot disentangle biology from economics, in that both are concerned with human behaviour

[8] One could contend that economics is moving along the reductionist perspective in search of more detailed answers to fundamental questions posed.

(Hirshleifer, 1978). It is inconceivable to think that economic behaviours are distinct from the study of human behaviours in biology.

Thus, from a biological perspective we can entertain the idea that a behaviour influential to the current economy may be adapted to a different environment (Robson and Samuelson, 2011). One must consider that the economy in its current form is very young from an evolutionary perspective. That is, the environment can move faster that evolution can keep pace with (Robson and Samuelson, 2011). As such, behaviours adapted to past environments may appear as being ill-suited (ibid). In order to understand the initial purpose of the behaviours and how they may be misplaced in current environments, one must understand a common framework for the analysis of economic preferences from an evolutionary perspective.

1.2.2 Evolutionary Mismatch - A Framework

Arthur Robson has provided extensive work on evolutionary economics, tying this closely with economic discussions (e.g., Robson and Samuelson, 2011), with work ranging from the evolutionary basis of preferences through to the consideration of the mismatch of these preferences with the environment. The evolutionary mismatch arises from the idea that behaviours, potentially risk-preferences, may have arisen in different environments and be suited to those environments. As such, when moving to a different environment the behaviour may not fit well and may be 'mismatched' and produce behaviour that is counterproductive (Netzer, 2009; Robson and Samuelson, 2011). As such, Robson and Samuelson (2011) argue that it is important to consider the environment in which the preferences may have been adapted to understand the effects the preferences have on the current environment.

Evolutionary mismatch can be understood through two layers of analysis; viz., proximate and ultimate. Proximate causes of behaviour are concerned with the mechanisms or machinery that lead to the behaviour (Burnham, 2013; Mishra, 2014). In this sense, proximate causes are descriptive of human behaviour. On the other hand, ultimate cause

is based in the evolutionary payoff of the behaviour (Burnham, 2013; Mishra, 2014). When considering only proximate causes of behaviour, certain actions may appear to be non-optimal and not maximising of utility. However, when considering the evolutionary payoffs of behaviours, they no longer appear as non-optimal, chiefly because not all behaviours and traits are selected to work in all environments (Burnham, 2013). One may consider that the proximate explanations view the behaviour in an isolated context and do not paint the entire picture, as the ultimate cause view does.

The distinction between proximate and ultimate cause highlights the schism between approaches taken in the discipline of economics to understand risk-taking and the biological approach to understanding risk-taking (Okasha, 2011). The former considers utility maximisation as the optimal choice (proximate), whereas the latter considers fitness to be the optimal choice (ultimate) (ibid)[9]. The approaches can lead to different conclusions of behaviours, given that biology anticipates a 'time-lag' due to the process of natural selection (Collins et al., 2016), whereas economics does not consider such a time lag. This can lead to anomalous results in economics, where behaviours appear non-optimal.

1.2.3 Applications of Evolutionary Economics

A number of evolutionary applications have been made to address economic problems with particularly strong growth in empirical literature the past decade. The approaches range from income disparity amongst nations (Spolaore and Wacziarc, 2009), macro-economic growth and entrepreneurship (Galor and Michalopoulos, 2012; Guedes et al., 2019), GDP distribution amongst countries (Gören, 2017) and new firm entry (Guedes et al., 2019) [10].

The study of Spolaore and Wacziarc (2009) examined the genetic distance between populations to explain income differences across countries[11]. The underlying premise of genetic distance is that greater genetic differences between two countries will create barriers to the

[9] Fitness from the perspective of biology refers to the reproductive success of the animal.

[10] For a thorough review of the various approaches taken in evolutionary economics, see (Collins et al., 2016).

[11] "Genetic distance is a measure of the difference in allelic frequencies across populations" (Guedes et al., 2019, p4).

diffusion of technology[12]. The authors find that greater genetic distance reduces country-level income. Scholars such as Guedes et al. (2019) have also analysed the effects of genetic distance on new firm entry across countries. The authors find that genetic distance has a positive relationship with new firm entry across countries. That is, the higher is the distance in a country, the higher is the start-up rate. The authors do not and perhaps more importantly with genetic distance measures, cannot provide explicit reasons as to why this may be the case. Reasons include lowered barriers to entry and diffusion, as per Spolaore and Wacziarc (2009). The inconclusive reasoning for the results perhaps highlights that genetic distance is a good starting point for evolutionary and biological research, but is by no means conclusive. To be more definitive, one may identify behaviours associated with economic preferences and search for the evolutionary basis. This can be found in the study of Dreber et al. (2009), in which the authors find a direct relationship between the dopamine four receptor - seven repeat (DRD4-7R) (the 'ADHD-gene' that is under positive selection) and financial risk-taking.

Risk taking is an important concept in various economic activities beyond financial risk-taking, such as in entrepreneurship. Scholars have previously investigated the evolutionary basis of entrepreneurship, with a particular focus on human risk-tolerance, given its importance in entrepreneurship (Hvide and Panos, 2014). For instance, the study of Galor and Michalopoulos (2012) utilises the ADHD gene as a proxy for risk-tolerance and novelty seeking. The unified growth theory (UGT) posits that the risk-neutral type (taken as the ADHD gene) has a linear utility function, in contrast the risk-averse type has a concave utility function. The risk-neutral type is willing to engage in risky production through entrepreneurship. It is proposed that this innovation helped humans to move out of the Malthusian trap. In essence, the ADHD gene was beneficial through entrepreneurship[13]. The theory further proposes that as economies matured this behaviour fell out of favour and a preference for the risk-averse type ensued. The preference for the risk-averse type may be explained by the growing division of labour in tandem with the maturation of the economy.

[12]It is important to bear in mind that genetic distance does not identify any particular set of genes associated with any traits or behaviours.

[13]The genetic basis of the evolutionary benefits of ADHD will be discussed in the coming section.

That is, according to Adam Smith, the purpose of the division of labour is to focus on one task, which greatly increases the individual's productivity (Smith, 1776). However, it is probable to contend that focussing on one stimulus for an extended period of time is not well-suited to the risk-tolerant type, if one is to take the ADHD gene as the proxy for this behaviour, given the known difficulty in this regard (Jensen et al., 1997).

The paper of Gören (2017) empirically tested the UGT at the genetic level. Using worldwide data on the distribution of the 'ADHD-gene', the findings suggest that there exists an optimal amount of the 'ADHD-gene'; above and below this point the GDP of the country reduces. Gören (2017) further supports the unified growth theory and the notion of the ADHD behaviours as representing risk-tolerance. Essentially, the behaviour is adapted to a previous environment that is drastically different to the current environment.

1.2.4 Conclusion

As a candidate for understanding a potential variation in risk-tolerance, ADHD is well-suited as it has a known increase in risk-tolerance and known usefulness in past environments. Symptoms akin to the behavioural disorder of attention deficit hyperactivity disorder (ADHD) display excessive risk-tolerance and increased novelty-seeking (Williams and Taylor, 2005). Evolutionary evidence suggests ADHD-like behaviours have been useful in past environments, assisting humans in exiting the single point of origin, migrating to new lands and relaying this information to the largely risk-averse population (Chen, 1999; Ding et al., 2002; Jensen et al., 1997; Williams and Taylor, 2005). In the modern context, ADHD is mainly considered to be a disorder, yet scholars propose that ADHD as a disorder exists due to the shift to industrialised societies, as the environmental landscape has changed too quickly for evolution to be in equilibrium (Robson and Samuelson, 2010; Jensen et al. 1997)[14].

1.3 Understanding ADHD

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder af-

[14]That is, for human genes to be in perfect synchronisation with the current environment

fecting around 2-5% of children in the UK (NHS UK, 2018), with a slightly higher distribution in the USA at 2-10% (Fletcher, 2014). ADHD can also affect adults, with an estimated 80% of children with ADHD exhibiting symptoms into adolescence and potentially adulthood (Farone et al., 2003). There are three primary symptoms of ADHD, viz.: (1) Poor attention span, (2) impulsive behaviour and (3) hyperactivity (Farone et al., 2003). The American Psychological Association notes that there are three types of ADHD; Inattentive, impulsive/hyperactive and combined type (APA, 2018). The cause of ADHD is argued to be partially genetic and partially environmental (Lenz et al., 2008). The gene most commonly associated with ADHD is the dopamine receptor four – seven repeat allele (DRD4-7R) (Lenz et al., 2008).

In diagnosing ADHD, clinicians use checklists that aim to capture the three symptoms of ADHD mentioned above. Within the checklists there exist cut-off points, beyond which it is considered likely that the individual suffers from ADHD (see for instance the Diagnostic and Statistical Manual 5 (American Psychiatric Association, 2013). However, ADHD may be not be a binary classification between clinical and non-clinical. Jensen et al. (1997) argues that the symptoms of ADHD exist along a continuum, with the implication that there exist individuals who exhibit the symptoms of ADHD but are not diagnosed. In fact, ADHD is often diagnosed as a disorder at the point it impacts upon the individual's quality of life (Barkley, 1997). Thus, individuals diagnosed with ADHD are often considered to be the most severe of cases (Asherson et al., 2012) and there exist individuals exhibiting symptoms who are not diagnosed, but may operate normally or more likely operate below their potential[15].

It is perhaps the case that the behaviours associated with ADHD are not evidence of a psychiatric disorder, but rather a product of the modern environment; i.e., a rejection of the behaviour by the environment (Jensen et al., 1997). Thus, when considering the case

[15]Consider the findings of Millioni et al. (2017), in which the study found individuals with ADHD symptoms and high IQ were less likely to be diagnosed with ADHD as they were better able to mitigate the symptoms of the disorder. This may be considered evidence that ADHD exists outside of a clinical definition.

of diagnosed ADHD individuals, it is only that these individuals exist along the extremes of the continuum and similar discussions could arguably be applied to those just below the clinical threshold. Indeed, this is of great interest if indeed ADHD behaviours exist along a continuum, do sub-clinical ADHD behaviours exhibit similar manifestations as clinical ADHD? Does sub-clinical ADHD exhibit benefits, such as greater risk-taking, which may better predispose sub-clinical ADHD to economic activities that require risk-tolerance, such as entrepreneurship?

1.3.1 Theories of ADHD

ADHD is often considered to be age-inappropriate behaviour and the prevailing explanation for this has been the executive function theory of Barkley (1997). This theory states that the poor inhibition is the primary deficit of ADHD, leading to subsequent effects on executive functions such as working memory. This theory has had a large effect on research in ADHD. However, the optimal stimulation theory has the potential to better explain the societal and economic effects of ADHD-like behaviours.

The optimal stimulation theory of Zentall and Meyer (1987) asserts that ADHD individuals exhibit lower states of arousal and the symptoms of ADHD are attempts to regulate the low state of arousal. As such, the argument follows that under tasks of high stimulation/motivation, the performance of ADHD individuals will not differ to those of their non-ADHD peers, as the higher stimulation results in the attainment of optimal arousal. The optimal stimulation theory, under its various names, has received strong empirical evidence[16]. The central theme of the empirical findings suggests that individuals with high-ADHD symptoms are prone to high reward and high stimulation as a means of attaining the optimal state of arousal[17].

Essentially, some scholars contend there exists an elevated motivational threshold in

[16]See for instance: Antrop et al. (2000); Groom et al. (2010); Kuntsi et al. (2009); Liddle et al. (2011); Shaw et al. (2005); Sikström and Söderlund (2007); Zentall and Myer (1987).

[17]In individuals with high ADHD-symptoms, this is likely due to the alterations in the dopaminergic system. See Sikström and Söderlund (2007) for further discussion.

individuals with ADHD symptoms (Groom et al., 2010: Liddle et al., 2011). As such, if sufficient stimuli are not readily available, the individual may seek out external stimuli of sufficient magnitude to increase arousal, which can lead to impulsive behaviours (Geissler et al., 2014: Sikström and Söderlund, 2007). This can be context specific, in that the stimulation level of an object is contingent upon its surroundings (Mushtaq et al., 2015). Thus, the optimal stimulation theories do not assert that impulsivity is not the primary symptom of ADHD, rather these theories posit that under-arousal can lead to impulsive behaviours that forego rational assessment and consideration (Malloy-Diniz et al., 2007). In other terms, the baseline state for these individuals is high-stimulation seeking and any activity that may represent high-stimulation will likely attract these individuals. It is perhaps unsurprising, therefore, that individuals with high ADHD-symptoms are prone to risk-seeking behaviours (Williams and Taylor, 2005); that is, high outcome variance (risk) carries high reward, which may attract individuals with these symptoms (Scheres et al., 2010). With regard to the inattention symptom domain, it is the same case as above; i.e., the individual seeks out stimuli within the local environment (Mushtaq et al., 2015), which leads to distractibility and inattention, both stemming from hypo-arousal (Geissler et al., 2014).

1.3.2 Decision Making in ADHD

The high risk-taking of individuals with high ADHD symptoms is evidenced in decision-making modelling, such as the Iowa Gambling Task (IGT). For instance, the study of Malloy-Diniz et al. (2007) investigated risk-taking using various measures, including the IGT. In a group of fifty adults with high ADHD symptoms, the authors found these individuals more frequently selected from the disadvantageous decks on the IGT, in comparison to the control group. Selecting from the disadvantageous decks is a risky choice, as the initial reward is greater, but the overall punishment is also greater. Thus, the mean payoff from this strategy is lower than if one were to choose from the less risky deck, in which the initial reward is lower but the punishment is also lower.

Malloy-Diniz et al. (2007) measured the impact of ADHD symptoms on three dimen-

sions of impulsivity; motor, cognitive and attentional. The authors argued that poor performance on the IGT in ADHD individuals may be related to cognitive impulsivity. Cognitive impulsivity refers to a lack of planning or forethought (Malloy-Diniz et al., 2007). The argument of the authors can be understood as the lack of consideration of ADHD in their decisions and this resulted in selecting disadvantageous choices. This argument is consistent with the above discussion and the optimal stimulation theories discussed earlier, viz., a sufficient level of motivation/stimulation reduces the impulsiveness in individuals high in ADHD symptoms. In this sense, it is probable to contend that the selection of high rewards (disadvantageous decks) is representative of attempting to obtain higher levels of stimulation that ADHD individuals may require. In other terms, ADHD individuals are driven to large rewards to normalise arousal states and this may lead to risk-seeking behaviour. The study of Garon et al. (2006) reports a similar finding to Malloy-Diniz et al. (2007), in that individuals with ADHD performed poorly on the IGT.

The finding in decision making studies that individuals with ADHD prefer high rewards is corroborated by temporal discounting in ADHD (Jackson and MacKillop, 2010). Scheres et al. (2010) note the previous findings and present empirical results. The authors find that individuals with ADHD hyperactive/impulsive type significantly discount future rewards, in preference for immediate rewards. The authors hypothesised that steep discounting in ADHD hyperactive/impulsive type is the result of aberrations in reward processing at a neural level.

Further evidence is found in Shoham et al. (2016), in which the authors employ the behavioral decision theory of Weber et al. (2002) to disentangle risk from perceived risk. That is, the authors posit that individuals with ADHD do not perceive risk the risk to be greater, but rather perceive the benefits to be greater. The meta analysis of Jackson and MacKillop (2010) highlights the equation for hyperbolic discounting:

$$V_d = V/(1 + kd) \tag{3}$$

Where V_d refers to the discounted value, V is the objective value, d refers to the delay duration and k the derived parameter that demonstrates the degree of future discounting (Jackson and MacKillop, 2010).

In the context of the optimal stimulation theory discussed above, it may be the case that individuals with ADHD seek out immediate rewards to satisfy baseline arousal. This does not dispute the finding of steep temporal discounting in ADHD, but rather from an evolutionary perspective, such behaviours do serve a purpose and may not be an aberration in antecedent environments or certain activities in the current environment, as will be seen in the closing discussion of this chapter.

1.3.3 Educational Attainment in ADHD

Given that ADHD individuals prefer large and or immediate rewards, it is unsurprising that educational attainment in ADHD children is poor. That is, modern school environments are poorly suited to low-attention and highly impulsive individuals, which is argued to be a behaviour adapted to antecedent environments (Jensen et al., 1997). Empirical evidence supports this notion, with ADHD children achieving lower school grades, more repetition of school years and higher rates of suspension and expulsion (Fletcher, 2014; Kent et al., 2010; Loe et al., 2007). In the study of Kent et al. (2011), the authors compared academic characteristics of diagnosed ADHD adolescents to non-ADHD adolescents. The findings are consistent with the broad literature on the topic, but more insight is provided as to the relationship between ADHD and poor educational attainment. The authors posit that the known difficulty in organisational capabilities of ADHD adolescents leads to difficulties in completing tasks, such as homework[18]. Further, the authors posit that certain courses, such as maths and history, may place more attentional demands than others, such as art and drama. On the other hand, human capital theory considers alternate inputs, such as socio-economic background of parents, which can adversely affect the development of hu-

[18]Poor organisational ability may stem from the reduced ability for long-term planning, as evidenced by temporal discounting studies discussed earlier

man capital beyond innate abilities[19].

More interesting however, is how poor educational attainment would translate in later life. Using the same cohort, Kuriyan et al. (2012) find that occupational status was negatively predicted by ADHD and disciplinary problems in school. Further, a greater portion of the ADHD group were in manual labour as opposed to skilled professional labour and had higher rates of job dismissals and quitting. Interestingly, ADHD participants were more likely to have held more full-time jobs than their counterparts. The authors attribute this result to the fact ADHD individuals were less likely to pursue further education and choose instead full-time employment. This result is similar to that of Fletcher (2013), in which educational attainment of ADHD individuals accounts for only a small effect on employment reduction. In addition, despite the fact the ADHD group had more work-experience, this did not translate to any increase in wages, where in fact the wages of the ADHD group were lower. Finally, with regard to occupational changes, Kuriyan et al. (2012) argue that ADHD individuals may be more responsible for leaving their jobs through simply quitting sooner. One may posit that ADHD individuals become bored with their jobs and seek further novelty in new jobs.

1.3.4 Maladaptive Behaviours in ADHD Symptoms

The high-risk taking associated with ADHD symptoms frequently leads individuals to activities of an extremely risky nature (Bush, 2010), such as criminal behaviour (Mahmut et al., 2008). ADHD individuals exhibit an increased rate of criminal behaviour, with an estimated 24% of the UK prison population exhibiting ADHD symptoms (Young et al., 2011). In comparison, the prevalence of adult ADHD in the UK adult population is approximately 1% (ibid).

The meta-analysis of Thapar et al. (2006) provides an overview of antisocial behaviours in ADHD. The findings of this review indicate that ADHD and antisocial behaviours are

[19]The interested reader can see chapter 3 of this thesis ('The Economics of Childhood Development - The Case of ADHD')

highly correlated. The mechanism through which they are related is understood to be the hyperactivity and impulsivity symptoms of ADHD (Thapar et al., 2006). The longitudinal study of Babinski et al (1999) aimed to uncover this relationship by correlating ADHD symptoms in childhood to official arrest records and self-reported crime as adults. The study found the inattentive symptom of ADHD did not predict criminal behaviour, whereas hyperactivity and impulsivity predicted a greater arrest record. This relationship is consistent with the earlier explanations of the optimal stimulation theory, in that impulsivity can lead to a lack of forethought, which can result in reactive crimes (Fletcher and Wolfe, 2009).

The notion that impulsivity is the core component driving antisocial behaviours in ADHD is corroborated by the study of Fletcher and Wolfe (2009). This study differs from Babinski et al. (1999) and Thapar et al. (2006) in that it relies on secondary data to analyse relationships between ADHD and different types of crimes. Triangulating data sources is extremely beneficial and can corroborate the finding of antisocial behaviours in ADHD. The main finding from this study is that impulsivity is the greatest predictor of antisocial behaviours in ADHD.

Interestingly Fletcher and Wolfe's (2009) paper also proposes that individuals with ADHD choose between legitimate activities and illegal activities. The authors argue this decision is based on the perceived lower rewards from legitimate activities and the reduced likelihood of punishment from illegal activities. Whilst this can be seen as an oversimplification of human behaviour, the element of reward is consistent with the aforementioned optimal stimulation theory of ADHD. This theory posited that individuals with ADHD are drawn to high stimulation activities and prefer immediate rewards to larger long-term rewards as a result of impulsive behaviours (Scheres et al., 2010). Thus, it is possible that individuals with severe ADHD symptoms may be drawn to antisocial activities as they may provide immediate rewards. In contrast, legitimate activities may be less attractive, as rewards may be delayed. This point is highlighted by the high unemployment rate amongst the clinical ADHD population (Asherson et al., 2012). In addition, it may be the case that human capital discussed earlier may determine the severity or existence between the

relationship between antisocial behaviours and ADHD; that is, more educated individuals may be less prone to antisocial behaviours[20].

1.3.5 Evolutionary Basis of ADHD Behaviours

The excessive risk-seeking of ADHD is often explained by the impulsivity symptom of ADHD, under the executive function theory (Barkley, 1997). However, when considering the optimal arousal theory in combination with an evolutionary perspective of ADHD-symptoms, behaviours that appear maladaptive may in fact be ill-fitted to the current environment. This then becomes a discussion of understanding the behaviour in its context, as explicated by Collins (2014) and Robson and Samuelson (2011). That is, there may be environments that closely replicate the antecedent environment the behaviour may have been selected for.

Authors have previously noted that ADHD behaviours were once advantageous to society. The study of Williams and Taylor (2005) used computational modelling to evidence that the confinement of ADHD to a small portion of society can be advantageous for the wider society through the transfer of vital information. The position of Williams and Taylor (2005) is supported by genetic evidence. The study of Chen (1999) found that long alleles of the DRD4 gene were strongly correlated with migratory distance, suggesting that the behaviours associated with long alleles of the DRD4 (novelty-seeking and increased risk of ADHD) may have been positively selected to assist with human migration. Ding et al. (2002) add to Chen (1999), showing greater linkage disequilibrium between the short and long allele of the DRD4[21]. Ding et al. (2002) suggest that the DRD4-7R may be associated with the movement of humans out of Africa, the single point of origin hypothesis. The authors posit that the behaviours associated with the allele could be beneficial if the distribution of these behaviours in the population is rare, which is akin to Williams and Taylor (2005).

[20] Research has not yet conducted in this area.

[21] In simple terms, linkage disequilibrium is a method for understanding the difference between two alleles. Extreme differences suggests non-random mutation (linkage disequilibrium), similarities suggests random and equal differences (linkage equilibrium)

Jensen et al. (1997) delve into the detail of the role of specific symptoms of ADHD and their application in past environments. The premise of the paper is that to better understand mental disorders one must view them from the lens of evolutionary biology and human adaptation. One of the most critical opening arguments of the paper is that the human brain can be viewed as an "adaptation machine, evolved to fit our species to a range of environments" (Jensen et al., 1997 p1673). This point is important as it highlights the heterogeneity of homo-sapiens; i.e., there is great variation in humans which is optimal for the survival of the individual and the species.

Jensen et al. (1997) demarcate the effect of each symptom domain on the perceived benefit. These are, motor activity (hyperactivity), attentional and impulsivity. For motor activity, the authors propose that increased motor activity may be efficient in foraging, spotting new opportunities and anticipating dangers in ancestral environments. This lends support to the argument that increased motor activity in ADHD does have some adaptive benefit. It is likely that hyperactivity is not a symptom on its own, but rather a manifestation of or adjacent to impulsivity, as per the classification of the APA of ADHD into Hyperactivity/Impulsivity (APA, 2018).

For the attentional domain Jensen et al. (1997) propose that ADHD individuals are well suited to scanning environments and paying attention to multiple stimuli. This, it is argued, is useful in dangerous situations and those with stimulus rich or novel environments. The argument follows that over-focussed attention in such situations could be maladaptive, as focussing on one repetitive stimulus would be dangerous in a predator rich environment. The key argument of Jensen et al. (1997) is that ADHD individuals are more attuned to high stimulation environments. In the previous sections, studies evidencing that the deficits of ADHD individuals were ameliorated in attentional tasks involving high stimulation were discussed. This again lends support to the argument of Jensen et al. and that of the arousal theories discussed earlier.

The final symptom, impulsivity, is hypothesised by Jensen et al. (1997) to confer an advantage in situations requiring fast response times, such as pouncing on potential prey or avoiding a potential predator. In such a situation, it is possible that long deliberation would result in missing a one-time opportunity. Such behaviour in these situations is emphasised by the relatively low penalty for a false positive response; i.e., responding aggressively to a neutral cue has little penalty, whereas no response to a threat could be life-threatening. Similar to the hypotheses of Jensen et al. with regard to increased motor activity and attentional variation, alone such a hypothesis regarding impulsivity may seem like conjecture, however, in section 1.3.2. we discussed the temporal discounting of ADHD individuals and their preference for immediate over delayed rewards. Such behaviour would initially appear sub-optimal and myopic, but in the context discussed by Jensen et al. the behaviour is beneficial, contingent upon the environment and task at hand.

Collectively, Jensen et al. (1997) propose their description of the ADHD symptoms in ancestral environments as being "response-ready", as opposed to "problem solving". The argument that ADHD behaviours are well-tuned to certain environments is well-evidenced in the study of Ariaal tribesman by Eisenberg et al. (2008). In this study, the authors investigated the DRD4-7R gene in settled and nomadic populations. The findings are consistent with the notion that in certain environments, such as nomadic environments, the carriers of this gene (and by corollary, ADHD-behaviours) fair better than non-carriers. This is primarily assumed to be because the gene carries adaptive benefits in nomadic environments, such as protecting livestock and acquiring food; in contrast, in settled populations the high-activity and unpredictable behaviour places the carriers at a disadvantage, as routine schooling may not be well-suited. The authors' position is further supported by evidence from Grady et al. (2013), in which carriers of the DRD4-7R survived longer than non-carriers.

1.4 A Theory of ADHD and Evolutionary Economics

The purpose of this final section is to synthesise the above review and to postulate on theoretical implications, providing grounds for empirical research in the future (chapters 2 and 3). We begin then by returning the discussion back to the economic context and to the initial purpose of the chapter explicated in section 1; viz., heterogeneity in risk-preferences provided by ADHD behaviours.

1.4.1 Different Utility Preferences in ADHD

The behaviours associated with ADHD are likely to have been adapted to past environments, in which they played a useful role through exploring new lands and providing novel information to the largely risk-averse population (Williams and Taylor, 2005). When moving to a new environment in which risk-aversion dominates, the behaviour is likely to be counterproductive (Galor and Michalopoulos, 2012). This is likely because the advantage of ADHD in past environments was positively selected but is vague in its actions. The behaviour simply attempts to seek more immediate reward and thus take more risk than the rest of the population. It has no specific instructions, only an end goal. This line of argument is taken from Robson and Samuelson (2011). Thus, when approaching environments outside of the selection environment, this behaviour continues to operate in this way, but may take risks that are wholly counterproductive for the individual and society. An additional component to consider in this is the interaction with the environment, which is likely to influence the behaviour. This component can be understood as human capital accumulation, which is likely to affect perceptions of risk and participation in negative risk activities. For example, greater parental input and higher socio-economic background can increase educational attainment and thus increase labour market success (Heckman and Mosso, 2014). This may shift the individual's perception of risk, wherein they are less susceptible to immediate rewards. Of course, human capital has always existed, from the earliest effects of ADHD-behaviours thousands of years ago, though, I argue that it is likely to exert an increasing influence on the adaptability and success of ADHD behaviours, because of the maturation of the economy, placing human capital (education, for instance),

as a barrier to employment and labour market success.

Thus far the discussion has trailed ADHD, through the application of evolutionary thinking we have outlined that ADHD confers an advantage in risk-tolerance, evidenced in various studies. Let us return the discussion back to economic risk preferences in earlier sections and combine this with discussion of the evolutionary basis of ADHD and hypothesise that ADHD has a different utility function, that is potentially adapted to antecedent environments. Expected utility theory may be considered as a biological production function (Robson and Samuelson, 2011), which endows upon the individual particular preferences with regard to risk, consumption and reproduction[22]. This is akin to that posed by Robson and Samuelson (2011), in that the oft-discussed utility function in economics has an evolutionary past. Evidence from temporal discounting and decision making studies show that ADHD individuals have a preference for immediate and or high rewards. The underpinning of a preference for high reward in ADHD was explained earlier with the low arousal theory of ADHD. It may not be the case that rewards are monetary, but rewards may in fact be perceived as risk in itself.

In order to mathematically represent the above discussion, the research must posit what has not been done so far in the literature; i.e., a different utility function in those with ADHD. This utility function interacts with the environment and produces the behaviours observed. It may be the case that understanding the interaction with the environment may lead to better approaches to harness the behaviours of ADHD. The equation below shows that the expected utility from a perceived reward is a function of perceived reward (R) and human capital (H_c). Perceived reward is a function of outcome variance (σ) to the exponent α, which represents ADHD. The interplay between human capital and perceived

[22]This approach extends the use of the expected utility function to explain evolutionary roots. Whilst earlier a criticism of expected utility theory was levied, this is likely due to its applications rather than the lack of benefit from the theory in itself.

reward is then shown below[23]:

$$E(u)_R = PU(R - H_c) + (1 - P)U(R) \tag{4}$$

Where:

$$R = \sigma^{\alpha} \tag{5}$$

In which:

$$0 < \alpha < 1 \tag{6}$$

and:

$$0 < H_c < 1 \tag{7}$$

The above is a simple normative equation of the mechanisms of ADHD, from the small (temporal discounting / educational attainment) to the large (occupational choice) and to the aggregate (economic growth, as per Gören (2017)). Human capital has a large effect on the utility derived from perceived rewards. That is, an individual with higher ADHD symptoms, but with higher human capital, derives less utility from high perceived reward than does the individual with lower human capital, likely due to their ability to regulate their need for high stimulation.

