The Inequality-Growth Nexus:

A Study on Institutions, Innovation, and the Trade-off Between Inequality and Growth

presented by

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A Thesis Submitted in Fulfilment of the Requirements for the Degree of Doctor of Philosophy of Cardiff University

October 2022

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Abstract

The present research examines the effects of economic institutions under the broader context of the inequality-growth nexus. We are able to identify from fixed effects panel estimations that although both institutional quality and innovations can offer significant contributions towards economic growth, this progress is made at the expense of economic equality. The interactions of the two variables of interest are found to be negative in signs within the inequality and the growth model, meaning the marginal effects of both innovations and institutions on growth and inequality diminish in their potency as their interacting counterparts increase in value. This indicates that while institutions and innovations are shown to be inequality-inducing, their interaction dampens the effect at higher values. Similarly, while both variables contribute positively towards growth, their interactions also possess negative coefficients, reduces the overall impact on growth in a display of potential institutional inefficiency and diminishing return on innovation. Furthermore, we uncover a transitory institutional effect on growth, where the partial effects of property right protection gradually diminish as the economy develop and are eventually replaced by the broader institutional effects. Additional testing of the model uses GMM and IV estimations, as well as additional robustness tests, reinforce the findings. To develop policy implications from our hypotheses and the empirical findings, we construct a theoretical framework of a voter-driven political model where the balance of the inequality-growth trade-off is set by a redistributive policy tool, determined by a median voter through their utility consideration between inequality and economic growth. We estimate the structural model using the indirect inference technique on long data for the UK from 1870 to 2018. The empirical estimation is not rejected by the Wald test, suggesting that our theoretical model cannot be rejected and is a good fit for empirical data.

Key words: inequality, economic growth, institutions, entrepreneurship, innovation, fixed effects, System-GMM, indirect inference, structural modelling, political economics.

Acknowledgements

I would like to express my most sincere gratitude to my primary supervisor Dr Joshy Z. Easaw, for without his kind guidance and tireless labour throughout the last 5 years and through the tribulation of the pandemic, the thesis and all that accompanied would be an impossibility. I would also like to thank him for trusting me with the tutorials of his taught module. In addition, I am equally grateful to my co-supervisors, Professor Patrick Minford and Dr Vassilis Logothetis, for their countless comments and practical support. If not for the commitment of my supervisory team I would remain ignorant and uninspired.

I would like to thank all the faculty at the Economics Section of Cardiff Business School, as well as the members of the support staff at the Research Office, for providing such a supportive environment for study and research. I greatly appreciate their professionalism and due diligence. Furthermore, I am grateful to my cohort for allowing me to represent them as a student representative, and the Section Student Staff Panel and the Business School Student Staff Panel for giving me the opportunity to participate. I have no doubt my experience serving as a student representative and the chair of the Panel would be helpful to me for the days to come.

I would also like to thank may friends and colleagues in the PhD programme. My days are brightened by the friendship and the support from my fellow comrades. I shall be ever so thankful.

Most importantly, I thank my loving parents for their unconditional trust and everlasting support. Without their encouragement I would have faltered and my faith wavered during times of darkness. Without their tremendous understanding and patience I would have achieved nothing of worth. I also thank my partner SiSi Bie, for standing by my side through thick and thin, especially during the dark days of the pandemic, and for giving me the fortitude to carry on.

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Chapter 1

General Introduction

The study of the inequality-growth nexus has been an ongoing endeavour for more than half a century. Started with the work of Kuznets (1955) and Kaldor (1955), numerous theories have been proposed to describe the relations between these two fundamental economic principles and through what channels and to what extend can inequality affect economic growth. Recent studies have brought tremendous progress and valuable insights on the workings of the nexus, including the identification of new transmission channels and the extension of the established ones, new empirical findings and novel techniques that are used to reach them. These studies use income inequality as either an explanatory variable to explain economic growth to establish direct causal effects, or as a dependent variable to explore potential effects caused by inequality on other indicators and their subsequent impact on growth. In the present thesis, we investigate how innovation and other productivity enhancing economic activities, in combination with the effects of institutional development, can influence inequality and ultimately economic growth.

Existing literature in this area has increasing diverging opinions, with no clear consensus on whether inequality is beneficial or detrimental to economic growth, and how innovation can lead to a change in inequality also remains unclear. Furthermore, we note that exploration into the role of institutions within the mechanism, theoretical or empirical, has been limited. In the literature, the studies that do examine the effects of institutions, either do so without considering the context of institutional interaction with other determinants of inequality and growth, or conclude with insignificant institutional effects. Such gap in the research motivates us to carry out the present study.

1.1 Research Questions

The various transmission channels identified through which inequality can have an effect on economic growth possess considerable significance both theoretically and practically. While the growth effects of innovation and the role of institutions have been examined to various extend in existing studies, we note that no research to date has made a concentrated effort to examine the combined effects of innovation and institutions in the inequality-growth nexus. We aim to address this gap in research. Additionally, we ask the question of how institutions, specifically economic institutions represented by the protection of property rights, and institutions in a broader sense, interact with innovation and entrepreneurial activities and how the interactions affect both inequality and economic growth. Lastly, we set out to address the policy implications that may be identified from empirical causal exploration, specifically potential trade-off between inequality and economic growth and how a policy tool can be developed to achieve optimisation within such dynamics.

1.2 Contribution

This study adds to the existing literature by exploring a novel transmission channel in the much-debated inequality-growth nexus: the impact of institution-driven innovation, productivity gain and entrepreneurship within inequality growth effect. Previous studies on this topic tend to focus on a series of narrow channels within the proposed dynamics while largely downplaying certain components that are otherwise crucial in understanding the mechanisms at work. Quite recently, a group of literature focuses on exploring the causal links between innovation and inequality (e.g., Benos & Tsiachtsiras 2019; Santamaría 2019; Aghion et al. 2018) and institutions and inequality (Amendola, Easaw & Savoia 2013; Risso & Carrera 2019), but few had examined the interactions between key economic and institutional indicators, or the combined channel proposed in this study.

With the backing of a theoretical framework developed exclusively for the assessment of the proposed hypothesis, which offers an additional contribution to the literature by introducing institutional indicators as a prominent component in a dynamic model, the empirical exploration of this study highlights the key roles institutions and institution-innovation interactions play in affecting inequality and economic growth. Moreover, considering the nature of institutional formation and the causal relations concerning inequality and growth, the findings of this study can possess notable policy implication and significance for sustainable economic development led by innovation and equality.

Furthermore, to be built on the findings of our empirical exploration, we aim to construct a policy model based on the hypothesised trade-off between inequality and growth. We make the assumption that economic growth can be achieved through sacrificing inequality and enriching the selected few, who are cable of engaging in innovation and entrepreneurship by bringing their concentrated wealth to bear, and thus contributing towards economic growth. This creates a dilemma where policy makers must balance between equality and economic growth: redistribution and transfer of wealth can reduce inequality, but at a cost of lowered growth momentum. To help capture such a trade-off, a theoretical framework is developed. Built on the work of Yang et al. (2021) the model takes the form of a dynamic equilibrium model that focus on the growth effect of entrepreneurship. We further extends the model to incorporate elements of economic institutional measures in the form of property right enforcement and accommodate measures of inequality for empirical testing. The construction of the model contributes to the literature by introducing economic institutions into a dynamic theoretical framework that would produce a solvable, optimal path for innovation and entrepreneurship, a feature of notable policy significance. On top of this we construct a second stage to the theoretical framework in the form of a median voter policy function, based on which the estimation and testing of the model will be carried out via indirect inference.

We also test the proposed hypotheses by conducting a series of empirical estimations on the interpretation of the model in the form of growth and inequality hypotheses that encompass the underlining mechanisms of the theory. These hypotheses are institutional effects on growth, institutional effects on inequality and the combined effect on inequality-growth relations. We test the hypotheses on different measures of inequality and innovation using various estimation methods and classifications, some of which are novel or otherwise rarely attempted in previous literature, with the inclusion of the GCIP database (Lahoti et al. 2016) and cross-country panel on institutions and composite institutions indexes being a few of the examples. The estimations show positive effects of institutions, innovation and the interaction of the two on economic growth and a negative correlation between institutions and economic equality (inequality-worsening effect of institutions), which may suggest a middle institution trap for developing countries. The results are consistent in terms of control variable and are comparable to published papers(e.g., Deininger & Squire 1998; Antonelli & Gehringer 2013; Halter et al. 2014). They also demonstrate statistical significance for variables of interest, thus providing empirical support to the proposed hypotheses. We also examine the robustness of the topic by conducting additional empirical testing with alternative measures of critical variables, such as proxies for innovation, with IV, system-GMM and quantile estimations to assess robustness. The advent of the project towards the aforementioned direction yields further contributions in the form of additional empirical discoveries.

In the last chapter of this thesis we build on the empirical findings to offer policy implications. We construct a theoretical framework of a median-voter driven political model determining the rate of redistributive transfer rate. The median voter balances the trade-off between inequality and innovation-driven economic growth by considering the utility they gain from economic growth and the disutility from inequality. There has been no prior attempt to incorporate political economics with micro-founded structural macroeconomic modelling. We estimate and test the validity of the model using the indirect inference technique, with long historical data collected from the UK. The results offer critical insights into voter preference between inequality and economic growth and may be of political significance to policymakers.

1.3 Thesis Outline

The rest of the thesis is organised into four chapters. Chapter two is a dedicated survey of the literature on the topic of inequality-growth nexus. It provides the necessary background information on the academic landscape surrounding the nexus by presenting empirical and theoretical studies examines various aspects of inequality and economic growth. The findings of these studies are compiled to offer context to conventional wisdoms and the techniques associated with them. Chapter three starts the main body of the thesis, presenting the outlines and reasoning for an empirical model and its subsequent estimation and testing. We also assemble a panel dataset for this purpose, the description of which is provided in chapter three. Various empirical techniques will be used to examine the model and assess the robustness of the findings. In chapter four a theoretical framework complementing the empirical work will be presented, in the form of a two stage dynamic household model. The first stage of this framework is to capture the behaviour of a representative household who has the capabilities to innovate and engage in entrepreneurial activities under the constraints of their budget and institutional conditions. The second stage introduces the role of a median voter who determines redistributive policies by considering the trade-off between inequality and economic growth. To assess the fitness of the theoretical framework the estimation and testing of the model is be carried out using the indirect inference technique, the description and outcome of which are presented in chapter five. Lastly, we discuss the policy implications derived from the findings.

Chapter 2

The Inequality-Growth Nexus: a Survey of the Literature

2.1 Introduction

Economic inequality as it stands has been a well-documented occurrence for as long as there have been human societies. From prehistoric tribalism to the feudal serfdoms of the Middle Ages, to contemporary capitalist society, the unequal distribution of income and wealth within a society or among multiple societies have been one of the defining interests for economic and sociological research. Consequently, a sizable literature on the topic of inequality can be found, both empirical and theoretical. The wide range of studies examine various causal relationships between economic inequality and various factors, such as growth and social stabilities while employing some vastly different models and perspectives.

The purpose of this literature review is to examine the studies conducted on the topic of the inequality-growth effect, covering major branches of sub-topics related to economic inequality in order to compile prominent studies and literature to offer critical insight regarding the topic at hand and associated sub-topics. This review will serve as a guide to introduce the reader to the academic landscape surrounding inequality and growth, offering an overview of the topic and set the stage from which new research can be carried out. An attempt will also be made to explore beyond the disciplinary boundary of economics as there are many transmission channels economic inequality can affect growth that fall outside the discipline of economics. The social impact of inequality on education, societal stability, political dynamics and the like will be presented, to provide a more comprehensive perspective on the topic.

We acknowledges that many literature surveys of this nature have existed (e.g., Thorbecke & Charumilind 2002; Neves & Silva 2013), exploring similar topics. This paper is prepared to distinguish itself from those existing surveys in the following ways: Firstly, to the best of knowledge, most of the surveys on this topic were not up to date, covering only some of the classical literatures. This paper covers literatures up until late 2020, which includes much frontier research. Secondly, while most of the aforementioned literature reviews focuses on one or few transmission channels, this paper aims to provide a much more comprehensive overview on the inequality-growth effect, focusing mainly within the field of economics, and touches other socio-economic fields to supplement the arguments. Thirdly, both theoretical and empirical studies are examined and brought forward in this paper.

To facilitate the accomplishment of goals listed above, this literature review is constructed in such way in order to shed light on first various causal mechanisms and theoretical frameworks proposed over the years and secondly on the empirics in support of the theories, also to provide an understanding of the topic at hand noting the shifting consensus that exist in prominent studies during the process. Hence, this literature review is organised into two major sections: after the Introduction and a brief overview of the academic landscape surrounding the study of inequality and growth, section one presents theoretical frameworks proposed by various past studies on the inequality-growth effect. Section two will be divided into five subsections to organise the empirics in a chronological order. This section is arranged in such fashion to highlight the flow of consensus (or the lack there of) in different periods, as it will be shown that change of consensus has evidently been a common occurrence in the field of study concerning the inequality-growth effect. Diagrams and tables will be presented on the side to help to achieve better understanding of the literatures cited.

2.2 Overview

Due the prominent position the issue of inequality takes in contemporary society, it is sensible that a sizeable literature exists in the discipline of economics as well as other fields attempting to explain the various causal mechanisms between economic inequality and other socioeconomic complements. Most economic studies carried out focus on the relations between inequality and economic growth, as well as how various efforts to manipulate economic inequality can affect growth. For the former, existing literature can be divided into two main schools of thoughts: those that argue for a positive relationship between inequality and growth, where the state of economic inequality can supposedly facilitate economic growth through a number of means; and those who argue for the opposite, a negative correlation between inequality and growth where greater economic inequality can slow down growth of an economy. There also exists a number of literatures arguing for a flexible or inconclusive correlation between the subjects at hand. The following section will be used to present past studies on the topic of the proposed causation between inequality and economic growth.

The hypothesised positive relationship can be rationalised in two of the following ways, based on classic wisdom: firstly, a wider wealth gap can imply a higher aggregate saving and investment amongst the wealthy compared to the poor, since the rich tend to possess more wealth than the amount that is required for sustaining daily life. Consequently, economic growth can come from investment, generated by the saving of the additional wealth. Arguments have been presented that through redistributive methods, taking wealth from the rich would result in a lowered saving for the economy, which would lead to slowed capital accumulation and economic growth. Secondly, a greater concentration of wealth among fewer people would mean that while the rest of the society has to divide their attention to satisfy basic needs of survival, those who possess large sum of wealth do not need to concern themselves with making ends meet. Instead, they can afford to spend their time to fulfil life's goal, to innovate or to pursue greater enlightenment, which would be a boon to both technological progress and economic growth as innovation would typically lead to efficiency enhancing breakthroughs. Furthermore, redistributive methods can damage the incentive of the wealthy to generate additional income, as they may see the effort of redistribution through taxation or other means as unfair and unjust. This could result in a lowered incentive to produce or to innovate, thus slowing economic growth. It may also encourage the wealthy to seek evasive methods to circumvent redistribution, which would risk undesirable outcomes that can further hinder economic growth. The above reasoning implies that greater inequality can facilitate higher economic growth, whereas improved equality can lead to the opposite.

The negative relationship between inequality and growth proposed by the opposite camp can be explained as follows: high inequality would result in a greater percentage of the population being poor and are subsequently constrained by their lack of monetary means. This could lead to a number of negative socio-economic effects such as reduced social stability, worsened health condition amongst the afflicted which would imply lowered productivity, sub-optimal level of education and little opportunity to engage in financial actions such as saving or investment. All the factors listed above and more can negatively affect socio-economic progress or even threaten stability and create uncertainty, thus damaging the economic prospect of the society. As a result, the above reasoning clearly implies that greater inequality can lead to slowed economic growth.

Based on both schools of thought presented above it was made clear that empirical studies on this topic would indeed be a perpetual tug of war in finding evidence to support one argument over another. It will be made evident in the empirical section as changes in consensus would be a frequent occurrence as new research technique are being developed over the years.

2.3 Foundational Work: Kuznets, the Inverted U-shaped Curve and the Wealth of Nations

To the best of knowledge, a great portion of the contemporary research on the topic of inequality and economic growth are built on the foundation laid by Simon Kuznets and his ground-breaking work in this field. The Kuznets Hypothesis (1955) points out that as the economy of a nation grows, which can be represented by a raise in per capita income, the economy would experience an initial rise and subsequent fall in income inequality. This hypothesis is visualised by an inverted U-shaped curve, since the proposed economic growth is to be a concave function of income inequality, hence the name. One reasoning behind the Kuznets Hypothesis is that, assuming in initial period the per capita income is kept low for a starting economy but as it develops, industrialisation and urbanisation would drive the low wage workers from low yielding jobs in the rural areas to industrialised urban areas, receiving higher wages while benefiting firm owners and entrepreneurs thus rising income inequality in the process. The continuous progress in economic development would then see an increase in urban population and decreased rural population (which is consisted of low wage workers) as the transfer of labour continues. This would lower inequality after the initial rise, resulting in the inverted U-shaped curve, as proposed by Kuznets.

This hypothesis was widely celebrated at the time but has since been contested by a number of studies, theoretical or otherwise. For instance, Deininger and Squire's study (1996) concluded that there was no concrete evidence to support the inverted U-shaped curve when a large multinational time series dataset is applied. Eusufzai (1997) noted a significant structural break in correlation between per capita GDP and income inequality when employing the Quandt Log Likelihood Ratio test on cross country data. It is also worth noting that while Kuznets did not apply empirical analysis to his theoretical framework, there exists a number of empirical studies using a range of datasets with conclusions that echoed with the proposed Kuznets Hypothesis (e.g., Galor & Tsiddon 1996; Jha 1996; Thronton 2001 and Chen 2003).

Another foundational work where a wide range of studies draw inspiration from is the casual link discussed in Adam Smith's *Wealth of Nations*. This particular theory states that in the backdrop the Industrial Revolution, aristocrats of the time seized the opportunity to bring their considerable wealth to bear on manufactured goods and entrepreneurship instead of providing financial support to peasants in return for political leverage; the peasants, without this source of income were turned off the land and starved, whereas the aristocrats gave up their political base and can no longer resist the encroachment of a changing political institutions in their territory. The implication of this change in dynamics had lead to the manufacturers investing their newly accumulated income in physical capital, which spurred economic growth at the cost of increased inequality. At the same time, the peasants, who were no longer favoured by the entrepreneurs and the upper class, lost the financial support but gained political power in return, thus become capable of influencing policies and gradually shifted institutional powers away from the aristocrats for decades to come.

2.4 Causal Mechanisms and Theoretical Studies on the Inequality-Growth Effect

In previous section a brief explanation on how economic inequality can either positively or negatively affect growth was presented. This section will be dedicated to expanding the explanations on the causal mechanisms behind the inequality-growth effect by examining existing literature. A number of theoretical studies on this topic will be presented in chronological order to provide an overview of the dynamics of the theories. It was made clear that inequality can in fact cause an impact on economic growth. The causation can be broken down into several distinct channels, among which the prominent ones will be presented. In addition, it is worth noting that the shift in theoretical consensus observed in the theoretical front are not dissimilar to that found in empirical studies (which this paper will discuss in detail in following chapters), with a few notable changes in popular believes over the course of several decades. While the basic theoretical approach suggests a direct impact inequality would impose on economic growth via aggregate saving, several indirect channels, including those that cross disciplinary boundaries were identified as necessary techniques developed over the years. This literature review notes several major channels where inequality can transmit an effect on economic growth: the direct saving channel, the credit market channel, fiscal policy channel, innovation/entrepreneurship channel, and socio-political stability/democracy channel. We acknowledge the existence of other transmission channels. It is a reasonable recognition considering how the interconnected nature of socio-economic topics can easily cause spill over effect as economic effects emitted by basic transmission channel ripple outwards affecting additional channels. There also exists the issue of the reverse causal effect which is arguably quite prominent and frequently observed in the research of inequality-growth effect. Due to various constraints and concern over project scope the five channels shall remain the main focus in this part of the review.

2.4.1 Direct Saving Channel

The concept of saving driven economic growth has varying implications under different broader models, it can either propel the economy to reaching the steady state under the classical Solow-Swam model, which was notably developed in the same period as the initial studies on the inequality-growth effect (Kuznets 1955), or have a more permanent implication on the economy under the more recent endogenous growth model, where such effect is considered to be correlated to an endogenously driven growth. With that in mind, the remaining part of this subsection will be presenting series of studies that explore the inequality-growth effect via the saving channel.

As noted in the previous section, the earliest work that can be found on the topic of inequality-growth effect was that of Kuznets (1955), whose hypothesis of an inverted U-shaped inequality-growth relationship can be counted as one of the cornerstones for the later development of theories. This hypothesis was expanded by Kaldor (1955). In his work Kaldor identified aggregate saving as a driving factor for the growth effect. Kaldor argues that due to the higher propensity to save, high-income population is more capable of generating investment in the economy and therefore can better facilitate economic growth than the low-income population. With that in mind, one can theorise that under high inequality, the concentration of income and subsequent wealth at the higher echelon of society creates higher aggregate saving, which is then channelled into investment and ultimately push the economy to grow further.

This hypothesis is logically sound in the sense that unevenly distributed wealth allows the excessive wealth held by fewer individuals to be saved rather than having it spent on necessities in a more evenly distributed economy, generating more investment through enhanced capital accumulation via saving. A number of studies, both theoretical and empirical, subscribed to this hypothesis at the time. Empirical studies utilising micro data on household saving were able to reach conclusions that were in support of the theory (e.g., Kelly & Williamson 1968; Ali & Tahir 1999). However, one must be advised that this hypothesis would only function under rather specific conditions. If one is to consider a New Keynesian model, where saving is seen to be negatively correlated to aggregate demand, a higher saving would actually hinder economic growth as it takes away the momentum of demand driven economic growth.