1.4.2 Dual Effects of ADHD - Application to Economic Activity

From the above discussion, any activity that has higher outcome variance is likely to attract the ADHD type. However, the argument is not so simple in its presentation. It is likely that the behaviour may not be attracted to positive contributions to the economy. Rather, the utility function may be indiscriminate in its selection of activities, and as mentioned above may interact with the environment, such as human capital discussed above. If we take the evolutionary basis, as discussed earlier the movement away from the environment of evolutionary adaptedness and movement to industrialised societies will displace the individual. In fact, according to the UGT of Galor and Michalopoulos (2012), one would expect that the risk-neutral/tolerant type is at a significant disadvantage, yet, it is not explicated

[23]In the equation above,'P' represents probability and can take any value between 0 to 1.

by Galor and Michalopoulos (2012) how this disadvantage would present in the mature economy, which leads to the need to better integrate this with the outcomes of ADHD, as is presented in chapter 3 of this thesis.

1.4.3 Contributions and Conclusion

This chapter has discussed and reviewed evolutionary economics, with particular reference to risk-tolerance. A key contribution has been developed from the application of evolutionary economics to identify ADHD as a potential source of heterogeneity in risk preferences. That is, two of the major contributions of this chapter are to first posit a different utility function in ADHD and secondly to highlight how this may interact with the environment. Equation four in this chapter succinctly captures these two contributions by incorporating both ADHD symptoms (α) and the environment in the form of human capital (H_c) into a utility function[24]

To date, such a utility function that explicitly incorporates the environment in ADHD has not been carried out, and this has created a gap in our understanding of ADHD and its application to the economy. As a result, the effects of ADHD in the economy are unclear. For instance, there is little understanding of how ADHD may influence positive economic activities that involve a high level of risk, such as entrepreneurship[25]. Further, the relationship between ADHD and negative economic outcomes is often viewed in one dimension, where ADHD is the sole cause of negative socio-economic outcomes. Yet, there is little discussion of how the behaviour interacts with different environments and how these environments may alter outcomes, signalling that the behaviour can be adapted to the environment; i.e., how do parent's socio-economic background and human capital accumulation influence economic outcomes?

In the section above, the equation above delivers the need to investigate two-fold the

[24]Human capital is accumulated in this context, and not explicitly innate, as is discussed further in the third chapter of this thesis.

[25]The possibility that ADHD may increase risk-tolerance, which may be useful in selection into entrepreneurship, is investigated in the second chapter of this thesis, 'Entrepreneurial Activity Predicted by Childhood ADHD Symptoms'

effect of ADHD on the economy. First, the effect of ADHD on economic activity through increased risk-tolerance, which is to be addressed in chapter 2, and second the effects of human capital on the perception of risk, and subsequent effects on economic activity, which is to be addressed in chapter 3.

2 Chapter 2 - Entrepreneurial Activity Predicted By Childhood ADHD-Like Behaviours

Having established ADHD as a potential source of risk and novelty, and accepting entrepreneurship as a gateway for such behaviour, in this chapter I apply our thinking to an empirical analysis, beginning with a review of risk and entrepreneurship to better understand how ADHD may fit within this activity.

The chapter is laid out in the following manner. The next section, 'Risk and Entrepreneurship', reviews the role of risk in entrepreneurship. This is approached from various angles. From the earliest definitions, which pose risk as the crucial element, to the more nascent approaches which identify sources of heterogeneity in risk tolerance. The following section, 'ADHD and Entrepreneurship', extends the discussion of identifying sources of risk by reviewing a possible source of risk-tolerance, ADHD. This leads to hypotheses development, which leads to the methodology, results and finally the discussion and conclusion of the chapter.

2.1 Risk and Entrepreneurship

Entrepreneurship is critical to long-run economic growth and has been called the engine of the capitalist economy (Åstbero et al., 2014; Bianchi and Henrekson, 2005; Parker, 2004; Schumpeter, 1942; Wennekers and Thurik, 1999). In addition, empirical evidence suggests entrepreneurship is important for job creation and innovation (Bianchi and Henrekson, 2005; Wennekers and Thurik, 1999) and is linked with macroeconomic growth (Galor and Michalopoulos, 2012; Gören, 2017). Entrepreneurship has various approaches and definitions. One definition considers entrepreneurship to be the establishment of one's own business (Nicolaou et al., 2011). This is the definition to be used throughout this chapter.

To begin, consider why entrepreneurship is considered a risk-laden activity. Richard Cantillon (1755) considered the economy to consist of two categories of people, entrepreneurs (as takers of risks) and non-entrepreneurs (as fixed-wage earners) (Brewer, 1992). The distinction between the entrepreneur and the non-entrepreneur is the unfixed wages the entrepreneur receives (ibid). Cantillon argued in the simplest form that entrepreneurs purchase commodities at known prices and undertake risk by selling at unknown prices (Brewer, 1992), leading to unfixed and variable wages. This school of thought was also discussed by Adam Smith (1776[26]). Smith (1776) notes that the undertaker receives profit as a return for their imagination, risk and effort, which furthers the wealth of the nation and assists in the division of labour (Evensky, 2015).

Since Adam Smith, scholars have furthered the role of risk-taking in entrepreneurship (Parker, 2004). Frank Knight (1921) proposed that risk and uncertainty are two distinct phenomena. That is, risk involves making decisions in a situation with known probable outcomes. On the other hand, uncertainty involves making decisions in situations in which the probability of the outcomes is unknown (Knight, 1921). The pertinence of Knightian uncertainty to entrepreneurship is noted by Bewley (1989, p2):

[26] A discussion of Adam Smith and the undertaker can be found in Evensky (2015)

"Under the Knightian characterisation, the entrepreneur is described as someone with unusual opinions or an unusually low level of uncertainty aversion"

Therefore, the entrepreneur under Knight's view is an individual able to make decisions under uncertain situations. It is argued by Parker (2004) that Knight did not view individuals as born-entrepreneurs, but individuals enter entrepreneurship based on the risk-adjusted returns. That is, the balance of choosing to become an entrepreneur must provide favourable returns in comparison to paid employment.

2.2 Different approaches to risk in entrepreneurship

Given the importance of entrepreneurship to economic growth, there have been multiple approaches to estimate and model risk-tolerance in entrepreneurs (Åstbero et al., 2014). For the purposes of this chapter, they can be categorised in the following five areas: (1) Theoretical and expected utility theory; (2) Proxy measures of risk-tolerance; (3) Decision making modelling; (4) Biological. The fifth and final area may be considered a combination of all of the above; (5) Tracking behaviours and psychological traits known to be related to risk-tolerance.

2.2.1 Theoretical and EUT

Entrepreneurship can be understood from expected utility theory (EUT). This is primarily because EUT can apply over occupational choices (Friedman and Savage, 1948), as a result of variance in income; a hallmark of entrepreneurship according to Adam Smith (Smith, 1776). Parker (2004) provides a pertinent overview of the application of neoclassical economics to entrepreneurship; models that help to answer who becomes an entrepreneur. Parker (2004) divides the models into three categories: (1) Homogenous individuals; (2) Heterogonous individuals; (3) Heterogeneous risk aversion.

The classification of Parker (2004) is similar to Shane and Venkataraman (2000), who divide the approaches into equilibrium and disequilibrium approaches. The disequilibrium approaches assume that entrepreneurship as a whole is an activity that can be undertaken

by a wide-range of people (ibid). In contrast, the equilibrium approach assumes that entrepreneurs have special attributes. For instance, Kihlstrom and Laffont (1979) in their influential paper posit that entrepreneurs are those who prefer uncertainty. This definition and approach is consistent with the earliest definitions of entrepreneurship (i.e., Knight (1921)).

Shane and Venkataraman (2000) posit the argument that entrepreneurship is a transitory process and it is perhaps unwise to assume that there exists some special attribute of entrepreneurs, as does the equilibrium approach. However, one may argue that equilibrium approaches are those that seek to reduce entrepreneurship to a simple model to allow for analytical tractability, the lack of which is a chief criticism and limitation of entrepreneurship thus far (Bianchi and Henrekson, 2005). Thus, the equilibrium approach may be considered a stepping stone or revolution in the wheel of theoretical advancements.

Further support for an equilibrium approach is the focus on the pre-eminent definition of entrepreneurship thereby focusing on a potentially influential sub-group of entrepreneurs; i.e., those who prefer uncertainty. It may be the case that this sub-group perform better as entrepreneurs. Thus, it follows below that the review begins with a discussion of the equilibrium approach, and perhaps the most influential of those is Kihlstrom and Laffont (1979).

The paper of Kihlstrom and Laffont (1979) utilises Knight's conception that the entrepreneur decides between becoming a labourer or an entrepreneur based on the available wages. That is, if entrepreneurship provides greater risk-adjusted returns, the individual chooses entrepreneurship over paid employment (Parker, 2004). To evidence this Kihlstrom and Laffont use the Arrow-Pratt risk-aversion formula to an entrepreneurship equilibrium model. Wages determine the choice between entrepreneurship and paid employment, and "wages adjust to the point where the supply of workers is equal to the entrepreneurial demand for labor" (Kihlstrom and Laffont, 1979 p745).

The study of van Praag and Cramer (2001) uses the same basis as Kihlstrom and Laffont

(1979), in that theoretical models are built regarding the entrepreneurs' risk-aversion and expected utility. The study departs from Kihlstrom and Laffont (1979) in that the model is then fitted to longitudinal data. As per the study of Kihlstrom and Laffont (1979), the aim of the entrepreneur is to maximise profit, which is consistent with the expected utility hypothesis of von Neumann and Morgenstein (1948). The individual chooses the occupation based on the greatest expected utility, which is measured by the Arrow-Pratt relative risk-aversion; i.e., the occupation that provides the greatest returns, be it a fixed wage from full-time employment or entrepreneurial profits. However, the main criticism of van Praag and Cramer's study is the same as that of Kihlstrom and Laffont (1979), in that the cause of risk-tolerance, and therefore the different expected utility function in entrepreneurs remains unexplored.

Despite the findings of van Praag and Cramer (2001), according to Åstbero et al. (2014) the returns from entrepreneurship are in most cases lower than salaried employment. Manso (2016) counters these findings by suggesting that entrepreneurs are in fact attracted to experimentation with new ideas. Further, Manso (2016) argues that existing studies rely on cross-sectional data of mean income and variance in income of entrepreneurs, which does not reflect the experimentation with new ideas.

The low returns from entrepreneurship highlights the fact that under expected utility theory, the decision to become an entrepreneur is negative and thus should not be undertaken. Mishra (2014) argues that this example strikes at the heart of the difficulties with expected utility theory, in that the currency of utility can be adapted post-hoc to suit various explanations and thus does not yield one universal truth.

Alternatively, one may argue that providing a different currency may in fact lead to a testable theory. In the model of Kihlstrom and Laffont (1979), the non-degenerate random parameter may in fact be the currency from which utility is derived. For instance, consider that returns (profit) from entrepreneurship do not necessarily reflect the utility derived from it. For instance, it is difficult to estimate the profits that will be generated

from entrepreneurship (Parker, 2004), as the model entails unknown parameters, as noted by Knight (1921). Thus, certain individuals may be drawn to the possibility of high returns (reward) from entrepreneurship. Utility in this context may refer to gratification from the risk in itself; i.e., the happiness derived from the risk taken to establish one's own business; i.e., the outcome variance. This was a point raised earlier by Åstbero et al. (2014); i.e., that the currency of for entrepreneurship may be non-pecuniary.

With the difficulties of applying EUT to entrepreneurship described above, it is unsurprising that scholars have noted a difficulty in applying neoclassical economic models to entrepreneurship (Bianchi and Henrekson, 2005). Bianchi and Henrekson (2005) note that the risk-tolerance of entrepreneurs composes a great deal of irrational behaviour, which does not lend itself well to standard modelling. In other terms, the entrepreneur as an individual level does not lend himself/herself well to analytical tractability, hence the entrepreneur is often missing in standard economic modelling. On the other hand, Bianchi and Henrekson (2005) note that at the aggregate level (industry/market), statistical laws and expected regularities may be present. This highlights the need to study risk-tolerance in entrepreneurs with larger data.

2.2.2 Panel data and Proxies

Moving from a theoretical to empirical discussion, an alternative approach to measuring risk-tolerance is to utilise proxies for risk and regress this against entrepreneurship. Such an approach is useful as large-scale data for various risk proxies is widely available, adding to convenience and statistical significance. The subsequent question is the choice of proxy for risk and the reliability of this as a measure of individual risk-tolerance. In the study of Hvide and Panos (2014), which utilises panel data from 400,000 Norwegian individuals, the proxies of risk in the study include stock market participation, personal leverage in the stock market, volatility of the stocks held and amount invested relative to individual wealth. The aforementioned independent variables were used to predict the dependent variables, entrepreneurship entry and the firm's performance. One may question the reliability of stock market participation and personal leverage as proxies for risk-tolerance. However,

the authors argue that the high standard deviation in stock market returns possess an element of inherent risk and high personal leverage leaves one liable to financial distress and bankruptcy. Further, the authors argue that risk-tolerance is a critical component of stock market participation in asset allocation theory. In this sense, the implicit assumption in this paper is that utility is non-monetary, as per the suggestion of Åstbero et al. (2014). That is, it is based on selection of prior outcomes that are determined by the high outcome variance.

Hvide and Panos (2014) find that the proxies for risk-tolerance do indeed predict entrepreneurship entry. More specifically, Hvide and Panos (2014) find that stock market investors were 50% more likely to start a firm than those who did not invest in the stock market. The authors contend that this finding is consistent with Knight's (1921), Kihlstrom and Laffont (1979) and Kanbur's (1979) initial hypothesis that less risk-averse individuals are more likely to become entrepreneurs. Further, the finding that less risk-averse individuals' firms perform more poorly is consistent with the initial theory, in that less risk-averse individuals would be willing to accept lower entrepreneurial returns for a given risk (Hvide and Panos, 2014)[27].

The study of Hvide and Panos (2014) provides strong evidence that risk-tolerance and entrepreneurship are related. However, similar to Kihlstrom and Laffont (1979), it is difficult to understand the root causes of this risk-tolerance and why such heterogeneity exists; i.e., what behavioural effects may be driving risk-tolerance? Whilst behavioural effects are accounted for through proxies for the respective behaviours (i.e., sensation seeking, overconfidence), it is not possible to fully understand the effects of these behaviours on risk-tolerance and selection into entrepreneurship and performance.

An alternative approach to panel data analysis is the measurement of decision making in entrepreneurs, as compared to non-entrepreneurs. This approach provides a different level of analysis of individual decision making and subsequent risk-taking.

[27]That is, a risk averse individual would need to be compensated to a greater extent to make the risk palatable.

2.2.3 Decision Making Modelling

Decision making modelling stems from the need to understand heterogeneity in risk-preferences. Whilst decision making as a science stems from neuropsychology, it bears many similarities with expected utility theory. In a typical decision-making task an individual will choose between multiple lotteries with differing probabilities and rewards. This is similar to the economic understanding of risk; i.e., risk is defined as the variation in probabilities and outcomes. This approach helps researchers to identify heterogeneity in risk preferences amongst individuals. Essentially, here we are reviewing if risk in entrepreneurship holds at different levels of analysis.

Lawrence et al. (2008) are among the first to assess the decision making in entrepreneurs. The authors compare the decision making of entrepreneurs to managers and found the entrepreneurs placed significantly more of their rewards on the likelihood of them being correct than did managers. Such a finding may represent a greater degree of confidence in entrepreneurs, as the entrepreneurs were willing to risk more points on decisions than non-entrepreneurs. The most interesting finding of the study is that the greater risk-taking correlated positively with self-reported impulsivity amongst the entrepreneurs. Lawrence et al. concluded that the risk taking of entrepreneurs appeared to be a form of 'functional impulsivity'. Functional impulsivity is argued to be impulsive behaviour that can be positively directed (Lawrence et al., 2008). Though, the authors mention only that impulsivity in participants was measured. It is therefore perhaps arbitrary to claim this to be a form of functional impulsivity without further investigation into the non-functional aspects of impulsivity; i.e., the negative effects of impulsivity on entrepreneurship.

In a similar manner to the Lawrence et al. (2008), Laureiro-Martínez et al. (2014) also used a decision-making model. The key aim of the authors' study was to determine the extent to which entrepreneurs and managers either exploited or explored in the gambling task. In this context, exploit refers to the preference to continually exploit the gamble known to provide the highest return. On the other hand, explore refers to the preference

to deviate from the gamble of highest return and explore gambles with unknown returns (Laureiro-Martínez et al., 2014); viz. in this context exploratory behaviours refer to risk-taking behaviour.

It may be argued that exploration is a necessity of this task in order to learn the pay-outs from different gambles. Thus, the similarities of exploration and exploitation amongst entrepreneurs and mangers may be less surprising. Perhaps the finding of greater interest is the ability of entrepreneurs to arrive at these decisions quicker than managers. This finding is consistent with the argument of Busentiz and Barney (1997), in that the entrepreneurs arrived at decisions quicker, possibly using heuristics such as overconfidence. This finding may be further evidence of overconfidence in entrepreneurs and is consistent with the findings of Lawrence et al. (2008), who found that impulsivity correlated with the greater risk-taking of entrepreneurs. Impulsivity is often understood as acting without sufficient forethought (Malloy-Diniz et al., 2007). As noted by Busentiz and Barney (1997) and evidenced by Laureiro-Martínez et al. (2014), entrepreneurs arrive at decisions with greater speed, with a potential lack of forethought.

The four-armed bandit task used in the study of Laureiro-Martínez et al. (2014) is similar to the Iowa Gambling Task (IGT) used in the study of Muehlfeld et al. (2015). The IGT was initially conceived to measure aberrant decision making in clinical patients (Beechara et al. 2005). Thus, 'healthy' individuals perform better on this task, in that they take less risks and are less drawn to high rewards (Stanton et al., 2011). Muehlfeld et al. (2015) used the Iowa Gambling Task (IGT) to measure the willingness of entrepreneurially experienced and entrepreneurially inexperienced students to explore novel options. A second sample of 100 entrepreneurs were also used to compare with the student group and the pooled "normal" data from the IGT database. Muehlfeld et al. (2015) found substantial differences between groups, which are described below.

First, the entrepreneurially experienced students selected from less advantageous decks more frequently and earned less reward than their inexperienced counterparts. Second,

entrepreneurs displayed remarkably similar behaviour to entrepreneurially experienced students. Entrepreneurs chose from disadvantageous decks more frequently, earned significantly less reward and switched between advantageous and disadvantageous decks more often. It is important to highlight the similarities of results between entrepreneurs and entrepreneurially experienced students, as this raises the validity of the student sample group as being closely aligned with entrepreneurs.

Muehlfeld et al. (2015) interpret their findings as the willingness of entrepreneurs (and entrepreneurially experienced students) to explore and persevere in a learning environment (i.e., learn the payoffs from different decks through frequent switching). Such behaviour in the IGT is often viewed as non-rational risk-taking behaviour (Garon et al., 2006; Mäntylä et al., 2012; Rivalan et al., 2009; Stanton et al., 2011). Thus, whilst Muehlfeld et al. (2015) do not assert that risk-taking is responsible for the poor performance of entrepreneurs in the IGT, the initial purpose of the IGT suggests that risk-taking may be responsible for their aberrant performance.

The collective evidence of decision-making modelling in entrepreneurs indicates that entrepreneurs do indeed take more risks. In fact, Lawrence et al. (2008) found the risk-taking behaviour of entrepreneurs was consistent with a younger age group (17-27 years old), despite having a mean age of 51 years. In comparison, managers, with a mean age of 50.5 years, were representative of their age group with regard to risk. Younger individuals are far more likely to take risks than their older peers (Tymula et al., 2012). Part of this risk-taking is believed to be the continued maturation of the part of the brain responsible for decision making and attentional control (Johnson et al., 2009). However, the study of Tymula et al. (2012) found that adolescents do not perceive themselves to be great risk-takers (despite evidence to the contrary). In the empirical study comparing age groups, the authors found that adolescents' increased risk-taking may in fact be driven by the increased tolerance of ambiguity amongst adolescents.

The finding that adolescents do not perceive themselves to be great risk-takers, despite

contrary evidence, has the potential to reinforce the notion that self-perceived risk-taking propensity is not an accurate measure of actual risk taking in the adolescent age group and potentially entrepreneurs. Thus, economic modelling of risk-taking in entrepreneurs is capable of disentangling perceived risk-taking propensity from actual risk-taking behaviour.

The findings of the aforementioned studies lend support to Knightian Uncertainty and Cantillon's notion of the entrepreneur as the risk-bearer in uncertain situations. This is because the entrepreneurs in the study of Lawrence et al. (2008) did not know the rate of return for their gamble. The entrepreneurs could potentially have lost significant amounts by gambling more than the group of managers, or gained less by being risk-averse. Yet, it appears an innate phenomenon drives the entrepreneur to take greater risks in uncertain situations. In a similar manner, the study of Laureiro-Martínez et al. (2014) also reinforces Knightian Uncertainty, in that entrepreneurs were better able to make decisions under uncertainty. Second, the authors' study potentially corroborates the notion of 'functional impulsivity', espoused by Lawrence et al. (2008), in that entrepreneurs made riskier decisions in less time, which raised their overall efficiency. Finally, in the study of Muehlfeld et al. (2015) entrepreneurs exhibit decision making performance that has previously been deemed as risk-seeking behaviour (Garon et al., 2006; Mäntylä et al., 2012; Rivalan et al., 2009; Stanton et al., 2011). The exploratory performance of entrepreneurs in the study of Muehlfeld et al. (2015) is similar to that found in Laureiro-Martínez et al. (2014), which further highlights the unique risk-seeking style of entrepreneurs. Taken together, the non-rational risk-taking of entrepreneurs means they earn less reward. This suggests that they are drawn to non-monetary reward, possibly risk/reward in itself (Astbero et al., 2014; Hvide and Panos, 2014; Manso, 2016).

There are some criticisms of these studies that must be addressed. First, most of the studies use small sample sizes, which may make the extrapolation of the findings challenging. Second, it is difficult to ascertain the extent to which decision-making studies reflect real-world decision making. This is mainly because decision making studies use simulated money to incentivise decisions, making it difficult to understand if simulated money alters

decision making, as participants may feel removed from tangible rewards and punishments.

Despite these limitations, the collective findings of decision-making studies and consistency with literature indicates that entrepreneurs are more risk-taking than controls and this may be driven by impulsivity. Individuals exhibiting significant impulsive traits also perform poorly on decision making tasks (Malloy-Diniz et al., 2007). It is perhaps unsurprising therefore that recent studies have begun to focus on these behaviours and their relationship to entrepreneurship. In addition, we will discuss later how individuals high in impulsivity display similar decision-making patterns as entrepreneurs.

The notion that impulsivity may be related to entrepreneurship may appear foreign, as impulsivity often has negative connotations, being closely aligned with attention deficit hyperactivity disorder (ADHD) (Nigg, 2001). For instance, impulsivity may be considered in an economic context to be a detrimental characteristic. However, there may be scenarios in which having dysfunctions in emotional processes may be advantageous. Shiv et al. (2005) posit that such a scenario may include driving on an icy road, in which a patient with dysfunctional emotions remains calm and fearless, not applying the brakes, where people with normal emotions do apply the brakes and lose control. The authors argue that there are scenarios in which abnormal emotional behaviour can be beneficial to the individual and perhaps to wider society. This is perhaps the heart of the argument, that there is a role to be played by impulsive behaviours in society and one of these avenues may be through entrepreneurship.

Here a key question arises: do impulsive behaviours mediate the different utility curves of entrepreneurs and partially explain entrepreneurial behaviours? Such a discussion could assist in demystifying the irrationality of entrepreneurship from an economic perspective. To answer this question, in the next section I draw inspiration from the biological linkages of entrepreneurship.

2.2.4 Biological

The past decade has seen an increase in the desire to incorporate aspects of biology to the prediction and understanding of entrepreneurship. This was evidenced with the decision-making studies mentioned above, which stem from neuropsychology. In this section, we divide our discussion into the theoretical and empirical realms.

A closely allied field of decision-making is neuroeconomics, which attempts to understand the neural substrates of decision making (Camerer et al., 2005). In fact, some scholars have proposed the same should be applied to entrepreneurship, under the field of neuroentrepreneurship (de Holan, 2013). De Holan (2013) argues that the tools of neuroscience can aid in answering long-standing questions in entrepreneurship. For instance, the author argues that key components of entrepreneurship, such as opportunity recognition and entrepreneurial orientation may be captured and better understood by neuroimaging. There are, however, numerous difficulties with this approach, such as the costs and expertise required for neuroimaging studies (de Holan, 2013). In addition, given the costs of the imaging studies, sample sizes are often small, making extrapolation and analytical tractability difficult. An interesting counter-argument against neuroentrepreneurship provided by Tracey and Schluppeck (2013). One of the key arguments of Tracey and Schulppeck is that behaviour and the subsequent neural activation do not necessarily imply causation. Further, the paper of de Holan (2013) does not explicitly concern itself with the core component of entrepreneurship, namely risk-tolerance (Bianchi and Henrekson, 2005).

Notwithstanding the above-mentioned limitations, the study of Laureiro-Martinez et al. (2014) has investigated the neural activity of entrepreneurs as compared to managers. The findings of this study with regard to decision making were discussed earlier. The findings in regard to neural activity also indicate that entrepreneurs appear to have different neural activity within the decision-making task. A similar result is found in the study of Ortiz-Teran et al. (2013), in which entrepreneurs had faster reaction times, higher impulsivity and different neural activity to the control group. The influence of impulsivity on the reac-

tion times of entrepreneurs was discussed is discussed in section 2.2.3, but it is worthwhile highlighting the empirical results evidencing this.

Neuroimaging studies prove to be very beneficial in understanding the deepest causes of behaviours from a reductionist perspective. However, they are small in number. Some scholars have taken an alternative biological approach with behavioural genetics. Johnson (2009) provides a balanced overview of the incorporation of behavioural genetics to entrepreneurship. The author argues that it is almost certain that some genetic influence may be found, though the usefulness of behavioural genetics may be questioned. That is, it may be difficult to understand entrepreneurship entry from behavioural genetic studies. The study of Koellinger et al. (2010) on the other hand argues that whilst the sample size required for a study in behavioural genetics is large, such approaches may help in understanding aggregate economic activity. In particular, the authors note that if low-risk aversion and novelty-seeking are heritable, one would expect to find an over-representation of entrepreneurship in countries where these genes have migrated to.

Some scholars have employed behavioural genetic approaches to understand entrepreneurship. The first of which may be considered to be Nicolaou et al. (2011). Nicolaou et al. (2011) sought to identify the relationship between common sensation-seeking/novelty seeking genes and entrepreneurial status in a large sample of twins using a genome wide association study (GWAS). The premise of this argument was that sensation-seeking/novelty-seeking behaviours may assist in the entrepreneurial process through risk-bearing. The authors did find a relationship between entrepreneurship and sensation seeking genes. However, GWAS studies are complex and it is therefore unsurprising that the result from Nicolaou et al. (2011) was not replicated in the study of van der Loos et al. (2011). This perhaps reinforces the argument of Johnson (2009), in that behavioural genetics is a complicated field and human behaviours are influenced by many factors, and not genetics alone. It is probable to contend that behavioural genetics is not ready as a tool to be used in this way.

Various scholars have attempted to investigate the hormonal basis for entrepreneurship.

One key avenue for this was testosterone and prenatal testosterone exposure (Unger et al., 2015). In the study of Unger and colleagues, the authors hypothesised that the relationship between testosterone and risk-taking would result in an increased likelihood of entrepreneurship entry. The results of the study are consistent with the authors' initial hypotheses. The authors consider their findings to be the impetus for research in entrepreneurship incorporating biological and psychological components. This finding is also corroborated in the study of Bönte et al. (2015); in which risk-taking is again considered to be mediated by prenatal testosterone exposure. In fact, the core hypothesis, that high levels of testosterone (biological) can influence risk-taking propensity (psychological) in economic domains (entrepreneurship), is provided by White et al. (2006).

Recently research has begun to focus on the evolutionary roots of entrepreneurial behaviour, incorporating insights and techniques from evolutionary biology. For instance, building on the work of Spolaore and Wacziarg (2009), Guedes et al (2019) investigated the genetic distance between countries, a measure of genetic similarities between two countries, and found that greater genetic distance was positively related to between country differences in new firm entry. However, genetic distance in itself cannot explain why there are differences between start-up rates between countries, only that after controlling for a number of factors, that genetic distance is correlated with differences in start-ups between countries.

In summarising this sub-section, biological approaches to understand entrepreneurship have provided encouraging results. Despite this GWAS studies are filled with many unexplained variables. On the other hand, hormonal studies provide a different perspective but do not comprehensively align with risk-tolerance, as does decision making modelling. Decision making modelling suggests a relationship between impulsivity, risk-tolerance and entrepreneurship.

As a final step in the discussion, it is necessary to incorporate education and entrepreneurship into our discussion to better understand the interplay between these components.

2.3 Education and Entrepreneurship

There are many theories considering the impact of education on career choices. Dickson et al. (2008) note that human capital theory examines the impact of acquired variables, such as education and experience on career outcomes. The premise behind human capital theory is that schooling produces skills that increase worker productivity (van der Sluis et al., 2005). As such, van der Sluis et al. (2005) argue that education is beneficial to economic growth. It seems paradoxical therefore to think that a key driver of economic growth, entrepreneurship, does not have a comprehensively positive relationship with education.

There is reason to believe that educational attainment may affect future entrepreneurship. For instance, Parker (2004) highlights that better educated individuals find themselves in sectors that require more education (i.e., knowledge-based industries). Further, Parker argues that more educated individuals are more likely to find themselves exposed to business opportunities and thus are more likely to take them. In a meta-analysis of research on the subject, Dickson et al. (2008) conclude on two main findings. First, educational attainment can assist in entrepreneurial performance (i.e., business profits; sales growth), which is consistent across countries and types of economy. However, selection into entrepreneurship provides ambiguous results, with some studies reviewed by Dickson et al. (2008) suggesting a relationship between higher education and selection into entrepreneurship, whilst others do not. Dickson et al. (2008) posit that the type of entrepreneurship may explain this phenomenon. In countries where necessity entrepreneurship (i.e., the individual chooses to become an entrepreneur due to limited employment opportunities) is more prevalent, education would have little effect. In contrast, where economic opportunities are greater, education can have a potentially inverse effect, as higher educational attainment can lead to better paying jobs, making selection into entrepreneurship a more difficult choice (Dickson et al., 2008).

The main findings from the meta-analysis of Dickson et al. (2008) come from the study of van der Sluis et al. (2005). This study focussed on the effect of education on enterprise

performance, finding that an additional marginal year of schooling increased income by 5.5%. Perhaps the most surprising result is that more educated individuals in developed economies choose salaried employment over entrepreneurship. This is presumably consistent with the above reasoning of Dickson et al. (2008); in that more education results in higher paying salaried employment, leading to lower expected utility from entrepreneurship, as per Kihlström and Laffont (1979) (see section 2.2.1). Evidence in support of this is found in the UK study of Taylor (1996), in which the authors found that entrepreneurship does not reward investment in education, beyond O-Levels (GCSE equivalent). One possible explanation for this is that self-employment in itself does not require a formal entry point.

In a similar study to that of van der Sluis et al. (2005), van der Sluis et al. (2008) focussed on the effects of education in industrialised countries through a meta-analysis of previous research. The authors find that selection into entrepreneurship is not related to educational attainment. However, as per the 2005 study in developing economies, educational attainment does aid in the performance of the business. A further important element is how educational attainment may aid the performance of businesses.

Some scholars posit that education may be a proxy for other human behaviours and traits that may be driving the relationship between entrepreneurship and education. The study of Koellinger (2008) hypothesised that high educational attainment is preceded by other characteristics. That is, highly intelligent and curious individuals are more likely to seek higher education. Thus, behaviours such as intelligence, curiosity and abstract thinking which are linked to creativity may lead to more innovative businesses. However, one may argue that these individuals must also be capable of bearing risk and uncertainty, according to the definitions of entrepreneurship by Cantillion (1755) and Smith (1776).

It may be the case that the effect of education on entrepreneurship may not be consistent across groups in society. For instance, the study of Borooah and Hart (1999) found that relative to Indian and white UK citizens, black UK citizens were less likely to partake in entrepreneurship. The authors attributed this partly to attributes such as education.

The argument here is that education may be a factor in improving the participation of black UK citizens in entrepreneurship.

Taken together, the results from various studies of educational attainment are ambiguous. It may be that different industries require different levels of education. For instance, high technology industries may require working knowledge of the industry, which carries with it a certain level of education. Some ambiguity may arise from the fact that there are many different types of entrepreneurship and different circumstances that lead one to entrepreneurship. Another aspect to consider is the group of society who may be prone underachieve academically, for instance those with behavioural disorders, who are likely to find routine schooling unappealing (Jensen et al., 1997); this may leave entrepreneurship as one option or low-skilled work as the other option.

2.4 Conclusion

At the beginning of this chapter the importance of risk in entrepreneurship was highlighted from its earliest definitions and theoretical approaches. The notion of risk in entrepreneurship was supported by empirical investigations; from proxies of risk in datasets, decision making modelling, neuroeconomic approaches to genetic and hormonal studies. The common theme in these approaches has been the role of impulsivity. Impulsivity was noted as a core concept in ADHD and this has become an area of investigation in entrepreneurship research; though, not explicitly for the role of ADHD as a source of risk in entrepreneurship. At the beginning of the chapter the irrationality of entrepreneurship was noted and this was supported in decision making modelling studies; i.e., the preference for high reward takes place of monetary pay-off. The next section of this research takes the relationship between entrepreneurship and ADHD even further. From this, the research will turn to address shortcomings in existing research and develop hypotheses to address the current shortcomings.

2.5 ADHD and Entrepreneurship; Hypotheses Development

In the previous section, it was discussed that studies in entrepreneurship focussing on biological and decision-making components found impulsivity to be closely related to entrepreneurs and their behaviours. For instance, decision making studies indicate that entrepreneurs take greater risks, and in the study of Lawrence et al. (2008) this correlated with high self-reported impulsivity. Further, in decision making studies entrepreneurs' performance was similar to individuals with psychiatric disorders, such as ADHD.

It is perhaps unsurprising, given the above discussion, that recent studies have begun to identify a domain of behaviour in which impulsivity forms the core component; viz., ADHD (Nigg, 2001). While reviewing these studies, it is important to consider that none of the studies focus on diagnosed ADHD individuals. Rather, these studies utilise assessments of ADHD with questionnaire scales, which capture the three components of ADHD: Impulsivity, hyperactivity and inattention (APA, 2017). Focussing on non-clinical ADHD symptoms in the non-clinical population is practical for researchers and may in fact yield hitherto unknown dimensions of these behaviours, as some scholars argue that ADHD is not confined to a small portion of society, but may exist along a continuum (Jensen et al., 1997).

The study of Verheul et al. (2015) was amongst the first to investigate this topic directly. The authors hypothesised that symptoms of ADHD are related to entrepreneurship through risk-taking (Verheul et al., 2015). This is perhaps unsurprising, considering the risk-taking associated with ADHD (Williams and Taylor, 2005), as discussed previously. The study of Verheul et al. (2015) investigated entrepreneurial intentions in relation to ADHD symptoms in over 10,000 students. The authors' results indicate that higher levels of ADHD symptoms led to greater entrepreneurial intentions in students. However, it must be noted that the effect size of the correlation between ADHD symptoms and entrepreneurial intentions in this study is small. Such a limitation on its own would perhaps weaken the significance of the study. However, the results of Verheul et al. (2015) are supported by the study of Thurik et al. (2016), who used a different sample and metric for

entrepreneurship.

The study by Thurik et al. (2016) investigated entrepreneurial orientation (EO) in a sample of French small business owners. EO is argued by Thurik et al. (2016) to represent the personalities of the entrepreneur. This is because EO is considered strategic thinking in larger companies, however, in smaller companies EO is influenced by the entrepreneur through the risk-taking and innovativeness of the entrepreneur due to the direct influence of the entrepreneur on business strategies and approaches (Thurik et al., 2016). To measure EO, Thurik et al. investigated the risk-taking propensity, innovativeness and pro-activeness using self-reported measures. The authors found a positive relationship between EO and ADHD symptoms, indicating that having greater ADHD symptoms predicts the EO of the business. However, as with the study of Verheul et al. (2015), the effect size is small. Nevertheless, given the different sample populations and different measures of entrepreneurship in these studies, the combined results of both studies indicate a positive relationship between exhibiting greater ADHD symptoms and entrepreneurship. That is, the study of Verheul et al. (2015) found ADHD symptoms predicted entrepreneurial intentions in a large group of students. However, the relationship between ADHD and entrepreneurship exists beyond merely intentions, as the study of Thurik et al. (2016) found ADHD symptoms to predict EO in established business owners.

Lerner (2015) advanced the notion of greater ADHD symptoms in entrepreneurship further[28]. Though, more specifically, Lerner (2015) investigated disinhibition (a core symptom of ADHD (Hegerl et al., 2010)) with regard to entrepreneurial action and the impact of high disinhibition on attracting resource providers. The authors found that high disinhibition assisted in aspects of nascent venturing, such as creativity, greater 'vision' and better recognition of opportunities. However, the authors also concluded that higher disinhibition reduced the ability to conduct administrative tasks and thus to attract investment from resource providers.

[28]Lerner et al. (2018a) have also published a similar paper concerning the behavioural inhibition and behavioural activation system, as it relates to ADHD symptoms.

The results from the study of Lerner (2015) provided a more detailed analysis of the impact of ADHD on the entrepreneurial process. On the one hand, the author notes the positive aspects of ADHD on the entrepreneurial process (such as innovation and risk taking). On the other hand, the ability to be creative and undertake risk reduces the ability to conduct administrative duties and thus attract resource providers. This is surely the paradox of entrepreneurship and the distinction between an entrepreneur and a manager. That is to say, the fact that entrepreneurs are able to innovate and take risks under uncertain situations is by definition their function (Carland et al., 1984). Lerner (2015) posits that an increase in administrative duties (i.e., too much red-tape) may lead to more failed businesses and fewer creative and potentially less successful entrepreneurs.

Further to the studies above, Wiklund et al. (2016) investigated the relationship between ADHD and entrepreneurs in a case study of fourteen entrepreneurs. The authors find that impulsivity was a key driver in this relationship. This finding is corroborated by the later study of Wiklund et al. (2017), in which the authors investigated the symptoms of ADHD in MBA students, finding that ADHD-symptoms and impulsivity (measured separately) were greater in those who had started a business and had entrepreneurial preferences. The comprehensive review investigates the effects of the separate symptoms on entrepreneurship. The authors find that inattention is not related to entrepreneurship, whereas hyperactivity and impulsivity are related to entrepreneurship. Specifically, impulsivity is primarily related to a lack of premediated thought, which assists in the entrepreneurial process. This is similar to that discussed in section two with regard to decision-making and impulsivity.

The studies reviewed by Antshel (2018) include that of Wiklund et al. (2018), the premise of which suggests that cognitive diversity can be advantageous in the realm of entrepreneurship and that utility is maximised for the individual by selecting into entrepreneurship; though this is not developed in the same manner as Kihlstrom and Laffont (1979). This argument is also proposed by Antshel (2018), in that the liabilities of ADHD in

the workplace may in fact be abilities in an entrepreneurial context. This line of argument is continued by the study of Lerner et al. (2018b), which proposes a conceptual framework akin to the yin-yang model; i.e., ADHD can be both helpful and a hindrance. Perhaps the most intriguing discussion in this theoretical paper is the impact ADHD can have on the entrepreneurial process, not simply entrepreneurial intentions or business start-up. There are multiple stages to the entrepreneurial process, from new-venture creation to innovation. The authors note that these have yet to be investigated thoroughly; i.e., how do the symptoms of ADHD affect business performance?

The review of the above section suggests a tentative relationship between ADHD symptoms and entrepreneurship, mainly through hyperactivity symptoms (Antshel, 2018). This is assumed to primarily be the result of impulsive behaviours and Lerner et al. (2018c) propose that impulse driven behaviours may explain at least some entrepreneurship as non-rational action. That is, as discussed above, impulsivity produces a lack of forethought, the likes of which may be useful for business venturing. Though, again, as with Wiklund et al. (2018), Lerner et al. (2018c) do not develop this idea further and do not align this with Kihlstrom and Laffont (1979).

The majority of these studies have focussed on selection into entrepreneurship at one particular age point; i.e., inviting entrepreneurs to self-report their symptoms. An approach such as this is prone to confirmation bias. When presenting participants with a survey investigating their ADHD symptoms, to what extent will the individuals seek to confirm the researcher's hypothesis? This point is valid on the basis that in diagnosing ADHD symptoms clinicians use life-history and measurement of behaviours from parents (Nigg, 2001). This limitation may be overcome by measurement of the behaviour from a third-party at a young age and tracking their behaviour into adulthood.

The limitation noted above does not undermine the findings of the studies but highlight the nascent nature of the field. The study of entrepreneurship and ADHD is certainly an interesting avenue underpinned by the similarities of the concepts. For instance, risk-taking

propensity is greater in ADHD individuals (Shoham et al., 2016; Williams and Taylor, 2005) and as discussed earlier, is argued to be crucial to entrepreneurship (Knight, 1921). Whilst the study of Verheul et al. (2015) found the relationship between ADHD and entrepreneurship is mediated by risk-taking propensity, the studies investigating ADHD and entrepreneurship have only briefly discussed these overlaps and not from an economic perspective.

Following from the above discussion, if indeed ADHD-like behaviours play a role in the modern economy through entrepreneurship, one would expect to find higher ADHD-like symptoms in entrepreneurs. I develop the relevant body of the literature by investigating childhood ADHD-like symptoms as predicting selection into entrepreneurship in later life over full-time employment in the UK.

Hypothesis 1a: Entrepreneurs exhibit higher ADHD-like symptoms in childhood than those individuals in full-time employment.

Further, a key limitation of existing literature is the focus on cross-sectional effects of ADHD symptoms on entrepreneurship; i.e., the effects of ADHD symptoms at only one age point in the individual's life. I go beyond existing research by examining the underlying relationship at different points in the lifetime of an individual. That is, I measure ADHD-like symptoms in childhood against later entrepreneurial activity across and within a 12-year period (from age 30 to 42). Tracking ADHD-like symptoms in childhood is akin to the approach adopted by clinicians when diagnosing ADHD, which requires the symptoms to be present in childhood (Faraone et al., 2009; Nigg, 2001).

In sum, the section tests two different assumptions; firstly, I hypothesise that individuals who are currently entrepreneurs would have higher ADHD-like symptoms in childhood than those individuals in full-time employment, and secondly, I hypothesise that all individuals who have acted as entrepreneurs across a prolonged period would have higher ADHD-like symptoms in childhood than those individuals who have always been in full-time employ-

ment:

Hypothesis 1b: Individuals who have been entrepreneurs at some point in their life will have greater ADHD-like symptoms in childhood than those individuals who have been in full-time employment over the same period.

Further, given the theoretical underpinning by Hvide and Panos (2014) that less risk-averse individuals may perform more poorly as entrepreneurs, I propose that individuals with higher ADHD-like symptoms are drawn to the possibility of high rewards (selection into entrepreneurship), but perform more poorly as entrepreneurs (given that ADHD-like symptoms are used a proxy for risk-tolerance, the above should follow).

Hypothesis 2A – ADHD-like behaviours will negatively influence business performance amongst entrepreneurs.

In order to test the above hypotheses I develop a methodology, which is explicated in the following section.

2.6 Research Design

2.6.1 Data Sample

For the analysis, I used data from the British Cohort Study (1970) (BCS), a repeat cross-sectional data set managed by the UK Data Service. The study began in 1970 and tracks the lives of approximately 17,000 individuals born within a single week in April 1970. The data provides information on the physical, educational and social development of the individuals included from the age of five and onwards, as well as economic, social and relationship data from the age of 26 (1996) onwards.

The BCS was deemed the most appropriate dataset to address the research requirements, as it contains survey instruments addressing ADHD-like symptoms in research participants. Data in the BCS is gathered by researchers through comprehensive surveys, including interviews, questionnaires and medical examinations. Interviews and questionnaires have been completed by participant's parents, teachers and the participants themselves. There have been nine survey rounds in total at the time of writing, with the earliest at birth and the latest in 2012-2013 (age 42). Overall, the BCS includes completed surveys for 11,295 individuals pertaining to ADHD-like symptoms, which constitutes the population for the current research.

It is worth mentioning that there is an underrepresentation of immigrants in the BCS dataset, as by its definition, only those born in the UK were initially recruited into the study. This may present some bias, as immigrants have a greater tendency to start businesses (Kerr and Kerr, 2016). This is a worthwhile limitation that must be kept in mind when interpreting the results presented in the next chapter[29].

2.6.2 Missing Data

There are three types of missing data that may be present in a dataset (Afifi et al., 2012); (1) missing completely at random (MCAR); (2) missing at random (MAR); not missing at

[29]The BCS is available to all UK-based researchers. Authentication is granted through institutional credentials and accepting the terms of use.

random (NMAR). MCAR refers to data that is missing but not due to the missing value itself or on other variables. MAR on the other hand refers to missing values not due to the value itself, but due to other variables. For instance, certain occupations may be less likely to report their income. Finally, NMAR refers to a value that is missing solely because of the value itself. For example, high earners may be less likely to report their earnings. The distinction between the examples of NMAR and MAR are based on the fact that in the latter example, the missing value is due to variable of interest; i.e., income.

There are implications for the treatment of missing data, with several possible approaches to treating missing data. The most common of which is deletion, either pairwise or listwise (Afifi et al., 2012). Doing so, however, can introduce issues of bias if the missing values are NMAR. That is, the missing value in itself carries meaning, thus deleting it may introduce bias. Another approach to dealing with missing data is to replace the value of the missing data. This can be achieved through single imputation, multiple imputation or model-based methods (ibid).

With regard to this research and the variable being scaled from the multiple variables, there exists missing values. In the age 10 sweep there are a total of 14870 respondents; approximately 12600 have completed at least some of behavioural ratings and 11295 have completed all of the ratings. In this sense, there are approximately 1305 individual missing values from those that participated in the behavioural surveys.

In this research the missing data was deleted listwise; that is, where responses to any of the variables were missing, any responses from the observation (cohort member) were deleted; this is often called complete-case analysis. One may argue that the missing data may be imputed to avoid the bias inherent in deleting missing data. However, given the human nature of the behaviour, predicting (imputing) behaviour based on other variables or other factors may be considered unseemly and is not pursued here.

Afifi et al. (2012) provides discussion on the usefulness of imputing missing data. For

MCAR and MAR data Afifi et al. (2012) suggests conducted complete-case analysis where possible. Where data are NMAR the authors note that some scholars conduct complete-case analysis and place caveats on the results. One can use the Little's test for missing data, which tests if the data is MCAR or MAR, but does not test if the data is not missing at random (Little, 1988). This is because by definition, the data required to test the assumptions is missing.

With regard to this research, there exists little reason that a teacher would not rate a child's behaviour. It is probable to contend that one variable is missing randomly from any one of the nine variables, forcing the deletion of the entire case. This differs from other variables where missingness may represent an underlying factor. For example, income data in low income earners may be missing because respondents do not want to disclose their income. Thus, I proceed with the analysis placing a caveat that the scale may not have data that is missing completely at random. Any subsequent results based on the scale should be interpreted with this in mind.

2.6.3 Discussion of high factor correlation

As can be seen in the path diagram, the correlation between Teacher Inattention rating and Teacher Hyperactivity rating is approximately 0.7. Discriminant validity indicates that this is not a problem. According to Fornell and Larcker (1981) and discussed by Henseler et al. (2015), discriminant validity is achieved if the squared correlation between factors is not greater than the average variance extracted. This is satisfied with the model and is presented in the footnote [30]. Further, given the third type of ADHD (i.e., combined type), such a correlation is unsurprising; one would not expect the factors of inattention and hyperactivity to be distinct. The explanation of such inconsistency may lie on unidentified factors influencing this type of ADHD, which is obviously a caveat beyond the scope of the current research project. In light of this, I ran the items as loading onto one factor in the CFA. This proved to have good model fit and the factor loaded correctly as the

[30] Average variance extracted (0.62 (Teacher Rated Inattention Rating), 0.63 (Teacher Rated Hyperactivity Rating)) $> 0.73^2 (0.53)$

combined type, although the SRMR was slightly higher at 0.08, but this is still on the limit of acceptable model fit (Hu and Bentler, 1999).

2.6.4 Model Variables

ADHD-Like symptoms. To identify the ADHD-like symptoms of the research participants in the sample, I run a confirmatory factor analysis to approximate the ADHD-like symptoms, as rated by teachers at the age of 10 years old. These variables originate in the Childhood Behaviour Scale from the 1980 sweep (age 10) and includes elements from the Conners' Hyperactivity Scale and Rutter Behaviour Scale. This approach avoids clinical bias in the diagnosis of ADHD (see Russell et al. 2014). I run confirmatory factor analysis to approximate ADHD-like symptoms rated by teachers when the research participant was 10 years old. I load onto two components, inattention symptoms (5 variables) and hyperactivity/impulsivity symptoms (4 variables). The model indicates strong fit, meeting the guidelines set by Hooper, Coughlan & Mullen (2008) and Kline (2011)[31]. See the section below, 'Confirmatory Factor Analysis', for detailed discussion.

Entrepreneurship and Business performance: Entrepreneurship is defined in a similar manner to Nicolaou and Shane (2009); i.e., "has the research participant ever owned a business?". From age 26 (1996), the BCS contains employment information. Further, detailed information regarding the type of self-employment (own business/contractor), business earnings, business profits and business size is available from age 30 (2000) and onward.

Employment: The BCS contains a wide range of data concerning the research participants' employment and economic activity. These are available from age 26 (1999) up to age 42 (2012). Starting at the age of 30, there are 503 business owners, compared with 7,014 full time employed individuals. This number rises to 1,070 business owners at the age of 42, where the number of full-time employed individuals drops to 5,245[32].

[31]Full diagrams and results for the confirmatory factor analysis can be found in the appendix.
[32]See table 14 and figure 5 in appendix for detailed graphic.

Control Variables: There are factors that can influence selection into entrepreneurship and may interact with other independent variables. Such factors include education (Dickson et al., 2008), gender (Zhang et al., 2009) and social class (Audretsch, Bönte and Tamvada, 2013). In the model estimation, I control for education in the regression models, whereas gender and social class are controlled for by sub-setting and analysing the data. Social class here is defined according to the available data in the BCS into six categories; (1) Professional; (2) Managerial-Technical; (3) Skilled Non-Manual; (4) Skilled Manual; (5) Partly Skilled; (6) Unskilled[33].

2.6.5 Confirmatory Factor Analysis

Throughout the confirmatory factor analysis, I use the coding programme 'R (1.1.447)' with the following packages: Lavaan package (0.5-23.1097), semPlot (1.1) and semTools (0.1-14).

There are two constructs derived from teacher ratings of the cohort member's behaviour at age 10; i.e., Primarily Inattentive and Hyperactive/Impulsive. Within the BCS, the following are identified as being closely related to the APA definition of ADHD and are used as indicator variables. They are derived from the Conners' Hyperactivity Scale and Rutter Behaviour Scale and the Childhood Behaviour Scale from the age 10 sweep in the British Cohort Study[34][35].

Inattentive Type	**Hyperactive/Impulsive Type**
Cannot concentrate on particular task	Excitable/Impulsive
Easily Distracted	Shows restless or overactive behaviour
Pays attention in class [negatively scored]	Squirmy and Fidgety
Fails to finish tasks	Interferes with others
Shows perseverance [negatively scored]	

Latent variables are constrained to a standardised measure i.e., the mean of latent

[33]This classification is chosen as it is consistent between the different age sweeps of the BCS; this allowed for easier harmonisation of the data for equation 10. One may consider that this social class also refers to the social classification of the job.

[34]A copy of the complete item list can be found in the appendix (Figure 7). The interested reader may also wish to refer to the complete file and discussion of the hyperactivity component in the a3723.ucb file in the age 10 sweep documents.

[35]All variables in the scale have a value between 1, being the lowest teacher rating for the variable, and 47 as the highest rating.

variables is 0 and variance is 1. This allows for latent covariances to be interpreted as correlations after the analysis.

2.6.6 Estimated Parameters

The estimated parameters (table 17) and the visual path diagram can be found in the appendix.

2.6.7 Estimator

The majority of indicator variables follow a non-normal distribution (see Appendix – Methodology). For this reason, I use weighted least squares-means adjusted (WLSM), which is a robust form of weighted least squares (DiStefano and Morgan, 2014). Further, the WLSM does not assume the data follow normal distribution (DiStefano and Morgan, 2014). The modification indices indicate good model fit (Robust CFI: 0.992; Robust TLI: 0.991; Robust RMSEA: 0.045 (p<=0.05=1.00); SRMR: 0.042).

2.6.8 Main Model Estimation

The first hypothesis states that entrepreneurs are likely to have greater ADHD-like symptoms than those in full-time employment at cross sectional data points. To test this hypothesis, I estimate the model with equation 1 as follows:

$$\gamma = \alpha + \beta_1\lambda + \beta_2\omega + \beta_3\tau + \epsilon^{AgePoint} \tag{8}$$

Where the dependent variable is a binary dummy variable of whether or not research participants are business owners at the age point or in full-time employed (γ), and the independent variables include the inattention rating (λ), the father's self-employment status as a binary taken from when the cohort member was 16 (τ) and the age the research participant left education as a dummy variable ($< 18 = 0; >= 18 = 1$) (ω). Model number 2 of table 1 includes an interaction term between the inattention rating (λ) and the father's

self-employment status (τ). As such, the model specification changes to the following:

$$\gamma = \alpha + \beta_1\lambda + \beta_2\omega + \beta_3\tau + (\beta_4\lambda * \tau) + \epsilon^{AgePoint} \tag{9}$$

The second hypothesis (1b) states that entrepreneurs are more likely to exhibit ADHD-like symptoms than other labour market participants. In the BCS database employment data is available at five age points, thus to test this hypothesis, I estimate equation 1 but using aggregated employment information across these five age points. Sample selection in this model is contingent upon non-missing data across four variables; viz., ADHD-like symptoms from age 10, education information from age 30, social class information and employment data. The last variable requires that those in full time employment have completed information across the 12-year period. This is done to ensure that non-responses from those in full-time employment are definitely not small business owners; i.e., a non-response for this individual could mean that they became a small business owner but did not respond in any sweeps. This robust approach, in addition to sub-setting the data by gender, limits the total sample size to 773 in the first model that selects between social class one or two at age 34, and to 477 in the second model that selects between social class one or two at any age point. This leads to the following equation:

$$\gamma = \alpha + \beta_1\lambda + \beta_2\omega + \beta_3\tau + \epsilon^{Aggregated} \tag{10}$$

Model number 4 of table 3 includes an interaction term between the inattention rating (λ) and the father's self-employment status (τ). As such, the model specification changes to the following:

$$\gamma = \alpha + \beta_1\lambda + \beta_2\omega + \beta_3\tau + (\beta_4\lambda * \tau) + \epsilon^{Aggregated} \tag{11}$$

For hypothesis H2A, I investigate business ownership continuity among the examined entrepreneurs by taking those research participants who owned a small business at the age of 30 and analyse their activity at the age of 34. If the research participant is still a small business owner, the value of 1 is assigned, otherwise a value of 0 if they are also present in

the age 34 dataset. This forms the dependent variable (π). Research participants who are in part-time self-employment are removed at this point from the analysis to capture those businesses that may have ceased to exist. The independent variables in the model include the binary inattention rating for inattention symptoms from age 10 (cut-off 90; $< 90 = 0$; $>= 90 = 1$) (λ). Finally, I control for full-time education so those participants who left education earlier and hence close their business to return to education once again will be removed. A binary dummy for the age the research participant left education ($< 18 = 0$; $>= 18 = 1$)(ω) is thus included.

I examine two different measures of performance: (a) earnings' growth from age 30 to age 34, and (b) take home income at age 42, so the research can get a clearer understanding of the performance implications. For the first performance test, I run a logistic regression model where the dependent variable is those business owners who have increased or maintained business earnings (assigning them a value of 1) or have seen a loss in earnings (assigning them a value of 0) (π). The independent variable includes the binary hyperactivity ratings for ADHD-like symptoms from age 10 (cut-off 125; $< 125 = 0$; $>= 125 = 1$) (λ) and the education variable ($< 18 = 0$; $>= 18 = 1$)(ω). I also control for gender effects by sub-setting, in which only male business owners are considered (the effect is not found in female business owners).

For the second performance test, I run a multi-linear regression model where the dependent variable is the reported take home income at age 42 (π). The independent variable here includes the teacher rated inattention from age 10 on a continuous scale (range = 5 - 235) (λ). As mentioned previously, the research takes education in the form of a dummy control variable ($< 18 = 0$; $>= 18 = 1$)(ω). Research participants with take home income above £80,000 are removed to avoid skewness presented by outliers (judged as three standard deviations above the median). Further, I control for gender effects by sub-setting, in which only male business owners are considered (the effect is not found in female business owners).

$$\pi = \alpha + \beta_1\lambda + \beta_2\omega + \epsilon \tag{12}$$

As a test of robustness I run the model estimation for hypothesis 1A again in table 1, however, in the following models I conduct propensity score matching. Propensity score matching attempts to reduce confounding effects in observational studies, attempting to replicate a randomised controlled trial (Austin, 2011; Deheja and Wahba, 2002). Propensity score matching creates two comparison groups based on observed covariates thought to be related to the outcome (discrete choice in labour market; business ownership or full-time employment) (Deheja and Wahba, 2002). This uses logistic regression to predict the outcome based on family income, father's education and CM's education in one model[36]; this logistic regression creates a propensity score which then determines the similarities between individuals. The second propensity score model has the age the CM left education included in the propensity score calculation, the first has the age of leaving education in the logistic regression. I use nearest neighbour matching to a ratio of 1:14 business owners to full-time employees, which is approximately the same as in the BCS dataset at age 30. The matched sample is reduced to 1,125. Thus, using another logistic regression, the employment status (γ) is predicted by gender (π), inattention symptoms (λ) and in model 1 of table 2 includes the age of leaving education ($<18 = 0$; $>=18 = 1$) (ω). This model does not constrain the sample by social class.

$$\gamma = \alpha + \beta_1\pi + \beta_2\lambda + \beta_3\omega + \epsilon \tag{13}$$

Finally, to measure the underlying hypothesis of hypothesis 1A, 1B and 2A combined I run the a multi-linear regression model of wages from full-time employment and earnings from self employment in two groups; those exhibiting low ADHD symptoms in childhood and those exhibiting high ADHD symptoms in childhood[37]. In this model, the dependent variable is earnings from self-employment or from full-time employment (π), taken from age 42. Independent variables include the employment status from age X (γ), either full-time employment (0) or business ownership (1). Education is included in the model (ω), and is taken as either not having a degree (0) or having a degree (1). Importantly, the analysis

[36]These conditioning variables have been chosen as they are known to predict labour market outcomes (Dickson et al., 2008; Johnson and Schoeni, 2011)

[37]The hypotheses collectively hold that individuals with high ADHD symptoms are driven to entrepreneurship through an increase in risk-tolerance.

is run on a subset of data. Wherein, the individuals are split into either the low ADHD group or high ADHD group. Thus, the model has the following equation:

$$\pi = \alpha + \beta_1\gamma + \beta_2\omega + \epsilon$$

2.7 Results and Discussion

Results for hypothesis 1A can be found in table 1 (models 1-4). The evidence offers only partial support to hypothesis 1A, this is particularly the case for the 'hyperactivity/impulsivity' symptom which exhibits limited significance and is thus not displayed in table 1. A notable exception to this is found at age 30, in which inattention symptoms provide clear support, with higher levels of inattention increasing the probability of business ownership. Overall, the results provide only a partial support for hypothesis 1A, as only inattention as a symptom seems to be linked to the investigated relationship and only at certain age points. Model 2, employment status at age 34, provides an interaction term between father's employment and the cohort member's inattention symptoms. The significant negative relationship suggests that children who have self-employed fathers with increasing inattention symptoms are less likely to become self-employed themselves. This interesting finding would require further investigation to understand better the determinants of this.