Additionally, the Kaldor hypothesis of direct saving channel relies on the assumption of a closed economy. As it was pointed out in later theoretical studies oriented around open economy, level of investment is affected by saving in a closed economy, whereas open economies would see the impact of saving being funnelled towards balance of payment rather than domestic level of investment. An open economy model would render the direct saving channel hypothesis invalid. This deficiency was pointed out in later investigation of the model. Regardless, the direct saving channel is a sound piece of reasoning overall and should be rightfully taken into consideration.

2.4.2 Credit Market Imperfection and the subsequent unified inequality-growth theory

A theory developed by Galor (2000) presented a hypothesis that incorporated several reasoning and constructed a "unified" model consisted of both positive and negative inequality-growth effects. Galor argues that for low-income developing countries, the aforementioned positive inequality-growth effect through rapid capital accumulation via savings from the rich overshadows the drawback saving would have on aggregate demand in a New Keynesian model. The reasoning behind it is that in an early stage of industrialisation process, the gain in capital via saving takes a more prominent role in pushing economic development. Galor continues to argue that at a later stage of development, as capital stock becomes plenty and creates a rise in the return on human capital investment, increasing its demand in the process. The effect capital accumulation would have on growth would be then outweighed by investment on human capital via education and growth driven by aggregate demand. This is the point where inequality can lead to a negative impact on economic growth because inequality creates barriers for the low-income population to invest in human capital. The poor also have limited capacity for consumption. Furthermore, under this scenario, the low-income population are then left with no mean to conduct meaningful investment in human capital as they cannot provide the collateral that is required for them to participate in loan seeking activities. This proposed scenario was presented in a study by Galor & Zeira (1993), where the concept of credit market imperfection was first introduced. Galor and Zeria used an overlapping generation model augmented with fixed cost of human capital investment and credit market imperfection, to show that the options of the poor in regard to occupational choice and investment opportunity in human capital via education were severely constrained as they are unable to cover the opportunity costs of receiving education, thus entering what the researchers called the "poverty trap" (Galor & Zeira 1993; Agion & Bolton 1997). This can have a direct impact on the quality of the workforce, hindering productivity and diminish the output of human capital and subsequently slow down economic growth.

Galor and Moav (2004) constructed a unified growth model that attempted an intertemporal reconciliation between the two stages of development where the inequality-growth effects shift from positive to negative, when the main drive for economic growth moves from physical capital accumulation to human capital accumulation as a starting economy develop from early stage to industrialised capacity. Note that this unified model mirrors the Inverted U-shaped curve proposal made by Kuznets.

2.4.3 Innovation and Entrepreneurship

Similar to the credit market imperfection hypothesis, an argument can be made to capital accumulation that is not dissimilar to the above theory. Banerjee and Newman (1993) constructed a model where both the rich and the poor are faced with the choice of engaging in entrepreneurship. Banerjee et al. noted that under unequal distribution and credit market imperfections as well as limited marginal return caused by constrained opportunities, low-income individuals may under-invest due to the constraints they face while the rich may choose to over-invest for the opposite reason. Both types of behaviour deviate from the optima and may negatively affect economic growth in a highly unequal environment.

In a very recent study by Yang, Minford and Meenagh (2021) the researchers entertained the concept of individual engaging in entrepreneurship under the framework of a heterogeneous agent model. The authors argue that high-income individuals are more likely to innovate as they possess not only the wealth necessary for innovation and risk-taking activities, but also the time to do so as procuring necessities for survival does not require much effort nor is it time consuming for them. The high-income population's incentive to innovate can play a significant role in pushing for technological progress and the subsequent economic growth. Later empirical testing using UK's data proved the theory to be significant. Yang et al. also stressed that redistribution efforts such as taxation can take away the positive effect on growth at a non-linear rate and the authority would be better advised to consider the trade-off between equality and level of innovation.

2.4.4 Fiscal Policies Channels

The notion that inequality can affect economic growth via fiscal policy is where observations of cross-disciplinary studies begin to emerge. Working in tandem with the aforementioned direct saving channel and the credit market imperfection theory, studies in the fields of political economics argue that under the median voter theory, inequality can cause a shift in preferred policies among the population due to the median voter being located in the low-income spectrum and can thus influence the implementation of said policies, which would then have an impact on economic growth. This theory, developed by Bertola (1993), whose work was supported by Alesina & Rodrik (1994) and Persson & Tabellini (1994), and later expanded by Perotti (1996) was named the endogenous fiscal policy. It is consisted of two components. First one being the political mechanism, describes that under the median voter theory, high inequality puts the median voter in the low-income bracket so that the preference for fiscal policies would favour higher redistributive taxation and redistributive government expenditure (Perotti 1996). This increased demand for redistributive effort can throttle economic growth, as discussed in previous sections. Note that this theory is dependent on the assumption that fiscal policies are dictated by a majority voting process that relied on the voters being perfectly informed and is not subjected to deviation, which only applies in a very thin selection of scenarios. The second component in the endogenous fiscal policy approach is the economic mechanism. It describes the theory that due to the distortionary nature of redistributive taxation and other means of redistribution, upon the implementation of such policies those who possess the means to innovate or to invest in either human capital or capital stock would be discouraged to do so, thus slowing down economic growth (Perotti 1996). In addition, as mentioned in a previous section, the rich faced with heavy taxation would likely seek opportunities to avoid being taxed, engaging in undocumented or unregulated economic activities in the process and consequently create more obstacles for economic growth. With the two components combined, the endogenous fiscal policy approach theorised a definitive negative correlation between inequality and economic growth. It is worth noting that the endogenous fiscal policy approach utilises a similar hypothesis that is also used to argue for a positive inequality-growth effect: the innovative power and the investment capability of the high-income population. Both sides of the argument seem to have reached an unintentional consensus that redistributive efforts would dis-incentivise the rich from engaging in investment or to innovate.

In a recent paper by Gründler and Scheuermeyer (2018) which was backed by the empirical findings from a follow-up study (Gründler 2018), two limitations to the endogenous fiscal policy approach were pointed out. Firstly, it is theorised that the negative effect redistributive methods would have on the incentive to invest or to innovate can be offset by encouraging risk taking activities and entrepreneurship while providing insurance to the risk takers by the government. Secondly, indirect redistributive methods, such as providing public goods and service or the implementation of some form of social safety net, can be utilised by governments to circumvent the negative effects caused by direct redistributive efforts such as taxes or transfers (Gründler 2018). Looking further back, the traditional belief of endogenous fiscal policy approach was challenged as early as in the early 2000s. A round of papers published during that period argued that political power to influence policies was in fact correlated with the wealth one may possess. A number of papers theorised that through lobbying and legislative influencing via campaign contribution or other means the rich is capable of preventing redistributive policies by bringing their resources to bear, overwriting the preference of a lower income median voter. This proposed mechanism would likely scale with the level of inequality, meaning that the rich would possess more legislative power in a more unequal environment. Combined with the credit market imperfection, which increase the difficulties for the low-income population to seek loan or to engage in investment, this can add to the proposed negative relationship between inequality and growth (Barro 1999). This new line of reasoning at the time was widely adopted during the same period and was embraced by a number of theoretical papers on this topic at a later date (e.g., Galor & Moav 2006; Acemoglu & Robinson 2008).

2.4.5 Socio-political Instability and Conflict

Another indirect channel through which inequality may transmit its effect to economic growth is the risk of promoting political and social instability and inciting conflict (Alesina & Perotti 1996; Alesina et al. 1996). Alesina et al. proposed the reasoning that investment can be negatively affected by a lack of certainty in the economic and political prospect of a society as investment typically requires reassurance on the possibility of recovering and subsequent profitability for justification. The researchers continue to argue that one of the primary drives for uncertainty is political and social instability. With that in mind, Alesina et al. make the argument that inequality enhances social division and political instability via several direct or indirect channels. As presented in the endogenous fiscal policy approach, the rich are capable of influencing politics and preventing the implementation of redistributive policies through various means. This can likely cause discontent among the lower income population. Furthermore, political influencing in that fashion is capable of incubating corruption and nepotism, which furthers the impact on social stability as well as reduce the overall competency of the administration. This proposed phenomenon of socio-political polarisation can quite definitively damage government credibility and reliability, thus ultimately create uncertainty, limiting investment and future economic growth (Alesina & Perotti 1996). Inequality, under this scenario can also reduce social mobility and cause low-income or unemployed/unemployable individual to engage in criminal activities, further adds to the degree of uncertainty and instability.

2.4.6 Additional Socio-Political Impact, Crime and Risk of Civil Unrest

Considering the main focus of this literature review is on the topics of economics, the wider impact of economic inequality on other aspects of socio-political landscape will not be featured prominently, however extra-disciplinary studies that are noteworthy will be mentioned to provide an enhanced perspective of the inequality-growth effect.

A number of studies published in the late 1990s argue for a negative correlation between inequality and health. The causal mechanism is fairly easy to understand: higher level of income typically indicates better health condition among the population, whereas high income disparity would suggest a larger group of low-income population being unable to afford healthcare. A number of empirical studies echoed this hypothesis (e.g., Adler et al. 1993; Pritchett & Summers 1996).

The effect of inequality can also be associated with violence and engagement of criminal activities. Similar to the public health concern, the argument for this channel is also straightforward: unemployment, low quality jobs and poor job security tend to sway the low-income population from abiding laws. Inequality has the potential to push the poor into engaging criminal activities while the negative psychological effect and the discontent caused by income or wealth disparity can incite hatred or even violence towards those who possess more wealth. Several schools of theories can be found regarding the causal links between inequality and crime, with some of the notable theories being the Strain Theory of Merton (1938), the Social Disorganisation Theory of Shaw and McKay (1942) and the Economic Theory of Crime by Becker (1968). As per stated at the beginning of this subsection, this survey will not go into detail on these literatures.

In addition to the above-mentioned potential to create crime and social discontent, it is also argued that inequality, under more extreme conditions, has the potential to create civil unrest and political disorder. This is theorised to be more likely to occur in less developed, undemocratic countries with substandard living conditions. Collier and Hoeffler (1998) argue that economic inequality can contribute to the likelihood of an outbreak of civil war.

2.4.7 Section Summary

To sum up this section, various causal mechanisms of the inequality-growth effect are presented in the form of transmission channels. While there are many more channels, direct or otherwise remains unexplored by this literature review, such as international trade, discrimination, social mobility and other channels through which inequality can leave an impact on economic growth, the more prominent and relevant channels are presented and accounted for. Backed by empirical studies, the study on the transmission channels followed a pattern in the shift of consensus throughout the years. Initial studies concluded with positive relationship between inequality and growth via the direct saving channel which was then accepted by a range of early studies. The consensus changed as more recent, diverse arguments were brought to light, such as the credit market imperfection theory, endogenous fiscal policies and inequality-driven innovation and entrepreneurship theory. The diversified transmission channels lead to mixed conclusions as more theories were developed. An attempt was made in the early 2000s to accommodate both the positive and negative inequality-growth effect under a unified model (Galor 2000) to explain varied observations from developed and developing countries, but a universal consensus on how inequality can affect economic growth has been noticeably absent and this lack of consensus would likely to remain, as the research frontier of inequality-growth effect continues to be pushed outward, both inside the field of economics and across disciplinary boundaries. To help better understand the flow of dynamics among the theoretical studies presented in this section, Figure 6.1 depicts a direct overview of reasoning of the noteworthy inequality-growth channels. Four conventional inequality-growth dynamics are shown in the figure: the basic positive saving channel, the fiscal policy channel, the socio-political instability channel, and the innovation and entrepreneurship channel. An unified model containing both positive and negative inequality-growth effect at different stages of economic development is also shown.

From the diagram it is not difficult to reach the conclusion that the logic employed by those who argue for positive inequality-growth effect and those who argue for the opposite are sound and sensible, while which effect overshadow the other remains unclear. In the following section empirical evidence will be presented for both schools of reasoning by adding tangible, empirical evidence into the arguments.

2.5 Empirical Evidence of Income Inequality's effect on Economic Growth

As mentioned in the Overview section, the study of Deininger and Squire (1996) finds no evidence that support the foundational Kuznets Hypothesis and the inverted U-shaped curve, however they did find a correlation between the initial level of economic inequality within an economy and the general level of subsequent growth by assembling an impressively sized dataset of cross-country Gini coefficients as well as other income distribution measurements. This is but one example of empirical studies conducted on the topic of inequality-growth effect that challenged the theoretical frameworks developed by previous studies. Due to the dynamic and unpredictable nature of carrying out empirical studies, their findings are considerably more diverse that the theoretical counterparts. This section presents a survey of the empirics in chronological order to help better understand the academic landscape on the study of the inequality-growth effect.

2.5.1 Initial Studies (Positive effect, pre-1990s)

A sizeable bulk of the early empirical studies after Kuznets' hypothesis argued that economic inequality is in fact growth enhancing (e.g., Kaldor 1956; Cook 1995) under the reason that greater inequality would yield more saving and therefore generate more investment, under the condition of a closed economy and that the wealthy possess a higher marginal propensity to save relative to the poor. Among the conditions the assumption of a closed economy is particularly crucial as an open economy with trade enabled would see saving being funnelled into balance of payment in the form of exports, instead of affecting domestic investment, as pointed out in the theoretical survey in previous chapters. Initial empirical studies on this topic noticeably rely on analytical works based on micro data such as household saving surveys to determine the causal link between inequality and growth, with the work of Kelly and Williamson (1968) being an example. Utilising micro data on the household saving behaviour in an LDC (Less Developed Country, a reoccurring terminology in inequality study, with Indonesia being the country of interest in this case) during the period of 1958-1959, Kelly et al. concluded with a positive relationship between saving and inequality, and therefore reinforced the hypothesis that higher inequality results in more saving and subsequently cause higher economic growth. Additional studies focused on personal saving and inequality (e.g., Houthakker 1961) can be seen being cited by relevant papers. In addition, as techniques in econometrics and analytical study progressed, literatures that employ cross country aggregate data began to surface. Cook (1995) reached a similar conclusion of a positive inequality growth effect by using an aggregated saving rate data collected from 49 LDCs. The finding was in support of the hypothesis proposed by Kaldor.

2.5.2 Early Studies (Negative effect, 1990s-2000s)

Beginning from late 1980s studies concluded with negative correlation between inequality and economic growth became noticeable (e.g., Perotti 1993; Alesina & Rodrik 1994; Persson & Tabellini 1994; Perotti 1996). In this period the employment of the reduced-form equations technique and their estimations via Ordinary Least Squares (OLS) is a common occurrence. A majority of the papers published during this period (the 1990s) had reached the conclusion of a negative inequality growth effect, contradicting previous empirics. It is also worth noting that a considerable portion of the related papers utilised political mechanism of voting and incorporating the median voter theorem into policy making processes such as government spending and taxation, or fiscal policies in general. This practice of fusing democratic process including the median voter theory into economic modelling to determine the link between inequality and growth can be observed frequently, it can also be considered to be a main reasoning behind the consensus of negative relationships between inequality and growth, as mentioned in the theoretical survey in previous sections.

To the best of knowledge, the earliest empirical study can be found that proposed a negative inequality effect on growth dated back to Alesina and Rodrik's work (1994). Alesina et al. constructed a simple two-equation endogenous growth model with inequality in the form of income distributive conflict included as a variable. The authors utilised a multi-national cross section dataset to base their estimations on. After regressing economic growth on the Gini coefficient of 46 countries with different degree of democracy, their finding suggests a negative correlation between inequality and growth for both democracies and non-democracies. Alesina et al. also carried out additional studies (1997) by examining land distribution as a measurement for inequality, also concluded with negative correlative results.

Persson and Tabellini (1994) utilised the OLS estimation accompanied by regional dummy variables to show a strong negative correlation between income inequality and economic growth. However, Tabellini et al. noted in their study that the inclusion of the regional dummies had reduced the significance of the effect, meaning that the effects discovered become less pronounced when regions are examined in isolation, potentially demonstrating bias. Also using the OLS method, Perotti (1996) concluded that inequality is positively correlated with fertility rate and negatively with investment in human capital via education, which suggests a strong negative impact on growth, since higher inequality would mean higher fertility and lower investment in education which are considered to be signs of staggered economic growth. This finding echoes the theoretical proposal developed during the same period, as mentioned in previous sections. It is worth pointing out that Perotti's finding is only statistically significant in developed countries that typically have higher income, functioning democracies and higher degree of social stability. Similar to the findings of Tabellini et al., Perotti observed a weakening in the inequality-growth effect when regional dummy variables are included. A later study by Alesina and Perotti (1996) conducted as a follow-up to previous research employ a similar method but on a larger sample of 71 countries. Robust results that were similar to previous findings were produced, suggesting a negative relationship between inequality and political stability. Combined with the finding that political stability is negatively correlated with investment which leads to slowed growth, they concluded that economic inequality is evidently having a negative impact on economic growth. The researchers argued that the findings coincide with the behaviours of a number of politically stable East Asian countries that were experiencing rapid economic growth (at the time of research) and their effort of implementing policies to reduce income and wealth inequality. Alesina et.al also compared said countries with their South American counterparts, noting the disparities in political stability and similarities in income level.

The findings as proposed by Alesina et.al can be explained in several ways. Firstly, under the median voter theory, greater economic inequality would lower the income of the median voter, thus shifting policy preference towards favouring redistribution. This would lead to higher preference towards distortionary taxation. Combined with the hypothesis that inequality creates social and political instability which would discourage investment, lower economic growth can be expected.

To attempt to sum up the studies of this period, nearly all of the studies cited above employed the Ordinary Least Square estimation or variants on cross country data. Most of them reached similar conclusions, that being a robust negative impact of inequality on growth. This is in conflict with theoretical studies conducted in early years but echoes the theoretical frameworks developed in the same period. These studies differ themselves from each other in several ways. Their samples are consisted with different cross-country data in numbers of observations and the periods when these observations were taken. Measures of inequality also differs, with two typical measurements being used: the Gini coefficient and the share of the fourth quantile. These two are most common amongst studies of the time, while some other forms of measurement such as share of third and fourth quantile and the Theil index were also used.

2.5.3 Criticisms and Subsequent Studies (2000s)

Literatures being critical of early studies surfaced after the turn of the century as challenges to the conventional belief of negative inequality-growth effect began to emerge. To cite the survey conducted by Neves and Silva (2013), major criticisms of the previous period of studies can be summed up in three distinct categories: Criticism on the quality of data; Criticism on the emphasis on income inequality and Criticism on the usage of cross-sectional data.

A number of literatures published in late 1990s and early 2000s criticised the quality of dataset from previous studies. Deininger and Squire (1996) argued that the lack of household surveys and the reliance on national statistics accounts accompanied by the insufficient income measurement had been one of the major flaws from early studies on the inequality-growth effect. Deininger et al. stated that the existence of non-wage income such as family production and other means were often ignored in the data gathering process, as well as flaws in coverage would subject studies based on these datasets to criticism. With that in mind Deininger et al. assembled a dataset of considerable quality, consisted of data collected from 693 observations across 108 countries on an annual basis since 1950. This dataset was later used by a large number of empirical studies and was constantly augmented and added upon by different sources, with the United Nations University – World Institute for Development Economics Research being one of the major contributors. In a later paper by Deininger and Squire (1998) they tested the dataset using the OLS estimation and reached a result that is not significantly different than previous studies. The researcher also observed a similar drop in statistical significance when regional dummies were introduced to the estimation, a reoccurring curiosity that can be found in a large number of studies.

In the same paper Deininger et al. also criticised previous studies' reliance on income distribution as a measure for inequality. Deininger et al. argued that land distribution should be used as an alternative to income distribution as the measure for inequality. Based on this hypothesis Deininger and Squire (1998) used land distribution instead of income distribution in their study and found a negative inequality-growth effect for LDCs that is significant even with the inclusion of regional dummies. This is not in support of the Kuznets Hypothesis.

Thirdly, there has been debates on the conventional usage of cross-sectional data and the merit of panel data as an alternative. A number of studies were carried out using panel data during the turn of the century (e.g., Li and Zhou 1998; Forbes 2000; Barro 2000 and Deininger & Olinto 2000). In Forbes' work (2000) the researcher summed up the benefit of using panel data in two ways: firstly, the adaptation of panel technique allows the researchers to control time-invariant effects that are specific to each country and are often unobservable in cross-country datasets. This allows the researcher to circumvent omitted variable bias that may occur during estimation. Secondly, Forbes argues that as opposed to cross-sectional data, panel data is able to capture via estimation how a change in level of economic inequality can affect the economic growth of a certain country. In addition to the above argument, Forbes (2000) used the First difference GMM method on a panel data of income distribution of 45 countries over the period of 29 years to estimate the inequality-growth effect and reached the conclusion of a positive correlation between inequality and economic growth for median to high income countries. The findings echo that of Li and Zhou (1998), where the researchers employed the fixed effect/random effects estimation on the same dataset assembled by the aforementioned, ground-breaking work of Deininger and Squire (1996). Note that while Both Li & Zhou (1998) and Forbes (2000) reached similar conclusions, the positive correlation found in Li and Zhou's study (1998) applies to the whole sample of 46 countries of mixed income level, whereas Forbes' finding (1998) only holds true for mid to high-income countries.