Models 1-4 of table 3 display the results for H1B. This hypothesis is more strongly supported than hypothesis 1A. As can be seen in table 3, the model tested for H1B indicates that inattention has a markedly positive impact on the probability of owning a small business (1-25 employees) across a 12-year period. Model 1 and 2 are robustness tests, removing the effects of social class. Model 4 of table 3 provides an insignificant interaction term between the father's self-employment status and the cohort members' inattention rating[38].

Furthermore, leaving education at or after the age of 18 in the first model has a negative effect on the possibility of business ownership across a 12-year period. This is an interesting finding in itself, given the inconsistencies in the literature concerning the relationship between education and selection into entrepreneurship (Dickson et al., 2008). A further finding from the analysis at this point is that the number of research participants who own their own business increases with age. This is not particularly surprising, given the

[38] All regressions were tested for multicollinearity and no issues were identified.

purported relationship between age and entrepreneurship (Azoulay et al., 2018).

Table 2 presents the robust results for hypothesis 1A at age 30. The results from this fully support findings in table 1 (model 1), as the results do not change after accounting for demographic information of the cohort member. This indicates that the initial model in table 1 (model 1) may have no confounding variables, such as education for instance. This is because education is added before the logistic regression in the propensity score matching model; as such, only those individuals of a similar educational background are compared to one another [39].

[39] As mentioned in the model specification (equation 13), model 2 of table 2 has the CM's education information in the propensity score matching; i.e., not in the logistic regression, as in model 1 of table 2. As such, individuals in model 2 are also matched according to their education variable, which is prior to the logistic regression.

Table 1: Hypothesis 1A

	Dependent variable: Entrepreneur (1) or Full Time Employee (0)			
	Age 30	Age 34	Age 38	Age 42
	(1)	(2)	(3)	(4)
Constant	-3.613^{***}	-3.102^{***}	-2.658^{***}	-2.642^{***}
	(0.475)	(0.455)	(0.350)	(0.634)
Father Self Employed	0.860^{**}	2.517^{***}	1.181^{***}	1.382^{***}
	(0.362)	(0.577)	(0.301)	(0.480)
	OR: 2.36	OR: 12.39	OR: 3.26	OR: 3.98
Inattention Rating	0.007^{**}	0.006	0.002	0.002
	(0.004)	(0.004)	(0.003)	(0.004)
	OR: 1.007	OR: 1.006	OR: 1.002	OR: 1.002
Education	-0.185	-0.532^{*}	-0.258	0.339
	(0.373)	(0.317)	(0.299)	(0.515)
	OR: 0.83	OR: 0.59	OR: 0.77	OR: 1.40
Inattention*Father Self Employed		-0.012^{**}		
		(0.006)		
		OR: 0.99		
Observations	644	607	625	160
Pseudo R^2	0.05	0.11	0.06	0.10

Note: *p<0.1; **p<0.05; ***p<0.01

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Table 2: Hypothesis 1A - Propensity Score Matched at Age 30

	Dependent variable: Own Business (1) or Full Time Employed (0)	
	(1)	(2)
Constant	-3.229^{***}	-3.201^{***}
	(0.299)	(0.264)
Education Binary	-0.291	
	(0.263)	
Gender	0.221	0.143
	(0.260)	(0.258)
	OR: 1.25	OR: 1.15
Inattention Rating	0.007^{***}	0.006^{**}
	(0.002)	(0.002)
	OR: 1.007	OR: 1.006
Observations	1,125	1,125
Pseudo R^2	0.034	0.016

Note: *p<0.1; **p<0.05; ***p<0.01

Ratio of case (self-employed) to control (full-time employees) is 1:14, which is approximately the weight in the raw sample

Table 3: Hypothesis 1B

	Dependent variable: Entrepreneur (1) or Full Time Employee (0)			
	No Social Class	No Social Class	SC 1 or 2 From Age 34	SC 1 or 2 From Age 34
	(1)	(2)	(3)	(4)
Constant	−1.958***	−2.581***	−3.086***	−3.500***
	(0.166)	(0.287)	(0.466)	(0.561)
Inattention Rating	0.003**	0.004*	0.006*	0.011**
	(0.001)	(0.002)	(0.004)	(0.005)
	OR: 1.003	OR: 1.004	OR: 1.006	OR: 1.01
Father Self Employed		0.850***	1.196***	2.269***
		(0.266)	(0.397)	(0.765)
		OR: 2.34	OR: 3.31	OR: 9.67
Education	−0.394**	−0.362	−0.384	−0.351
	(0.162)	(0.261)	(0.386)	(0.389)
	OR: 0.67	OR: 0.70	OR: 0.68	OR: 0.70
Inattention Rating * Father Self Employed				−0.012
				(0.008)
				OR:0.99
Observations	1,632	779	422	422
Pseudo R^2	0.017	0.044	0.077	0.091

Note: *p<0.1; **p<0.05; ***p<0.01

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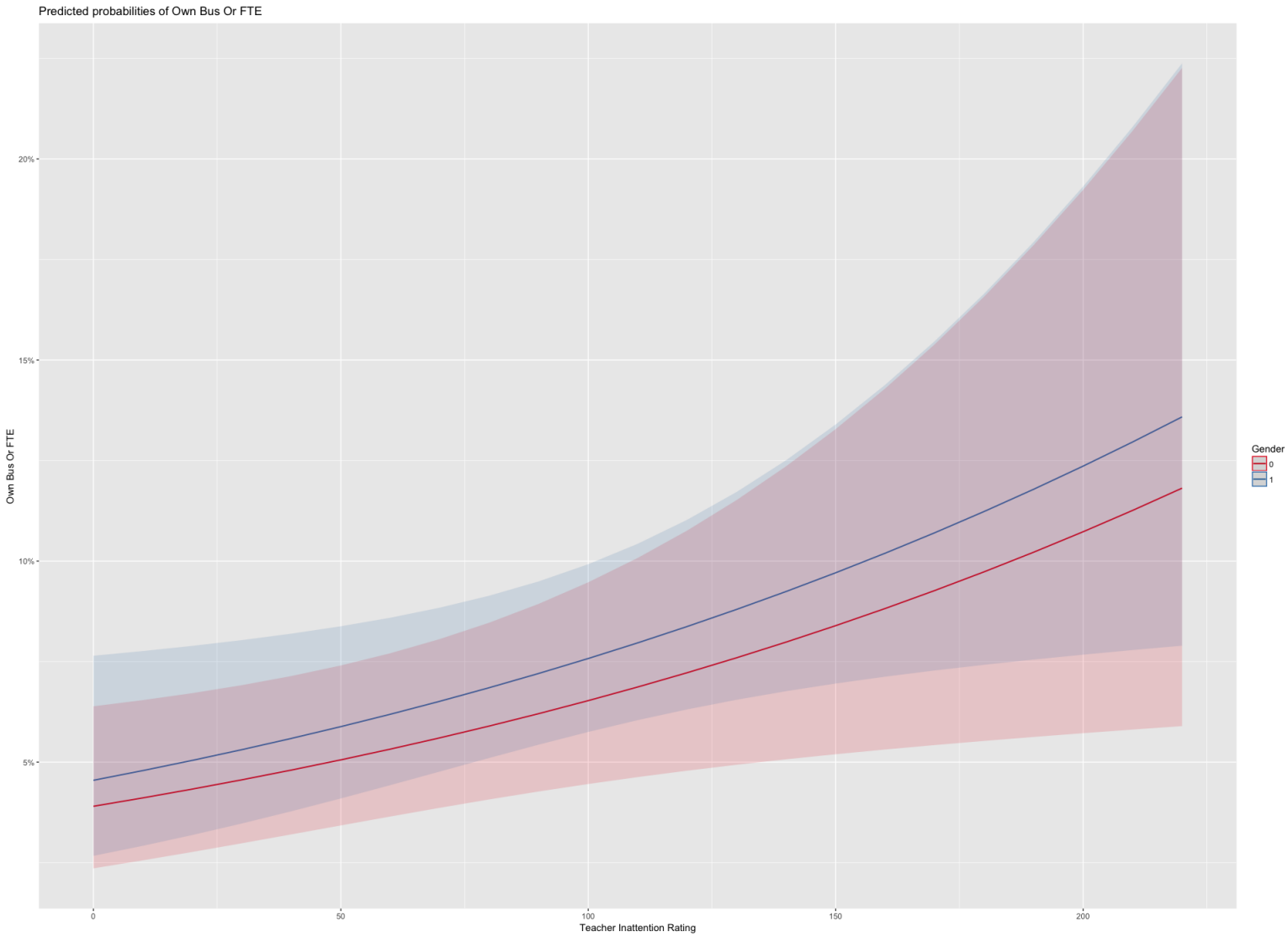

Figure 1: Hypothesis 1A - Propensity Score Matched (Table 2)

Table 4 presents the results for hypothesis 2A. Overall there exist a negative effect of ADHD symptoms on business performance and hypothesis 2A is supported. Business performance is measured across business continuity (model 1), business earnings' growth (model 2) and take home income (model 3; with robust standard errors). The probability of business continuity decreases by 17%, for inattention ratings approximately 20% above the median[40]. Education has no significant effect on business continuity. Similarly, education has no effect on earnings' growth (model 2). However, in model 2, the dummy variable for hyperactivity does have a negative effect. Hyperactivity/impulsivity approximately 30% above the median reduces the probability of earnings growth by 46% amount. Finally, model 3, a multi-linear regression with robust standard errors, suggests that each point increase in inattention rating from age 10 (range = 5 - 235) reduces income by £48. Further, the dummy variable for education suggests that leaving education at or after 18 increases earnings by over £6500[41].

Table 5 presents additional findings for the overall chapter, as discussed earlier and described in equation 14. The results from these multi-linear regression models show that in the high ADHD group (model 1), the median pay from either self-employment earnings or full-time employment salary is lower than in the low ADHD group (model 2). In addition, standard deviation is greater in the high ADHD group. The key independent variable of employment status is only significant in the high ADHD group, suggesting that business ownership increases pay in the high ADHD group by above $27,000.

[40]

$$\frac{e^{\alpha+\beta_1\lambda+\beta_2\omega}}{1+e^{\alpha+\beta_1\lambda+\beta_2\omega}} \tag{15}$$

[41]In choosing the sample for this model, it is possible that the outcome of interest and selection of the sample are not independent of one another; i.e., sample selection bias. This may be corrected in the future using a Heckman two step correction.

Table 4: Hypothesis 2A

	Dependent Variable (below)		
	Business Continuity	Earnings Growth	Take Home Income at 42
	Logistic	*Logistic*	*OLS*
	(1)	(2)	(3)
Constant	1.120***	1.058***	27,078.040***
	(0.291)	(0.350)	(2132.38)
Binary Inattention Rating	−0.719**		
	(0.332)		
	OR: 0.487		
Education	−0.540	−0.4970	6,585.523***
	(0.352)	0.6007	(2447.15)
	OR: 0.583	OR: 0.608	
Binary Hyperactivity Rating		−2.101**	
		(0.878)	
		OR: 0.122	
Inattention Rating			−48.744**
			(17.48)
Observations	174	67	325
Pseudo R^2 / R^2	0.049	0.137	0.058
F Statistic			9.915*** (df = 2; 322)
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 5: Additional Finding for Chapter 2

	Dependent variable: Full-time Pay or Earnings from Self-Employment in GBP	
	Male High ADHD	Male Low ADHD
	(1)	(2)
Constant	20,227.900***	22,823.200***
	(533.4)	(557.3)
Full-time Employee (0) or Business Owner (1)	27,561.750***	1,116.324
	(10232.9)	(3480.8)
Education	7,649.628***	5,562.324***
	(2254.9)	(1203.9)
Standard Deviation	24,312	17,394
Median	17,844	20,800
Observations	1,130	1,221
R^2	0.072	0.020
F Statistic	11.28*** (df = 2; 1127)	10.91*** (df = 2; 1218)

Note: *p<0.1; **p<0.05; ***p<0.01
Yearly profit is checked to be reported at least 9 months and less than 14 months
With Robust Standard Errors
Extreme outliers are removed, three in total

2.7.1 Discussion

Inattention is significant at ages 30, which lends only partial support to hypothesis 1A; this is particularly the case when considering the fact that hyperactivity/impulsivity is not significant at all in hypothesis 1A. This finding contrasts the majority of literature on the topic, which proposes that hyperactivity/impulsivity may be the key determinant of the relationship between ADHD and entrepreneurship, as it allows for 'acting without thinking' (Antshel, 2018; Wiklund et al., 2019). Whilst the result presented here does contrast the literature, it does not mean 'acting without thinking' in the selection into entrepreneurship is untrue, only the that there is a significant overlap relationship between hyperactivity/impulsively and inattention is to be kept in mind. The fact that inattention is significant supports the notion explicated in the literature review of this chapter, that individuals exhibiting high inattention symptoms in childhood will be more tolerant of risk and uncertainty.

Additional support for this is found in the additional findings for chapter 2 (table 5), in which the result is split into the high ADHD group and the low ADHD group. In the former, the standard deviation of the combined yearly income/profit from the business is greater, yet the median is lower. In the high ADHD group business ownership over full-time employment predicts a significant increase in the individual's earnings. Taken together, the findings support the premise proposed in the literature review, that individuals with higher ADHD-like symptoms in childhood would be drawn to risk and standard deviation in income. Further, the findings add credence to the position held by Manso (2016), in that entrepreneurs may be drawn to risk in itself.

The results from the propensity score matching in table 2 may add support to the equilibrium concept of Shane and Venkataraman (2000) and Kihlstrom and Laffont (1987), in that there exists a unique element that entrepreneurs possess. This is chiefly due to the fact that the propensity score matching compares more directly individuals who are similar to one another in terms of their socioeconomic background and thus can reduce endogeneity,

or unobserved effects that may reduce the 'unique' contribution of ADHD-like symptoms in assisting in entrepreneurship. On the other hand, it is possible that as proposed by Galor and Michalopoulos (2012), the risk and novelty seeking individual is poorly suited to the mature environment. What the authors did not consider is the possibility that this type of individual may still be drawn to entrepreneurship through being ill-suited to the environment. However, in the data presented here, I would contend that necessity or opportunity entrepreneurship cannot be fully investigated. Results and discussion presented in chapter three may elucidate further on this topic [42].

Results for hypothesis 1B suggest that the effect of inattention is significant in predicting entrepreneurship, more so than hypothesis 1A; i.e., over a 12 year period than at any one age point. The understanding here is that individuals with high ADHD-like symptoms in childhood may have a greater probability of selecting into entrepreneurship, but at the same time this may be a hindrance (hypothesis 2A). This argument is similar to that presented by Busenitz and Barney (1987), Hvide and Panos (2014) and Lerner (2015). Namely, that Busenitz and Barney (1987) contend that entrepreneurs would make poor managers, simply for the fact that administrative duties are not well suited to the entrepreneur and in fact differentiates the entrepreneur from the manager. Similarly, Lerner (2015) found this to be the case with higher ADHD-like symptoms and the attraction of resource providers. In support of the above, Hvide and Panos (2014) find that whilst the proxies for risk in their study increase selection into entrepreneurship, it simultaneously decreases business performance[43]. It may be the case, as in this research, that risk-tolerance increases selection into entrepreneurship but hinders performance. This is certainly an argument that can be held with the current findings of the chapter.

Education appears to have a negative effect on selection into entrepreneurship, presumably this is as noted by Dickson et al. (2008), in that in mature economies with more economic opportunities higher education has a greater return in salaried employment. Thus,

[42]Diagnostic plots for the propensity score matching can be found in the appendix

[43]These findings from the current research validate the approach of treating ADHD as a proxy for risk-tolerance.

given that the data is taken from the UK, the results are perhaps unsurprising in this regard. Additional support for Dickson et al. (2008) is found in the fact the education increases the take-home income of the individual, supporting the idea that education can improve business performance. Alternatively, given that this is measured at age 42, it is possible that this is due to the combination of their previous experience in industry translating to self-employment at a later age. That is, a mediating effect of education on industry experience which is then translated to self-employment. This would be an interesting avenue for future research.

Finally in discussion of the results presented above, it is worthwhile noting that the findings presented are only found in males. One can hypothesise that this is likely due to the fact that both business ownership (Hopp and Martin, 2017) and ADHD-like symptoms are greater in males (Mowlem et al., 2019). With regard to business ownership there may exist inequalities between the genders in access to resources. Further, there are also greater effects with regard to reporting ADHD symptoms, with research showing that females are more likely to have their symptoms under-rated (Mowlem et al., 2019); it is possible that this has been the case in the BCS dataset. However, in assessing which of these assumptions is likely more dominant, it is possible that the distribution of business ownership is more powerful as an explanation. Of the 503 business owners at age 30, only 173 are females. As such, business ownership may be more dominant in males and this is likely due to inequalities between the genders[44].

2.7.2 Contributions

The contributions made in this chapter are mainly empirical in nature and build on the limitations of extant studies. Extant studies have utilised cross-sectional analysis of entrepreneurs or entrepreneurial tendencies. These studies have shown there exists a mild positive relationship between entrepreneurship and ADHD-like symptoms. Whilst these studies have made good progress on the topic, they fall short in key areas and can be improved in a number of ways.

[44]Results for female cohort members can be found in the appendix.

First, ADHD symptoms are measured alongside participants' entrepreneurial status. This in itself has two limitations. First, in the clinical sense ADHD symptoms must be present in some degree from childhood. This approach likely would negate the second limitation, which is the inability of extant studies to disentangle the presentation of ADHD-like symptoms from the stress of the entrepreneurial process. That is, ADHD may be considered as a behaviour found in the general population in lower amounts (Danneman and Gören, 2018). These symptoms may be increased at some point in an individual's life due to a traumatic event or other significant event (NHS, 2019). Thus, it is difficult for extant studies to disentangle the effects of the entrepreneurial process from the symptoms of ADHD. Further, there is an element of subjects' confirmation bias. In which, the participant is aware of the study purpose and the entrepreneur seeks to confirm the known objective of the study. To overcome these limitations, the current research analysed childhood ADHD-like symptoms and regressed against later occupational choice. This method disentangles the process from the behaviour, allowing for the effect of ADHD on entrepreneurship to be independently analysed.

Given this novel methodological approach, the analysis presented thereafter is also novel. For instance, this is the first research to evidence the positive and negative effects of ADHD-like symptoms from childhood on the entrepreneurial process. Further, it is the first study to show how business performance is affected by ADHD-like symptoms in childhood. It is also the first research to analyse this relationship across and within a twelve year period. Previous research has focused on cross-sectional analysis, but this does not allow for the analysis of the relationship between ADHD and entrepreneurship over time.

Finally, the robustness tests contribute to the field in a number of ways. First, the propensity score matching (PSM) is the first of its kind in this application. The PSM allowed for the entrepreneurs to be matched with full-time employees of a similar socioeconomic background, thereby controlling as much as possible for any endogeneity in the model. To the best of my knowledge, this is the first such approach. Second, in table 5,

the results from the standard deviation and medians of the high and low ADHD group were presented. I will not discuss again the results of the regressions, only that this to the best of my knowledge is a novel approach highlighting the benefits of entrepreneurship in children with high ADHD-like symptoms in later life.

2.7.3 Limitations

The first limitation concerns the measurement of the ADHD variable being an approximation for the ADHD symptoms, identified from the Conners' Hyperactivity Scale and the Rutter Behaviour Scale, and not from a full proof diagnostic checklist, such as the DSM 5 (American Psychological Association, 2013). Nevertheless, since the results are consistent with the preceding literature on ADHD behaviours (i.e., poorer educational attainment and more rule-breaking behaviours (Fletcher, 2013; Kent et al., 2010; Loe et al., 2007; Mahmut et al., 2008; Young et al., 2011), and have been validated by the factor analysis preceding the estimations, the research is confident of the validity of the interpretation.

The second limitation concerns the realisation that individuals with very high ADHD-like symptoms may be less likely to take part in future sweeps in the BCS (as confirmed by analysis of the response drop-off rate)[45], skewing the directionality of the findings. This is likely because individuals with high levels of ADHD symptoms are more forgetful (Thapar et al., 2005) and may miss reminders to take part in the study. It is possible that this limitation could be overcome by imputing the ADHD-like symptoms at the necessary cross-sections. However, after careful analysis of the type of missing data (Afifi et al., 2012), I came to the conclusion that this approach is likely to induce more bias and thus chose not to pursue it.

[45]See appendix.

2.7.4 Conclusion

This chapter concerned the role of ADHD in entrepreneurship. The hypothesised relationship was argued to be underpinned by the elevated risk and novelty seeking provided by ADHD-like behaviours. Chiefly, that ADHD-like symptoms would change the individual's utility function in favour of taking more risk. This would result in an increased probability of entrepreneurship but may hinder performance. This was confirmed through analysis of the BCS dataset. However, this effect was small, which is consistent with previous research.

In chapter one, it was predicted that the majority of individuals with high ADHD symptoms would be more likely to be driven to activities with negative outcomes, chiefly due to the maturity of the economy favouring risk-aversion. This relationship is quite complex and the equation presented at the end of chapter 1 proposed that the environment and development of human capital would be crucial in labour market success. As such, chapter three concerns itself with investigating the economics of childhood development.

3 Chapter 3 - The Economics of Childhood Development - The Case of ADHD

Individuals predisposed to high risk-tolerance, through ADHD-like behaviours for instance, will have little room for positive activities, according to the unified growth theory of Galor and Michalopoulos (2012). Chapter 2 of this thesis outlined the potential for positive outcomes. However, more often than not this elevation in risk-tolerance has an overwhelmingly negative effect. The purpose of this chapter is to explore the avenues through which ADHD is negatively influencing economic and social activity. From the outset, there is a need to be clear that this is the majority of individuals with ADHD. In this chapter I formalise this negative effect using human capital theory. Further, I will show that even in the case of a positive effect on ADHD in entrepreneurship, there exists a negative element within it that may explain a long-standing question in entrepreneurship research; viz., the 'dark-side' of entrepreneurship (Zhang and Arvey, 2009).

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder affecting around 2-5% of children in the UK (NHS UK, 2016). ADHD can also affect adults, with an estimated 80% of children with ADHD exhibiting symptoms into adolescence and potentially adulthood (Farone et al., 2003). There are three primary symptoms of ADHD, viz.: (1) Poor attention span, (2) impulsive behaviour and (3) hyperactivity (Farone et al., 2003). The American Psychological Association notes that there are three types of ADHD; Inattentive, impulsive/hyperactive and combined type (APA, 2018). The dominant theory of ADHD is the executive function theory espoused by Barkley (1997). An alternative theory is the optimal stimulation theory posed by Zentall and Myer (1987), which proposes that the symptoms of ADHD are attempts to attain an optimal state arousal. The optimal stimulation theory has received strong support [46][47].

[46]See for instance: Antrop et al. (2000); Groom et al. (2010); Kuntsi et al. (2009); Liddle et al. (2011); Shaw et al. (2005); Sikström and Söderlund (2007); Zentall and Myer (1987).

[47]The interested reader can see chapter one of this thesis or Sikström and Söderlund (2007) for the dopaminergic basis of the optimal stimulation theory.

The chapter begins with a review of the negative outcomes of ADHD and our current understanding of the mechanisms underlying this. It then follows into an application of ADHD to explain rule-breaking behaviours in entrepreneurs. After this, the chapter proposes a model and develops hypotheses to improve our understanding of the underlying mechanisms of the negative outcomes of ADHD.

3.1 ADHD and Economics

There are known negative outcomes of ADHD and direct costs to the economy. Doshi et al. (2012) in a meta-analysis find that the costs of ADHD to the U.S. economy ranged from $143 to $266 billion per annum. The majority of these costs are the results of productivity and income losses ($87-$138b).

It is important to consider that not all of the negative outcomes of ADHD are the result of increased risk-tolerance. Some of the outcomes discussed form part of a long chain of events. For instance, ADHD individuals perform poorly in school (discussed below). After this fact, education has an effect on career progression, wage growth and influence into crime. It seems apparent then that an early intervention to stem educational burdens will potentially improve outcomes. This line of thinking is formalised by the human capital theory. Human capital theory is discussed below and is used as the main lens to understand ADHD in the economy.

3.2 Human Capital Theory

Human capital theory is a salient development from the discussion in chapter 1, in that it is one of the best examples of the need to expand what is studied in economics. Becker (1962) popularised the use of human capital theory, which places parental rearing, family status and early education as crucial to labour market success. Almost everything an individual does affects their economic activity and subsequently the composition of the economy. In chapter 1, 'Evolutionary Basis of Economic Risk-Tolerance Through ADHD', for instance, the thesis explicated the importance of incorporating evolutionary biology. The work presented here then closely follows the philosophy of Gary Becker, who was also cited in chapter 1 for his work on evolutionary economics (Becker, 1976).

Human capital refers to the investment in humans as sources of capital; the individual can benefit from investments in education, training and parental rearing, much like the investment in capital in an organisation (Becker, 1994). There are various components that influence human capital. Becker (1994) argues that education and training are by far the most important investment in human capital. Educational achievement can be influenced by cognitive skills, some of which may be innate (Dannemann and Gören, 2018). Innate factors that influence educational attainment may include IQ and attentional components, such as ADHD (ibid).

James Heckman is a prominent proponent and investigator into human capital theory (Heckman and Mosso, 2014). Specifically, Heckman emphasises and investigates the importance of childhood development on economic success. Heckman divides predictors of economic success into cognitive and non-cognitive abilities (Cunha and Heckman, 2009). The former relates to scholastic achievement, such as test scores. Non-cognitive abilities refer to traits such as, inter alia, perseverance, risk-aversion and motivation (ibid). Both are considered to be important in the determinants of 'white-collar employment', in addition to other behaviours such as, inter alia, smoking, occupational choice and wages (Cunha and Heckman, 2009). Interestingly, Heckman and Mosso (2014) emphasise that parental

inputs, rather than family resources may be more important in the economic success of the child. That is, spending time with the child and providing cognitive stimulation (reading to the child, for example) is more important than the income of the parents, yet, a higher income more readily facilitates 'good parenting' (ibid).

A corollary to the argument of 'good parents' is that they are smarter and have 'good genes'; as such, they earn more and the advantage is conferred onto the children, who are also smart. This point is tackled by Cunha and Heckman (2009), with evidence from studies showing that the environment is an important point to consider in the expression of genes, in that good environments may alter gene expression; the extent to which this is a causal effect is unclear (Heckman and Mosso, 2014). That is, do good genes select good environments, or are good genes only expressed in good environments? Evidence with regard to the gene most commonly associated with ADHD suggests that the environment is more important. The study of Bakermans-Kranenburg and van Ijzendoorn (2011) found that positive rearing environments are more beneficial for those with the 7R allele than in those without. Similarly, the study of Chi et al. (2016) found a significant negative interaction between the 7R gene and neighbourhood poverty on educational attainment; i.e., children with the 7R gene from poorer neighbourhoods were more likely to have poorer educational attainment than non-carriers (the reverse by logic is not true; i.e., the 7R gene does not have poorer educational attainment than non-carriers in non-poor neighbourhoods). Thus, the environment is important in the expression of genes, which are not the sole determinants of childhood behaviour and its effects on labour market success.

The salient points for the discussion are the influences of 'innate' factors on human capital development and labour market success. That is, the influence of ADHD as an innate factor in human capital development.

3.2.1 Human Capital Theory and ADHD

The discussion of the 7R allele in the above paragraphs leads to the natural review of the role of ADHD and childhood development. It is sensible to conceive that ADHD would present

various challenges in the child's development and subsequent labour market success. Here we will begin to formalise this notion with economic preferences related to ADHD, such as time preferences and hyperbolic discounting. The reason for choosing these concepts is based on the definition of these preferences being closely aligned with the behaviours observed in ADHD. Consider for example time-preferences.

3.2.2 Time-Preferences and ADHD

Time preferences are critical to economic decisions (Stigler and Becker, 1977). It can be understood as the ability of an individual to be 'future oriented'. A common and simple example of this is the question:

"Would you prefer $10 today or $11 tomorrow?"

This reveals the individual's time preferences. It may, in layman's terms, be understood as patience. Time preferences are critical to the development of human capital (Cadena and Keyes, 2015). One must understand the long-run benefit of investing in education at a young age. Yet, those with high ADHD-symptoms may be considered as being present oriented, impatient and unable/unwilling to see the benefits of future investment. The consequences in a more broad sense of self-control are expounded by Moffitt et al. (2011), who found that childhood poor self-control predicts poorer adult outcomes such as, inter alia, physical health, criminal offending and personal finances. These findings are robust to controlling for socio-economic background and IQ.

It thus seems logical that children with high-ADHD symptoms may represent those with steep time-discounting functions. This may start from a micro level, as exhibited in the decision making studies in ADHD, in which children with ADHD are driven to high and immediate rewards (Malloy-Diniz et al., 2007). It may also translate into the classroom and the ability to perceive investment into scholastic results as beneficial to their future success in the economy. That is, if a child cannot concentrate in a classroom, this impacts on their ability to learn and subsequently, their educational attainment is lower; thus their

human capital is lower, resulting in lower occupation and lower pay. Essentially, this may make the individual less 'marketable' in the labour market.

The study of Currie and Stabile (2006) directly tested the effect of ADHD on educational outcomes, loosely relating this with human capital accumulation. Using data from the USA and Canada, the authors measure ADHD-symptoms, not diagnosis of ADHD, to understand the effects of ADHD symptoms across a continuum on educational outcomes. This is useful in understanding the effects of sub-clinical ADHD and separating from the severe cases of ADHD[48].

The authors present two main findings of pertinence to this review. First, hyperactivity symptoms are significantly related to poorer test scores and educational attainment. Second, the authors present the effects of family income on hyperactivity and receiving treatment and education. Income may be treated as a proxy for the parent's socio-economic background. Income has little effect on receiving treatment, but has an effect on education in high income families, in which those with high ADHD symptoms from high income families are less likely to repeat grades. This finding is perhaps unsurprising, given the discussion above on the ability of wealthier parents to facilitate 'good parenting' and thus improve the child's human capital (Heckman and Mosso, 2014). It is perhaps not as strong as one might expect, in that grades do not improve in high versus low income families for children with high ADHD-symptoms, but only the lessening of grade-repetition. A possible explanation for this is the focus of Currie and Stabile (2006) on hyperactivity symptoms, in that little investigation is conducted into the effects of inattention symptoms, as in Merrell and Tymms (2001), in which UK schoolchildren's educational attainment was more severely impacted by inattention and combined ADHD symptoms, rather than hyperactivity-impulsivity symptoms.