As mentioned at the beginning of this subsection, a more diverse range of studies with conflicting results were published during this period, after panel data techniques and Deininger & Squire's dataset became more widely used. There was no consensus regarding the conclusions drawn from empirical studies. As opposed to Li & Zhou (1998) and Forbes (2000)'s findings, a study conducted by Deininger and Olinto (2000) used GMM methods to estimate the panel data of both land and income distribution for 60 countries over a period of 24 years and reach a negative correlation between inequality in terms of land distribution and growth, and a positive link between a simultaneous inclusion of both land and income distribution as measures of inequality and economic growth. Barro (2000) used Three-stage Least Square estimation on panel data of income distribution for 84 countries over roughly the same period and concluded that the inequality-growth effect is positive in high income countries and negative in low-income countries. The results became statistically insignificant once both high and low-income countries were included as a whole. All the studies cited above drew their data from the Deininger and Squire dataset, which used the Gini coefficient as its measurement for inequality. This fact stands as a testament to the contribution Deininger and Squire had brought to the study of inequality-growth effect.

Neves and Silva (2013) hypothesised in their literature survey that the diverse findings of literature published in that periods can be explained in three possible ways. Firstly, considering the significant weakening effect regional dummy variables had on earlier studies it can be theorised that inequality's effect on economic growth could be vastly different across countries. Since panel data allows the capture of time-invariant nationally dependent variables that cannot be observed in conventional cross-sectional data, it is not difficult to contribute the diverse findings displayed in studies to the utilisation of panel techniques. Secondly, considering conventional studies employed cross section data with typical gap of 25 years in growth rate observations, panel data, including the Deininger and Squire dataset has a much shorter period gap of 5 years. This could also be a contributing factor as long-run inequality-growth effect may very much differ from the short-run effects. Neves et al. cited the work of Knowles (2005), arguing that it is not unreasonable to speculate that various factors in play due to inequality and subsequent effort of redistribution take effects in different time frame. For instance, the effect inequality may have on political and social stability may take longer to materialise than the impact on incentive to invest or save. Thirdly, the methods of estimation in empirical studies may differ according to the type of data used. While it is typical for cross-sectional studies to employ OLS estimation, panel data estimations are more varied. The panel studies cited earlier utilised a wide range of estimations, namely GMM, fixed effect/random effect, and 3SLS.

Furthermore, it is also noteworthy that the usage of panel techniques also has several significant drawbacks. One of these drawbacks is identification problem and the risk of reversed causal effect. As shown in the above survey several studies reported significant weaker results when additional control variables (often in the form of regional dummies) were introduced. Reversed causal effect is a particularly notable issue in the study of inequality-growth effect because of the dual relationship between the two subjects. Growth can just as easily cause an effect on the level of economic inequality than the reversed relationships, which is being discussed in this review. This issue is pointed out in a number of studies of the time, but many researchers choose to not directly engage this issue until more recently with the help of advanced modelling techniques.

During the survey of the literature we note that when examining panel data that contains a mixture of developed and developing countries that are otherwise not comparable in their economic and socio-political conditions, potential findings may be overshadows by larger, more pronounced effects in the empirics. This may have been present in a series of papers that we reviewed. To address this potential bias, we therefore propose to carry out multiple rounds of estimations on different groups of samples, specifically by grouping developed and developing countries separately to isolate any distinctive effects.

2.5.4 The 2000s

Empirical studies on the inequality-growth effect after the previously mentioned period build on top of the diversified approaches developed during that time and embrace a much more flexible viewpoint while challenging the conclusions derived from earlier studies. A significant trend for this period is that literature tend to display an interchangeable attitude regarding how inequality can affect growth differently under varying conditions. Note that some earlier research has already theorised this viewpoint, namely how the inequality-growth effect differs between high-income, well-developed countries and low-income, developing countries (Barro,2000) and how merging the two categories of countries could significantly weaken the results.

To the best of knowledge, Galor (2000) was the earliest to make an attempt to reconcile the conflicting findings by constructing a unified model that satisfies both schools of thoughts under varying circumstances. Galor's work, while not empirical, set the framework of a "unified model" that accommodates different environments that could lead to positive or negative inequality-growth effects. The period between 2000 and 2010 also saw an increased diversity in datasets used by various studies. While a sizeable portion of literature still employed Deininger and Squire (1996)'s dataset, the usage of alternative datasets became noticeable, namely World Institute for Development Economics Research's dataset on world income inequality can be seen in a number of studies (Bleaney and Nishyama 2004; Castelló 2010; Chambers and Krause 2010). Other datasets such as Penn world table (version 6.3, Herzer and Vollmer, 2012) can also be seen.

It is worth noting that the studies published within this period overwhelmingly favoured negative correlation between inequality and growth, with rare exceptions such as Castelló and Domenéch (2002), Voitchovsky (2005), Bengoa and Robles (2005), the works of whom concluded with positive relations under specific conditions, namely within high-income developed countries (Voitchovsky 2005; Bengoa and Robles 2005) or using human capital distribution instead of income distribution as measurement (Castelló and Domenéch 2002). There are several other notable studies during the period.

For country-specific studies, Ali & Tahir (1999) and Cheema & Sial (2012) carried out studies of inequality-growth effect in Pakistan and concluded with positive correlations between concerned variables. Similar positive relationships were also discovered by Wodon (1999) for Bangladesh where the researcher also found that the positive inequality-growth effect is significantly higher in urban environment and in the case of Bangladesh while economic growth saw a considerable reduction in urban poverty, the level of inequality was widened as well. In addition, Deolalikar conducted research of a similar manner for Thailand and a number of other South-eastern Asian countries (2002) and reached comparable results.

A behaviour of inverted-U-shaped relationship between inequality and growth, similar to that proposed by the Kuznets Hypothesis was found by Chen (2003), who considered the possibility of a non-linear inequality-growth effect. Chen conducted an OLS estimation of growth on Gini coefficient and squared Gini coefficient, using cross-sectional data of income distribution in 42 and later 69 countries over a period of 22 years and reached the above conclusion. Further studies that entertained the notion of non-linear inequality-growth effect include that of Banerjee and Duflo (2003). After regressing growth on Gini coefficient as a measure of inequality using panel data, Banerjee et al. concluded that any deviation from current inequality would result in staggered economic growth, be it an increase or decrease in inequality.

One noteworthy similarity observed in literatures that concluded with negative correlations was that while estimations show statistically significant results, a number of studies have shown statistical insignificant or inconclusive results when the methods were applied to developed and high-income countries, or when no distinctions between rich and poor countries were made (Knowles 2005; Castelló 2010). This observation is suspected to coincide with the reoccurring phenomenon in early studies where regional dummies render the estimation results statistically insignificant.

2.5.5 Recent Publications (2010s-present)

The following period continued the previous trend of diversified research methodologies, origin of data and subsequent outcomes. Notable empirical studies include Ncube et al. (2014), Halter et al. (2014), Kolawole et al. (2015), Bagchi and Svejnar (2015), Kennedy et al. (2017), Iyke and Ho (2017), Krueger (2018) and most recently Baek (2018). While most of the above studies utilised methodologies that are not dissimilar to that from previous periods, a noticeable trend among these publications is a stronger, localised emphasis on LDCs, with the work of Ncube et al. (2014) focused on the Middle East and North Africa and that of Kolawole et al. (2015) being based in Nigeria. Both of the studies used OLS for their estimations and income distribution as their measurements. Ncube et al. employed cross-country data for the region of interest while Kolawole et.al used time series data on one specific country.

The above-mentioned studies did not share a consensus regarding the inequality-growth effect. Ncube et.al (2014) found a negative overall effect between inequality and growth while certain channelled effect of inequality can in fact enhance growth. Halter et al. (2014) proposed to examine the inequality-growth relationship with consideration of different time horizons. After conducting GMM estimation on a set of panel data they concluded with a short-term positive effect and a long-term (overall) negative inequality-growth effect. Bagchi and Svejnar (2015) incorporated a factor to conventional methods to account for politically connected billionaires' wealth as a measure of inequality and an instrument variable (accompanied by a second IV, the exchange rate) in a panel of 26 countries over a period of 15 years. The researchers discovered statistically significant negative inequality-growth effect. Bagchi et al. also noted that when political connections of billionaires were taken into consideration via corruption, politically unconnected wealth inequality, income inequality and initial poverty's effect on growth were weakened to the level of non-significance. Kennedy et al. (2017) examined panel data from Australia with the adaptation of distribution of human capital and income distribution as measures of inequality. Concluding evidence suggested that inequality, derived from taxation statistics and income distribution, can affect economic growth negatively after a lag of several years. Kennedy et al. noted that their finding coincides with previous findings for developed regions in North America and Europe. Iyke and Ho(2017)'s study in Italy is in support of the findings. In the theoretical paper by Yang et al. (2017) the researcher entertained the concept of innovation and entrepreneurship driven by the high-income population which facilitates growth under a heterogeneous-agent growth model. The subsequent empirical testing on quarterly data collected in the UK proved the hypothesis to be robust that suggests a positive inequality-growth effect, and a greater effect in the long run. Both Krueger (2018) and the most recent Baek (2018) argued for flexible inequality-growth effect under different conditions. Specifically, Baek's finding (2018) suggests a N-shaped curve of relationship between inequality and economic growth, partially in support of Kuznets hypothesis of inverted U-shaped curve.

From this point it can be argued that considering the increased quantity of mixed findings form most recent literatures and the trend from the early stages of inequality-growth research going forward, a new consensus is in the process of forming where the impact of inequality would have on growth is believed to operate in different fashions, depend on specific factors, such as the stage of development countries in question are currently in, the region of the economy in question as well as other socio-economic factors. It can be assumed that the diversification of findings in the field of inequality-growth research will likely continue as newer research and analytical techniques develop. New theoretical frameworks being published can also facilitate this growing trend.

2.5.6 Section Summary

To sum up this section, a clear flow of changes in the general consensus within the academia regarding the causal link between economic inequality and growth can be observed. From the initial studies with limited empirical evidence, it was theorised that inequality could positively affect economic growth as per Kuznets Hypothesis, which was backed by a number of empirical literatures published in later years. As time moved forwards towards 1990s, consensus of a negative inequality-growth effect was reached, with literatures that commonly employed cross-sectional data and OLS estimations. The dataset used during this period was later challenged, which led to the assembly of the widely used dataset of Deininger and Squire. Studies became increasingly diversified at the turn of the century, which saw the usage of panel data as substitute to cross-sectional data and alternative estimations to the OLS became more common, as did the findings with a number of studies that concluded with positive inequality-growth effect. Flexible or inconclusive findings also emerged during that period. The trend established during the time saw further development in subsequent years as more specified and diversified studies being carried out, as advanced techniques for empirical analytical work and theoretical frameworks began to be developed. This period also saw an increase in country-specific studies being carried out, partially replacing the old convention of utilising multinational datasets. One shared finding of the period is that the inequality-growth effect tends to be negative for developed, high-income countries while being positive for less developed and low-income countries, which coincides with the initial hypothesis of an inverted U-shaped curve proposed by Kuznets over a half of a century ago. Table.1 provides a compiled list of cited literature within this section to provide a better overview of research and their respective methodologies as well as their findings.

2.6 Secondary Effects: Recent Studies on Growth, Inequality and Institutional Effects

In this section we examine a series of contemporary literature that explored the relations between the three critical aspects: institutions, innovation and inequality, and the interactions between these aspects and their overall impact on growth, where applicable. This is presented as complementary to the main body of the literature review sections and serves as additional context to the academic landscape surrounding this topic.

2.6.1 Innovation-inequality Effects

There exists an extensive literature that explored the links between innovation, institutional quality (or institutional development), inequality and the implication on economic growth. While one can argue with confident that technological innovation, whose effects are often combined with those of human capital accumulation can be growth-enhancing, conventional wisdom, both theoretically and empirically, divide over the causal links between innovation and inequality. The causal links become more unclear when one is to consider the many channels that involve innovation in the form of entrepreneurial activities or institutional establishment under the context of the inequality-growth nexus. A sizable literature of empirical nature point towards a negative relationship between level of innovation and income inequality (i.e., higher innovation activities in terms of productivity gain reduces income inequality) but fail to factor the institutional context or other aspects. We identify a series of recent literature for this review that are deemed to be relevant, both in terms of area of focus and techniques.

It is commonly argued that innovation as a drive for productivity gain and technological progress, which are some of the basic determinants of economic growth, can impact the distribution of wealth in an economy. The reverse causation effect in this dynamic would likely to be equally prevalent. As one is set out to explore the innovation-entrepreneurship channel in the inequality-growth nexus, the effect between innovation and inequality cannot be ignored.

As stated above, a number of papers in the selected group that examine the innovation-inequality effect conclude with a negative relationship between innovation activities and inequality (e.g., Antonelli & Gehringer 2013; Benos & Tsiachtsiras 2019; Adrián Risso & Sánchez Carrera 2019, Santamaría 2019) while studies conducted in Europe or otherwise developed regions contest this finding (e.g., Aghion et al. 2018). Reverse causation is found in a paper examining the inequality-innovation effect (how does inequality affect innovation activities) suggesting innovation causes inequality in selected regions (Teslios, 2011), which again contradict with the first group of studies.

From a theoretical point of view, innovation activities can assert a negative effect on inequality (improving equality) through the increase of real wage and subsequent saving-driven capital growth. Following the Schumpeterian framework, regular innovation in the sense of technological change induced by entrants and competition can promote the destruction of monopolistic rent brought by previous technological innovation. Schumpeter argues that fast technological change can reduce income inequality while a slower pace encourage monopolistically rents and the reinforcement of barrier to innovation imposed by the incumbent. This line of reasoning is often cited to argue for a negative relationship between innovation and inequality.

In the paper by Antonelli and Gehringer (2013) the researchers adopt this argument in the constructing the hypothesis that innovation can induce economic growth through gain in productivity, which in turn increases labour productivities and wage and ultimately reduces income inequality through a combination of the above-mentioned mechanics and widened competition. The combined mechanism echoes that of the inequality-growth nexus which invokes the effect of entrepreneurship on economic growth and inequalities. The researcher tests the hypothesis with the following empirical model:

$$Ineq_{it} = Tech_{it} + inv_{it} + GDPcap_{it} + gov_{it} + FI_{it} + \gamma_t + \varepsilon_{it} \tag{2.1}$$

Where income inequality is dependent on technological change, investment, GDP per capita, government expenditure and international financial integration, respectively. They adopt a fixed-effect panel technique using a dataset consisting of samples from a number of developed and developing countries between 1995 and 2011. The specific usage of observations are as follows.

The main dependent variable, income inequality is measured by the Gini index from Eurostat and World Bank Development Indicators database, an immensely popular database in related research. The researcher refers to the WIPO for the number of patent applications made each year, national phase entries. Measurements for government spending in percentage to GDP and trade openness are referenced from the Penn World Tables. GDP per capita and investment variable are from The World Economic Outlook. Lastly, the researchers referenced the work of Chinn and Ito (2008) for the measurement of financial integration. The specifics of this variable do not hold interest for the project at hand. Technological variables are instrumented with their first and second lagged observation. This procedure is consistent with a number of other studies as technological is typically believed to have a lagged effect on the economic system. The empirical results point towards a strong inequality-reducing effect from the technological variables, with EU countries seeing stronger effect. The researchers argue that this may be due to the institutional framework present in the EU countries.

Similar conclusions are reached in the study by Benos & Tsiachtsiras (2019) who employ fixed effect panel studies with a database consisted of annual observation from 29 countries between the year of 1978 and 2016. The following empirical expression is used for the estimations:

$$Log(y_{it}) = A + B_i + B_t + b_1 log(innov_{i(t-1)}) + b_2 X_{it} + \varepsilon_{it} \tag{2.2}$$

The dependent variable y_{it} is the measure of inequality, which the equation takes the logged form. A, B_t and B_i are the constant, year (time) and country fixed effect, respectively. Measure of innovation has one-year lag and is also logged. For inequality measurement the Gini index variant is used with the smallest standard deviation from the Standardised World Income Inequality Database. For measure of innovation the researchers cited The Science, Technology, and Innovation Microdatalab of OECD, from which they extracted both quality and quantity measures of innovation on EPO patents. The OECD Patent Quality Indicators database is also cited and the OECD REGPAT database. The control variables are extracted from the World Bank Database, which includes domestic credit financial sector as a percentage of GDP), general government final consumption expenditure as percentage of GDP as indicator for government size, GDP per capita and unemployment rate and population to indicate business cycle. One deems it worth noting that the researchers employed five measures of innovation for separate analysis. The empirical findings suggest similar reduction in personal income disparities with innovation, in support of the work presented prior. By adopting IV analysis, reverse causation between innovation and inequality is rejected with charges for the use of intellectual property receipts and links between citing and cited patent as instruments.

In a recent paper by Santamaria (2019), the researcher examines the same combination of dynamics between inequality and innovation in the sense of investment in research and development under the European context. The researcher employs a similar regression procedure to the previous two studies, that being a cross-country panel data analysis. The regression model featured in this study is as follows:

$$Log(ineq_{it}) = \alpha_n X_{it} + \beta_n Y_{it} + \gamma_n Z_{it} + \delta_n S_{it} + \mu_{ni} + \varepsilon_{it} \tag{2.3}$$

Three variants of the model are invoked: $n = 1, 2, 3$ each corresponding to a measurement of inequality, that being the Gini coefficient after social transfers, S80/S20 ratio and Top 10 percent income share, respectively. The independent variables are innovation institutions, social protection variables, labour market institutions, vector of control composed by other determinants of inequality and country fixed effects, respectively. To proxy the innovation institutions X_{it} the researcher constructs a composite index as the measurement for innovation. The expression is shown as equation(2.4):

$$Inno_{index} = (Broadband_{norm} + R\&D_{norm} + Pat_{norm} + Perso_{norm} + ECI_{norm})/5 \tag{2.4}$$

Where $Broadband_{norm}$ measures Broadband subscription per 100 people, a proxy for ICT connectivity condition, $R\&D_{norm}$ is research and development expenditure as percentage of GDP, Pat_{norm} Patent application per million of active population as measure for technological performance, $Perso_{norm}$ is *R&D* personnel and researchers as percentage of total labour force and lastly ECI_{norm} is the economic complexity index, which measures the knowledge intensity of an economy by considering the knowledge intensity of the exporting products. Refer to the Observatory of Economic Complexity for detail. All variables are normalised. Y_{it} is social protection. It is measured by the accumulated growth rates of aggregated yearly mean of social protection expenditure as a percentage of GDP. Z_{it} are labour market institutions, which is measured by union density and collective bargaining. The researcher notes the scarcity of data available in this area.

The empirical findings indicate a strong negative relationship between innovation (and innovation institutions) and inequality regardless of development grade of the economy or inequality indicator. The researcher further notes that social protection plays a role in the differences between inequality rates between countries, as higher social protection expenditure tends to be observed in more advanced and less unequal countries. Overall findings of this study are in support of the general belief in around this topic.

2.6.2 Institutions-growth Effects

In a recent paper Acemoglu et al. (2019) empirically re-examine a conventional belief, that democratic society can positively impact GDP per capita. The researchers approached this topic with panel data technique which is set to control country specific fixed effects and GDP dynamics. The researchers also introduced a new index for democracy.

The researchers start off by pointing out that recent literature (that is, up until this publication) has somewhat been led away from a positive democracy growth effect due to recent political and economic event such as the economic stagnation in countries after democratisation effect of the Arab Spring, and the tremendous growth experienced by China, a single-party state. The researchers argue against this trend. The argument is presented early in the paper that flaw may exist in prior studies in terms of measuring democracies, specifically the flaw in democratic indexes, as the researchers brought forward the argument that these existing indexes suffer from measurement error and bias which lead to scores that do not represent actual state of the democratic institutions.

Acemoglu et al. construct an unbalanced panel dataset consists of observations from 175 countries with sample taken from 1960 to 2010. The index for democracy is a composite index which contains observations from several datasets, that include Freedom House and Polity IV, with the latter being a prominent dataset that this researcher intends to utilise. The researchers assign code to countries as democratic or non-democratic based on the combined observations of the above indexes and refer to existing studies when such combination is not applicable. The democracy variable is set to be dichotomous meaning that the index takes one out of two possible value to indicate whether a country at a given time is democratic.

For other variables, log GDP per capita (extracted from the World Bank Development Indicators) is selected as the main dependent variable. A series of other variables are also included in the regression, which includes investment, trade exposure, education measured in enrolment in secondary and primary school and more. Acemoglu et.al then go on to construct the panel model. The panel analysis consists of three stages, the baseline model, IV estimation and the inclusion of additional channels. Equation (2.5) describes the baseline model:

$$y_{ct} = \beta D_{ct} + \sum_{j=1}^{p} \gamma_j y_{ct-j} + \alpha_c + \delta_t + \varepsilon_{ct} \tag{2.5}$$

Where log GDP per capita for country c at time t is denoted as y_{ct} and is dependent on the measure of democracy for country c at time t, D_{ct}. Country-specific fixed effects α_c, and year fixed effects δ_t are included. $\sum_{j=1}^{p} \gamma_j y_{ct-j}$ is the lag term for GDP to examine the long-term effects. Regression results show strong and significant coefficient for democracy variable under the baseline model.

In the second stage the Arab Spring is cited to argue for a regional effect of democratisation, and potential wave effects of political transition. Based on this argument the Acemoglu et al. propose to instrument democracy with the regional effect, the expressions of which are shown below:

$$D_{ct} = \sum_{j=1}^{q} \pi_j Z_{ct-j} + \sum_{j=1}^{p} \phi_j y_{ct-j} + \theta_c + \eta_t + \upsilon_{ct} \tag{2.6}$$

Where:

$$Z_{ct} = \frac{1}{|I_c|} \sum_{c' \in I_c} D'_{ct} \tag{2.7}$$

From the above equations, one may take note that democratic indicator D_{ct} is now instrumented with another expression with lagged GDP per capita $\sum_{j=1}^{p} \phi_j y_{ct-j}$, country and time fixed effect θ_c and η_t, respectively, and the instrument variable Z_{ct}, with takes the form as shown above. Z_{ct} is the average democracy indicator in the region for countries other than country c. In this way whether a country is democratic is now dependent on the democratic landscape of the region rather than staying exogenous, which is a sound assumption. The subsequent first stage and 2SLS estimation conclude with significant and strong effect of democracy indicator, which coincide with the baseline estimation. The researcher also acknowledges that with similar results being produced in two different methods of estimation the hypothesis is reinforced as a result. Lastly, a series of additional mechanism is introduced through which democracy may have an impact. This includes most of the variables listed in the table above. Now the regression model takes the form:

$$m_{ct} = \beta D_{ct} + \sum_{j=1}^{p} \gamma_j y_{ct-j} + \sum_{j=1}^{p} \eta_j m_{ct-j} + \alpha_c + \delta_t + \varepsilon_{ct} \tag{2.8}$$

Where the dependent variable is now one of the several potential channel, which include share of investment in GDP, TFP, economic reforms, education, child mortality and social unrest indicator. Subsequent analysis shows that being a democracy would have a positive impact on the likelihood of economic reform, tax revenue share, education, and child mortality. The finding suggests the existence of multiple channel implication of democracy, as supported by common sense and conventional belief.

Boudreaux (2019) argues the growth-enhancing property of entrepreneurship and institutions can only be found in developed countries after examining the role of both entrepreneurship and pro-market institutions on growth, a finding that is supported by the work of Galindo-Martín et al. (2019) and Bosma et al. (2018). The inequality effects are left out in these studies. Broadly speaking, institutions are commonly examined as a cause for indirect growth and inequality effects, often occurring alongside with those induced by entrepreneurial or financial activities. Another group of studies employs the panel threshold technique to examine the growth effects of various determinants, with institutional quality acting as the threshold variable (e.g., Aluko et al. 2020; Ruiz 2018 and Abdulahi et al. 2019), which concludes that a high level of institutional quality is the requirement for economic growth.

2.6.3 Institutions-inequality Effects

In a paper by Amendola et al.(2010) the researchers examine the relationship between inequality and the development of institutions in developing economies. By employing both panel and cross-section techniques with samples from middle-to-low-income economies in Africa, Asia and Latin America the researchers are able to determine that redistributive implication as an indicator for inequality can be seen as having a negative link with the level of property rights protection: Strong enforcement of property right can evidently increase income inequality, the effect of which is more pronounced in samples with low level of democracy. The researchers argue that the build-up of institutions in developing countries contributes to an increased concentration of wealth distribution, as the wealthy and politically powerful are able to exploit opportunities that are otherwise not available to the rest of the population to accumulate and guard increasing returns protected by institutions. This argument coincides with conventional belief that economic institutions are designed to protect the interest of the privileged elites. The researcher also notes that political institutions in the form of democracy can weaken the negative impact of the institution-inequality channel. Four variables are employed in the benchmark OLS regression, with the average inequality index being the dependent variable to capture the proposed impact, political institutions measured by the level of democratisation, economic institutions i.e., property right protection and control variables including regional dummies and other long-run inequality determinants (economic development, economy of scale effects and their iterations). The researchers construct the empirical framework to accommodate for both cross-sectional and panel analysis. The following equations describe the model:

$$ineq_{i,t,t-1} = \beta_0 + \beta_1 I_{i,t,t-1} + \beta_2 Q_{i,t,t-1} + \beta_3 \left(Q_{i,t,t-1} \cdot I_{i,t,t-1}\right) + X'_{i,t,t-1}\varphi + \varepsilon_{i,t,t-1} \tag{2.9}$$

$$ineq_{it} = \beta_0 + \varphi ineq_{i,t-1} + \beta_1 I_{it} + \beta_2 Q_{it} + \beta_3 \left(Q_{it} \cdot I_{it}\right) + \sum_{n=1}^{k} \varphi_n \cdot X_{it,n} + \mu_i + \lambda_t + \omega_{it} \tag{2.10}$$

Equation (2.9) is iterated from a baseline function with no interaction between the two main variable, I_t and Q_t, which stand for level of democratisation and level of economic institutions, respectively. By including a lagged dependent variable as well as explanatory variables from the previous period one may capture the long-term effects of the variables of interest and also attenuate the reverse causal effect as the variables are now intertemporal. The term $\left(Q_{i,t,t-1} \cdot I_{i,t,t-1}\right)$ allows for interaction effects between the two main variable, I_t and Q_t. By adding this term, the researchers add a partial effect of economic institutions that is conditional on the political institution. This can be expressed in the following first order condition:

$$\frac{\partial I}{\partial Q} = \beta_2 + \beta_3 I_{i,t,t-1} \tag{2.11}$$

This first order condition implies that the effect of a change in Economic institutions on inequality would not only depend on the estimated effect β_2 but also the value of political institutions, or rather the averaged value of it. The combined effect on inequality would be set to unit change in economic institutions when $I_{i,t,t-1}$ is set to zero. Regarding the sign of the coefficients the researchers argue for a positive β_2 and a negative β_3. This argument is consistent with the aforementioned hypothesis. A negative β_3 implies that the combined effect of political and economic institutions reduces inequality.

For equation (2.10) which is used in panel estimation, a fixed effect estimator μ_i for country i are introduced to examine the country-specific fixed effect. λ_t denotes the time-specific effect and error term is denoted as ω_{it}. Furthermore, the researchers argue for a persistent inequality variable in the regression in the form of a lagged dependent variable. The above concludes the empirical setup. The remaining part of this section will touch on the data used in this study.

As stated in previous sections, a number of datasets are used to construct the database used in the analysis. The dependent variable is set to be measured by Gini coefficient of disposable household income, extracted from World Income Inequality Database (WIID). Economic institutions, or property right protection is measured by the Legal structure and security of property right score, extracted from the Fraser

Economic Freedom Index. The significance of the subjectivity of this index is noted. Political institutions are measured by a combination of two variables extracted from the Vanhanen index. The specifics of this operation are shown in the table of variables below. Lastly, several control variables are included, which includes share of agricultural land occupied by family farms (to measure land and asset inequality) by Vanhanen. Several additional variables are employed from the World Development Indicators, including GDP per capita, annual inflation (CPI) and the ratio of monetary aggregate M2 on GDP.

Cross-sectional results show initial insignificance of the economic institutions coefficient, which becomes significant when the interaction term between political and economic institutions is included, displaying significant coefficients for both β_2 and β_3. Subsequent cross-sectional analysis shows result that coincide with the original hypothesis, that a positive relationship between property right enforcement and inequality. Overall, the results suggest that higher income inequality can be observed in countries with high property rights protection. The effect is shown to be larger when the combined effected is considered, meaning that in countries with low democratic score inequality is observed to be higher with increased property right protection. This supports the initial hypothesis. Panel study echoes the findings of the cross-sectional results. The study shows diminished but still significant effect between property right enforcement and inequality. Inequality is seen to increase with greater property right protection. Democratisation attenuates this positive effect. This finding is supported by the work of Ouattara and Standaertb (2020) as they note, property right protections under the oversight of democratic institutions can reduce inequality via redistribution efforts.

2.6.4 Section Summary

In this section we examine a series of recent studies to assess the inequality and growth determining effects of innovation and institutions. As described in numerous transmission channels formulated via either theoretical frameworks or empirical explorations, institutions are said to play a non-insignificant role in contributing towards growth and changes in inequality. Similarly, innovations alongside with entrepreneurship and productivity altering economic activities are also shown to possess growth and inequality changing effects. We establish that economic institutions in the form of property right protection and enforcement can encourage innovation and entrepreneurial activities, as those who engage in said activities would be incentivised to do so if their economic gains can be safeguarded against expropriation and unwarranted exploitation. This would also have the effects of increasing inequality, as the concentration of wealth would lead to more innovation and entrepreneurship, which in turn lead to higher concentration of wealth. Political institutions, on the other hand, is shown to have a dampening effect on the process. While this line of thinking is intuitive and not without empirical backing, innovation is also said to have an inequality-reducing effects, as demonstrated in some studies where innovation would lead to increased labour productivities, boosting economic growth while increasing labour wages and thus reduce wealth gap.

2.6.5 Reversed Causation: the Growth-Inequality Nexus

While inequality may affect economic growth through a wide range of transmission channels, both economic and socio-political, the reversed effects are equally prominent. The growth-inequality nexus [1] outlines how economic growth and development may have an impact on inequality. This topic is of par-

[1] Not to be confused with the inequality-growth nexus, which is the focus of this thesis.

ticular interest to economists focused on the field of development, especially concerning the effects on poverty and regional development. One intuitive onlook suggests that if growth is distributed equally than household income would grow at the same rate, benefiting the high-income households considerably more than their low-income counterpart, thus increasing inequality. This is quite a basic reasoning, and the literature offers insight into more extensive transmission channels.

Fosu (2015) explores the inequality effects of growth and the effectiveness of Sub-Saharan Africa's effort on growth led poverty reduction and find mixed results in Sub-Saharan Africa countries relative to other comparable developing nations. The author argues that low income may have been the inhibiting factor that limits the effectiveness of income growth in reducing inequality and poverty, particularly in African countries. Similar findings are also derived from the work of Thorbecke (2013). Fosu further comments that the poverty reduction effort in SSA countries has not been as effective as that which took place in Asian countries during similar stages of development, this argument is supported by the work of Jin and Lee (2016), who examine the relationship between growth income inequality within China and find significant causal effects.

Proano et al. (2023) examine the role of financial development in shaping growth led inequality effects and conclude that financial institutions facilitate equitable economic growth in a significant way. The authors argue that financial development allows middle income households access to the financial market and generate additional income to the participants, and thus ensuring equitable income growth and reduce inequality. Their findings reinforce the work of De Haan and Sturm (2017) and Rewilak (2017) on the inequality effects of economic development.

2.7 Concluding Remarks

This chapter provides a comprehensive review of the theoretical and empirical work carried out on the topic of the inequality-growth nexus. We started off by presenting the theoretical frameworks developed over the course of more than half a century, followed by the empirical works ordered chronologically. We then present the literature focused on the effects of critical components that are of interest to this study, including the growth and inequality effects of innovation, institutions both economic and political in nature, and the interactions between them. We are able to identify a number of transmission channels proven theoretically or empirically and numerous relations between variables of interest. The lack of consensus regarding how each component can produce a growth or inequality effects is also noted, indicating a research gap which we shall aim to fill. The lack of consensus also provides a good opportunity for further studies and investigations.

Chapter 3

Examining the Institutions-Innovation Channel within Inequality-Growth Nexus

3.1 Introduction

The study of how inequality affects growth in economics and other inter-disciplinary research has been ongoing for more than half a century, with earlier works (such as Kuznets 1955) suggesting positive causal links between inequality and growth, meaning that high inequality would lead to more economic growth. This position has been increasingly challenged as new theoretical and empirical techniques emerge and more transmission channels are proposed or identified (e.g., Alesina & Rodrik 1994; Banerjee & Newman 1993; Deininger & Olinto 2000). Thus, one may argue that as the trend continues, the lack of consensus as to how the key components may operate in the inequality-growth nexus will remain as newer research diverge from existing ones, both in methods and conclusions.

We add to the discussion by focusing on a major transmission channel, the innovation and institutional interaction channel, to explore if the causal link between inequality and economic growth would support or contradict existing studies. The context under which we carry out our study, at the time of writing, has not been extensively explored or well-understood. To relate to prior research on related topics, the work of Amendola et al. (2013) and Yang et al. (2021) are of notable relevancy to the current study. The former interacts political and economic institutions to examine their effects on redistribution, a technique that is used extensively in this work, while the latter proposes an entrepreneurship transmission channel between inequality and economic growth in a theoretical framework, which serves as a critical reference in the assembly of empirical models used in this study.

To examine the combined effects of innovation and institutional quality on inequality and economic growth, we hypothesise that both economic institutions in the form of enforcement of property right protections and measures for innovation or other productivity indicators are growth-enhancing but induce inequality. This would suggest that a higher level of property right protection encourages economic activities as those who engage in such activities may be reinsured that the fruit of their labour can be safeguarded against expropriation or rent-seeking behaviours. The increase of economic activities naturally leads to more economic growth, but at the expense of equality, as those with the means to carry out entrepreneurial ventures or engage in innovation would obtain the most yield. At the same time, the poor would more likely be concerned with necessities and have little disposable resources to participate in productivity-gaining endeavours. Such mechanism creates economic growth and worsens inequality. This hypothesis is in line with conventional belief regarding innovation, inequality and growth (see Banerjee & Newman 1993; Amendola et al. 2013 and Yang et al. 2021).

Such reasoning is apparent in Figure 3.1, which plots inequality and growth figures against institutional quality, measured by the Fraser Institute property right protection index, and innovation measured by patent applications for 155 countries in 1990. Clear positive correlations can be observed for institutions and innovation, pointing towards their growth enhancing effects as well as their footprint in increasing inequality.

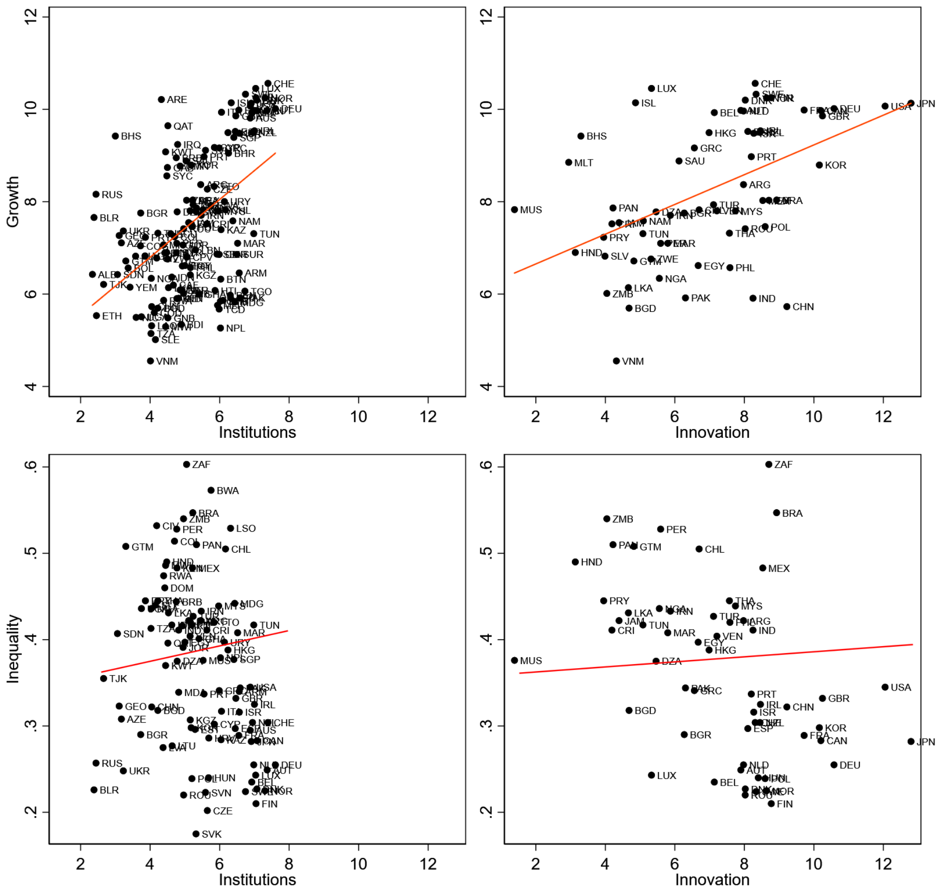


Figure 3.1: Growth and inequality effects of economic institutions and innovation, 1990

However, we acknowledge that when considered under such context, innovation and economic institutions may interact and produce marginal or partial effects on dependent variables, be it inequality or growth. This is represented in the empirical models as an interaction term between variables of interest. We test the hypothesis with cross-country panel data consisting of 155 countries between 1970 and 2018.

Logged total patent application for each nation is selected as the measure for innovation[1] and the protection of property right is used to appropriate the quality of economic institutions, following Amendola et al. (2013). Using a standard fixed effects estimation framework and later GMM and IV estimations, as well as additional robustness estimations of different time dimensions and alternative estimators, the results show that both innovation and institutions are significantly and positively related to inequality and growth, thus confirming the hypothesis of growth-enhancing yet inequality inducing effects of innovation and institutional quality. More significantly, our findings also show that the interactions between innovation and institutions are negative and decreasing, suggesting that the partial effects of innovation and institutional quality conditional on their counterparts actively dampens their overall impact on inequality or economic growth. In selected instances, the interacting partial effects can overshadow the effects entirely. We then further test the hypothesis on different development groups, where developed and developing countries are distinguished in separate estimation attempts. Findings from these estimations further confirm our results as statistically significant, which bring notable economic and policy implications.

The rest of the chapter is structured as follows. Section 2 introduces an outline of existing literature on the issue of institutions, innovations and the inequality-growth nexus from a broader context. Section 3 introduces the empirical models and data used in this research. Section 4 presents the findings from the fixed effects estimations and the marginal effects between variables of interest. Section 5 addresses potential endogeneity concerns with IV and system GMM estimations; further robustness assessment is also included. Lastly, section 6 offers concluding remarks.

3.2 Relevant Literature

The inequality-growth nexus has been a point of interest for academic research for more than half a century, with multiple transmission channels identified over the decades. One of the first transmission channels proposed is the direct saving channel, which links inequality to enhanced economic growth via higher saving propensity of the rich (Kuznets 1955; Kaldor 1956). Later studies have gradually become more elaborate, with some incorporating socio-economic components into the mechanism, such as socio-political instability [2] (Alesina & Perotti 1996; Alesina et al. 1996), redistribution [3] (Alesina & Rodrik 1994; Persson & Tabellini 1994 and Perotti 1996) and innovation and entrepreneurship [4] (Banerjee & Newman 1993 and Yang et al. 2021) are some examples. Whereas earlier studies tend to present evidence favouring positive transmission channels between inequality and growth, diverging theories and empirical results started to emerge as new theoretical and empirical techniques were adopted, with more studies introducing negative transmission channels while some reinforce the classical channels with newer theories and empirical findings (e.g., Deininger & Olinto 2000; Banerjee & Duflo 2003; Kolawole et al. 2015). Since the turn of the century, an increasing number of empirical and theoretical studies

[1]Additional measures are also employed as alternatives for innovation or other key economic indicators to expand the scope of the research as well as provide robustness support: total trademark application, R&D expenditure as a percentage of GDP and total factor production

[2]Inequality is theorised to cause socio-economic instability and class conflict, which diminish investor confidence and impose uncertainty.

[3]Alesina & Rodrik (1994), Persson & Tabellini (1994) and later Perotti (1996), who argue that high inequality can lead to reduced economic growth due to the median voter being located in the low-income bracket, therefore favouring more redistribution and limit investment and innovation as a result. This is also known as the median voter channel or direct fiscal policies channel.

[4]Where inequality is argued to lead to more innovation and entrepreneurial activities, as the rich can dedicate more time and resources to innovate and engage in entrepreneurship as they do not concern themselves with fulfilling their basic needs and thus increase productivity gain and ultimately boost economic growth, unlike the poor who have to spend the majority of their time and income on food and shelter.

have argued for nonlinear relations between inequality and growth (e.g., Chen 2003; Voitchovsky 2005; Castello 2010, Halter et al. 2014 and Baek 2018). The diversity and the usage of novel analytical and modelling techniques such as panel analysis and structural modelling, and the apparent lack of consensus attest to the significance of the topic.

While the study on the inequality-growth nexus has been extensive, how the effects of institutions contribute towards or formulate a transmission channel between inequality and economic growth and how they interact with other key economic indicators have not been thoroughly examined to the same extent as the previously described channels (e.g., Alesina & Perotti 1996). Nevertheless, there exists literature that explores the links between innovation, institutional quality, inequality and the implication on economic growth. Conventional wisdom indicates that innovation serves as a drive for technological progress, which is one of the fundamental determinants of economic growth and can impact wealth distribution. The reverse causation effect in this dynamic would likely be equally prevalent. As one is set out to explore the innovation-entrepreneurship channel in the inequality-growth nexus, the effect between innovation and inequality cannot be ignored. Among them, a number of papers conclude with negative relations between innovation and inequality or an inequality-reducing effects[5]. Reverse causation is found in a paper examining the inequality-innovation effect (how does inequality affect innovation activities), suggesting innovation causes inequality in selected regions (Teslios 2011), which contradicts prior studies.

As for the effects of institutions on either inequality or growth, literature that examines the underlying mechanisms has been considerably sparse. A prominent example is the work of Amendola et al. (2013), in which economic and political institutions are interacted to assess their effects on inequality. The finding suggests that economic institutions, in the form of property right protections, are inequality inducing while political institutions, when interacting with economic institutions, reduces the overall adverse impact. Madsen and Murtin (2017) incorporated the effects of property right protection in their study that is predominately focused on the effects of education on growth in the UK. Their results show insufficient evidence for consequential effects of property right protection on British economic growth, a verdict we hope to empirically re-examine under a broader context. Boudreaux (2019) assesses the role of both entrepreneurship and pro-market institutions on growth concluding that the growth-enhancing property of entrepreneurship and institutions can only be found in developed countries, a finding that is supported by the work of Galindo-Martín et al. (2019) and Bosma et al. (2018)[6]. Another group of studies employs the panel threshold technique to examine the growth effects of various determinants, with institutional quality acting as the threshold variable (e.g. Aluko et al. 2020; Ruiz 2018 and Abdulahi et al. 2019), which concludes that a high level of institutional quality is the requirement for economic growth. Lastly, as Ouattara and Standaertb (2020) note, property right protections under the oversight of democratic institutions can reduce inequality via redistribution efforts. Another relevant study by Biurrun (2022) examined the role of institutions in how innovation can affect inequality, with data covering some 20 European countries for between 1995 and 2017. The author finds that innovation has an inequality-reducing effects in developed countries with institutions playing a significant role in defining this relationship.