[48]Sub-clinical ADHD symptoms could occur, for example, due to differences in socioeconomic status and or parental rearing (Russell et al., 2014)

3.2.3 Education in ADHD

Education is one of the most thoroughly researched areas in ADHD. ADHD children achieve lower school grades, more repetition of school years and higher rates of suspension and expulsion (Arnold et al., 2015; Fletcher, 2014; Kent et al., 2010; Loe et al., 2007; Polderman et al., 2010). In the study of Kent et al. (2010), the authors compared academic characteristics of diagnosed ADHD adolescents to non-ADHD adolescents. The findings are consistent with the broad literature on the topic (Arnold et al., 2015), but more insight is provided as to the relationship between ADHD and poor educational attainment. The authors posit that the known difficulty in organisational capabilities of ADHD adolescents leads to difficulties in completing tasks, such as homework. This argument is held by Arnold et al. (2015), in that success in the school environment requires skills beyond learning information. For instance, one needs to be able to possess organisational and time-management skills. Both of these skills are known to be lacking in ADHD (Sibley et al., 2015). As such, Kent et al. (2011) posit that certain courses, such as maths and history, may place more attentional demands than others, such as art and drama. Interestingly, the meta-analysis of Arnold et al. (2015) finds that treatment for ADHD can significantly improve educational outcomes.

The subsequent question is the extent to which the quality of parental input (i.e., 'good parenting') can influence in a different direction the educational outcomes of ADHD[49]. That is to say, Heckman and Mosso (2014) posit that the quality of parental input can alter positively the accumulation of human capital; is this increase in quality parental rearing a plausible avenue through which children with high ADHD symptoms may improve their educational attainment? In addition to this, the study of Currie and Stabile (2006) found little effect of high income on educational outcomes in ADHD, but there have been few studies that have investigated the effect of socio-economic status on educational attainment in ADHD, despite the known association between ADHD and low socio-economic

[49]It is important to keep in mind that this is not to say that ADHD or its symptoms are caused by 'bad parenting', only that it is possible that ADHD symptoms may be more responsive/may require greater parental input.

status (Russell et al., 2014).

Given the discussion above with regard to poor educational attainment and thus poor accumulation of human capital in ADHD individuals, it would seem to follow from the findings of Moffitt et al. (2011) that individuals with ADHD would be predisposed to more criminal offences through poor educational attainment rather than solely through the symptoms of ADHD; i.e., individuals with high ADHD symptoms who are highly educated would have no greater probability toward crime than those with low ADHD symptoms.

3.2.4 Antisocial Behaviour in ADHD

The meta-analysis study of Thapar et al. (2006) provides an overview of antisocial behaviours in ADHD. The findings of this review indicate that ADHD and antisocial behaviours are highly correlated. The mechanism through which they are related is understood to be the hyperactivity and impulsivity symptoms of ADHD (Thapar et al., 2006). The longitudinal study of Babinski et al (1999) aimed to uncover this relationship by correlating ADHD symptoms in childhood to official arrest records and self-reported crime as adults. The study found the inattentive symptom of ADHD did not predict criminal behaviour, whereas hyperactivity and impulsivity predicted a greater arrest record. This relationship is consistent with the explanations of the optimal stimulation theory[50], in that impulsivity can lead to a lack of forethought, which can result in reactive crimes (Fletcher and Wolfe, 2009). Further, individuals with ADHD also exhibit higher incarceration rates, with an estimated 24% of the UK prison population exhibiting ADHD symptoms (Young et al., 2011). In comparison, the prevalence of adult ADHD in the UK adult population is approximately 1% (ibid). Interestingly, as with the effect of treatment on educational outcomes by Arnold et al. (2015), the study of Lichtenstein et al. (2006) finds that treatment of ADHD reduces the rates of criminality by approximately 32% in men and 41% in women.

The notion that impulsivity is the core component driving antisocial behaviours in ADHD is corroborated by the study of Fletcher and Wolfe (2009). This study differs from

[50]See for instance Sikström and Söderlund(2007).

Babinski et al. (1999) and Thapar et al. (2006) in that it relies on secondary data to analyse relationships between ADHD and different types of crimes. Triangulating data sources is extremely beneficial and can corroborate the finding of antisocial behaviours in ADHD. The main finding from this study is that impulsivity is the greatest predictor of antisocial behaviours in ADHD. With regard to the question posed above, the effect of educational attainment on participation in antisocial behaviours in ADHD, Fletcher and Wolfe (2009) find the effect of ADHD onto antisocial behaviours to be independent of educational attainment, though controlling for education does reduce risky behaviour by 10-20%.

Fletcher and Wolfe (2009) utilise the argument of Mocan et al. (2005), in that there are two types of human capital and engaging in criminal activity increases the criminal human capital and depreciates 'legal' human capital. The authors support their findings and propose that the lower legal capital in ADHD leads to the increase in illegal capital. This results speaks to the need to review labour market outcomes in light of educational attainment and antisocial behaviours. The need for legal human capital may be particularly lower if an individual chooses self-employment, in which there may be less of a need to conform with societal norms and thus possess legal human capital.

3.3 Labour Market Outcomes for ADHD

Scholars have taken various approaches with diagnosed ADHD individuals and those in a non-clinical sample, measuring their ADHD-like behaviours. Beginning with a discussion of the relationship between income (wage or salary) and ADHD, the study of Beiderman and Faraone (2006) finds that individuals with ADHD have lower household income than those not diagnosed with ADHD. Interestingly, this effect is independent of educational attainment, in that higher educational attainment does not protect against reduced income in ADHD. Similarly, the study of Fletcher (2014) shows a negative impact of earnings in ADHD, though, in comparison to Beiderman and Faraone (2006) this study involves more advanced analysis, controlling for variables such as school quality; maternal education; scholastic ability. Fletcher (2014) finds that yearly earnings in ADHD are reduced by around 35%. The most recent study reporting reduced income effects in ADHD is that of

Vergunst et al. (2019), in which teacher ratings of childhood inattention and hyperactivity predict lower income in later life. The common theme amongst these studies, however, is the absence of the effect of full-time work experience on earnings, particularly on hourly earnings, which is also absent in the aforementioned studies and literature to date.

Occupational type is known to be affected in ADHD (Barkley et al., 2006; Biederman and Faraone, 2006). Kuriyan et al. (2012) delve deeper into the effects of ADHD in childhood on occupational status, finding that occupational status is negatively predicted by ADHD and disciplinary problems in school. In the study, a greater portion of the ADHD group were in manual labour as opposed to skilled professional labour and had higher rates of job dismissals and quitting. Interestingly, ADHD participants were more likely to have held more full-time jobs than their counterparts. The authors attribute this result to the fact ADHD individuals were less likely to pursue further education and choose instead full-time employment. This result is similar to that of Fletcher (2014), in which educational attainment of ADHD individuals accounts for only a small effect on employment reduction. In addition, despite the fact the ADHD group had more work-experience, this did not translate to any increase in wages, where in fact the wages of the ADHD group were lower. With regard to occupational changes, Kuriyan et al. (2012) argue that ADHD individuals may be more responsible for leaving their jobs through simply quitting sooner. One may posit that ADHD individuals become bored with their jobs and seek further novelty in new jobs.

Recently there has been a growing interest in self-employment (entrepreneurship) as a possible outcome for individuals with ADHD (Antshel, 2018). Indeed, the evidence presented in the meta-analysis of Antshel (2018) supports the idea that individuals with ADHD have a mildly greater probability of becoming entrepreneurs. This could be for a number of reasons. For instance, income is not constrained by educational attainment, as per traditional employment (Parker, 2004). That is, if individuals are less educated, this can constrain their earnings, however, in entrepreneurship no formal educational requirements exist (ibid). Second, individuals with ADHD are predisposed to risk tolerance, which is

a hallmark of entrepreneurship (Smith, 1776). However, as discussed above, whilst self-employment may not present the same requirements on legal human capital as other forms of employment, there may be an increase in the criminal human capital, partially in the willingness to not conform to societal norms and or the increase in tolerance of uncertainty.

The study of Loughran et al. (2013) provides a pertinent discussion of criminal capital, especially as compared to human capital. Criminal capital accumulates through experience and can facilitate useful criminal activity (Loughran et al., 2013; Mocan et al., 2005). In the paper of Loughran et al. (2013) the authors highlight the differences between human and criminal capital. An important point noted here is that the accumulation of traditional human capital assumes a level of rationality that allows one to be future-oriented. In contrast, criminal investments are likely driven by present-oriented behaviour (ibid). The authors note that entry into the illegal criminal market are more likely to be driven by the immediacy of the earnings. Certainly there is no need for traditional human capital in entry into illegal capital. Thus, those who are more present-oriented may struggle to accumulate traditional human capital and equally may be driven to illegal market entry.

3.3.1 Criminal Capital and Self-employment

There are parallels between self-employment and illegal market entry, in that neither require the accumulation of traditional human capital (education) and both have the potential for high immediate rewards. The notion that entrepreneurs may be inclined to criminal or antisocial behaviours can be traced back to Gould (1969), stating that to understand the entrepreneur one must look at the juvenile delinquent. In the paragraphs that follow I review the literature on the interplay between criminal behaviour and entrepreneurship to elucidate the similarities between criminal activity and self-employment.

In the entrepreneurship literature, criminal/antisocial behaviour is often referred to as the 'dark side of entrepreneurship' (Hmieleski and Lerner, 2016; Klotz and Neubaum, 2015). The dark side of the entrepreneur is continued in contemporary literature, with Zhang and Arvey (2009) positing that entrepreneurs may be predisposed to moderate levels of rule-

breaking. In the study of Zhang and Arvey (2009: p436) rule-breaking refers to the "failure to conform to the applicable normative expectations of the group". As noted by Zhang and Arvey, by definition of entrepreneurship, the entrepreneur must be creative and therefore break rules. The study of Zhang and Arvey considered entrepreneurs as those who owned or were partners of their respective businesses. To test this hypothesis, Zhang and Arvey (2009) investigated the rule-breaking of entrepreneurs and managers. Both groups were instructed to recall their rule-breaking tendencies in their adolescence. Rule-breaking was measured using Likert-scale questions and divided into two factors; modest rule-breaking and severe rule-breaking. Modest rule-breaking involves behaviours such as delinquency and family/school offences, whereas severe rule-breaking referred to substance abuse and severe crime, such as theft (Zhang and Arvey, 2009; p441). The results of the study indicate that modest rule-breaking in adolescence has a positive relationship with entrepreneurial status in adulthood. Interestingly, the relationship between rule-breaking and entrepreneurial status was mediated by risk-taking propensity. This finding is interesting because risk-taking propensity is pivotal to entrepreneurship (Zhang and Arvey, 2009) and in this study the pivotal factor was associated with a negative social outcome.

Whilst the study of Zhang and Arvey (2009) does support the potential antisocial and criminal tendencies of entrepreneurs, one may question the methodological rigour of asking participants to recall their rule-breaking tendencies, as the recollection of an individual's rule-breaking is subject to the ability of the individual to recall accurately. Therefore, an entrepreneur may not accurately remember their rule-breaking in adolescent years or they may conceal certain truths to avoid judgement by the entrepreneur's peers.

The study of Aidis and Van Praag (2007) and Fairlie (2002) provide different approaches to those of Zhang and Arvey (2009) and thus may overcome the above-mentioned limitations. These studies focus on explicit engagement in illegal activities. Fairlie (2002) found that in a longitudinal study, youths who engaged in drug-dealing activities were far more likely to become self-employed and start their own business, than those who did not. The author interprets this finding in the neoclassical sense of entrepreneurship, in that drug-

dealers may exhibit lower risk-aversion. This finding is corroborated by that of Aidis and Van Praag (2007), finding that Lithuanian youth who engage in grey and black-market activities have stronger business performance. The authors present this as an unconventional form of human capital accumulation which may be beneficial to the performance of the business. This is perhaps akin to that presented by Loughran et al. (2013), in which experience in criminal activity assists in furthering crime. The difference, of course, being the participation in entrepreneurship. However, in this study one must be aware of the potential informality of the Lithuanian economy.

Obschonka et al. (2013) may be considered an extension and replication of Zhang and Arvey's study, in that the central hypothesis was to test the rule-breaking and antisocial tendencies of established entrepreneurs using a similar metric for entrepreneurial status. Obschonka et al. (2013) used a longitudinal study of Swedish children, from which they gathered data on registered crime from official records. Such an approach alleviates the aforementioned recall biases of Zhang and Arvey (2009). The findings of Obschonka et al. (2013) support the findings of Zhang and Arvey (2009). The authors found early antisocial and rule-breaking behaviour correlated positively with entrepreneurship. However, registered crime (a more serious form of rule-breaking) did not correlate with entrepreneurship. Obschonka et al. (2013) argue that more serious crime impinges upon entrepreneurship. This finding is consistent with Zhang and Arvey (2009), in that severe rule-breaking is not correlated with entrepreneurship and in fact may be detrimental to the process. In contrast, moderate rule-breaking and early antisocial tendencies appear to assist in entrepreneurship. The manner through which rule breaking may be achieved is through an increase in risk-taking behaviours, which may also assist in committing to an entrepreneurial venture (Zhang and Arvey, 2009). A similar study by Levine and Rubenstein (2017) notes that a combination of intelligence and illicit behaviour in childhood predicts entrepreneurial entry.

There are limitations to the study of Obschonka et al. (2013), such as the reliance on registered crime to measure severe rule-breaking behaviour. It is possible that the participants may have committed a severe crime that was not registered. Owing to such mistakes,

the most rigorous approach may be a measure of rule-breaking of entrepreneurs in a predefined laboratory test, such as the one used in Arend (2016).

Arend (2016) maintain the same hypothesis as Zhang and Arvey (2009), in that entrepreneurs must by definition break rules in order to succeed. The author's approach to test this hypothesis differs from Zhang and Arvey (2009) and Obschonka et al. (2013). In place of recalled antisocial tendencies or registered crime, Arend (2016) uses a laboratory game with predefined conditions to measure rule-breaking tendencies in entrepreneurs and non-entrepreneurs. The game incorporates a critical component; viz. the ability to break the rules of the game, which must first be discovered by the participant. Arend (2016) found that entrepreneurs discovered that the rules of the game could be broken at a faster rate than non-entrepreneurs. Further, the entrepreneurs broke the rules to a greater effect, in that they obtained more rewards than non-entrepreneurs whilst breaking the rules. The ability of entrepreneurs to understand and quickly exploit the rules of the game are similar to those found in the study of Laureiro-Martínez et al. (2014); in which entrepreneurs arrived at decisions quicker than non-entrepreneurs. This may be further evidence that rule-breaking may be related to risk-taking behaviour in entrepreneurs, as fast decision making in the study of Laureiro-Martínez et al. (2014) required decision-making under uncertainty.

Two conclusions may be drawn from the above review. First, the studies reviewed above regarding the rule-breaking and antisocial tendencies of entrepreneurs indicate that risk-tolerance may mediate this relationship. Second, there is little discussion of human capital on the role of such antisocial/criminal behaviours. Furthermore, there is no discussion of so-called criminal capital, only that presented by Aidis and Van Praag (2007), which presents participation in illegal activities as an alternative form of human capital. Criminal capital may be important in the consideration of rule-breaking in entrepreneurs, as entrepreneurship may represent a quasi-rule-breaking activity, which entails some element of non-conformity to societal norms. Thus, those who are less likely to accumulate human capital may be driven to labour market activities that do not hold human capital as a barrier to entry, such as entrepreneurship. Yet, at the same time, the lack of human

capital may lead to an acquisition to criminal capital, in those predisposed to high risk-tolerance and presenting present-oriented behaviours, such as those with ADHD; this has not yet been investigated in the literature.

Whilst poor education can lead to lower human capital accumulation and a potential drive to labour market outcomes that do not impose this as a barrier, lower human capital is more likely to lead to unemployment, which is thus discussed in the next section.

3.3.2 Unemployment and ADHD

There are a number of studies that find a relationship between high unemployment and ADHD (Fletcher, 2014; Stein, 2008; Zwaan et al., 2012). The recent paper of Cairó and Cajner (2018) expounds this difficulty well. Through the analysis of job retention rates, the central question of the authors' work is why there are different job retention rates amongst the different education groups; i.e., why do those with low education lose their job more quickly than their high education counterparts? As such, as low education individuals may have the same unemployment outflow rate (job finding rate) as high education individuals, the number of jobs held may actually be higher in the low education group. In fact, Barkley et al. (2006) and Fletcher (2014) found similar in ADHD individuals, in that the ADHD group was more likely to have held more jobs, but this did not result in higher pay[51]. Cairó and Cajner (2018) posit that the underlying premise is that high education may receive more job-specific training. This follows the line of argument by Becker (1962), in that job-specific training would disincentivise separation between employer and employee. In contrast, low education employees may receive no training as the job is likely to be low-skilled and one that can be undertaken by a greater number of people with little training for the job.

A complimentary explanation to the above is that ADHD individuals are less likely to

[51]The reader will note that there was an earlier discussion of the lack of incorporation in existing studies of labour market experience in the calculation on the effects of ADHD on earnings. The same holds true, as neither Fletcher (2014) nor Barkley et al. (2006) incorporate labour market experience into their calculations.

enrol into higher education (college/university) and thus have more time to gain work experience. This line of argument, however, is refuted by Barkley et al. (2006). The authors find that the ADHD group were more likely to be fired due to the severity of their symptoms, accounting for 20% of the variance. Thus, the effects of ADHD on unemployment may be driven by more than simply low education, it may be a lack of ability to 'fit' into a workplace.

An interesting aspect of the relationship between ADHD and unemployment is understanding how high unemployment and frequent job switching would affect ADHD individuals later in life. Lensing et al. (2015) find that older adults with ADHD have poorer health, which is related to their unemployment. In Lensing et al. (2015) the participants were diagnosed later in life, making it challenging to understand how the effects could be mitigated by earlier diagnoses.

3.4 Hypotheses Development

In the sections above a number of aspects related to ADHD have been discussed, namely, education and labour market outcomes in ADHD. In the section below, the review highlights where the gaps in understanding exist and how the review aims to address these.

Individuals with ADHD perform poorly in school environments, achieving lower grades, having higher rates of expulsion and more grade repetition[52]. This is likely because individuals with ADHD find the classroom environment difficult, with constant attention and staying seated proving difficult. A further explanatory factor to this is the temporal discounting and preference for immediate reward (Scheres et al., 2010). Consider in temporal discounting and decision making studies, the individual of the ADHD type is drawn to the perceived high reward. However, in more macro (real world) decisions the human capital plays a role, altering environments in which risk can be positively harnessed.

The importance of developing human capital for labour market success was discussed above. The first hypothesis aims to establish the baseline level of human capital development:

Hypothesis 1A: ADHD-like symptoms in childhood negatively influence educational attainment in later life.

In the review above it was noted that few studies have attempted to understand the effect of parent's socio-economic status on the ADHD child's educational attainment. There has been a further lack of research in understanding the effects of parent's socio-economic status on children with high ADHD-like symptoms; not ADHD as a clinical diagnosis[53]. Such an approach may be important as there may be a bias towards diagnosis in lower

[52](Arnold et al., 2015; Fletcher, 2014; Kent et al., 2010; Loe et al., 2007; Polderman et al., 2010)

[53]A notable exception of this was Currie and Stabile (2006), which found little effect of parent's high income on educational attainment in ADHD. However, this study focusses on a sample from the USA and country differences in the distribution of ADHD (see earlier sections defining ADHD) may siginificantly affect results.

socio-economic groups (Russell et al., 2014). Thus, measuring ADHD symptoms across a sample may overcome this diagnosis bias and allow for the effect of socio-economic status on education in ADHD behaviours to be understood. Heckmann and Mosso (2014) posit that parents with more financial resources would not necessarily endow more human capital onto the child; yet, such a position may facilitate good quality parenting. Thus, parents from higher socio-economic backgrounds may more readily be able to support children with high ADHD-like symptoms than those parents from lower socio-economic backgrounds. This leads to hypothesis 1B:

Hypothesis 1B: Parents from a higher socio-economic background increase the educational attainment of children with high ADHD-like symptoms

The review of literature above found that whilst studies have investigated and reported on lower earnings in ADHD (Vergunst et al., 2019; Fletcher, 2014), these studies focussed on yearly earnings and failed to include the effects of full-time work experience on pay, which is considered to be critical in labour economics in determining pay (Joshi et al., 2007). Further, these studies have also not included the socio-economic background of the parents. This leads to the following two interrelated hypotheses that account for both full-time experience and family socioeconomic background:

Hypothesis 2A: ADHD-like symptoms in childhood depress log hourly earnings in those in full-time employment, after accounting for full-time work experience.

Hypothesis 2B: Children with high ADHD-like symptoms in childhood with similar educational attainment from higher socio-economic backgrounds earn more than their counterparts from lower socio-economic backgrounds[54].

Given the above discussion of hypotheses one and two, it follows that if education is poor, pay is low and the individual possesses an increased risk-tolerance, the ADHD type

[54]Earnings refer to log hourly earnings.

may be driven to entrepreneurship for the potential of increased pay. Loughran et al. (2013) proposed that individuals who are present-oriented may be more likely to acquire criminal capital and seek immediate reward. The review found that individuals with ADHD are known to be present-oriented and prefer immediate rewards. Thus, they may be drawn to both entrepreneurship and criminal activities and this may explain the so-called 'dark-side' of entrepreneurship (Zhang and Arvey, 2009). This leads to hypothesis 3:

Hypothesis 3A: ADHD-like symptoms in childhood increase selection into entrepreneurship but also lead to increased substance abuse.

Whilst poor education and low pay may facilitate entrepreneurship,the literature suggests that unemployment is likely to be greater in individuals with ADHD (Fletcher, 2014; Stein, 2008; Zwaan et al., 2012). However, the studies to date have focussed on unemployment in reference to the alternative being full-time employment if the individual cannot 'fit' into the workplace (Barkley et al., 2006). It is possible that the alternative may be business ownership and this has not been investigated to date. This leads to the following hypothesis.

Hypothesis 3B: ADHD-like symptoms in childhood increase selection into entrepreneurship, but also increase the probability of unemployment.

Individuals with ADHD are known to have higher rates of criminal incarceration (Young et al., 2011) and substance abuse (Collins et al., 2006). This is likely again due to the utility provided from illegitimate activities being greater than legitimate activities. Thus, the final hypothesis concerns the increased risk-tolerance of ADHD which may present in greater arrest records.

Hypothesis 4A: ADHD-like symptoms in childhood increases probability of arrest.

3.5 Research Design

3.5.1 Data Sample

For the analysis in this chapter, I follow that outlined in chapter 2 (2.6 - Research Design). It differs only in the model variables and model estimations, which have been described below.

3.6 Model Variables

ADHD-Like symptoms. To identify the ADHD-like symptoms of the research participants in the sample, I run a confirmatory factor analysis to approximate the ADHD-like symptoms, as rated by teachers at the age of 10 years old and described above. These variables originate in the Childhood Behaviour Scale from the 1980 sweep (age 10) and includes elements from the Conners' Hyperactivity Scale and Rutter Behaviour Scale. I ran a confirmatory factor analysis to approximate ADHD-like symptoms rated by teachers when the research participant was 10 years old. I load onto two components, inattention symptoms (5 variables) and hyperactivity/impulsivity symptoms (4 variables). The model indicates strong fit, meeting the guidelines set by Hooper, Coughlan & Mullen (2008) and Kline (2011) .

Employment: The BCS contains wide range of data concerning the research participants' employment and economic activity. In this analysis employment information is taken from age 30.

Education: There are three variables used to represent the CM's educational attainment. The first is level of whether or not the CM has a bachelors degree or higher; this information is taken from the data at age 34. The second proxy used for educational attainment is the age the CM left education; this is taken from age 30. The final education variable is the highest educational qualification the CM has achieved, parsed into six levels: 0 is no education; 1 is certificate of secondary education (CSE); 2 is GCSE or equivalent; 3 is A-Level or equivalent; 4 is degree or equivalent; 5 is higher degree.

Rule-breaking behaviours: Rule-breaking behaviours are defined according to Zhang and Arvey (2009) and Young et al. (2011); viz., cocaine usage and incarceration (arrests). Data for this is taken from age 30, in which the CM provides information on having ever been arrested and on usage of cocaine.

Family Socio-economic Status: There are two proxies used to estimate the CM's family's socio-economic status. First, I estimate this using housing tenure; i.e., owned outright; being bought (mortgaged); council rented; privately rented (furnished and unfurnished); tied to occupation. This information is taken from age five. The second proxy for family socio-economic status is combined income of both parents, which is an ordinal variable ranging from 1 (£50 per week) to 11 (£500 per week). This information is taken from the age 16 data (1986). After accounting for inflation, the upper bound is almost £1500 per week in 2018.

Control Variables: There are factors that can influence educational attainment, rule-breaking behaviours and labour market success. For instance, educational attainment can be influenced by family socio-economic background and gender (Sewell and Shah, 1967; Dias et al., 2018); rule breaking-behaviour can be affected by gender (Zhang et al., 2009); and labour market success can be affected by education, work-experience, family socio-economic background and gender (Dias et al., 2018). In the model estimations, I control for education, father's education and socio-economic background in the regression models. Gender is controlled for in the regression models and also by sub-setting and analysing the data.

3.7 Main Model Estimation

The first hypothesis states that ADHD-like symptoms in childhood negatively effect educational attainment. To estimate this I run a logistic regression, in which the dependent variable is the age the CM left education (π), represented as: a binary between leaving before 18 (0) or leaving at or after (18) (1); whether the CM has no degree (0) or has

at least a bachelor's degree (1). The independent variables include the age the father left education (ω) and the ADHD-like symptoms (θ).

$$\pi = \alpha + \beta_1\omega + \beta_2\theta + \epsilon \tag{16}$$

Hypothesis 1B states that the parents' socio-economic background would increase the educational attainment of children with higher ADHD like symptoms in childhood. To estimate this I run a logistic regression, the dependent education variable is whether or not the CM has no degree (0) or has at least a bachelor's degree (1) (π). Socio-economic background is taken as housing tenure of the parents at age five and I create multiple dummy variables to represent the various degrees of tenure (γ). I include an interaction term between housing tenure and ADHD symptoms (θ).

$$\pi = \alpha + \beta_1\gamma + \beta_2\theta + (\beta_1\gamma * \beta_2\theta) + \epsilon \tag{17}$$

Hypothesis 2A asserts that ADHD-like symptoms in childhood depress log hourly earnings in full-time employees. In order to assess this I run a multi-linear regression, in which the dependent variable is the log-hourly pay from age 34 (λ). Independent variables include the ADHD symptoms (θ), level of education (π)[55] and total full-time experience (τ). Hypothesis 2B stated that the family socio-economic status would increase the earnings of children with high ADHD symptoms, this is presented in the same table and the regression equation with the addition of (ω) and is presented in equation .

$$\lambda = \alpha + \beta_1\theta + \beta_2\pi + \beta_3\omega + \beta_4\tau + \epsilon \tag{18}$$

$$\lambda = \alpha + \beta_1\theta + \beta_2\pi + \beta_3\omega + \beta_4\tau + \epsilon \tag{19}$$

Hypothesis 3A denotes that entrepreneurs with ADHD-like behaviours will exhibit more maladaptive behaviours than full-time employment. To test this hypothesis, I estimate the

[55]0 is no education; 1 is certificate of secondary education (CSE); 2 is GCSE or equivalent; 3 is A-Level or equivalent; 4 is degree or equivalent; 5 is higher degree.

effect of ADHD symptoms as a moderator of maladaptive behaviours in entrepreneurs, measured effectively as an interaction term, as shown in equation 3:

$$\gamma = \alpha + \beta_1\theta + \beta_2\lambda + (\beta_1\theta * \beta_2\lambda) + \epsilon \tag{20}$$

Here, the dependent variable is a binary dummy variable whether the individual has ever taken cocaine before the age of 30 or been arrested (π). The independent variables include the employment status (small business owner or full-time employed) (θ), the ADHD symptoms in childhood (λ) and the interaction term between them.

Hypothesis 3B extends hypothesis 3A in extending employment outcomes to include unemployment. In order to estimate I run a multi-nomial logistic regression, in which full-time employment is taken as the reference outcome (0), unemployment is the first level and business ownership is the second level (γ). Independent variables include ADHD symptoms (θ) and the age of leaving education (π).

$$\gamma = \alpha + \beta_1\theta + \beta_2\pi\epsilon \tag{21}$$

Finally, hypothesis 4A states that ADHD-like symptoms in childhood increase the probability of arrest. In order to test this I run a logistic regression, in which the dependent variable is whether or not the CM has ever been arrested (τ). Independent variables include the ADHD-rating from childhood (θ) and the CM's education (π).

$$\tau = \alpha + \beta_1\theta + \beta_2\pi + \epsilon \tag{22}$$

3.8 Results and Discussion

Table 6: Hypothesis 1A

	Dependent variable: No Degree (0); Bachelor's Degree or Higher (1)			
	(1) Male - Inattention	(2) Male - Hyperactivity	(3) Female - Inattention	(4) Female - Hyperactivity
Constant	6.681***	6.593***	5.117***	5.280***
	(0.788)	(0.777)	(0.714)	(0.710)
Father's Education	−0.205***	−0.216***	−0.162***	−0.179***
	(0.023)	(0.022)	(0.021)	(0.021)
	OR: 0.815	OR: 0.806	OR: 0.850	OR: 0.836
Hyperactivity/Impulsivity Rating		−0.008***		−0.009***
		(0.002)		(0.002)
		OR: 0.992		OR: 0.991
Inattention Rating	−0.011***		−0.013***	
	(0.001)		(0.001)	
	OR: 0.989		OR: 0.987	
Observations	1,494	1,494	1,933	1,933
Pseudo R^2	0.169	0.124	0.137	0.089

Note: *p<0.1; **p<0.05; ***p<0.01
Father's age of leaving education is inversed.