From a theoretical point of view, innovation, entrepreneurship and productivity gain are said to reduce inequality via rising real wage and saving-driven capital growth. Following the Schumpeterian frame-

[5]i.e., higher innovation activities in terms of productivity gain reduces income inequality (e.g., Antonelli & Gehringer 2013; Benos & Tsiachtsiras 2019; Adrián Risso & Sánchez Carrera 2019; Santamaría 2019) while studies conducted in Europe or otherwise developed regions contest this finding (e.g., Aghion et al. 2018).

[6]These studies looked at the role of entrepreneurial activities and market and business-based institutions on economic growth, but do not consider the effects under the context of institutions from a broader, socio-economic sense. The inequality effects are also not explored. Furthermore, we note that institutions are commonly examined as a cause for indirect growth and inequality effects, often occurring alongside with those induced by entrepreneurial or financial activities.

work, regular innovation in the sense of technological advancement induced by entrants and competition can promote the destruction of monopolistic rent brought by previous technological innovation. The Schumpeterian framework argues that fast technological change can reduce income inequality while a slower pace encourages monopolistic rents and the reinforcement of barriers to innovation imposed by the incumbent. This line of reasoning can be adopted when arguing for a negative relationship between innovation and inequality. A relevant theory is proposed by Antonelli and Gehringer (2013) that innovation can create economic growth through gain in productivity, which in turn increases labour productivities and wage and ultimately reduces income inequality through a combination of the above-mentioned mechanics and widened competition across the labour market. The combined mechanism echoes that of the inequality-growth nexus, which invokes the effect of entrepreneurship on economic growth and inequalities. Similar conclusions are reached in the study by Benos & Tsiachtsiras (2019)[7]. To summarise, the study of the effects of innovation and institutions on inequality does not present a consensus. Similar to the aforementioned studies, it presents opportunities for further investigations into this topic.

3.3 Hypothesis and Empirical Framework

We propose the following propositions to capture the mechanism between the principal economic indicators that we are interested in:

1. Economic institutions, in the sense of better property right protection, encourages economic activities.

2. Economic activities generate innovation and entrepreneurial return, which promote technological progress and enhance productivity.

3. Higher productivity leads to greater output, which translates into growth.

4. Innovation and technological progress reduce income inequality.

5. Inequality can promote economic growth through the channel of entrepreneurship and innovation, as greater wealth and income disparity allows the concentration of wealth, which provides base for innovation (shown in the theoretical survey and part of the literature review covering the inequality-growth nexus). This may manifest in the interactions of institutions and some economic indicators.

Several assumptions are made in these propositions. The first assumption is an exogenous economic institution in the form of property right protection and enforcement. The reasoning behind this assumption is twofold. Firstly, we aim to simplify the theoretical process by limiting agent choices and produce a streamlined model for empirical estimation. Secondly, we deem it appropriate to argue that individual's effort in shaping up institutional quality can be neglected. This line of argument can be further reinforced by the notion that government or any form of authority is not considered in the theory, thus making the variable rightfully exogenous. This assumption is relaxed in the final chapter of this thesis where we consider household agency in shaping institutional and economic policies.

Proposition 4 invokes our literature review on the causal relationship between innovation and economic inequality, where we examine a series of recent literature on this topic, all of which concluded with a negative casual effect between the two variables. While to the best of knowledge the referenced literature

[7] Fixed effect panel studies are carried out on a database consisting of annual observation from 29 OECD countries between the year 1978 and 2016, and regressed unequally with measures of innovation

does not cover the effect of institutional variables (political or economic), the researcher see no obvious contradictions between the dynamics between innovation and technological innovation illustrated in these studies (that of a negative relationships, where improved rate of innovation reduces inequality either due to the destruction of monopolistic rent due to increased competition or the increase in real wage caused by technological improvement and productivities) and the mechanisms in the previous three propositions.

Proposition 5 references a large size of the literature, both empirical and theoretical, on the topic of the widely examined inequality-growth nexus. As pointed out in the previous chapter, the proposition references a specific channel in the inequality-growth effect with regard to saving, entrepreneurship, and innovation. This particular channel was first introduced by Kaldor (1956) as an argument for positive inequality-growth effect, as greater concentration of wealth allows higher saving rate and by extension higher capital accumulation. This argument was called into question later by more recent studies and was re-defined by later publications such as Banerjee and Newman (1993) and Yang et al. (2018).

Note that proposition 5 conflicts with proposition 4 in some way, specifically concerning the impact on inequality and growth. Proposition 4 assumes a negative relationship between innovation and inequality: higher rate of innovation reduces inequality whereas proposition 5 states higher inequality promotes innovation via entrepreneurship. By extension this implies a feedback effect in the dynamics between innovation and inequality and their subsequent effect on economic growth: proposition 2 and 3 assumes higher innovation generate growth; proposition 4 and 5 states higher innovation reduces inequality, which reduce momentum on innovation, thus slowing down growth. We acknowledge the seemingly conflicting argument presented in the propositions but argue that the dynamics described is instead a trade-off rather than a contradiction and is therefore by design. The mechanism between proposition 4 and proposition 5 can be illustrated in figure 3.2.

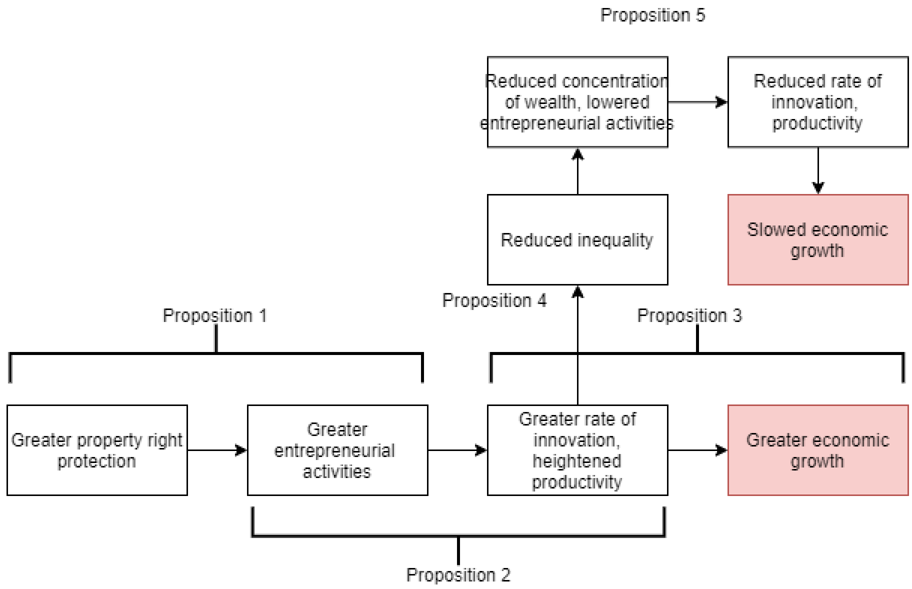


Figure 3.2: Propositions and hypotheses, the inequality-growth effects

As shown in figure 3.2, Proposition 5 suggests slowed economic growth as a result of reduced inequality, based on the entrepreneurship channel in the inequality-growth effect, which is in conflict with the parallel dynamics of innovation-productivity-growth effect. The research question, under this context, would be whether the effect of innovation-driven economic growth under certain institutional pretext can be offset by the impact of a reduction in innovation due to how the former affects inequality, which in this case is seen as a catalyst for innovation or an interaction effect. Note that this diagram shows the mechanism behind each of the proposition, it is not meant to be taken as an indicator for casual relationship or imply endogeneity. To organise the propositions into an empirically testable format, we condense them into two hypotheses for preliminary empirical testing and estimation, the following sections introduce them in detail.

Firstly, the improvement of economic institutions in better property right protection may encourage entrepreneurial activities that boost innovation. Increased innovation translates to technological progress, enhancing productivity and ultimately leading to more economic growth. Inequality can promote economic growth through the transmission channel of entrepreneurship and innovation, as greater wealth and income disparity allow the concentration of wealth, providing a base for innovation.

Secondly, as illustrated in existing literature, innovation and technological progress may reduce inequality. This may be due to the resulting higher wages stemming from increased productivity, as illustrated in existing literature. Meanwhile, innovation may also increase inequality due to a different mechanism, as it accelerates the accumulation of wealth for the selected few, the effect of which may be enhanced by institutional development.

As one can quickly note, the above propositions contain many conflicting dynamics, namely the role of institutional qualities in shaping entrepreneurship. Suppose greater inequality under the protection of property right enforcement creates opportunities for innovation, which reduces inequality as a result of productivity gain; what is the overall impact on inequality? How does the combined effect influence economic growth? One may attempt these questions by considering the causal links in steps.

3.3.1 The Inequality Model

To analyse the above-proposed effect on inequality we present a simple regression model, which tests the hypothesis concerning innovation, institutional quality, and inequality:

$$\begin{aligned} ineq_{it} = \beta_0 + \beta_1 inno_{i,t-1} + \beta_2 inst_{i,t-1} + \beta_3 \left(inno_{i,t-1} \cdot inst_{i,t-1}\right) \\ + \alpha_i + \alpha_t + \sum_{j=1}^{p} \mu_j X_{i,t} + \varepsilon_{it} \end{aligned} \tag{3.1}$$

where $ineq_{it}$ denotes inequality being dependent on lagged innovation and institutions, and the interaction between the two. We elect to use lagged explanatory variables to circumvent potential reverse causal effects that might arise. $(inno_{i,t-1}\ inst_{i,t-1})$ captures the partial effect of innovation which is assumed to be conditional on the economic institutional measure, as $\frac{\partial Ineq}{\partial inno} = \beta_1 + \beta_3 inst_{i,t-1}$. The inclusion of the interaction term imposes non-linearity within the context of the model. We justify this by arguing that intuitively the levels of innovation and institutional qualities interact with each other and generate non-linear effects on dependent variables. At a given level of institutions the effects of innovation or other economic activities may have additional effects on inequality and later economic growth. Similarly, one could argue for the presence of partial effects initiated from institutions conditional on the level of innovation, or how technologically or economically developed a nation is. Economic institution in the form of property right protection can incentivise innovation, as one tends to be more inclined to innovate when the fruit of their labour is protected against expropriation. For the inverted partial effect, we also argue that the partial effect of institutions conditional on innovation can manifest with the establishment of rigid institutions and institutional inefficiencies, or vice versa, where a heightened level of institutions protects equality with improved technologies and productivities from innovation.

Countries specific variables are identified by i. Country and period specific fixed effects, α_i and δ_t, are also included to capture specific fixed effects in panel groups or during certain periods.

3.3.2 The Growth Model

Now suppose an expression for economic growth with wider implication, which features the relevant variables for the testing of the growth hypothesis:

$$\begin{aligned} y_t = \phi_0 + \phi_1 ineq_{i,t} + \phi_2 inno_{i,t-1} + \phi_3 inst_{i,t-1} \\ + \phi_4 \left(inno_{i,t-1} \cdot inst_{i,t-1}\right) + \gamma_i + \gamma_t + \sum_{n=1}^{q} \mu_n X'_t + {}_{it} \end{aligned} \tag{3.2}$$

where logged output is the dependent variable and innovation, institutions and a series of control variables in $\sum_{n=1}^{q} \mu_n X'_t$ are the explanatory variables. In this model $\phi_1 ineq_{i,t-1}$ denotes inequality as an explanatory variable to capture the inequality-growth effect. The control variables include descriptive measures as indicators for the economy, such as investment, human capital in terms of education (enrolment), child mortality rates, financial flows, tax revenue, financial flow and integration and trade exposure. A detailed description of control variables in addition to the key dependent and independent variables as well as their summative statistics is available below. Overall, the growth model shares a similar setup with the inequality model. This is done to ensure a level of symmetry between the models and allows better illustration of the effects of interest[8].

Similar to the inequality model, we employ lagged institutions and innovations as explanatory variables. The justifications are twofold. Firstly, we argue that both institutions and innovations are slow-moving and improve incrementally over long periods. The effects of institutional improvements as well as the fruit of innovation take time to come into effect. Secondly, we acknowledge that while the effects may be slow to manifest, the initial surge of growth and inequality effects warrant the inclusion of a one year lag in variables. Intuitively one may argue that the effects on growth and inequality might likely be long lasting, but we are interested in the initial surge of effects. The examination of the trailing effects on inequality and growth may prove to be a promising follow-up study to the present thesis.

3.4 Data Description

For panel estimation, this study utilises aggregate data at national level. We take observations from the Standardised World Income Inequality Database (SWIID) (Solt 2016) as measures for inequality in the form of standardised Gini indexes for up to 192 countries from 1960 to 2019. We discard the first decade and the most recent two years of observations due to low availability among developing countries and most of the world, respectively. This yields an inequality panel from 1970 to 2018. Furthermore, as observations are unbalanced between countries and observation availability favouring recent years, as shown in Figure 3.3, robustness estimations are carried out taking three time dimensions of different

[8] The growth and inequality models are conceived independently and should be considered as separate entities unless stated otherwise in specific context.

lengths into account[9] to safeguard against introducing potential bias in unbalanced panel analysis. This is also done to offset the potentially low data availability in developing countries in earlier years which may again result in biased estimations. Two sets of institutional measures are selected to approximate

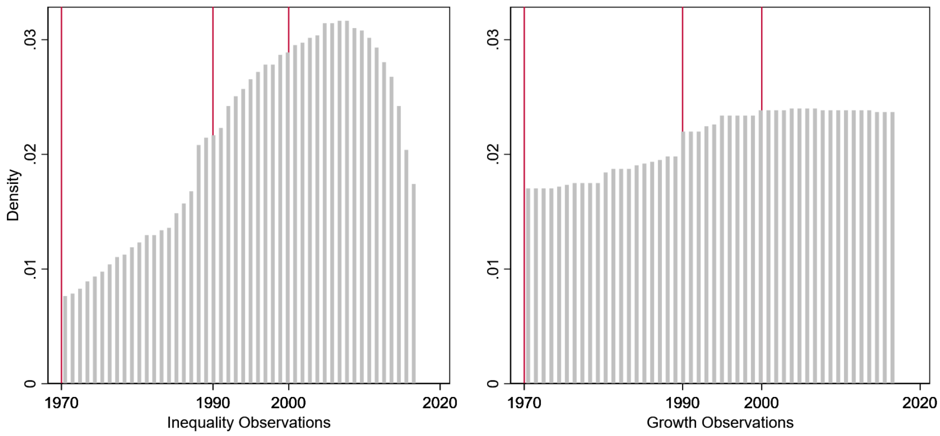


Figure 3.3: Dependent variables data availability, inequality and growth

economic institutions: protection of property rights index[10], and a composite index for legal system and property rights[11], data for both of which are extracted from the Fraser Institute Economic Freedom of the World Index 2020. The composite index incorporates eight components: scores for judicial independence, impartiality of courts, military interference in rule of law and politics, legal system integrity, legal enforcement of contracts, regulatory costs of the sale of real property, police reliability and protection of property rights. The property right index captures the extent of property rights enforcement. It is, therefore, a justifiable choice for institutional measures. In contrast, the composite index takes its value by averaging the scores of the components mentioned above and is arguably representative of a broader sense of institutional quality. This makes the composite index a valid alternative measure. Furthermore, the composite index was adjusted to reflect gender disparity in legal and property right system. Refer to Fike (2017) for methodological detail of the adjustment.

The scores for protection of property rights are the average of three sub-components, as described in the summary report on the Fraser Institute Economic Freedom Index (2020). The first source was collected from the World Economic Forum's Global Competitiveness Report survey question, where a score between 1 and 7 is given to an economy based on the perception of the extent of protection of property rights, including over financial assets. For example, a score of 1 would indicate that property rights are poorly defined and not protected by law, and a score of 7 would indicate clear definition and robust protection. This first sub-component is a subjective measure which expresses the judgments of key individuals on subject matters for investors and business communities and does not necessarily reflect the overall perception of the extent of property rights protection in a given country. However, the additional sub-components that have been gradually added to the index can arguably boost its credibility and viability to be used as a measure for the research at hand. The second source incorporated into the scores is the property rights index from the V-Dem Institute, which accounts for gender disparities. Lastly, the third source is extracted from the Country Policy and Institutional Assessment from the World Bank. Both augmentations are adjusted to be scaled to the baseline index to ensure consistency (Gwartney 2020).

[9] 1970-2018, 1990-2018 and 2000-2018

[10] As protection of property rights score

[11] As legal system and property rights score

The property rights index, and the composite institutional index, carry specific characteristics that might be subject to criticism. Namely, these indicators do not carry information on internal variation of property rights and institutional qualities but reflect on the level of qualities for a nation as a whole (Isaksson 2011; Amendola et al. 2013). As more recent iterations of the indexes are adjusted for gender inequalities, the disparities between other societal groups, such as income, education levels and ethnicities are not defined. A summary of statistics for measures of institutions can be seen in Table 3.1.

Four measures are selected that are intuitively and logically appropriate for the approximation of innovation and entrepreneurship: total trademark application, total patent application, expenditure on research and development as a percentage of GDP, and logged TFP, with patent application being the primary measures and the remaining three as the alternatives. The choice of including four different measures in the estimation process is to assess the performance of each of the variables as well as capturing any potential pattern and similarities that may exist between estimations, as we believe a certain degree of comparability and interchangeability these measures may demonstrate.

Out of the four measures, one may argue that logged research and development expenditure as a percentage of GDP and (logged) total patent application would best represent the level of innovation present in an economy at a given time. Data for R&D expenditure is extracted from The UNESCO Institute for Statistics, which measures the share of gross domestic expenditures on research and development. The data includes basic, applied research and experimental development expenditures in business enterprises, government, higher education institutions, and private non-profit institutions. It is worth noting that with the inclusion of private institutions and enterprises and higher education, this variable captures government R&D projects and all domestic R&D expenditure, which makes this variable a suitable candidate for the research at hand. However, a critical deficiency that one may discover concerning this data is its comparatively low coverage. Despite its comprehensiveness in measuring R&D expenditure, the data does not appear to be widely available for a large selection of countries, particularly developing nations. Moreover, for those countries where the data is present, it would typically cover only the most recent decade, which may not be sufficient for estimations. Nevertheless, a sizeable literature has utilised R&D expenditure as a measure for innovation, Risso et al. (2019) being an example.

Total patent application is the sum of patents filed to the relevant patent offices for exclusive rights for an invention by resident and non-resident of a country in a given year. Patent applications as a measure has been widely used by academics in empirical studies (e.g., Aghion 2019 and Antonelli & Gehringer 2017). Data for resident and non-resident applications are extracted from World Intellectual Property Organization (WIPO), available as a series from the WDI. By combining the two series, one can effectively measure the annual total amount of patents filed in the protection of a new invention in a country in a given year. Despite the fact that it does not measure the level of innovation input as the previous variable, one may argue that it does capture the result of said innovation as well as exposure to the result of innovation abroad. The assumption that patents filed by non-resident can be treated as domestic innovation[12] is adopted as these applications would be filed with the intention of seeking protection for the invention within a territory as a prelude for the introduction of the said invention rather than to prevent or hinder innovation competitively. The assumption is made to address the potential bias that might arise concerning the intention of filing for patents. Due to the skewness present in the raw observations, we take logged values of the data.

Total trademark application measures applications to register a trademark with the intellectual property office of a territory to grant exclusivity to the owner of the trademark for using said mark to identify goods or services. Similar to total patent application, this variable includes applications from direct res-

[12] As opposed to domestic and national

ident and non-resident filings. The same assumption is imposed on this variable, which being that the applications of trademark by resident or non-resident are filed with the intension of introducing the goods or services protected by the trademark to the market rather than preventing or restricting competition. Under the assumption, total trademark application can therefore be used as an appropriate measure for entrepreneurship (or innovation to a lesser extent). The data for total trademark applications are directly extracted from the World Intellectual Property Organization (WIPO), available as a series in the WDI. Both total trademark application and the aforementioned total patent application enjoy significantly greater coverage relative to R&D expenditure, as shown by the summary statistics in Table 3.1.

Logged TFP is used to approximate productivity and as an alternative measure for innovation. We argue that TFP can be used as an alternative measure for technological progress and, by extension, innovation under specific conditions, as there has been studies that assess the viability of using TFP to approximate innovation (e.g., Hall 2011). To further validate this, one may consider a simplified macroeconomic model with a Cobb-Douglas production function: $Y_t = A_t\ K_{t-1}^{\alpha}\ N_t^{1-\alpha}$, with Y_t being output, A_t productivity[13], and K_{t-1}^{α} and $N_t^{1-\alpha}$ denoting weighted capital and labour input, respectively. Following a traditional growth model (e.g. Yang et al. 2021), exogenous productivity growth within the context of a DSGE model may take the form $A_t = (\theta_1 + \theta_2 Z_t)A_{t-1} + \varepsilon_t$, where θ_1 and θ_2 are constants and Z_t denotes an undefined factor. In that case, one could assign Z_t to intuitively and theoretically represent a productivity-augmenting variable, as either innovation and entrepreneurship, since both under the current context are expected to be productivity-enhancing and, by extension, growth-enhancing. Therefore, one can therefore argue that while TFP would not be used as a measure for innovation under any conventional circumstance, one would be justified to adopt it as an alternative measure supplementary to other, more common measures. The data for TFP are extracted from Penn World Table (PWT). TFP has the most extensive coverage out of all four measures, as shown in Table 3.1.