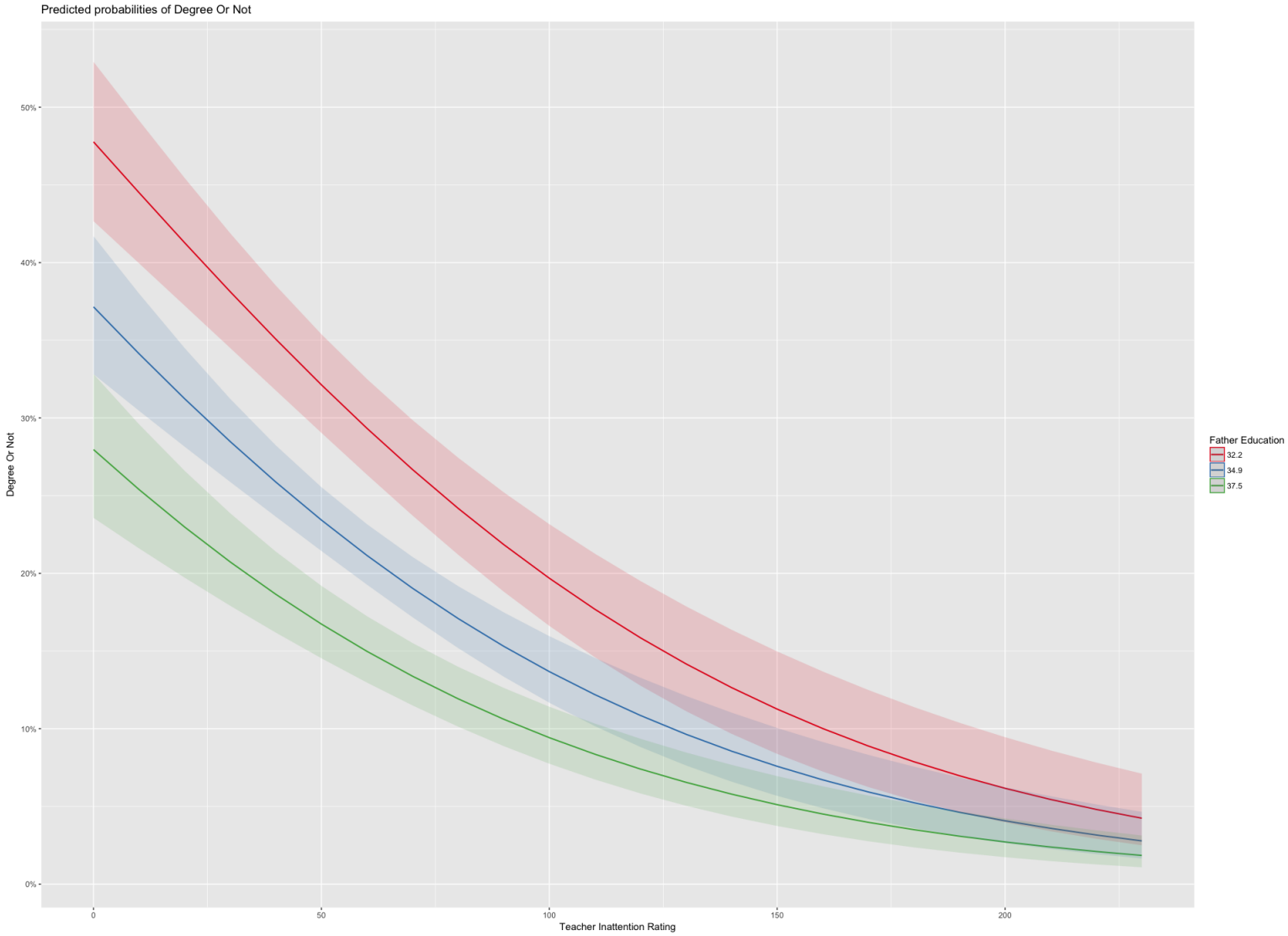

Figure 2: Hypothesis 1A - Predicted Probabilities for Females

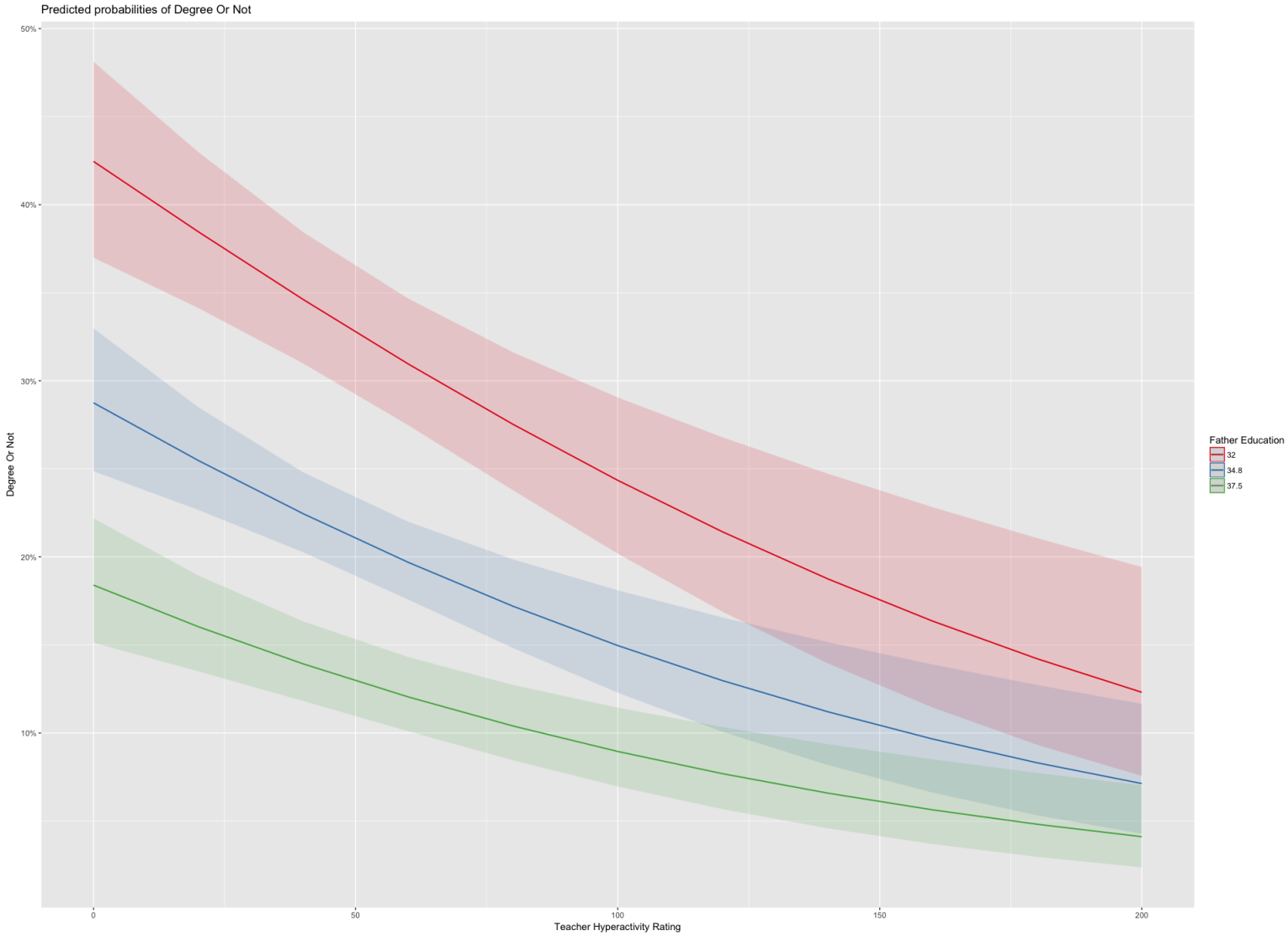

Figure 3: Hypothesis 1A - Predicted Probabilities for Males

3.8.1 Hypothesis 1A

Results for hypothesis 1A can be found in table 6 arranged into four models; by gender and ADHD-symptom type. Overall the results from table 6 as they relate to hypothesis 1A are consistent with prior research on the topic of educational attainment in ADHD (Arnold et al., 2015)[56]. Both inattention and hyperactivity/impulsivity have an overwhelmingly negative effect on the education proxies. For instance, in table 6, at the median values for father's age of leaving education (15 years old) and inattention rating (77), the CM has an 18% probability of obtaining a degree [57]. At 40% above the median inattention rating this drops by almost 5% to 13.2%. A more stark difference is found with movement of father's education. If the father leaves education at 21 years old (possibly with a university degree) and inattention is held at the median, the CM has a 42% probability of obtaining a degree. Yet, at this same age of the father leaving education, the CM with an inattention rating 40% above the median has a 34% probability of obtaining a degree, which is a 3.2% increase over the same inattention rating at the father's age of leaving education at 15 years old. As can be seen in the discussion above and the marginal effects plot (figures 2 and 3), the effect of ADHD increases alongside the father's age of leaving education. This suggests that the father's education may move in tandem with the ADHD symptoms of the CM [58]. It is possible that the father's education represents the human capital the father has, which allows for greater effects on the CM's human capital.

What is unique about the results presented here as compared to prior research on the topic can be understood two-fold. First, as mentioned in the methodology, the ratings for ADHD are approximations of ADHD. This is beneficial, as it allows one to capture the potential effects of ADHD across a continuum. Second, the models presented in table six include the CM's father's age of leaving education. Insofar as this study is aware, this is

[56]This further highlights the validity of the approximation of ADHD-like symptoms in the methodology as a marker for ADHD.

[57]As taken from equation 12, the probability is calculated thus:

$$\frac{e^{\alpha+\beta_1\omega+\beta_2\theta}}{1+e^{\alpha+\beta_1\omega+\beta_2\theta}} \tag{23}$$

[58]There is no moderation effect in models presented in table 6.

the first study to account for the effect of father's education on ADHD-like symptoms in childhood [59].

The CM's father's age of leaving education has a strong negative effect on the CM's educational attainment across males and females. One can postulate on a number of factors that the father's education represents. For instance, it may reflect the father's socio-economic status, as educational attainment is related to career success and earnings (Heckman and Mosso, 2014). The father's educational attainment may, at the same time, represent traits such as intelligence (Deary et al., 2007), which may be transmitted to the CM (Plomin and Deary, 2015). One can further postulate that the father's age of leaving education represent their ADHD-like symptoms. It is probable to contend this because ADHD is partially heritable (Thapar et al., 2005) and the father may transmit these behaviours to the CM. Alternatively, or in addition to the above, the father's age of leaving education may represent their familial socio-economic background; i.e., the CM's grandfather is poorly educated and this has a chain effect on the CM (social mobility). The findings for hypothesis 1A are consistent with Bakermans-Kranenburg and van Ijzendoorn (2011) and Chi et al. (2016), in that the environment of the child can affect their educational attainment more so in those with higher ADHD-like symptoms, than in those without. However, the effect is negative; i.e., the child with lower ADHD has an increasing probability of attaining higher education that the child with higher ADHD symptoms.

[59]It is important to highlight that the father's age of leaving education is inversed in table 6.

Table 7: Hypothesis 1B

	Dependent variable: No Degree (0); Bachelor's Degree or Higher (1)			
	(1) Females-Hyperactivity	(2) Males-Hyperactivity	(3) Females-Inattention	(4) Males-Inattention
Constant	-2.300^{***}	-2.308^{***}	-1.812^{***}	-1.704^{***}
	(0.166)	(0.182)	(0.178)	(0.197)
Family Income	0.242^{***}	0.231^{***}	0.225^{***}	0.218^{***}
	(0.025)	(0.025)	(0.025)	(0.026)
	OR: 1.27	OR: 1.26	OR: 1.25	1.24
Inattention Rating			-0.013^{***}	-0.011^{***}
			(0.002)	(0.001)
			OR: 0.99	OR: 0.99
Hyperactivity/Impulsivity Rating	-0.010^{***}	-0.007^{***}		
	(0.002)	(0.002)		
	OR: 0.99	OR: 0.99		
Observations	1,858	1,565	1,858	1,565
Pseudo R^2	0.114	0.108	0.152	0.155
Note:				*p<0.1; **p<0.05; ***p<0.01

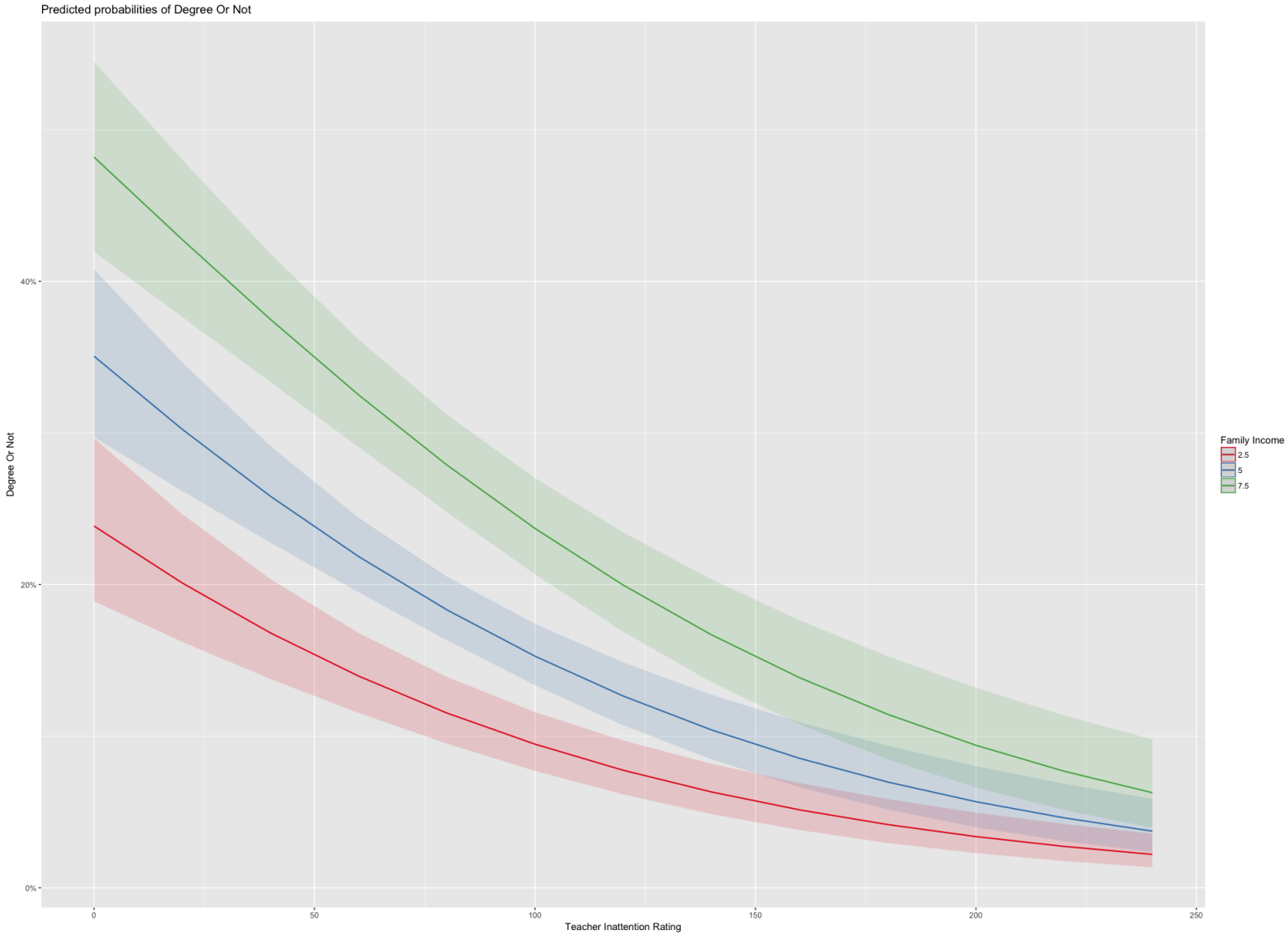

Figure 4: Hypothesis 1B - Males Only

3.8.2 Hypothesis 1B

Hypothesis 1B develops on the findings from hypothesis 1A, namely that the father's education may represent their human capital and their socio-economic background and this interacts with the child's ADHD-like symptoms in obtaining a higher educational attainment. Results for hypothesis 1B are presented in table 7. Family income, from the age 16 data set, is taken as representing the parent's socio-economic background.

Family income is significant across genders and ADHD-symptom domain in predicting the obtainment of a degree. At the medians for family income and inattention ratings, the probability of obtaining a degree for males is 15.7%[60]. Yet, a CM with an inattention rating 40% above the median has an 11.7% probability of obtaining a degree. At the highest family income level, this probability increases to 46%[61]. Yet, a male CM with inattention ratings 40% above the median has a 38% probability of obtaining a degree. This is similar to the results presented and discussed in hypothesis 1A, in that family socioeconomic background has a stronger positive effect on educational attainment in those with low ADHD-like symptoms, than in those with higher ADHD-like symptoms.

The results for hypothesis 1B suggest that unsurprisingly socio-economic background has a large effect on the attainment of a degree. The study of Currie and Stabile (2006) found little effect of family income on academic outcomes. Here, children from higher income families (derived either directly from family income or father's education in table 6) have an increased probability of greater educational outcomes.

There is a dynamic interaction with ADHD-like symptoms and education, in that as socio-economic background increases, there is an increasing negative effect of ADHD on the education outcome. That is, at the median levels of the socio-economic proxy, the effect of ADHD-like symptoms is smaller than at the higher levels of the socio-economic proxy, as

[60] Family income has a value of 4, representing between 7800-10,399 per annum in 1986. This is equivalent to 22,452-29,933 in 2018.

[61] The highest income value is 11, which represents the family income above 26,000 per annum, which is equivalent to 74,840 in 2018.

visible in figure 4. The literature has to date not uncovered this issue and beyond conjecture and further investigation it is not clear as to why or how this effect is occurring.

Table 8: Hypothesis 2A and Hypothesis 2B

	Dependent variable: Log Hourly Pay at Age 34			
	Females	Males	Females	Males
	(1)	(2)	(3)	(4)
Constant	1.821***	2.037***	1.920***	2.105***
	(0.086)	(0.076)	(0.073)	(0.052)
Family Income	0.032**	0.038***		
	(0.012)	(0.010)		
Education	0.090***	0.100***	0.095***	0.124***
	(0.029)	(0.019)	(0.021)	(0.013)
Full-Time Experience	0.001***	0.001	0.001***	0.001***
	(0.001)	(0.0004)	(0.0004)	(0.0003)
Inattention Rating	−0.002***	−0.001***	−0.002***	−0.001***
	(0.001)	(0.0004)	(0.0006)	(0.0003)
Observations	310	444	572	815
R^2	0.151	0.171	0.085	0.140
F Statistic	13.614*** (df = 4; 305)	22.703*** (df = 4; 439)	17.590*** (df = 3; 568)	43.914*** (df = 3; 811)

Note: *p<0.1; **p<0.05; ***p<0.01

Hourly earnings below £4 were removed for males

All models have robust standard errors.

Inattention rating is zero-centred to allow for easier interpretation of the constant.

3.8.3 Hypothesis 2A & 2B

Results for hypothesis 2A and 2B can be found in table 8. In table 8, models one and two are split by gender and include household annual income as a control variable. Models three and four are split by gender, but do not include the control variable of household income.

Overall the results suggest that inattention ratings in childhood have a strong negative effect on log hourly pay pay at age 34 in table 8. This is consistent across genders and when controlling for family income (taken as representing CM's father's socio-economic background). With regard to hypothesis 2B, the effects of socio-economic background on annual pay in those with high ADHD-like symptoms in childhood, this hypothesis is not supported by the results presented in table 8. This is because no moderating effect of family income on ADHD and subsequently annual pay is found. There remains an effect of both income and the inattention rating. For instance, the difference in log hourly pay as inattention increases by 30% (with all other variables at the median levels in the model) is approximately a 21% decrease. Raising the family income two levels from the median of 200-249 per week to 300-349 per week, and adjusting the inattention again by 30% (whilst holding all other variables at the median) also results in a 21% decrease, suggesting that family socioeconomic background does not dynamically interact with ADHD symptoms; i.e., the effect of ADHD symptoms on income are not strictly increasing or decreasing greatly as family income increases. This suggests that the effect of ADHD on income is consistent across socio-economic backgrounds.

Perhaps unsurprisingly, education has a large effect on annual pay across all models. Furthermore, family income is significant, in that a clear relationship exists; the higher is family income, the higher is the CM's income. One can assert that this is a case of social mobility, or lack thereof [62].

[62] Multi-collinearity is checked and no issues were found.

Results from table 8 provide support for hypothesis 2A. It falls short perhaps in the fact that hyperactivity/impulsivity is found to be insignificant (see appendix). It is difficult to say why this is the case, given the fact that little research on pay and ADHD exists. One immediate contention is that hyperactivity/impulsivity simply does not negatively influence pay in the labour market. It is possible that such behaviours may be beneficial, as they may increase other attributes, such as networking ability. At the very least, the results indicate that the behaviours are not in a hindrance in the dataset.

Perhaps surprisingly, full-time experience is not a significant predictor of log hourly pay when considering family income in males. It remains unclear as to why this is the case and is certainly worthy of further investigation. One can postulate that family income, representing the socio-economic background of the cohort member, provides early advantages in life that are more significant than later experiences in the workplace[63].

In regard to the literature, the closest study to the current approach is that of Vergunst et al. (2019). However, as discussed in the literaure review previously, previous studies such as Biederman and Faraone (2006), Fletcher (2014) and Vergunst et al. (2019) failed to account for the effect of labour market experience into earnings. This study is potentially the first to show that inattention symptoms rated by teachers in childhood have a negative effect on log-hourly earnings, even after accounting for education, full-time work experience and socio-economic background in childhood.

Barkley et al. (2006) posited that the effects of ADHD on income were similar across education levels. This is confirmed in this study; at the medians for inattention ratings, full-time work experience and education (GCSE), an individual has an hourly wage of 10.84. At 30% above the median inattention rating this drops 2.5% to £10.56. If the individual has a higher degree and all else is held at the median, the individuals earns 15.72 per hour. Increasing the inattention by 30% again reduced this to 15.32, which is approximately the

[63]The interaction between independent variables was tested and none were found; future research may consider industry sectors in this analysis to better understand this anomalous result.

same 2.5% reduction as at the GCSE education level. The result suggest that the disparity in pay in ADHD may be further accounted for by other factors beyond education[64].

Overall, it is likely that the low pay of ADHD relates to the type of work engaged in, as noted by Kuriyan et al. (2012)[65].A discussion of the type of employment leads us naturally to hypothesis 3A.

[64]The researcher is further investigating this phenomenon.

[65]One may naturally question as to why employment type analysis was not conducted in this place. The research is interested in understanding raw income data, rather than work engaged in and considers basic human capital effects, as in Joshi et al. (2007).

Table 9: Hypothesis 3A

	Dependent variable (below)	
	Cocaine Before 30 (1) or Not (0)	Arrested Before 30 (1) or Not (0)
	(1)	(2)
Constant	-1.834^{***}	-1.407^{***}
	(0.082)	(0.071)
SBO (1) or FTE (0)	0.594^{***}	0.772^{***}
	(0.186)	(0.163)
	OR: 1.81	OR: 2.16
Hyperactivity/Impulsivity Rating	-0.405	0.506^{***}
	(0.261)	(0.176)
	OR: 0.67	OR: 1.66
Employment Type*Hyp/Imp Rating	1.119^{**}	-0.521
	(0.468)	(0.424)
	OR: 3.06	OR: 0.59
Observations	1,683	1,683
Pseudo R^2	0.025	0.025

Note: *p<0.1; **p<0.05; ***p<0.01
SBO refers to small business owner; FTE refers to full-time employees.
Employment Type refers to the aforementioned

Table 10: Hypothesis 3B

	Dependent variable: Own Business (1) or Full Time Employed (0)	
	Inattention Rating	Hyperactivity/Impulsivity Rating
	(1)	(2)
Constant	−3.036***	−2.893***
	(0.141)	(0.131)
Education	−0.546***	−0.553***
	(0.190)	(0.171)
	OR: 0.58	OR: 0.58
Gender	0.417***	0.475***
	(0.134)	(0.133)
	OR: 1.52	OR: 1.61
Binary Inattention Rating	0.127	
	(0.146)	
	OR: 1.14	
Binary Hyp/Imp Rating		−0.254*
		(0.144)
		OR: 0.78
Binary Inattention Rating*Education	0.652**	
	(0.265)	
	OR: 1.92	
Binary Hyp/Imp Rating*Education		0.623**
		(0.268)
		OR: 1.87
Observations	5,194	5,194
Pseudo R^2	0.018	0.015
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 11: Hypothesis 3B

	Dependent variable: Employment Status			
	FTE (1) or Unemployed (0)		Own Business (1) or Unemployed (0)	
	(1)	(2)	(3)	(4)
Constant	4.155***	3.614***	0.952***	1.316***
	(0.218)	(0.176)	(0.218)	(0.268)
Hyp/Imp * Degree Or Not		0.010	0.015*	
		(0.006)	(0.008)	
		OR: 1.01	OR: 1.02	
Inattention * Degree Or Not	0.006			0.011**
	(0.004)			(0.005)
	OR: 1.006			OR: 1.01
Gender	0.168	0.008	0.187	0.266
	(0.174)	(0.171)	(0.209)	(0.213)
	OR: 1.18	OR: 1.008	OR: 1.21	OR: 1.30
Degree Or Not	−0.567	−0.293	−0.852**	−1.187**
	(0.392)	(0.330)	(0.426)	(0.487)
	OR: 0.57	OR: 0.75	OR: 0.43	OR: 0.31
Hyp/Impulsivity		−0.007***	−0.008***	
		(0.002)	(0.003)	
		OR: 0.99	OR: 0.99	
Inattention	−0.010***			−0.008***
	(0.002)			(0.002)
	OR: 0.99			OR: 0.99
Observations	4,234	4,234	448	448
Pseudo R^2	0.035	0.012	0.034	0.050

Note: *p<0.1; **p<0.05; ***p<0.01

Table 12: Hypothesis 3B

	Dependent variable: Occupational Choice
	Multinomial With Full-Time Employment as Reference
1:(Constant - Own Business)	-2.503^{***}
	(0.644)
1:Teacher Inattention Rating	0.003^{**}
	(0.001)
	OR: 1.003
1:Age of Leaving Education	-0.022
	(0.034)
	OR: 0.98
2:(Constant - Unemployed)	-1.659^{*}
	(0.923)
2:Teacher Inattention Rating	0.007^{***}
	(0.002)
	OR: 1.007
2:Age of Leaving Education	-0.117^{**}
	(0.051)
	OR: 0.89
Observations	3,342
Pseudo R^2	0.014
Note:	*p<0.1; **p<0.05; ***p<0.01

3.8.4 Hypothesis 3A & 3B

The underlying premise for hypothesis 3A is that self employment (or entrepreneurship) may seem more attractive to high ADHD individuals, as their education is lower (H1), pay is lower (H2) and they have increased risk-tolerance and novelty-seeking (Williams and Taylor, 2005; chapter 1 of this thesis). Entrepreneurship may thus seem attractive, as pay is uncertain, it could be extremely high; however, in most cases, the return is actually lower than paid employment (Åstbero et al., 2014; Manso, 2016), making entrepreneurship an irrational choice from a strictly neoclassical expected utility theory perspective (Allais and Hagen, 1979). However, this does not stop individuals from venturing into this activity, possibly due to the potential for high rewards. Individuals with ADHD are driven to high rewards (Scheres et al., 2010). Thus, entrepreneurship may be well-suited to the risk-tolerant individual, according to Khilstrom and Laffont (1987). Yet, the equation provided in chapter 1 indicates that utility for the ADHD-type is increased over outcome variance. That is, the search for risk in ADHD does not stop when the individual becomes an entrepreneur and this in combination with a lack of human capital may provide further insight into the so-called 'dark-side' of entrepreneurship.

Results for hypothesis 3A can be found in table 9. Overall, the results indicate support for hypothesis 3A, with the interaction of employment type and the binary variable for hyperactivity/impulsivity predicting cocaine usage before age 30. That is, small business owners with greater hyperactivity ratings have an increased probability of cocaine usage. The result adds further complexity to the discussion of the 'dark-side' of entrepreneurship. ADHD-like symptoms, specifically hyperactivity/impulsivity, may contribute to rule-breaking behaviours in entrepreneurs. This possibly works through the increased risk-taking, stemming from the need to raise baseline arousal in individuals with higher ADHD-like symptoms. With regard to the effect of human capital and the so-called 'dark-side' of entrepreneurship, education has no effect on the relationship and is thus not displayed. That is, the relationship may be driven by ADHD-like symptoms alone, and not the accumulation of human capital. It is possible that criminal capital accumulation takes

place of the formal human capital accumulation, as posited by Loughran et al. (2013) and ADHD is important in this process.

Interestingly, the results regarding arrests, taken as representing severe rule-breaking, indicate that entrepreneurship has an effect on arrests, but there is no interaction with ADHD-like symptoms. The results from model two of table 9 contradict prior literature on the topic of the 'dark-side' of entrepreneurship, which stated that severe rule-breaking would be unrelated to entrepreneurship (Obschonka et al., 2013; Zhang and Arvery, 2009). The reasons for this remain unclear, particular in regard to a lack of interaction with ADHD-like symptoms. Zhang and Arvey (2009) propose that severe rule-breaking may impinge on education and future career prospects or on venture capitalists' funding decisions. It remains unclear as to why this relationship exists.

3.8.5 Hypothesis 3B

Hypothesis 3B concerned the unemployment and wider labour market effects of ADHD-like symptoms in childhood. Results for hypothesis 3B are presented in tables 10, 11 and 12. All employment information is taken from the age 30 dataset.

Beginning with table 10, the target variable is whether or not the CM is a business owner or is in full-time employment. Models 1 and 2 present interaction terms between ADHD-like symptoms in childhood and the education proxy. These interaction terms are significant, indicating that the inattention symptoms slightly above the median and leaving education at or after 18 have an increased probability of business ownership. Similarly, hyperactivity symptoms approximately 30% above the median have a positive interaction with the education proxy. In table 10, the gender is also significant, indicating that being male increases the probability of business ownership, however, it is difficult to interpret this in light of the interaction term presented in models 1 and 2 of table 10.