Lastly, we employ a series of control variables in estimations for each hypothesis with slight variations. Estimations of the growth model contain secondary school enrolment, trade exposure, child mortality, share of agricultural land, government consumption, money growth and financial openness as control variables, with observations extracted from the World Development Indicators (WDI). Gini index is used as an additional variable as it accesses the inequality-growth effect with the presence of institutional and innovation measures. The control variables for the inequality model are secondary school enrolment, child mortality, government consumption, money growth and logged GDP per capita with a one-period lag. Trade exposure as a control variable is excluded based on an existing group of studies that concluded with non-significant trade-driven inequality effects (e.g., Lawrence and Slaughter 1993; Kurokawa 2014). Data for government consumption and money growth are collected from the Fraser Institute Economic Freedom index. Financial openness is an objective index of scores from 0 to 10 measuring restrictions on cross-border financial transactions, based on the Chinn-Ito Index of de jure financial openness (Chinn and Ito 2008). A summary of the control variables can be found in Table 3.2.

To classify development groups, we look to the IMF's list of advanced economies for reference, which was published in the World Economic Outlook (2020) to classify developed countries. This decision is made considering that there are no definitive criteria or lists that define developed countries from developing countries. The list contains 39 countries and regions, 35 of which are present in the database used for this study. Another reason for adopting this criterion is that it coincides with the OECD member states, which ensures consistency and adds an additional layer of definition for economically advanced countries or regions.

[13] Which is typically measured by TFP, e.g. Minford et al. 2009; Le et al. 2016.

Variable	N	Mean	SD	Min	Max	Development stage	Source
Property Right	7142	5.20	1.16	1.95	7.89		Fraser Economic Freedom Index
	1600	6.48	0.74	3.65	7.89	Developed	
	5542	4.83	0.98	1.95	7.61	Developing	
Composite Institutions	7215	4.93	1.59	1.71	8.49		Fraser Economic Freedom Index
	1615	7.05	1.05	3.20	8.49	Developed	
	5600	4.31	1.12	1.71	7.62	Developing	
Logged Patents	3157	6.94	2.31	0.69	14.14		World Development Indicator
	1149	8.06	2.32	1.10	13.31	Developed	
	2008	6.30	2.04	0.69	14.14	Developing	
Logged TM	3768	8.68	1.75	0.00	14.56		World Development Indicator
	1147	9.59	1.31	5.30	13.01	Developed	
	2621	8.29	1.78	0.00	14.56	Developing	
Logged RnD	1772	-0.60	1.20	-5.21	1.57		World Development Indicator
	699	0.42	0.63	-1.59	1.57	Developed	
	1073	-1.26	1.00	-5.21	0.76	Developing	
Logged TFP	4915	-0.01	0.24	-1.24	1.96		Penn World Table
	1536	-0.08	0.15	-0.71	0.28	Developed	
	3379	0.02	0.26	-1.24	1.96	Developing	

Table 3.1: Summary statistics: institutions and innovation measures

Variable	N	Mean	SD	Min	Max	Source
Gini Index	4808	38.46	8.90	17.50	67.20	SWIID
Logged GDP per Capita	6596	7.75	1.65	4.05	11.69	World Development Indicator
Trade Exposure	6194	0.76	0.51	0.00	4.43	World Development Indicator
Secondary Enrolment	5234	0.65	0.34	0.00	1.64	World Development Indicator
Child Mortality	7155	68.86	71.80	2.10	375.80	World Development Indicator
Agricultural Land	6685	0.39	0.22	0.00	0.91	World Development Indicator
Government Consumption	5804	19.65	7.99	1.68	66.55	Fraser Economic Freedom Index
Money Growth	5754	0.19	1.05	-0.65	22.90	Penn World Table
Financial Openness	6183	4.64	3.58	0.00	10.00	Fraser Economic Freedom Index

Table 3.2: Summary statistics: control variables

3.5 Empirical Results: Fixed Effects Estimations

3.5.1 The Inequality Model

This chapter showcases the primary empirical estimations for the inequality and growth model, which test the hypothesis for the variables of interest and their interactions. Table 3.3 displays an overview of the fixed effects estimations with robust standard error for the inequality model with a mixed panel of developed and developing countries over the maximum time dimension of 1970-2018. Column (1) through (6) show the results of where property right protection is used as the proxy for institutional quality, column (7) to (12) are the results with composite institutional index as the alternative measure. Regressions without the interaction terms are included in odd columns. As shown in a mixed country panel, there is little evidence to support the variables of interest as statistically significant. Institutions are shown to be positively correlated to inequality in column (9), where the measures are trademark and the composite institutions index, indicating an inequality-inducing effect with better institutional quality. This observation is consistent with previous studies (Amendola et al. 2013). In column (12) we see a significant and positive correlation between total factor production (TFP) and inequality, with the composite institutional measure being the proxy for institutions. This indicates that productivity gain is inequality-inducing. In the same estimation, the interaction between institutions and TFP is shown to be significant and negative. Across all estimations, the institutional effects on inequality is the most pronounced when innovation is involved, as shown in column (2). The largest inequality-inducing effects can be observed originating from TFP, and similarly the dampening effects is also the largest when it is interacted with institutions.

	Patent		TM		TFP		Patent		TM		TFP	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Property Right	-0.033	0.096	-0.027	-0.033	0.003	0.005						
	(0.040)	(0.101)	(0.035)	(0.121)	(0.031)	(0.032)						
Institutions							0.039	-0.002	0.049*	-0.049	0.022	0.017
							(0.033)	(0.079)	(0.029)	(0.108)	(0.025)	(0.027)
Patent	0.004	0.112					0.003	-0.030				
	(0.021)	(0.099)					(0.020)	(0.058)				
Trademark			0.039	0.035					0.036	-0.020		
			(0.029)	(0.072)					(0.028)	(0.056)		
TFP					0.007	0.382					-0.008	0.781**
					(0.111)	(0.442)					(0.114)	(0.312)
Property Right*Patent		-0.019										
		(0.016)										
Property Right*TM				0.001								
				(0.014)								
Property Right*TFP						-0.069						
						(0.084)						
Institutions*Patent								0.005				
								(0.009)				
Institutions*TM										0.011		
										(0.011)		
Institutions*TFP												-0.158**
												(0.066)
Constant	0.472	-0.324	-0.004	0.029	0.091	0.099	0.232	0.522	-0.242	0.370	-0.016	0.007
	(0.627)	(0.807)	(0.518)	(0.796)	(0.511)	(0.510)	(0.627)	(0.841)	(0.493)	(0.832)	(0.495)	(0.488)
N	2052	2052	2262	2262	2710	2710	2052	2052	2262	2262	2710	2710
R-sqr	0.971	0.971	0.973	0.973	0.976	0.976	0.971	0.971	0.973	0.974	0.976	0.977
adjR-sqr	0.970	0.970	0.973	0.973	0.976	0.976	0.970	0.970	0.973	0.973	0.976	0.976
F	1695.107	1504.896	1993.984	1966.905	2579.744	2517.103	1755.772	1826.238	2098.462	2256.330	2330.314	2229.571
dfres	106	106	117	117	106	106	106	106	117	117	106	106
BIC	974.543	974.903	962.095	969.812	1050.821	1056.510	972.778	979.747	955.628	961.249	1047.863	1029.091

* p<0.10, ** p<0.05, *** p<0.010

Table 3.3: This table shows the results from the fixed effects estimation for the effects of institutions, innovation and their interaction terms on inequality, carried out on a panel data of countries in mixed stages of development. Alternative measures for innovation are also included to show the effects of entrepreneurship, productivity gain and R&D expenditure. Descriptive and testing statistics include sample size, R-square and adjusted R-square, F statistics, degrees of freedom and Bayesian Information Criterion (BIC). The variables interacting with institutions are shown on top of each column. Odd-numbered column shows the results without the interaction terms, even-numbers shows the results with the interaction terms.

To better illustrate the information carried by the interaction term between variables of interest following precedent (e.g., Brambor et al. 2006, Amendola et al. 2013, Aghion et al. 2018), the marginal effects of both institutions and innovation [14] on the dependent variable are plotted. Figure 3.4 displays said marginal effects. The left diagram shows that the marginal effects of institutions on inequality when the given levels of productivity are low are positive and, therefore, inequality-worsening. However, the adverse impact gradually decreases in potency at a higher level of productivity as it eventually becomes negative at the tail-end, where productivity is at the highest. This would suggest that given the interaction between institutions and productivity, the marginal effects of institutions start as inequality-inducing at lower productivity but transition into inequality-reducing at higher productivity. Similar effects can also be observed in the diagram on the right – positive but decreasing marginal effects of innovation on inequality at a given level of institutions. The evidence from Figure 3.4 shows that when interacting the marginal inequality effects of both productivity as a proxy for innovation and institutions are downward-sloping and initially and terminally significant. The effects are most prominent at the left and right tails - signalling that the marginal effects are most significant when the economy is at early stage of development. As shown, the inequality model does not offer concrete findings supporting the significance of the

[14]In this case TFP. Though it is debatable if TFP can be used as a valid proxy for innovation, it is included to approximate productivity as an alternative to patent application (for innovation) and trademark application (for entrepreneurship). Justification for including TFP can be found in previous chapters.

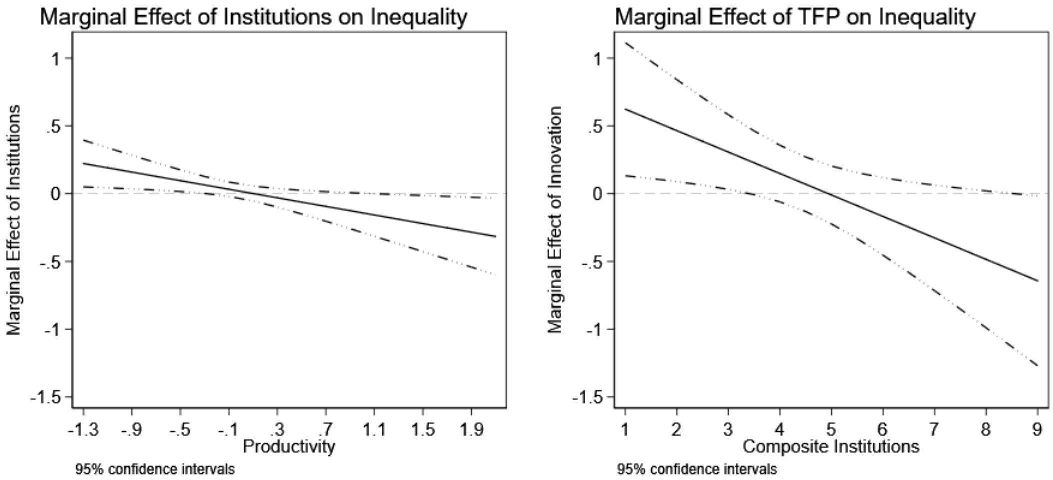


Figure 3.4: Marginal effects of variables of interest on inequality

variables of interest when tested in a mixed panel containing both developed and developing countries. It would then be logical to ask the question of if the condition of development stages can be applied to extract more meaningful results. We then further test the model by distinguishing developed countries from developing countries with a development dummy variable, holding other specifications constant. The results are displayed in table 3.4.

After the distinction between developed and developing countries is made, several characteristics can be observed from the estimation results. Firstly, the variables of interest for developed countries demonstrate consistent results compared to previous estimations, namely positive and significant coefficients for institutional and innovation measures, indicating their inequality-inducing effects. This finding is consistent with previous studies (e.g., Amendola et al. 2013). The interaction terms are negative, suggesting once again diminishing marginal effects. Note that the performance of variables of interest in statistical significance remains mostly satisfactory when logged trademark application and TFP are used as measures for innovation. When TFP is interacted with property right however, no statistical significance can be observed, but consistent and significant results can be seen when TFP interacts with composite institutions. Secondly, the proposed effects are more evident in developed countries relative to developing countries [15], with column (1) (3) and (7) displaying both innovation and institutions as well as their interaction being statistically significant. In all three instances, institutions, either property right protection or composite institutional quality, have positive and significant coefficients, confirming their inequality-inducing effects. Similarly, the interaction terms possess negative coefficients which again demonstrate diminishing marginal effects for either institutions or innovation on the dependent variable.

We also note that the size of the institutional effects, approximated by either property right protection and the composite institutions index, are more pronounced in developed countries. This shows that a change in institutional quality creates comparatively more inequality for the developed world. This applies under all three measures of innovation. Similarly, apart from TFP, both patent application and trademark appli-

[15] Shown in later robustness tests, smaller time dimension increases variable performance for developing countries. One may theorise that a larger time dimension may favour developed countries against developing countries who may have comparatively poorer data availability, thus causing wanted balance issues. By applying two additional time dimensions in robustness tests, the results demonstrate statistical consistencies with regards to coefficient signs and scale for variables of interest. See the following chapter for an outline of these estimations.

	Patent		TM		TFP		Patent		TM		TFP	
	Developed	Developing	Developed	Developing	Developed	Developing	Developed	Developing	Developed	Developing	Developed	Developing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Property Right	0.272**	0.054	0.488*	-0.107	-0.014	0.005						
	(0.130)	(0.175)	(0.275)	(0.171)	(0.050)	(0.034)						
Institutions							0.493*	-0.113	0.503	-0.108	-0.008	0.031
							(0.248)	(0.103)	(0.346)	(0.128)	(0.044)	(0.030)
Patent	0.298**	0.105					0.376*	-0.096				
	(0.113)	(0.170)					(0.188)	(0.066)				
Trademark			0.397*	0.029					0.325	-0.017		
			(0.210)	(0.097)					(0.257)	(0.062)		
TFP					-0.089	0.203					1.278*	1.090***
					(2.617)	(0.326)					(0.635)	(0.402)
Property	-0.038**	-0.015										
Right*Patent	(0.017)	(0.030)										
Property			-0.053*	0.009								
Right*TM			(0.028)	(0.021)								
Property					-0.056	-0.049						
Right*TFP					(0.390)	(0.060)						
Institutions							-0.046*	0.022				
Patent							(0.025)	(0.014)				
Institutions									-0.040	0.018		
TM									(0.033)	(0.014)		
Institutions											-0.270***	-0.265***
TFP											(0.088)	(0.089)
Constant	-0.611	-0.207	-1.126	-0.095	0.866	-0.239	-2.259	1.092	-1.391	0.116	0.858	-0.397
	(1.503)	(1.240)	(2.312)	(1.042)	(1.418)	(0.544)	(2.260)	(0.923)	(3.426)	(0.915)	(1.327)	(0.521)
N	903	1149	892	1370	1096	1614	903	1149	892	1370	1096	1614
R-sqr	0.962	0.978	0.959	0.980	0.966	0.983	0.962	0.978	0.959	0.981	0.966	0.983
adjR-sqr	0.960	0.977	0.957	0.980	0.964	0.982	0.960	0.977	0.957	0.980	0.964	0.983
dfres	32	73	30	86	32	73	32	73	30	86	32	73

* $p<0.10$, ** $p<0.05$, *** $p<0.010$

Table 3.4: This table shows the results from the fixed effects estimation for the effects of institutions, innovation and their interaction terms on inequality, carried out on a panel data where developed and developing countries are separated. Alternative measures for innovation are also included to show the effects of entrepreneurship and productivity gain. Descriptive and testing statistics include sample size, R-square, adjusted R-square and degrees of freedom. The variables interacting with institutions are shown on top of each column. Odd-numbered column shows the results for developed countries, even-numbers shows the results from developing countries.

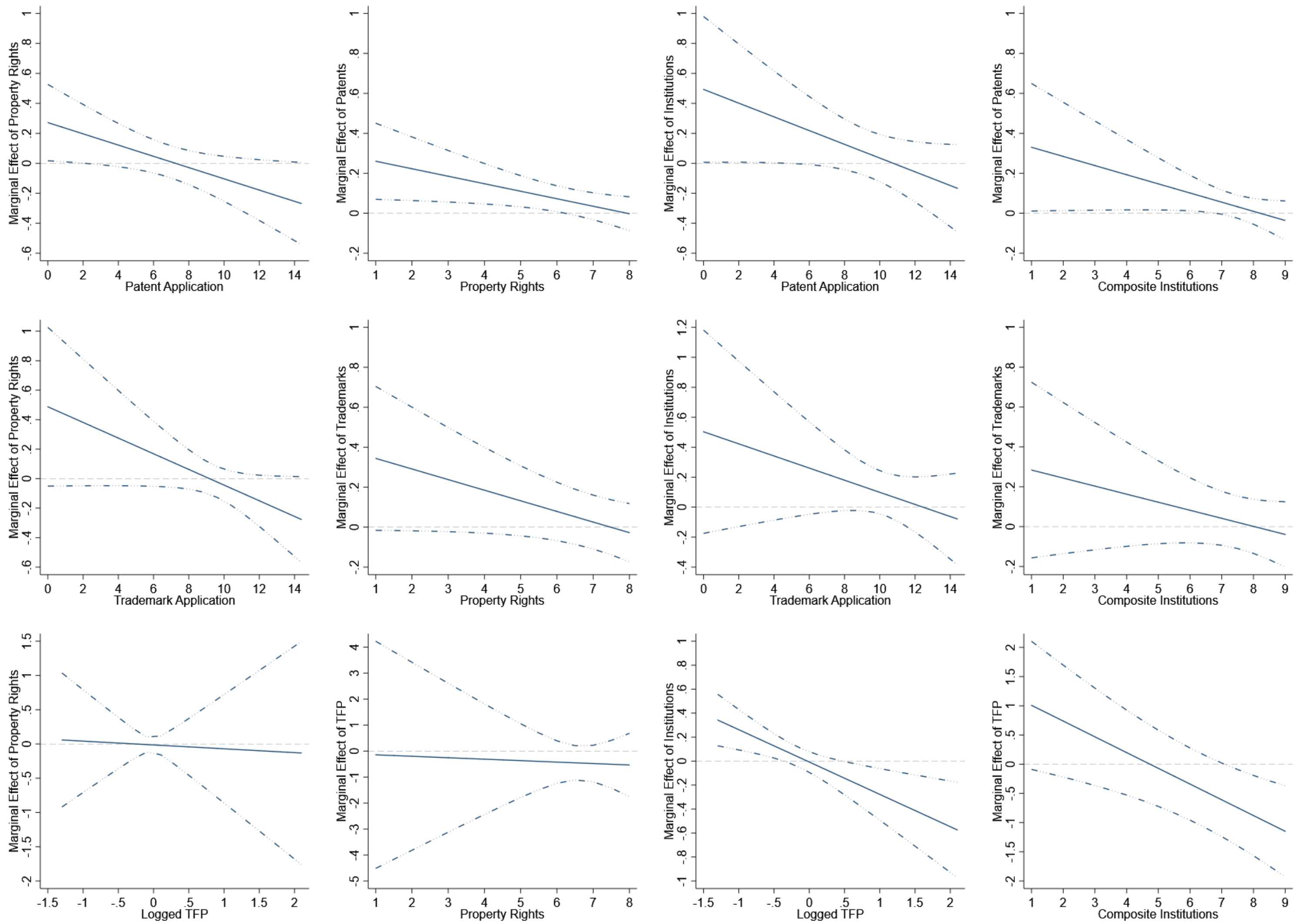


Figure 3.5: This matrix of diagrams shows the marginal effects of either institutions or innovation on inequality conditional on their interacting counterparts. The estimations are carried out on developed countries. Each row shows the results of a measure of innovation: row 1 uses total patent application, row 2 uses total trademark application and row 3 uses TFP. The first two columns shows the marginal effects of property right and innovation or entrepreneurship or TFP, and the last two column shows the marginal effects of composite institutions and the innovation measures.

cation, approximating innovation and entrepreneurship, respectively, have greater effects on inequality in developed countries.

In terms of economic implication, this relation can be explained as follows. Higher institutional values, measured by the current variables, implies a higher degree of property right enforcement as guard against expropriation and unlawful redistribution, as well as more complex institutional operations. Strong enforcement may benefit those with means more than those without in accumulating wealth via entrepreneurship or innovation, thus generating growth and inequality. At the same time, the positive correlation between innovation and the dependent variable signifies that innovation also increases inequality. The marginal effects between the variables of interest captured by the interaction term display negative signs, meaning the marginal effects are downwards sloped and diminishing. This suggests that both marginal effects (the marginal effects of institutions at given levels of innovation and the marginal effects of innovation at given levels of institutional quality) are decreasing. The first marginal effects can be explained as some form of redistributive return at a higher level of innovation, which reduces the inequality-worsening effect of innovation. The latter marginal effects may describe a similar relation, as higher institutional levels provide a certain degree of redistribution that would reduce the adverse impact on inequality.

Graphically the marginal effects of a change in either innovation or institutional quality on inequality conditional on levels of their counterpart for developed countries [16] are shown in figure (3.5). Each row of figure (3.5) shows the marginal effects on inequality for a measure of innovation: logged patent application, logged trademark application and TFP, respectively. Column (1) and (3) are the marginal effects of institutional measures, property right protections and composite institutions, respectively, on inequality at given levels of innovation. Column (2) and (4) shows the effects of innovation conditional on the two measures of institutions. Row (1) shows that the marginal effects of both patent application and institutions, measured by property right protections as well as the composite index, are decreasing at higher levels of their interactions and are significant in initial values. The findings imply that while both institutions and innovation are inequality-inducing, their interactions dampen the overall impact. In row (3), the marginal institutional effects can be seen to eventually become negative, or inequality-reducing, when productivity is high. The reversed marginal effects are also significant, shown in the bottom-right graph. As for row (2), where logged trademark application is used as the measure for innovation, although the marginal effects for various combinations of measures are consistently downward sloping, none are significant.

3.5.2 The Growth Model

Table 3.5 gives the results of instances where the growth model is tested. The setup is comparable to the estimations of the inequality model, with minor changes in the usage of control variables to reflect on theoretical and empirical wisdoms [17]. The time dimension is between 1970 and 2018. The even-numbered columns display the estimation results with the interaction terms and the odd columns without. Column (1) to (6) show the results with three measures of innovation against property right protection as the measure for institutions, and column (7) to (12) are where the composite institutional index is used instead. As shown in column (1), (3) and (7), both innovation and institutions are shown to be positively correlated to growth, a finding that is consistent with conventional belief and demonstrates similar

[16] As seen in 3.4 there is insufficient evidence to support the statistical significance of the interaction terms for developing countries. Therefore the marginal effects diagrams may not be significant in any meaningful way and are thus not presented in the main body. Individual diagrams are available upon request.

[17] Please refer to model and data description for details and justifications.

growth-enhancing effects for patent and trademark application. The results become less consistent when interaction terms are added. In column (4) and (10), the interaction terms between trademark application and property right protection and composite institutions respectively show significant and positive coefficients, indicating that the interactions between the amount of trademark applied and institutions have a significant and positive effect on GDP per capita and can thus induce growth. However, the two variables of interest in these instances are shown with significantly negative coefficients. Estimations with trademark application are the only instances where such phenomena can be observed as significant. The effects of patent and TFP are shown to be positive with or without the presence of the interaction term. When looking at the size of the effects, we note that the growth effects of property right are comparable to the institutional effects when estimated with different approximations of innovation. TFP is shown to be the most effective at driving growth, an observation that is consistent with conventional wisdom.

To better examine the curious effects of trademark application and how it interacts with institutional measures, the marginal effects of their interaction are plotted, presented in figure 3.6. The diagrams correspond to the results in column 4 and 10 in table 3.5, respectively. The left diagram shows the marginal effects of trademark application at given levels of property rights and the right shows the effects conditional on the composite institutional index. Both effects are significantly positive and increasing with institutional quality, which overshadows the negative effects of the individual variables of interest [18]. This indicates that both trademark application and institutions positively affect GDP per capita when interacted.

	Patent		TM		TFP		Patent		TM		TFP	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Inequality	0.008	0.008	0.006	0.004	-0.009	-0.009	0.011	0.009	0.007	0.004	-0.009	-0.009
	(0.012)	(0.012)	(0.012)	(0.011)	(0.010)	(0.010)	(0.013)	(0.013)	(0.012)	(0.011)	(0.010)	(0.010)
Property Right	0.117***	0.029	0.091***	-0.292**	0.019	0.021						
	(0.029)	(0.082)	(0.032)	(0.140)	(0.031)	(0.032)						
Institutions							0.088**	-0.068	0.065	-0.475***	0.024	0.023
							(0.042)	(0.089)	(0.046)	(0.114)	(0.034)	(0.032)
Patent	0.062**	-0.010					0.058**	-0.067				
	(0.031)	(0.076)					(0.028)	(0.088)				
Trademark			0.128***	-0.075					0.128***	-0.174***		
			(0.042)	(0.069)					(0.042)	(0.064)		
TFP					1.011***	1.422**					1.007***	1.299**
					(0.164)	(0.706)					(0.147)	(0.586)
Property Right *Patent		0.013 (0.011)										
Property Right*TM				0.042*** (0.014)								
Property Right *TFP						-0.076 (0.135)						
Institutions *Patent								0.021 (0.014)				
Institutions *TM										0.059*** (0.013)		
Institutions *TFP												-0.061 (0.106)
N	1866	1866	2091	2091	2517	2517	1866	1866	2091	2091	2517	2517
R-sqr	0.880	0.880	0.867	0.871	0.913	0.913	0.877	0.879	0.866	0.874	0.913	0.913
adjR-sqr	0.877	0.877	0.865	0.868	0.911	0.911	0.874	0.876	0.863	0.871	0.911	0.911
F	119.461	114.639	127.392	114.752	213.580	239.097	121.492	120.097	138.675	132.361	231.743	213.495
dfres	101	101	112	112	103	103	101	101	112	112	103	103

* p<0.10, ** p<0.05, *** p<0.010

Table 3.5: This table shows the results from the fixed effects estimation for the effects of institutions, innovation and their interaction terms on growth, carried out on a panel data of countries in mixed stages of development. Alternative measures for innovation are also included to show the effects of entrepreneurship, productivity gain and R&D expenditure. Descriptive and testing statistics include sample size, R-square and adjusted R-square, F statistics, degrees of freedom and Bayesian Information Criterion (BIC). The variables interacting with institutions are shown on top of each column. Odd-numbered column shows the results without the interaction terms, even-numbers shows the results with the interaction terms.

Following the treatment of the inequality model, we then assess the growth model by subjecting it to development panels where the distinction between developed and developing countries is made clear.

[18] The partial effects of institutions conditional on the value of logged total trademark application are also significantly positive and upwards slopping. This means that the effects of institutions on growth are positive and increasing at higher levels of trademark application. In combination, the two-way partial effects create a significant and positive impact on the dependent variable. An outline of the marginal effects diagrams is available in the following chapter.

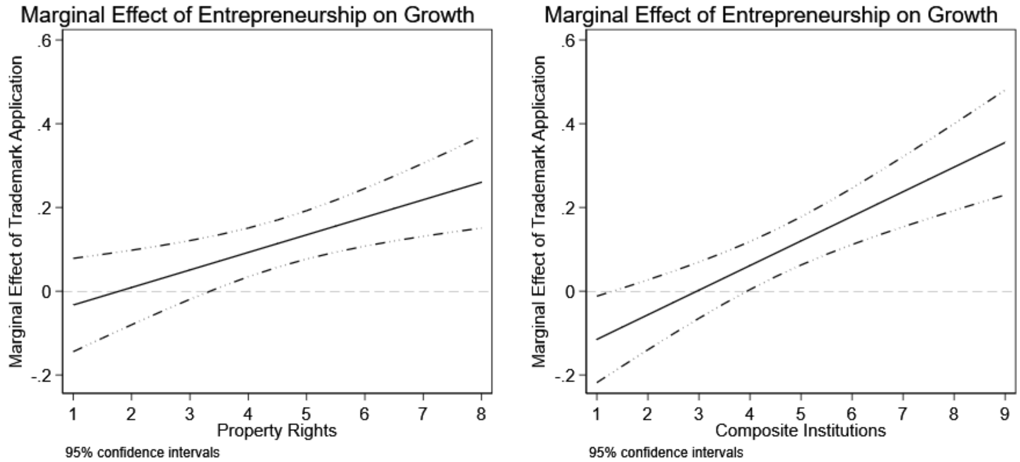


Figure 3.6: Marginal effects of variables of interest on growth.

The results of these estimations are shown in table 3.6.

Similar to the setup in table 3.4, the effects of innovation and institutions on growth alongside with their interactions are displayed for developed and developing countries. In the odd-numbered column, property rights protections are positively correlated to the dependent variable, suggesting positive institutional effects on economic growth, though only statistically significant in column (1). The composite institutional index does not show any statistical significance. Conversely, for developing countries, the effects of property right, though adverse, do not demonstrate significance when estimated with measures for innovation other than trademark, which displays a negative coefficient. As explored in table (3), such negative effects in column (4) and (10) are coupled with significant and positive interaction terms that, at higher values of the interacting variables, yield overall positive growth effects. Results in column (2), (4), (8) and (10) indicate that inequality is positively and significantly correlated with the dependent variable, which implies a positive inequality-growth channel for developing countries and thus reinforcing some conventional wisdom (Kuznets 1955; Kaldor 1956; Cook 1995; Cheema & Sial 2012; Kolawole et al. 2015; Yang et al. 2021). This was not observed in estimations with TFP, however. Overall, the separation of developmental status produces unique results for developed and developing countries that are otherwise not captured in the mixed panel, with the interaction between innovation and institutions being positive and significant for developing countries in column (2), (4) and (10). This would suggest that when interacting with their counterpart, the partial effects of both innovation and institutions are increasing in their growth-enhancing properties as their conditional variables increase in value. For developed countries, however, the interaction terms are seen as negative (though not significant) in column (1), (3), (5) and (11). This implies that for developing countries, the partial effects of innovation and institutions when interacting are evidently negative and thus reduce GDP as the interacting variables increase in value[19]. Overall, both property right protection and composite institutions are shown to be better at stimulating growth only when interacted with innovation, whereas the entrepreneurship and TFP-led estimations see developing countries benefiting more from institutional quality. Furthermore, it has been shown that both the effects of innovation and the interactions generate more growth in developing countries relative to their developed counterpart, which reinforce the economic implications for development strategy.

[19]The negative coefficients for the interaction terms are seen to have more statistical significance for developed countries in estimations with smaller time dimensions or when omitting time fixed effects in estimations. The results are available on request.

	Patent		TM		TFP		Patent		TM		TFP	
	Developed (1)	Developing (2)	Developed (3)	Developing (4)	Developed (5)	Developing (6)	Developed (7)	Developing (8)	Developed (9)	Developing (10)	Developed (11)	Developing (12)
Inequality	0.006	0.026**	-0.012	0.024**	-0.010	0.007	0.006	0.027**	-0.012	0.023**	-0.009	0.007
	(0.010)	(0.012)	(0.014)	(0.011)	(0.010)	(0.011)	(0.010)	(0.013)	(0.013)	(0.011)	(0.010)	(0.012)
Property Right	0.217**	-0.155	0.230	-0.476***	-0.007	0.020						
	(0.090)	(0.116)	(0.221)	(0.162)	(0.038)	(0.042)						
Institutions							0.093	-0.155	-0.096	-0.647***	0.007	-0.036
							(0.145)	(0.120)	(0.202)	(0.145)	(0.036)	(0.033)
Patent	0.060	-0.090					-0.080	-0.026				
	(0.071)	(0.113)					(0.116)	(0.106)				
Trademark			0.123	-0.149**					-0.170	-0.222***		
			(0.162)	(0.070)					(0.151)	(0.071)		
TFP					2.645**	1.593**					2.103***	0.568
					(1.238)	(0.610)					(0.553)	(0.457)
Property Right *Patent	-0.014	0.031*										
	(0.010)	(0.018)										
Property Right*TM			-0.014	0.057***								
			(0.023)	(0.017)								
Property Right*TFP					-0.193	-0.159						
					(0.198)	(0.121)						
Institutions *Patent							0.007	0.022				
							(0.016)	(0.019)				
Institutions *TM									0.027	0.070***		
									(0.021)	(0.016)		
Institutions *TFP											-0.115	0.055
											(0.090)	(0.101)
N	789	1077	806	1285	984	1533	789	1077	806	1285	984	1533
R-sqr	0.956	0.890	0.945	0.878	0.974	0.898	0.955	0.889	0.946	0.882	0.975	0.897
adjR-sqr	0.953	0.885	0.941	0.874	0.973	0.894	0.952	0.884	0.943	0.878	0.973	0.893
dfres	31	69	30	81	31	71	31	69	30	81	31	71

* p<0.10, ** p<0.05, *** p<0.010

Table 3.6: This table shows the results from the fixed effects estimation for the effects of institutions, innovation and their interaction terms on growth, carried out on a panel data where developed and developing countries are separated. Alternative measures for innovation are also included to show the effects of entrepreneurship and productivity gain. Descriptive and testing statistics include sample size, R-square, adjusted R-square and degrees of freedom. The variables interacting with institutions are shown on top of each column. Odd-numbered column shows the results for developed countries, even-numbers shows the results from developing countries.

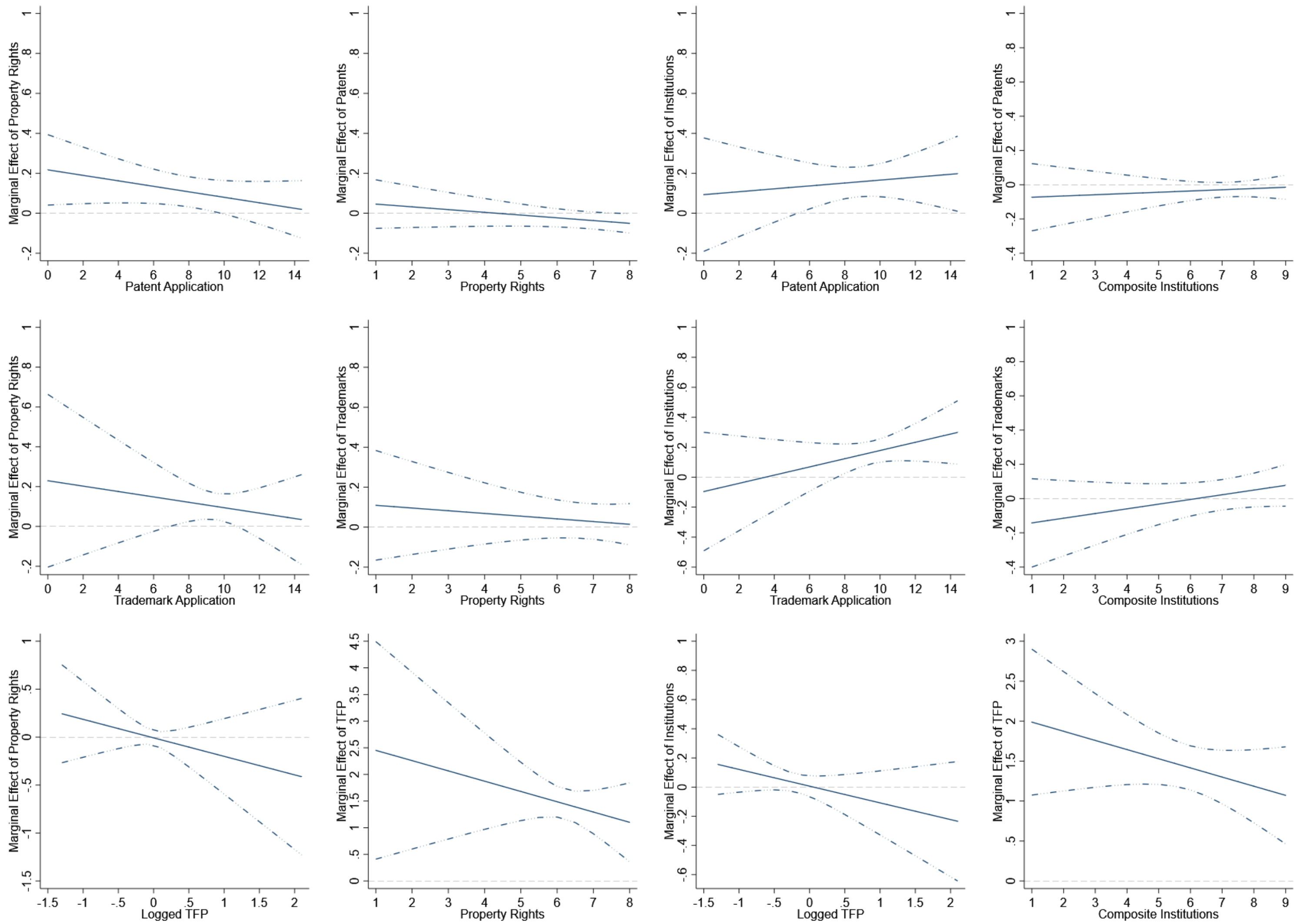


Figure 3.7: This matrix of diagrams shows the marginal effects of either institutions or innovation on growth conditional on their interacting counterparts. The estimations are carried out on developed countries. Each row shows the results of a measure of innovation: row 1 uses total patent application, row 2 uses total trademark application and row 3 uses TFP. The first two columns shows the marginal effects of property right and innovation or entrepreneurship or TFP, and the last two column shows the marginal effects of composite institutions and the innovation measures.

We then look at the marginal growth effects of the interacting variables at given values of their counterpart. Figure 3.7 shows these effects. Evidently, while some interaction terms do not display overall statistical significance in some instances, the marginal effects are partially significant at given levels (Graph 1 and 2 corresponding to column (1) of table 3.6, for instance). Specifically, the second and fourth graph in the last row, which shows the partial effects of productivity conditional on property right and institutions, respectively, demonstrate significant diminishing effects on the dependent variable. This suggests that the effects of productivity on growth for developed countries diminish as institutions expand and improve in quality.

To explain this phenomenon, one may theorise that industrialised, technologically advanced societies with established entrepreneurial and innovative bases typical of developed countries can suffer from diminishing returns and inefficiencies, reducing the growth-enhancing effects of innovation and economic institutions. This could be explained by the notion that iterative innovation contributes less to technological progress or growth enhancement than prior iterations or additional layers of bureaucratic institutions slowing down or outright discouraging innovations and entrepreneurial activities. Both effects may hinder economic growth. Similar phenomena can be observed across various measures for innovation and institutions, which further adds to the evidence.

Lastly, in figure 3.7 a contradicting behaviour can be noted in the first and third diagrams on the first row. The diagrams depict the marginal effects of property right protection and composite institutions on economic growth, respectively, conditional on the level of patent application. One can note that while the marginal effects of property right shown in diagram 1 are decreasing and significant at lower levels of patent application, the opposite holds true in diagram 3. Namely, at higher levels of patent application, the partial effects of composite institutions become significant and is, in fact, increasing. In combination, this apparent shift in overall effects on growth may indicate a non-linear impact institutions may have on economic growth. Specifically, we theorise that at lower levels of patent application property right protection is sufficient in creating positive marginal effects on economic growth when interacting with innovation. Evidently, such effects are diminishing due to reduced efficiency in management and protection as more applications are filed. When the level of patent application is sufficiently high, property right protection alone can no longer generate significant partial effects on economic growth, during which the highly innovative economy transitions into what is described in diagram 3. Under this regime, the composite institutions, a variable that incorporates the value of property right protection as a part of a weighted average, begin to assert a positive and increasing marginal effect on economic growth conditional on the increasing level of patent application. To contextualise such behaviour, one may consider an economy where very few patents are filed. In this environment, very little is needed to construct the institutions that enforce property right protection, and the cost of doing so is low. As more patent applications are filed, additional institutional bodies may be needed to validate, regulate and enforce protection, resulting in progressively higher costs. When such dynamics are initiated, property right protection alone may suffer from diminishing returns and inefficiencies to the point where the positive marginal effects dissipate. It would be at this point where more complex institutions are required to continue creating positive marginal effects on growth as the economy becomes more innovative. [20]

To further confirm the robustness of this finding, we carry out estimation with the property right score taken out of the composite institutional index. The results show increased statistical significance both

[20] An example of this can be a medieval economy, where property is the field and what is produced in the field. Protecting property right against expropriation in this context would entail guarding the field and the store with fences and guardsmen. But as more elaborate tools and more advanced forms of property are produced, additional measures would then be required to provide adequate property right protection. This progress would continue as additional layers of institutions are added: courts to settle dispute, patent offices to document inventions, and banks and royal treasuries to guard property against expropriation, all of which lie outside the conventional definition of property right protection but are part of the broader economic institutions.

in coefficients and marginal effects, which further support our findings and imply a transfer of marginal positive growth effects from economic institutions (in the form of property right protection) to non-economic institutions as an economy becomes more innovative[21].

3.6 GMM & IV Estimations

3.6.1 Model Setup

A prominent issue in fixed effects estimations is the potentially biased results caused by the endogeneity of regressors, which often manifest as reverse causation or unexplained components in the error term. In previous estimations reverse causation is partially addressed with the introduction of lagged explanatory variables, a common practice that is well documented (for instance, Leszczensky et al. 2019 and Bellemare 2017) as it is impossible for historical observations to have causal effects on future observations. To address other potential bias from endogeneity, we employ the system generalised method of moments estimator (system GMM) with lagged explanatory variables in levels and differences as instruments and a series of instrumental variable (IV) estimations to assess the robustness of the findings.

To address the issue of potentially endogenous regressors and reverse causation, we elect to employ system GMM estimator as part of the robustness check. As discussed in previous sections one may easily make the argument that the variables of interest present in the estimations might quite likely be endogenous, as innovation as well as other indicators used to approximate economic activities could be affected by control variables included in the estimations. Therefore, alternative estimators are justified to assess the overall robustness of our findings. First introduced by Arellano and Bond (1991), Arellano and Bover (1995) as well as Blundell and Bond (1998), system GMM is typically used to estimate panel data with endogenous regressors and small time length, which utilises lagged explanatory variables in levels and differences as instrument. While we acknowledge that our maximum time dimension is sufficiently large to justify using standard GMM estimator, two out of the three time dimensions (1990-2018 and 2000-2018) do not share this advantage. Furthermore, considering the size of the mixed-countries panel, we argue that the length of our largest possible time dimension (1970-2018) relative to our sample size also warrants this estimator.

One issue regarding the system GMM estimation that demands attention is the size of time dimension and number of groups. Stretching the time dimension to include all observations between 1970 and 2017 risks increasing the instrument counts considerably, thus weakening the results and risk overidentification. The number of instruments should not exceed the number of groups and be kept reasonably below that number. With this in mind, we provide the results of IV and GMM estimations for 2000-2017. Similar problems can also be found when distinguishing developmental status. The risk of overidentification is also present in estimations of developed countries, as the number of groups is severely constrained relative to developing countries. This issue is circumvented by making alterations to the regression model in separate estimations to accommodate alternative structures that would include the effect of economic development while not compromising the number of groups relative to the instrument count, in the form of a three-way interaction between the other two variables of interest.