Table 11 presents four models, comparing employment outcomes between full-time employment and unemployment, and business ownership and unemployment. The results for

the first two models are insignificant, as the interaction terms, ADHD and education proxy (degree obtainment), are not significant. That is to say, having a degree has no effect on the outcomes with ADHD symptoms, it is not to say that ADHD does not have an effect on unemployment (see discussion below). Models three and four have significant interaction terms, though the interaction between hyperactivity/impulsivity symptoms in childhood and degree obtainment is only significant at the 90% confidence interval. In comparison, the inattention symptoms are significant above the 95% confidence interval. Thus, model four shows that inattention in combination with having a degree increases the probability of business ownership over unemployment.

Finally, for hypothesis 3B is the presentation of the multinomial logistic regression in males in table 12. The reference level here is full-time employment. Results are significant, but for the business ownership over full-time employment are not particularly large. For instance, at the median levels (not accounting for the insignificant education variable), the CM has a 9% probability of business ownership, however raising the inattention rating by 40% only increases this probability 1%. In contrast, the effect of ADHD in unemployment is much greater. At median values (age 16 for leaving education and 92 for inattention), the CM has a 21% probability of being unemployed. Increasing the inattention rating by 40% raises this probability to 27%.

Overall the results support both hypothesis 3A and 3B, but in the face of literature add more complexity to the relationship. Whilst studies have found that unemployment is greater in ADHD (Cairó and Cajner, 2018), here the study has demonstrated that business ownership is an option, but the risk-tolerance/novelty-seeking of ADHD can lead to an increase in the engagement of maladaptive behaviours, such as cocaine usage. As such, it is probable to contend that ADHD-like symptoms may contribute to the increase in the so-called criminal capital espoused by Mocan et al. (2005), though, not directly through experience in engaging in illegal activities but a potential avenue may be arising in engaging in cocaine usage and this may skew the perceptions of legality of other activities.

Results for hypothesis 3B suggest that education in combination with ADHD-like symptoms has a significant and strong effect on avoiding unemployment. This is found in tables 10, 11, and 12, which take various approaches to test the hypothesis. Whilst studies have found that unemployment is greater in ADHD (Cairó and Cajner, 2018) and educational attainment is lower in ADHD (Arnold et al., 2015), the interaction between education and ADHD-like symptoms on unemployment remains unclear. The results presented indicated that educational attainment can avoid unemployment in those with high ADHD-like symptoms. This likely will present an avenue for policymakers to decrease unemployment in a population with high unemployment.

Yet, the relationship between education and unemployment may be more complex, given the results from hypothesis 1B, in which parents' socio-economic background has a strong positive effect on educational attainment in those with high ADHD-like symptoms. As such, it may be the case that children from lower socio-economic backgrounds have a double negative effect, from being born into a lower socio-economic background, which increases probability of unemployment, and having high ADHD-like symptoms, which also increases the probability of unemployment.

Table 13: Hypothesis 4A

	Dependent variable: Arrested Before 30 (1) or Not (0)			
	(1) Males	(2) Females	(3) Males	(4) Females
Constant	-1.324***	-3.281***	-1.446***	-3.405***
	(0.075)	(0.135)	(0.095)	(0.164)
Degree (1) Or Not (0)	-0.919***	-0.946***	-0.831***	-0.841***
	(0.137)	(0.304)	(0.139)	(0.308)
	OR: 0.40	OR: 0.39	OR: 0.44	OR: 0.43
Hyperactivity/Impulsivity Rating	0.007***	0.010***		
	(0.001)	(0.002)		
	OR: 1.008	OR: 1.01		
Inattention Rating			0.006***	0.007***
			(0.001)	(0.002)
			OR: 1.006	OR: 1.007
Observations	2,983	3,375	2,983	3,375
Pseudo R^2	0.061	0.036	0.056	0.034
Note:				*p<0.1; **p<0.05; ***p<0.01

3.8.6 Hypothesis 4A

Results for hypothesis 4A are presented in table 13. Hypothesis 4A is split by gender and ADHD symptom type. Overall the results provide strong support for hypothesis 4A. The results are consistent across ADHD symptom type and gender. That is, both hyperactivity/impulsivity and inattention symptoms in childhood increase the probability of arrest before age 30. This probability is significantly greater in males. In males with no degree and median hyperactivity symptoms the probability of arrest before age 30 is 26%. In comparison, females with no degree and median hyperactivity symptoms have a 5% probability of arrest before age 30. The effect of obtaining a degree more than halves the probability of arrest to 13% in males and 2% in females. Increasing the hyperactivity symptoms by 50% in males with no degree raises the probability of arrests to 30% and 15% in those with degrees. The effect of hyperactivity symptoms is much smaller in females, with a 0.8% increase in those without degrees and 0.2% increase in those with degrees, respectively.

The fact that inattention is significant contrasts with the literature, in that Fletcher and Wolfe (2009) and Babinski (1999) stated that only hyperactivity/impulsivity was related to antisocial behaviours. This result is likely due to the fact the variable for ADHD used in this research is an approximation of and exists along a continuum, and not a discrete classification of ADHD and not ADHD as a diagnosis in itself. The results are similar to the study of Fletcher and Wolfe (2009), in that the effects of ADHD on antisocial behaviours (arrests) are independent of educational attainment. However, similar to the study of Fletcher and Wolfe (2009), controlling for education does decrease the probability by 16-17% in males. However, insofar as this study is aware, this is the first of its kind to show the effects of ADHD-like symptoms along a continuum on the probability of arrest.

3.9 Limitations

The research has some limitations that must be addressed and borne in mind when interpreting the results. Whilst the research results are consistent with and develop prior literature, the ADHD-like behaviours are approximations of the symptoms associated with the clinical condition of ADHD. This fact is by design of the research (i.e., ADHD-like symptoms in childhood are taken along a continuum). However, it would not be correct to claim that ADHD as a clinical condition is related to any of the results presented in this chapter.

3.10 Contributions

The research makes contributions in five regards. First the research is potentially the first to find a relationship between the various negative socio-economic outcomes and ADHD along a continuum. Prior research has found a relationship between the negative outcomes and diagnosed ADHD individuals. This research shows that sub-clinical ADHD may also be impacted by these negative outcomes. Second, the research shows that the so-called 'dark-side' of entrepreneurship may be mediated by the very factor increasing selection into entrepreneurship; viz., ADHD-like symptoms in childhood. This again is the first research of its kind and contributes to the literature. Thirdly, the research indicates that there may be more complexity to the 'dark-side' of entrepreneurship, in that severe rule-breaking may in fact be greater in entrepreneurs. The fourth contirbution concerns the interaction between the father's education and the CM's educational attainment, which is to the best of the researchers' knowledge the first of its kind. Finally, the research, again to the best of its knowledge, is the first to explicitly incorporate the effects of full-time experience and family socio-economic background on log-hourly earnings.

4 Discussion and Concluding Remarks

The purpose of this chapter is to draw to a close the three chapters discussed previously and summarise the findings of the thesis overall. The opening chapter, 'Evolutionary Basis of Economic Risk-Tolerance Through ADHD', reviewed approaches to risk in economics and laid the foundations for the following chapters to empirically investigate the propositions posed. In chapter 1, it was noted that risk in neoclassical economics enters exogenously and little attention is given to the cause of risk-tolerance. As such, the chapter explored various approaches to understand the causes of heterogeneity in human risk-tolerance. Human behaviour is invariably rooted in biology and this led to a review of a biological component known to be related to risk-tolerance, namely the behavioural disorder known as ADHD. ADHD presented an interesting case, due to the fact that from an evolutionary perspective the behaviour was beneficial, yet it is now classified and understood as a disorder. The evolutionary basis of ADHD led to a review of evolutionary economics and an integration of ADHD into this discussion to understand how and why it is that ADHD is seen as problematic in the contemporary economy. A key finding of this review was the need to understand the distinction between the proximate and ultimate cause of the behaviour; the former concerned the current effects of the behaviour, whilst the latter concerned the initial purpose for the behaviour. In ADHD, this was deemed to be the risk and novelty seeking provided, which assisted humans in moving to new lands. To understand this behaviour in an economic context, a different utility function for ADHD was proposed and an equation to predict outcomes in the modern economy (equation four) [66].

To this end, equation four in chapter one allowed for the development of chapters two and three, both empirical in nature. Chapter two investigated entrepreneurship as an economic activity that may be better suited to individuals with high ADHD symptoms due to their increased tolerance for risk.

[66]

$$E(u)_R = PU(R - H_c) + (1 - P)U(R) \tag{24}$$

Using data from the British Cohort Study the research found a positive relationship between ADHD-like symptoms in childhood and later entrepreneurial activity. The effect was most profound over a twelve year period, in which selection into entrepreneurship was greater in individuals with higher ADHD-symptoms. Yet, further analysis found the performance of businesses was affected by ADHD-like symptoms in childhood, suggesting that ADHD-like symptoms increase selection into entrepreneurship but may hinder business performance. The results in the context of chapter 1 support the position of Galor and Michalopoulos (2012), that ADHD behaviours can increase entrepreneurship. There is a slight contrast in that Galor and Michalopoulos' position holds that this occurs in immature economies, and the data here is revealed from the UK, a mature economy. However, in support of Galor and Michalopoulos, it could be that the effect of ADHD on entrepreneurship may be more pronounced in immature economies, certainly the effect is not as large in the results presented in chapter 3. Further, data on business performance highlight that the symptoms akin to ADHD are negatively impacting business performance. Thus, data from immature economies may be revealing. One would expect to find a stronger relationship in this regard.

Developing on work from chapter two, the purpose of chapter three, 'The Economics of Childhood Development - The Case of ADHD', was to understand the opposing concept of ADHD, negative economic effects of ADHD and how these can be understood. In order to understand and conceptualise the negative effects of ADHD, the research used the human capital theory. This allowed for the importance of environmental effects on ADHD to be better understood, and thus how the negative outcomes may be overcome.

Using data from the British Cohort Study (BCS), the results from chapter three support the position that individuals with higher ADHD-like symptoms in childhood are less suited to mature economies and thus present deleterious economic and societal participation. The results presented in chapter three are stronger than those presented in chapter two, suggesting that this is the more likely route for ADHD-individuals; this is particularly the case with findings from chapter 3 showing that ADHD-like symptoms increase the probability of un-

employment more than ADHD-like symptoms increase the probability of entrepreneurship. This arguably lends further support to the position of Galor and Michalopoulos (2012), in that the majority of individuals with risk-tolerance are poorly suited to mature economies.

The overarching finding from the chapter is the interaction between employment outcomes, socio-economic background and ADHD-like symptoms along a continuum in childhood. For instance, an increase in education increases the probability of avoiding unemployment in tandem with ADHD-like symptoms, suggesting that early human capital accumulation is particularly important in those with higher ADHD-like symptoms in childhood. Compounding this finding was the effect of family socioeconomic background on early human capital accumulation. The findings stress the need for early identification of high ADHD-like symptoms, not only ADHD as a clinical diagnosis, as the results show that the effects exists along a continuum.

4.1 Contributions

The research contributes to knowledge in multiple fields, given its interdisciplinary nature. Perhaps the overarching contribution is the blurring of lines between disciplines. The opening of chapter one began with Alfred Marshall's position on the importance of biology to economics. Chapter one made the case for the biological approach to economic phenomena and chapters two and three empirically tested this. There is a great need to understand that economic phenomena, particularly preferences, have their roots in biology. The results from this thesis are encouraging and insightful. Whilst it was possible to take an altogether different route to the issues at hand, but the approach taken, I hold, is the most accurate for the topic at hand.

Beyond the theoretical contributions of chapter one and novelty of the interdisciplinary approach, the empirical contributions include a further positive link between ADHD and entrepreneurship. In comparison to previous research on the topic, I use childhood ADHD-like behaviour. This is the first research of its kind to show that entrepreneurial activity can be predicted from age 10. Second, the research shows the dual effects of ADHD-

like behaviours with the same cohort. Whilst there can be positive effects, the effects are overwhelmingly negative and lend support to the unified growth theory. There is a delicate interplay between the family's socioeconomic background and the child's later socioeconomic success. Interestingly, this effect of family socioeconomic background is stronger in those with higher ADHD-like symptoms, suggesting that the behaviours are particularly susceptible to socioeconomic backgrounds.

4.2 Policy Recommendations

It is clear from this research that education can play a large role in the relationship between ADHD-symptoms and socioeconomic outcomes. This is supported by the results from hypothesis one of chapter three, in which education is negatively predicted by ADHD-like symptoms. An intervention in those with ADHD may reduce the probability of negative outcomes, as is indicated by hypothesis 3B (tables 11,12 and 13) of chapter three, in which higher education reduced the predictive effects of ADHD-like symptoms on unemployment towards business ownership. Thus, the overarching recommendation with regard to policymakers would be to identify the symptoms of ADHD at an early age and provide interventions to reduce the likelihood that children with ADHD are not educated to their potential.

A more novel recommendation is proposed through the results found in chapter two, in which the symptoms of ADHD, particularly inattention, have a positive relationship with selection into entrepreneurship. Yet, at the same time, performance is reduced by the symptoms of ADHD, leading to two suggestions along the same line of argument. That is, to increase entrepreneurship, policymakers may positively target and provide training for those with high ADHD-like symptoms in childhood. This approach would also ensure adequate training in business operation, which may increase the individual's businesses' performance.

4.3 Future Research

Future research may look at a similar subject matter but compare this to an immature economy in which human capital accumulation is less of a barrier to entry than in a mature economy. This would allow for a further hypothesis espoused by the unified growth theory to be tested, that in immature economies it is possible that the behaviours may be advantageous.

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6 Appendix

Table 14: Employment Data in BCS

Age	Total Obs	FT Employment	PT Employment	FT Self Employed	PT Self Employed	Own Business	Further Education	Unemployed	FT Employed Median Yearly Income Gross	FT Own Business Median Yearly Earnings (Gross)
26	9003	6035	693	550	120	N/A	307	395	£10,192	£13,000 (SE only)
29	11261	7014	1253	749	126	503	144	364	£16,440	£14,000 (P/(L))
34	9665	5555	1498	794	166	609	83	193	£24,000	£17,500 (P/(L)) £11,000 Earnings
38	8874	4859	1493	922	223	793	60	206	£25,200	N/A
42	9841	5245	1701	1112	296	1070	39	237	£30,000	£20,000 (Take home)

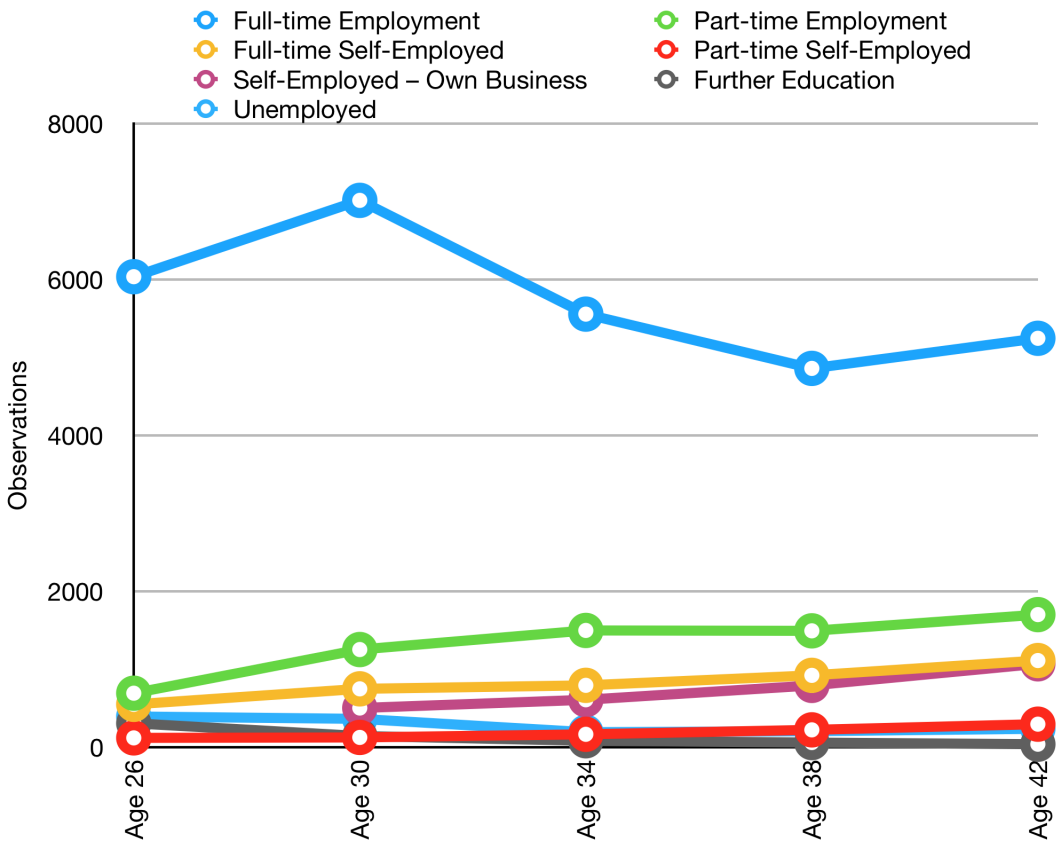

Figure 5: Employment Observations in BCS

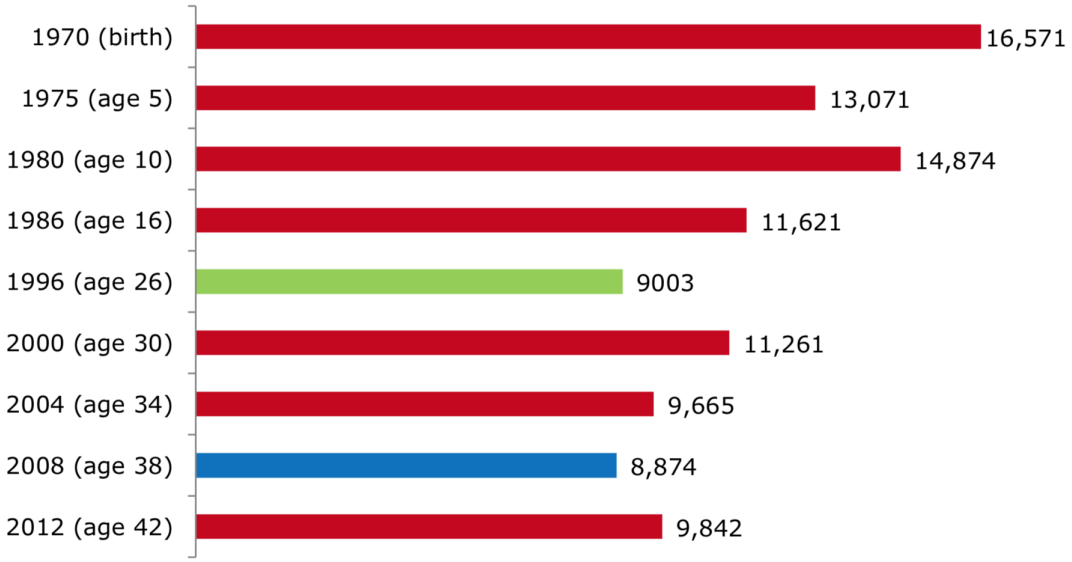

Figure 6: Response Drop-Off Rate in British Cohort Study - BCS7472 (Age 42), Technical Manual (Page 8)

Table 15: List of Variables Used in Chapters 2 & 3

Variable	**Range**	**Source**
Hyperactivity / Impulsivity	Continuous: 4- 188	Age 10 (Teacher rating)
Inattention	Continuous: 5-235	Age 10 (Teacher rating)
Employment status	Categorical: Full-time employed; Business Owner; Unemployed	Ages 26, 30, 34, 38, 42
Education	Categorical or Binary: Degree status (binary); Age of leaving education (binary); Level of attainment (categorical - see p.108)	Age 30
Father's employment status	Binary: Business owner or not	Age 16
Gender	Binary: Male or Female	All ages
Business continuity	Binary: Business exists at age 34, or does not exist	Ages 30 and 34
Take-home income (self-employed) (£)	Continuous: GBP	Age 42
Earnings' growth	Binary: Earnings' growth from age 30 to age 34	Ages 30 and 34
Father's education	Categorical: Age of leaving education	Age 16
Family income	Categorical: 1 (<50 GBP per week) - 11 (>500 GBP per week)	Age 16
Earnings from age 34	Continuous: GBP	Age 34
Full time experience	Continuous: 0-325 (months)	Age 34
Cocaine usage	Binary: Ever taken cocaine (Yes/No)	Age 30
Arrest history	Binary: Ever been arrested (Yes/No)	Age 30

4.43 **The Hyperactivity Debate**

In view of the importance of the debate over the existence and definition of the hyperactivity syndrome, considerable attention has been paid to this issue, both in the Child Behaviour Scale an in the analyses of that scale. It is clearly of much importance both in health terms - for example, how justified is the prescribing of stimulant drugs to reduce the appearance of the phenomenon in children thought to be seriously hyperactive? - and in educational terms, where it is often contended that the hyperactive child is a serious problem because he (less frequently she) disturbs other children in the class and cannot concentrate sufficiently to keep pace with the rest of the class.

The scale contains 14 items which have been described in the literature, specifically or in more general terms, as indicative of hyperactive behaviour. The items in question were the following:

Q. 3 Cannot concentrate on any particular task, even though the child may return to it frequently
Q. 9 Teases other children to excess
Q.16 Interferes with the activities of other children
Q.22 Is excitable, impulsive
Q.24 Shows restless or over-active behaviour
Q.25 Squirmy and fidgety
Q.26 Is easily distracted
Q.29 (Negatively scored) Pays attention to what is being explained in class
Q.36 (Negatively scored) Shows lethargic and listless behaviour
Q.38 Hums or makes other odd vocal noises at inappropriate times
Q.39 Given to rhythmic tapping or rhythmic kicking during class
Q.48 (Negatively scored) Child completes tasks which are started
Q.49 Request must be satisfied immediately - is easily frustrated
Q.51 Fails to finish things he starts

Items 9, 16, 22, 24, 25 and 38 are fairly similar to Conners' hyperactivity items, while items 24 and 25 are cited by Rutter as strong hyperactivity items.

The term hyperactivity is used very widely in the literature. It has been reported to be associated with minimal brain dysfunction, with

Table 4.42. Final Component Score Coefficients for rotated solution of 9 principal components of Child Behaviour Scale

Component 1 Anti-Social Behaviour	Component 2 Disorganised Activity	Component 3 Neuroticism/ Anxiety	Component 4 Clumsiness	Component 5 Poor Hand-Eye Co-ordination	Component 6 Hyper-kinesis	Component 7 Introversion/ Extraversion	Component 8 Behavioural Trauma	Component 9 Competent Dressing
Q. 5 Complains about things .133	Q. 1 Daydreaming .167	Q. 2 Afraid of new things .194	Q. 6 Trips easily or bumps into things .291	Q. 7 Deft with hands -.306	Q.38 Hums, odd noises .410	Q.22 Excitable, impulsive -.224	Q. 4 Wets pants .466	Q.15 Competent Dressing .724
Q. 8 Displays temper .163	Q. 3 Cannot concentrate .148	Q.19 Behaves nervously .220	Q.10 Clumsy in games .330	Q.27 Manipulates small objects easily -.308	Q.39 Rhythmic tapping .415	Q.33 Solitary child .350	Q.41 Soils pants .470	
Q. 9 Teases to excess .146	Q.12 Bored in class .145	Q.20 Fussy .162	Q.14 Difficulty kicking ball .320	Q.35 Uses scissors competently -.336	Q.45 Face or body twitches .361	Q.36 Lethargic, listless .197	Q.46 Truants .433	
Q.16 Interferes with others .109	Q.13 Perseveres -.163	Q.23 Worried, Anxious .269	Q.18 Difficulty picking up small objects .180	Q.40 Inadequate control pencil, brush .256		Q.44 Sullen and sulky .182	Items which do not feature strongly in any component score:	
Q.21 Changes mood quickly .134	Q.17 Confused with diffic. task .102	Q53* Anxious/ Unworried scale .244	Q.28 Drops things .196	Q.50 Holds writing instruments well -.333		Q.52 Extravert/ Introvert scale -.342	Q.11 Cries easily Q.24 Restless, overactive Q.25 Squirmy, fidgety Q.30 Miserable, unhappy Q.31 Obsessional	
Q.34 Quarrels with others .169	Q.26 Easily distracted .162		Q.42 Has classroom or play ground accidents .172				----------	
Q.37 Destroys Belongings .084	Q.29 Pays attention -.158		Q.47 Fearful in movement .232				*Qs. 48 and 53 are possibly superfluous	
Q.43 Bullies .162	Q.32 Forgetful with complex task .131							
Q.44 Sullen, sulky .158	Q.36 Lethargic, listless .101							
Q.49 Easily frustrated .088	Q.48*Completes tasks -.148							
	Q.51 Fails to finish tasks .156							

N = 8836

Notes: 1. Table reports component score coefficients.
2. Item loadings of .40 or over are used originally to define a component.
3. Within any one component, items are chosen whose coefficient values are $\geq$ half the value of the highest coefficient in that component.
4. For missing item values, individual means substituted within each component. If all items absent, sample mean is inserted.

Figure 7: A compilation of the Conners' Hyperactivity Scale and Rutters' Behaviour Scale (left); Childhood Behaviour Scale (right) - Page 238 of file a3723.ucb of the Age 10 Sweep in the British Cohort Study

Table 16: Reliability Table for Confirmatory Factor Analysis (Chapters 2 3)

total		TeachInat	TeachHyp
0.905	alpha	0.882	0.870
0.926	omega	0.886	0.872
0.926	omega2	0.886	0.872
0.927	omega3	0.881	0.863
0.623	avevar	0.615	0.634

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Table 17: Parameter Estimates Table for Confirmatory Factor Analysis (Chapters 2 3)

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
est	32	24.994	28.139	0.000	9.588	21.451	95.082
se	32	0.500	0.687	0.000	0.097	1.106	1.858
z	28	91.722	45.296	15.690	47.665	119.407	184.443
pvalue	28	0.000	0.000	0.000	0.000	0.000	0.000
ci.lower	32	24.014	26.894	0.000	9.368	20.555	91.913
ci.upper	32	25.973	29.394	0.000	9.808	23.911	98.251
std.lv	32	24.994	28.139	0.000	9.588	21.451	95.082
std.all	32	0.756	0.406	0.000	0.455	1.005	1.497
std.nox	32	0.756	0.406	0.000	0.455	1.005	1.497

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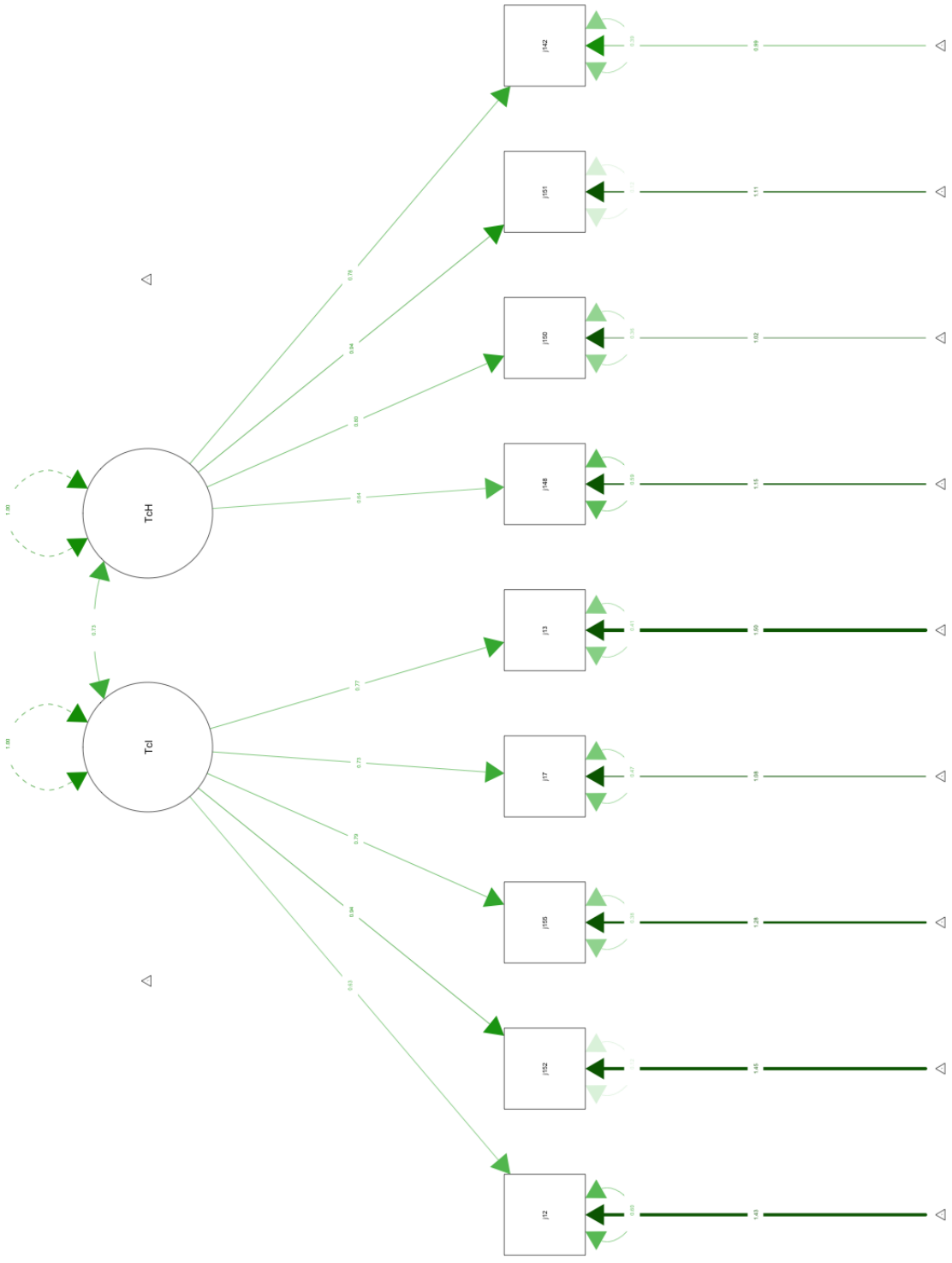
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TcI
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j151
j150
j148
j13
j17
j155
j152
j12

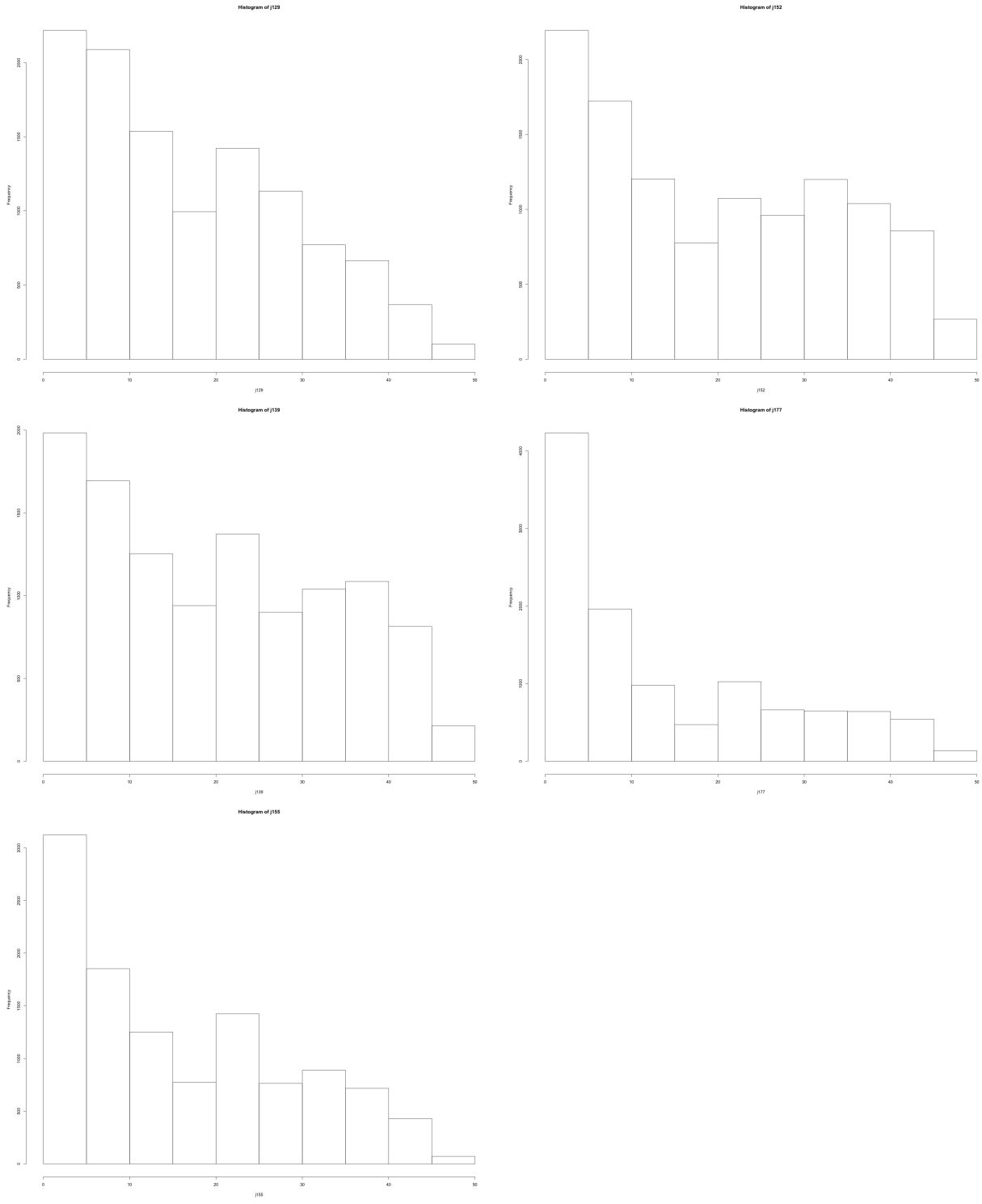

Figure 9: Histogram for Confirmatory Factor Analysis Items - Inattention

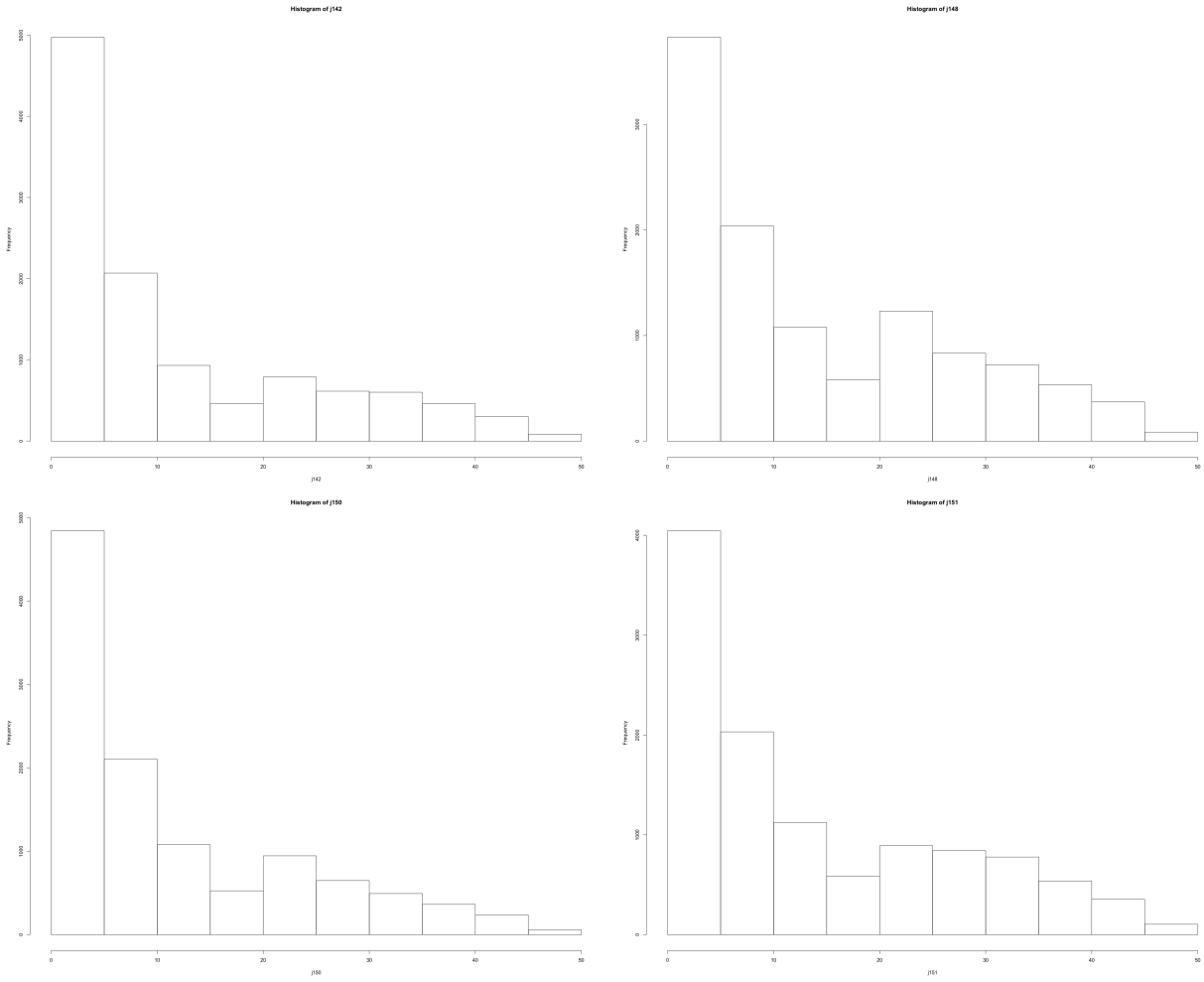

Figure 10: Histogram for Confirmatory Factor Analysis Items - Hyperactivity/Impulsivity

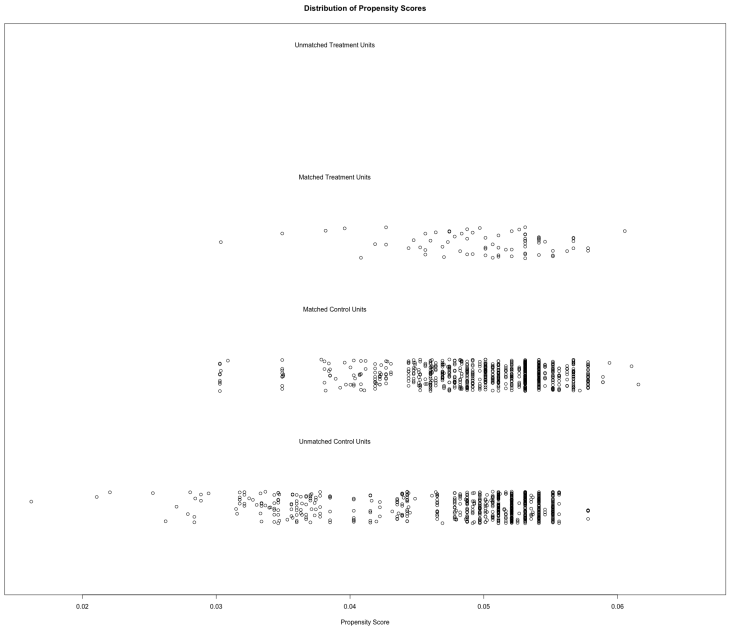

Figure 11: Distribution for Propensity Score Matching Without Education (Table 2)

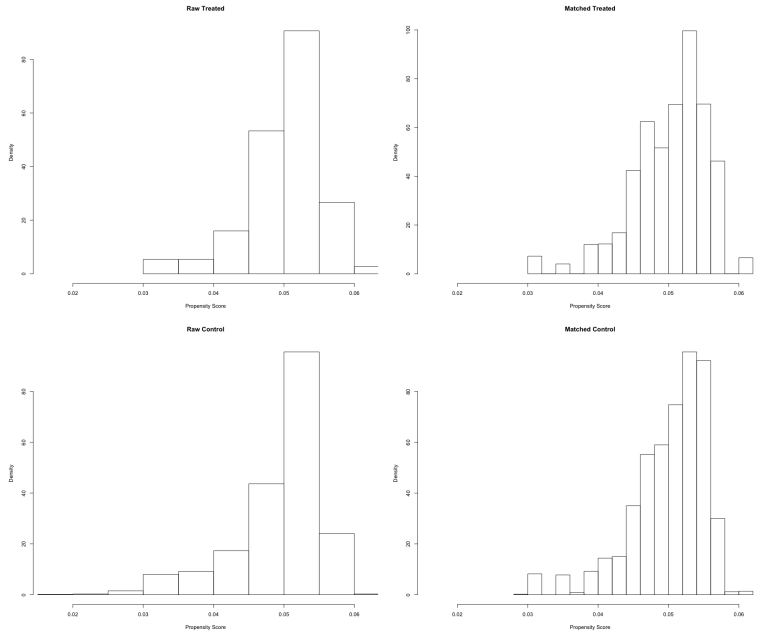

Figure 12: Histogram for Propensity Score Matching Without Education (Table 2)

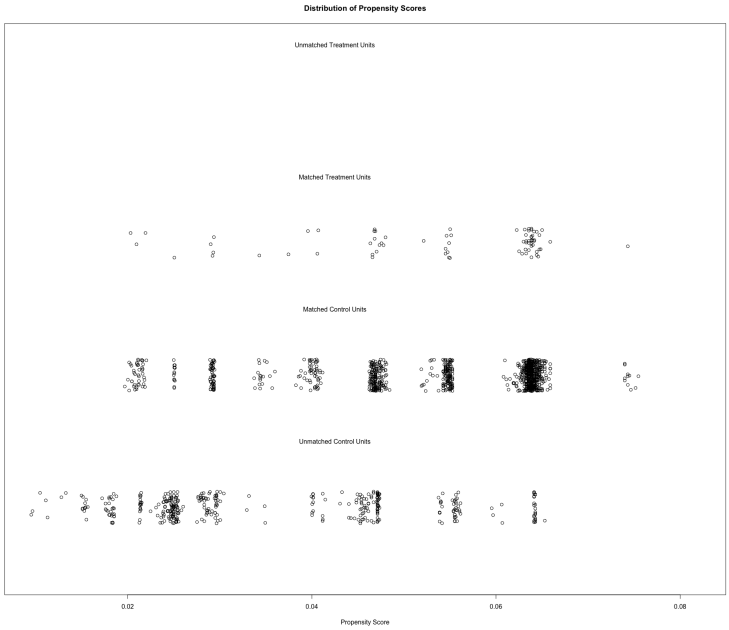

Figure 13: Distribution for Propensity Score Matching With Education (Table 2)

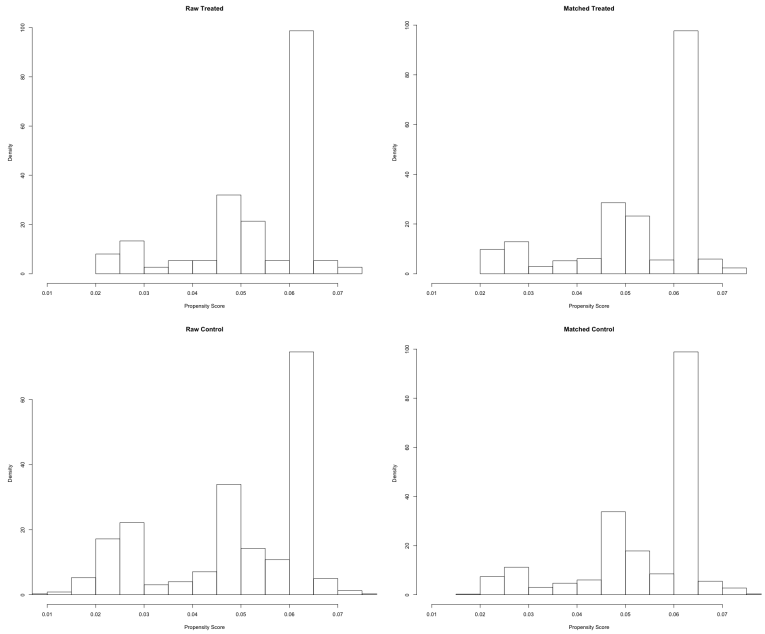

Figure 14: Histogram for Propensity Score Matching With Education (Table 2)

Table 18: Unmatched Data for Propensity Score Matching

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Means Treated	3	12.737	17.796	0.050	2.565	19.080	33.080
Means Control	3	12.704	17.575	0.049	2.671	19.032	32.771
SD Control	3	1.656	1.430	0.006	1.212	2.481	2.544
Mean Diff	3	0.032	0.263	−0.213	−0.106	0.155	0.309
eQQ Med	3	0.0001	0.0002	0.000	0.000	0.0002	0.0004
eQQ Mean	3	0.249	0.253	0.001	0.121	0.373	0.507
eQQ Max	3	4.338	5.854	0.014	1.007	6.500	11.000

Table 19: Matched Data for Propensity Score Matching

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Means Treated	3	12.737	17.796	0.050	2.565	19.080	33.080
Means Control	3	12.812	17.783	0.050	2.656	19.193	33.125
SD Control	3	1.464	1.306	0.005	0.934	2.194	2.524
Mean Diff	3	−0.076	0.095	−0.182	−0.113	−0.022	0.0001
eQQ Med	3	0.000	0.000	0	0	0	0
eQQ Mean	3	0.111	0.107	0.0002	0.060	0.167	0.213
eQQ Max	3	1.334	1.154	0.001	1.001	2.000	2.000

Table 20: Balance Observations

	Control	Treated
All	1,444	75
Matched	1,050	75
Unmatched	394	0
Discarded	0	0

Table 21: Propensity Score Matching Percentage Improvement

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Mean Diff.	3	63.260	42.216	14.573	50.049	87.604	89.684
eQQ Med	3	33.333	57.735	0	0	50	100
eQQ Mean	3	57.536	40.449	11.111	43.713	80.749	85.182
eQQ Max	3	58.037	50.533	0.000	40.909	87.055	92.292

6.1 Insignificant Results - Chapter 2

Table 22: Hypothesis 1A - Insignificant Results

	Dependent variable: Business Owner (1) or Full Time Employee (0)			
	Age 30	Age 34	Age 38	Age 42
	(1)	(2)	(3)	(4)
Constant	-3.078^{***}	-2.613^{***}	-2.783^{***}	-2.520^{***}
	(0.390)	(0.322)	(0.321)	(0.538)
Hyperactivity Rating	0.003	0.0005	0.004	0.001
	(0.004)	(0.004)	(0.003)	(0.006)
	OR: 1.003	OR: 1.005	OR: 1.004	OR: 1.001
Education	−0.382	-0.554^{*}	−0.238	0.288
	(0.357)	(0.308)	(0.295)	(0.492)
	OR: 0.68	OR: 0.57	OR: 0.79	OR: 0.75
Father Self Employed	0.920^{**}	1.548^{***}	1.214^{***}	1.392^{***}
	(0.361)	(0.307)	(0.300)	(0.479)
	OR: 2.51	OR: 4.70	OR: 3.37	OR: 4.02
Observations	644	607	625	160
Pseudo R^2	0.035	0.098	0.061	0.098

Note: *p<0.1; **p<0.05; ***p<0.01

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Table 23: Hypothesis 1B - Insignificant Result

	Dependent variable: Entrepreneur (1) or Full Time Employee (0)			
	No Social Class	No Social Class	SC 1 or 2 From Age 34	SC 1 or 2 From Age 34
	(1)	(2)	(3)	(4)
Constant	-1.628^{***}	-2.436^{***}	-2.895^{***}	-2.926^{***}
	(0.128)	(0.241)	(0.403)	(0.437)
Hyperactivity Rating	-0.000	0.004	0.006	0.007
	(0.002)	(0.003)	(0.004)	(0.005)
	OR: 1.00	OR: 1.004	OR: 1.006	OR: 1.007
Education	-0.490^{***}	-0.427^{*}	-0.454	-0.455
	(0.158)	(0.254)	(0.379)	(0.379)
	OR: 0.61	OR: 0.65	OR: 0.64	OR: 0.63
Father Self Employed		0.891^{***}	1.262^{***}	1.357^{**}
		(0.265)	(0.396)	(0.640)
		OR: 2.44	OR: 3.53	OR: 3.88
Hyperactivity*Father Self Employed				-0.002
				(0.009)
				OR: 0.99
Observations	1,632	779	422	422
Pseudo R^2	0.011	0.041	0.073	0.073

Note: *p<0.1; **p<0.05; ***p<0.01

.

Table 24: Hypothesis 1B - Insignificant Result

	Dependent variable: Entrepreneur (1) or Full Time Employee (0)
Constant	-2.840^{***}
	(0.259)
Hyperactivity Rating	0.004
	(0.003)
	OR: 1.004
Education	-0.415
	(0.257)
	OR: 0.660
Gender	0.291
	(0.254)
	OR: 1.338
Observations	1,125
Pseudo R^2	0.02
Note:	*p<0.1; **p<0.05; ***p<0.01

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Table 25: Hypothesis 2A - Insignificant Results

	Dependent Variable (below)		
	Business Continuity	Earnings Growth	Take Home Income at 42
	Logistic	*Logistic*	*OLS*
	(1)	(2)	(3)
Constant	0.6059**	0.976**	31957.09***
	(0.2483)	(0.4466)	(3653.64)
Binary Hyp/Imp Rating	0.124		
	(0.316)		
	OR: 1.132		
Education	−0.4238	−0.3788	15471.48 ***
	(0.343)	(0.5905)	(5713.84)
	OR: 0.655	OR: 0.685	
Binary Inattention Rating		−0.428	
		(0.584)	
		OR: 0.122	
Hyperactivity/Impulsivity Rating			−-64.30
			(33.53)
Observations	174	68	325
Pseudo R^2 / R^2	0.013	0.018	0.025
F Statistic			6.9*** (df = 2; 344)

Note: *p<0.1; **p<0.05; ***p<0.01

Binary inattention rating is taken as the median rating (91)

6.2 Insignificant Results - Chapter 3

Table 26: Hypothesis 2A - Insignificant Results

	Dependent variable: Log Hourly Pay at Age 34			
	Females	Males	Females	Males
	(1)	(2)	(3)	(4)
Constant	1.882***	2.028***	1.939***	2.082***
	(0.0936)	(0.089)	(0.081)	(0.062)
Education	0.102***	0.112***	0.108***	0.137***
	(0.026)	(0.020)	(0.019)	(0.013)
Full Time Experience	0.001***	0.001	0.001***	0.001***
	(0.0007)	(0.0004)	(0.0004)	(0.0002)
Hyperactivity Rating	−0.002**	−0.001	−0.001*	−0.0003
	(0.001)	(0.0005)	(0.0007)	(0.0004)
Family Income	0.033**	0.041***		
	(0.0128)	(0.010)		
Observations	310	444	572	815
R^2	0.141	0.161	0.076	0.132
F Statistic	15.22*** (df = 4; 305)	24.43*** (df = 4; 439)	22.22*** (df = 3; 568)	42.94*** (df = 3; 811)

Note: *p<0.1; **p<0.05; ***p<0.01

.

Table 27: Hypothesis 3A - Insignificant Results

	Dependent variable (below)	
	Cocaine Before 30 (1) or Not (0)	Arrested Before 30 (1) or Not (0)
	(1)	(2)
Constant	-1.846^{***}	-1.645^{***}
	(0.107)	(0.099)
SBO (1) or FTE (0)	0.684^{***}	0.869^{***}
	(0.266)	(0.254)
	OR: 1.98	OR: 2.38
Binary Inattention Rating	-0.724	0.594^{***}
	(0.156)	(0.317)
	OR: 0.48	OR: 1.81
Employment Type*Inattention Rating	0.1313	-0.372
	(0.346)	(0.311)
	OR: 3.06	OR: 0.69
Observations	1,683	1,683
Pseudo R^2	0.020	0.037

Note: *p<0.1; **p<0.05; ***p<0.01
SBO refers to small business owner; FTE refers to full-time employees.
Employment Type refers to the aforementioned
Inattention rating is a binary at the median value.

Table 28: Hypothesis 3B - Insignificant Results

	Dependent variable: Multinomial With Full-Time Employment as Reference
1:(Constant - Own Business)	-1.652^{***}
	(0.602)
2:(Constant - Unemployed)	-0.877
	(0.879)
1:Teacher Hyp/Imp Rating	-0.002
	(0.002)
	OR: O.99
2:Teacher Hyp/Imp Rating	0.007^{***}
	(0.002)
	OR: 1.007
1:Age of Leaving Education	-0.049
	(0.034)
	OR: 0.95
2:Age of Leaving Education	-0.146^{***}
	(0.051)
	OR: 0.86
Observations	3,342
R^2	0.011
Log Likelihood	$-1,425.826$
LR Test	32.390^{***} (df = 6)
Note:	*p<0.1; **p<0.05; ***p<0.01

6.3 Chapter 2 - Insignificant Results for Females

Table 29: Hypothesis 1A- Insignificant Results for Females

	Dependent variable: Entrepreneur (1) or Full Time Employee (0)			
	Age 30	Age 34	Age 38	Age 42
	(1)	(2)	(3)	(4)
Constant	−4.390***	−4.051***	−3.395***	−3.506***
	(0.719)	(0.605)	(0.474)	(0.838)
Inattention Rating	0.006	0.009*	0.005	0.005
	(0.006)	(0.005)	(0.004)	(0.006)
	OR: 1.006	OR: 1.009	OR: 1.005	OR: 1.005
Education	−0.062	0.199	0.529	1.517**
	(0.603)	(0.498)	(0.396)	(0.724)
	OR: 0.94	OR: 1.22	OR: 1.70	OR: 4.56
Father's Self-Employment Status	1.038*	1.108**	1.076***	−0.086
	(0.569)	(0.490)	(0.378)	(0.831)
	OR: 2.82	OR: 3.03	OR: 2.93	OR: 0.92
Observations	525	425	408	131
Pseudo R^2	0.041	0.051	0.058	0.083
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 30: Hypothesis 1A - Insignificant Results for Females

	Dependent variable:			
	Age 30	Age 34	Age 38	Age 42
	(1)	(2)	(3)	(4)
Constant	-4.060^{***}	-4.029^{***}	-3.321^{***}	-2.884^{***}
	(0.645)	(0.562)	(0.444)	(0.758)
Hyperactivity/Impulsivity Rating	0.004	0.013^{**}	0.006	-0.003
	(0.008)	(0.006)	(0.005)	(0.010)
	OR: 1.004	OR: 1.01	OR: 1.006	OR: 0.99
Education	-0.172	0.184	0.519	1.266^{*}
	(0.595)	(0.499)	(0.396)	(0.716)
	OR: 0.84	OR: 1.20	OR: 1.68	OR: 3.55
Father's Self-Employment Status	1.046^{*}	1.079^{**}	1.061^{***}	-0.015
	(0.569)	(0.488)	(0.377)	(0.823)
	OR: 2.85	OR: 2.94	OR: 2.89	OR: 0.99
Observations	525	425	408	131
Pseudo R^2	0.033	0.058	0.057	0.073

Note: *p<0.1; **p<0.05; ***p<0.01

.

Table 31: Hypothesis 1B - Insignificant Results for Females

	Dependent variable: Entrepreneur (1) or Full Time Employee (0)	
	(1)	(2)
Constant	-3.368^{***}	-3.326^{***}
	(0.275)	(0.305)
Father's Self Employment Status	1.114^{***}	1.116^{***}
	(0.268)	(0.268)
	OR: 3.05	OR: 3.05
Hyperactivity / Impulsivity Rating	0.0004	
	(0.004)	
	OR: 1.0004	
Inattention Rating		-0.0003
		(0.002)
		OR: 1.0003
Education	0.494^{*}	0.485^{*}
	(0.263)	(0.267)
	OR: 1.64	OR: 1.62
Observations	1,106	1,106
Pseudo R^2	0.05	0.05
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 32: Hypothesis 2A - Insignificant Results for Females

	Dependent variable: Below			
	Business Continuity		Earnings Growth	
	(1)	(2)	(3)	(4)
Constant	0.373	0.815	−7.970	−8.197
	(2.156)	(2.029)	(8.517)	(8.446)
Education	−0.044	−0.063	0.505	0.477
	(0.120)	(0.118)	(0.497)	(0.507)
	OR: 0.96	OR: 0.94	OR: 1.66	OR: 1.61
Binary Hyp/Imp Rating				1.019
At median value				(1.171)
				OR: 2.77
Inattention Rating	0.003			
	(0.005)			
	OR: 1.003			
Hyp/Imp Rating		0.003		
		(0.006)		
		OR: 1.003		
Binary Inattention Rating			−0.353	
At median value			(1.192)	
			OR: 0.96	
Observations	86	86	15	15
Pseudo R^2	0.012	0.008	0.189	0.242
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 33: Hypothesis 2A - Insignificant Results

	Dependent variable: Take Home Income at Age 42 for Business Owners	
	(1)	(2)
Constant	−9,061.374	−16,171.530*
	(9,581.715)	(8,800.219)
Inattention Rating	−7.876	
	(25.549)	
Hyp/Imp Rating		69.543**
		(34.023)
Education	1,500.639***	1,701.156***
	(490.036)	(467.597)
Observations	273	273
R^2	0.040	0.054
F Statistic (df = 2; 270)	5.589***	7.715***
Note:		*p<0.1; **p<0.05; ***p<0.01

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6.3.1 Chapter 3 - Insignificant Results for Females

Table 34: Hypothesis 3A - Insignificant Results for Females

	Dependent variable: Below			
	Cocaine (1) or Not (0)		Arrested (1) or Not (0)	
	(1)	(2)	(3)	(4)
Constant	−2.506***	−2.539***	−3.745***	−3.594***
	(0.117)	(0.119)	(0.207)	(0.192)
Binary Hyp/Imp Rating		−0.031	0.799***	
At median value		(0.170)	(0.251)	
		OR: 0.97	OR: 2.22	
SBO (1) or FTE (0)	0.203	0.172	1.180**	−0.030
	(0.413)	(0.443)	(0.508)	(0.742)
	OR: 1.23	OR: 1.19	OR: 3.25	OR: 0.97
Binary Inattention Rating	−0.101			0.573**
At median value	(0.170)			(0.242)
	OR: 0.90			OR: 1.77
Employment Type*Binary Inat	0.557			0.550
	(0.561)			(0.888)
Employment Type*Binary Hyp		0.557	−1.804**	
		(0.572)	(0.890)	
		OR: 1.75	OR: 0.16	
Observations	2,223	2,223	2,223	2,223
Pseudo R^2	0.004	0.004	0.021	0.014
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 35: Hypothesis 3B - Insignificant Results for Females

	Dependent variable: Multinomial - FTE as Reference	
	(1)	(2)
1:(Constant)	-1.737^{***}	-1.025^{**}
	(0.548)	(0.512)
2:(Constant)	-2.003^{***}	-0.844
	(0.736)	(0.699)
1:Inattention Rating	0.003^{**}	
	(0.001)	
	OR: 1.003	
2:Inattention Rating	0.008^{***}	
	(0.001)	
	OR: 1.008	
1:Hyp/Imp Rating		-0.001
		(0.001)
		0.99
2:Hyp/Imp Rating		0.007^{***}
		(0.001)
		1.007
1:Education	-0.061^{**}	-0.081^{***}
	(0.028)	(0.028)
	OR: 0.94	OR: 0.92
2:Education	-0.111^{***}	-0.147^{***}
	(0.039)	(0.039)
	OR: 0.89	OR: 0.86
1:Gender	-0.070	-0.144
	(0.121)	(0.119)
	OR: 0.93	OR: 0.87
2:Gender	0.063	-0.038
	(0.145)	(0.143)
	OR: 1.07	OR: 0.96
Observations	5,476	5,476
R^2	0.019	0.013
LR Test (df = 8)	84.521^{***}	59.653^{***}
Note:		*p<0.1; **p<0.05; ***p<0.01

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