Specifically, three alternative regression models are tested to address the above issues: firstly, we include a second order lagged dependent variable. The reasoning behind the inclusion of lagged dependent vari-

[21]The results of the additional estimations are available upon request.

able of multiple orders is theoretical in nature. We expect that the current level of dependent variable may be heavily determined by its past level, both for inequality and growth. In equality is seen as slow-moving while growth may be strongly affected by its past value. Secondly, in replacement of separate estimations for development groups, we introduce a three-way interaction between innovation, institutions and developmental status. Lastly, a third alternative model combine the previous two alterations.

For IV estimations and further robustness assessment of the previous results we instrument property right protections with a measure for judicial independence. We argue that property right protections, as an extension of political-economic institutions, is affected by the judiciary's ability to function independently. Being separate from other branches of governmental institutions or private actors allows improvements in its functionalities, including better protections of property rights. And due to its base in political institutions we argue that judicial independence does not impose direct effects on either inequality or growth. The measure for judicial independence is qualitative score constructed partially from Staton and Linzer's global measure of judicial independence (2015), extracted from the Fraser database (Gwartney, 2020).

3.6.2 The Inequality Model

Table 3.7 shows the results of system GMM and IV estimations in column (1)-(6) and (7)-(9) respectively. The p-values for first and second order auto-correlated disturbances, Hansen J statistics for overidentification, and number of instruments are reported for GMM estimations. As the model includes a lagged dependent variable as regressor, we expect first order auto-correlation, meaning it is within expectation for the p-values for AR(1) to be below significance level, thus rejecting the null hypothesis. This is true for all GMM outcomes as displayed in the table. However, the rejection of the AR(2) tests in column (1), (3) and (5) is problematic as the absence of serial error correlation is rejected for the mixed-country and developed country models as well as the revised model with three-way interactions, calling the validity of these instruments in question. Further issue is present for the developed country estimation shown in column (5) with regard to overidentification. This is evident by the unreasonably large Hansen test statistics and the reported instrument count exceeding number of groups, which can be caused by the small panel size, an issue that will be persistent in the estimation demands different methods to circumvent. Column (6) shows the estimation for developing countries. The results support those from fixed effects estimation, displaying positive coefficients for both institutions and innovation with regard to inequality, thus suggesting inequality-worsening effects from higher institutional values and level of innovation. The negative interaction between the two variables can also be observed, which implies once again a dampening effect on the dependent variable. The results for developing countries are shown to be significant and robust in terms of test statistics and instrument count, with the signs being consistent with previous estimation outcomes.

The results from the reversed models are shown in column (3) to (5), which contain a three-way interaction between the two variables of interest and the development status, an additional lagged dependent variable of the second order, and both additions, respectively. Evidently, the issue of too many instruments is resolved within these estimations as the need to divide the panel between developed and developing countries is no longer present. Both variables of interest and their interaction demonstrated statistical significance in column (3) and (4). While column (3) displays second order serial correlation, it is not the case for the remaining two. As both variables of interest, institutions and innovation, as well as their interaction term show consistent signs across estimations, their relations with inequality can be determined. As evident by the fixed effects estimation and the subsequent GMM estimations, both institutions and innovation are shown to positively affect inequality, or in other words, inequality inducing. Their interac-

	GMM						IV Estimations		
	Base	2 Lags	3-Way Interact	Both	Developed	Developing	Mixed	Developed	Developing
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Property Right	1.022**	0.296	1.662*	1.237*	1.140*	2.077*	0.062	0.003	0.189**
	(0.518)	(0.208)	(0.928)	(0.722)	(0.625)	(1.152)	(0.057)	(0.098)	(0.075)
Patent	0.836**	0.290**	1.317**	0.978*	1.096**	1.531*	0.112**	0.104	0.191***
	(0.376)	(0.142)	(0.627)	(0.533)	(0.546)	(0.795)	(0.050)	(0.089)	(0.063)
Property Right	-0.127*	-0.042	-0.234**	-0.177*	-0.130	-0.276*	-0.016**	-0.004	-0.037***
*Patent	(0.070)	(0.027)	(0.119)	(0.103)	(0.081)	(0.164)	(0.008)	(0.013)	(0.011)
Development			13.689	10.819*					
			(9.119)	(6.216)					
Development			-2.268	-1.878*					
*Property Right			(1.610)	(1.086)					
Development			-1.839	-1.574*					
*Patents			(1.192)	(0.888)					
Three-way			0.327	0.271*					
Interaction			(0.200)	(0.154)					
N	1224	1223	1224	1223	510	714	1219	509	710
Groups	102	102	102	102	33	69	97	32	65
Instrument Count	39	44	44	44	43	43			
AR(1)	0.001	0.000	0.002	0.000	0.045	0.033			
AR(2)	0.014	0.235	0.022	0.173	0.003	0.227			
Hansen J	0.360	0.985	0.373	0.993	1.000	0.564			
R-sqr							0.957	0.912	0.969
adjR-sqr							0.953	0.904	0.965
F							2017.315	425.814	1721.966
BIC							122	49	99

* p<0.10, ** p<0.05, *** p<0.010

Table 3.7: This table shows the results of system-GMM and IV estimations for the inequality models. The results from the initial model (marked as Base) is shown alongside with those from the revised models, the specifics of the revision is shown on top of each column. In addition, separate estimations for developed and developing countries are also shown. Statistics include sample size, number of groups, instrument counts for the GMM estimations, AR(1) and AR(2) autocorrelation test statistics, and Hansen J statistics for the GMM results. R-square, adjusted R-square, F statistics and BIC are shown for the IV estimations.

tion term, however, displays negative sign, which implies that the interaction between the two variables dampen the impact on inequality, reducing the inequality-worsening effects.

Examining the results from IV estimation, the coefficients demonstrate largely consistent signs and improved statistical significance which provide further support for the findings.

3.6.3 The Growth Model

As the estimations of the growth model use the same panel, similar issues regarding too many instruments persist, making distinguishing developmental status difficult without risking overidentification. The results of GMM estimations for the growth model are showcased in Table 3.8.

Column (1) displays the results from the baseline system GMM estimation, Column (2) displays the results from a revised model with a lagged dependent variable and Column (3) and (4) shows the results from developed and developing countries. Subsequent IV estimations are shown in column (5)-(7) for mixed panel, developed and developing countries respectively. As expected, estimations within development groups fared poorly due to the restricted sample size and a large time dimension. Models with mixed countries demonstrated significance for the variables of interest as shown in column (1), the base model, and column (4), the revised model. In both instances innovation and institutions are positively correlated with GDP, implying growth-enhancing effects. Once again, the interaction terms show negative coefficients which bear statistical significance. Note that for the base model, AR(1) was not rejected due to the fact that no lagged dependent variable was included as regressor, while serial correlation was

	GMM				IV Estimations		
	Base (1)	1 Lag (2)	Developed (3)	Developing (4)	Mixed (5)	Developed (6)	Developing (7)
Ineq	-0.060*	-0.002	-0.055	-0.028	-0.043***	0.037***	-0.068***
	(0.036)	(0.030)	(0.054)	(0.026)	(0.009)	(0.012)	(0.010)
Ppty Rgt	1.197**	0.750*	0.361	0.776	0.349***	0.285***	-0.100
	(0.601)	(0.394)	(0.612)	(1.020)	(0.075)	(0.083)	(0.107)
Patent	1.081**	0.619*	0.299	0.890	0.043	0.108*	-0.326***
	(0.516)	(0.331)	(0.617)	(0.755)	(0.065)	(0.059)	(0.090)
Ppty Rgt	-0.157*	-0.106*	-0.027	-0.155	-0.019*	-0.029***	0.049***
*Patent	(0.083)	(0.054)	(0.090)	(0.139)	(0.011)	(0.009)	(0.015)
N	1122	1122	463	659	1113	462	651
Groups	98	98	31	67	89	30	59
Instruments	48	32	48	48			
AR(1)	0.267	0.018	0.272	0.549			
AR(2)	0.547	0.200	0.383	0.547			
Hansen J	0.366	0.477	1.000	0.222			
R-sqr					0.504	0.773	0.594
adjR-sqr					0.455	0.751	0.546
F					60.503	104.932	53.525
BIC					266	-377	174

* $p<0.10$, ** $p<0.05$, *** $p<0.010$

Table 3.8: This table shows the results of system-GMM and IV estimations for the growth models. The results from the initial model (marked as Base) is shown alongside with those from the revised models, the specifics of the revision is shown on top of each column. In addition, separate estimations for developed and developing countries are also shown. Statistics display sample size, number of groups, instrument counts for the GMM estimations, AR(1) and AR(2) autocorrelation test statistics, and Hansen J statistics for the GMM results. R-square, adjusted R-square, F statistics and BIC are shown for the IV estimations.

expected in the revised model in column (4) with the inclusion of a lagged dependent variable. Both the base model and the revised model passed relevant tests with respectable instrument count relative to the number of groups.

GMM estimations of the growth model demonstrate improved results to the fixed effects estimations, as the latter mostly fail to produce statistically significant coefficients for the variables of interest, potentially due to the issue of endogeneity. The relations between the variables and their interaction terms and the dependent variables can also be explained in a manner that is not dissimilar to their fixed effects counterparts. In terms of the IV estimations the previously observed dynamics persist with both inequality's diverging impact on growth between development groups and the signs and significance for the variables of interest.

3.7 Concluding Remarks

Despite the sheer size of literature on the inequality-growth nexus the role of institutions and the mechanism of how it interacts with other key variables have sparsely examined or inconclusive, according to prior research. We contribute to the study by identifying a novel transmission channel that interacts innovation and institutions to examine their effects and joint effects on inequality and growth. Evidence from a mixed country panel fixed effects regression points towards positive innovation and institutional effects on both economic growth and inequality, suggesting that both innovation and institutions contribute to economic growth while worsening inequality. The interaction of the two variables of interest shows a significant and negative effect on the dependent variable, despite the individual effects being positive. This indicates that innovation conditional on levels of institutions, and vice versa, reduces the overall positive effects on either growth or inequality.

With regards to the inequality effects, we argue that the interaction between innovation and institutions dampens the adverse impact on equality and acts as a buffer between innovative progress and worsening inequality. For the growth model, as the interaction terms between variables of interest are negative and the marginal effects of both display statistical significance. We present the argument that a level of institutional or innovative inefficiencies may emerge and manifest as the negative marginal effects on growth originated from innovation, conditional on higher level of institutions, or institutions conditional on the level of innovation. Regressions with development groups that distinguish between developed and developing countries yield comparable results where the negative interacting effects on inequality and growth are shown to be more prominent in developed countries, providing evidence to the hypothesis of institutional or innovative inefficiencies and higher levels of development. The dampening effects on inequality persist in developed and developing countries.

We then test the robustness of our findings by subjecting the models to a series of further estimations, which includes system GMM and IV estimations over various specifications and variable approximations, all of which produce comparable and significant results, thus confirming our hypotheses.

Chapter 4

The Innovation-Institutions Effects: a Closer Look at the Interactions

4.1 Introduction

In the previous chapter we presented the estimations of the principal hypotheses and the findings derived from them. The purpose of this chapter is to provider a more in-depth assessment of the hypotheses and estimations that are complementary to the main body. The additions serve either as further robustness assessment to reinforce the main findings, or as supplementary work that provide additional insight to the main mechanisms. The rest of the chapter is organised as follows. In the next section we present the findings from a restricted growth model without inequality being a explanatory variable, to assess if the proposed effects of institutions and innovation as well as their interactions can in fact be observed when examined under a growth framework rather than the inequality-growth mechanism. Section 3 presents a suite of fixed effects estimations aimed to assess the overall robustness of the growth and inequality hypotheses under two different categories of specifications: alternative measures for innovation in the form of share of R&D expenditure, and three augmented panel sets with different time dimensions. In section 4 we adopt a novel quantile estimation technique to further investigate information that is otherwise obstructed when using conventional estimation techniques. Section 5 concludes this chapter.

4.2 Simple Growth Model

We carry out an additional round of estimations of the growth model without inequality being included as an explanatory variable. The purpose of this attempt, apart from further testing the robustness of the findings, is to assess the effects of interactions between innovation and institutions on growth outside the context of the inequality-growth nexus, while holding other specifications constant. The augmented growth model is shown as follows.

$$y_t = \phi_0 + \phi_1 inno_{i,t-1} + \phi_2 inst_{i,t-1} + \phi_3(inno_{i,t-1} \cdot inst_{i,t-1}) + \gamma_i + \gamma_t + \sum_{n=1}^{q} \mu_n X'_{n,t} + {}_{it} \tag{4.1}$$

Where y_t is growth measured by logged GDP per capita, $inno_{i,t-1}$ is lagged innovation, $inst_{i,t-1}$ lagged institutions, γ_i and γ_t are fixed individual and time effects respectively. The inclusion of the fixed effects is again to capture specific effects to individual samples or during a specific time period. This is done to maintain consistency with the baseline estimations [1]. $\sum_{n=1}^{q} \mu_n X'_t$ is a vector of control variables, including secondary school enrolment, trade exposure, child mortality, share of agricultural land, government expenditure, money growth and financial openness. The model is estimated using the panel set assembled for the principal estimations, which contains observations for the above-described variables from 155 countries between 1970 and 2018. Innovation is approximated with logged patent application, as well as logged trademark application and TFP[2]. Two measures for institutions are employed: a score for property right protection, and a composite institutional measures. Observations for both are extracted from the Fraser Institute Economic Freedom Index. Table 4.2, 4.3 and 4.4 display the results, for panel dimension starting with 1970, 1990 and 2000, respectively. Similar to the principal estimations the justifications for estimating the model with three different time dimensions is the limitation that developing countries tend to have poorer data availabilities, with a sizeable portion of said data being more recent. By estimating the models in three different time dimensions we address this limitation so that potential bias estimating for developing countries may produce can be identified when compared to estimations for developed countries.

Due to the considerable size of the estimation results shown in the following tables, it is difficult to display all marginal effects diagrams for each estimation. To circumvent this and prevent the loss of information by simply omitting the marginal effects diagrams, we employ a stylised coding system to describe the significance and shapes of each marginal effects of innovation and institutions, conditional on the values of institutions and innovation respectively. Table 4.1 provides a guide on how the stylised system can be interpreted.

Table 4.2 displays the results from estimations with the largest possible time dimension, 1970-2018. The left half of the table shows the results from estimations where property right is used as the measure for innovations, and the results in the right half are when the composite institutional index is used. We observe statistical significance for property right and the composite index in many instances, with most displaying positive signs. This indicates property right and institutions in a broader sense are positively correlated to growth, thus confirming the growth enhancing effects. There are also instances where the coefficients of institutions are shown to be significantly negative, exclusively when logged trademark application is used to approximate innovation, or entrepreneurship. We note that in those estimations the effects of trademark applications are also significantly negative, but their interactions with institutions are positive. Upon examining the marginal effects we notice that the positive marginal effects overtakes the negative effects of both trademark applications and institutions, producing an overall positive growth effects. This observation is consistent with previous estimations. In other instances we note that property right and institutions have statistically significant positive effects on growth in developed countries, while being negative in developing countries. Patent application does not display significance growth effects, but the signs are positive. TFP measuring productivity is shown to have a significantly positive effect on growth, a finding that is in line with conventional belief. Lastly, one may take note that in many instances the marginal effects of either institutions at given level of innovation, or innovation at given level of institutions are partially significant even when the interaction terms fail to display statistical significance. This indicates that in these estimations the interactions are significant at specific levels, a finding that was previously discussed.

[1] Refer to prior chapters for justifications and reasoning for the inclusion of the fixed effects estimators.

[2] The latter two may also measure entrepreneurship and productivity and can be view as such, but are categorised as innovation for the sake of simplicity.

The remaining two tables, 4.3 and 4.4 present the same set of estimations but on a medium and short time dimension, from 1990 and 2000 to 2018, respectively. We observe similar behaviour in statistical significance and signs for variables of interest as well as their interaction terms. The negative individual effects of institutions and logged trademark application, measuring entrepreneurship and the positive interactive effects of these variables and the overall positive growth effects are particularly curious, in the sense that this behaviour is quite different to that in estimations where patent or TFP is used. In those instances, the effects of both innovation and institutions are individually positive and growth enhancing, but the interactive effects of these variables are significantly negative, which reduce the overall positive effects. The opposite is observed when entrepreneurship is present, as measured by trademark application. We theorise that entrepreneurship may rely on the effects of institutions more so than innovation measured by patent application, or TFP, measuring productivity.

To summarise, the restricted growth model without the inclusion of inequality produces comparable results to the principal estimations. By comparing the results from the simple growth model with the inequality-growth model we can establish that the growth effects of institutions and innovation as well as their interaction do not originate from inequality and that direct growth effects can be observed.

Table 4.1: Notation guide for the estimation tables.

Legend		
Coefficient properties	*	Significant at 10%
	**	Significant at 5%
	***	Significant at 1%
	No Star	Not significant
	+	Positive coefficient
	-	Negative coefficient
Marginal effects properties	*↗	Upwards slope, mostly significant
	*↘	Downwards slope, mostly significant
	↗	Upwards slope, no significance
	↘	Downwards slope, no significance
	!(n)↗	Upwards slope, special case (n)
	!(n)↘	Downwards slope, special case (n)
	→	Flat or very weak marginal effects

Marginal diagrams	
1st row	The marginal effects of innovation on the dependent variable, conditional on the value of institutions.
2nd row	The marginal effects of institutions on the dependent variable, conditional on the value of innovation.

Margin special case !(n)	
n=1	Initially significant
n=2	Significant at tail
n=3	Significant in the middle
n=4	Highly Significant with switching signs.

This table shows the stylised marginal effects of innovation conditional on institutions, and marginal effects of institutions conditional on innovation on growth and inequality. If a marginal effect is coded 1 it means the effect is only significance when the conditional variable is low in value, and the effect decreases in significance as the interacting variable rises in value. Code 2 indicates significance at the tail, where the conditional variable is high in value. This implies that the partial effect starts as insignificant, but the effect increases in significance as the conditional variable increase in value. Code 3 and 4 indicate that the marginal effects are generally significant, while code 4 indicates that the marginal effect of a variable conditional on the interacting counterpart crosses in sign, either start as positive and transition into negative, or in reverse while maintaining its statistical significance.

Table 4.2: The simple growth model, 1970-2018

	Patent			TM			TFP			Patent			TM			TFP		
	Mixed (1)	Dev (2)	unDev (3)	Mixed (4)	Dev (5)	unDev (6)	Mixed (7)	Dev (8)	unDev (9)	Mixed (10)	Dev (11)	unDev (12)	Mixed (13)	Dev (14)	unDev (15)	Mixed (16)	Dev (17)	unDev (18)
PptyRgt	-0.000	0.216***	-0.168	-0.285**	0.209	-0.360**	0.059*	-0.002	0.075*									
	(0.080)	(0.077)	(0.113)	(0.126)	(0.189)	(0.153)	(0.035)	(0.036)	(0.044)									
Inst										-0.007	0.103*	-0.230**	-0.514***	-0.148	-0.771***	0.075**	0.038	0.040
										(0.090)	(0.057)	(0.112)	(0.129)	(0.131)	(0.137)	(0.033)	(0.035)	(0.035)
Patent	-0.026	0.064	-0.101							-0.030	-0.064	-0.100						
	(0.075)	(0.065)	(0.106)							(0.085)	(0.056)	(0.094)						
Trademark				-0.102*	0.091	-0.113							-0.228***	-0.224*	-0.306***			
				(0.060)	(0.145)	(0.069)							(0.068)	(0.113)	(0.070)			
TFP							1.156	2.379*	1.409*							1.129**	1.843***	0.833*
							(0.751)	(1.171)	(0.736)							(0.483)	(0.611)	(0.447)
PptyRgt*Patent	0.015	-0.014	0.033*															
	(0.011)	(0.009)	(0.018)															
PptyRgt*TM				0.041***	-0.012	0.043**												
				(0.013)	(0.020)	(0.017)												
PptyRgt*TFP							-0.043	-0.159	-0.116									
							(0.138)	(0.188)	(0.138)									
Inst*Patent										0.015	0.006	0.035**						
										(0.014)	(0.007)	(0.017)						
Inst*TM													0.065***	0.031**	0.086***			
													(0.014)	(0.013)	(0.016)			
Inst*TFP																-0.045	-0.092	-0.002
																(0.092)	(0.099)	(0.100)
Partial effects: Inst cond. Inno	↗ *	↘ *	↗	↗ !(4)	↘ !(3)	↗ !(4)	↘	↘	↘	↗ !(3)	↗ *	↗ !(1)	↗ !(4)	↗ !(2)	↗ !(4)	↘ !(3)	↘	→
Partial effects: Inno cond. Inst	↗ !(2)	↘	↗ !(2)	↗ *	↘	↗*	↘ *	↘ *	↘ !(3)	↗ !(2)	↗	↗ !(2)	↗ !(4)	↗	↗ !(4)	↘ *	↘ *	→ *
N	1979	808	1171	2286	827	1459	3008	1043	1965	1996	821	1175	2305	841	1464	3023	1058	1965
R-sqr	0.868	0.958	0.867	0.849	0.947	0.844	0.905	0.977	0.884	0.868	0.958	0.869	0.859	0.950	0.861	0.907	0.977	0.883
adjR-sqr	0.865	0.956	0.862	0.846	0.944	0.839	0.904	0.976	0.881	0.865	0.955	0.864	0.857	0.948	0.857	0.905	0.976	0.879
dfres	108	31	76	117	30	86	105	31	73	108	31	76	117	30	86	105	31	73

* $p<0.10$, ** $p<0.05$, *** $p<0.010$

This table shows the results from the estimations of the restricted growth model, with the largest possible time dimension, 1970-2018. Two measures for institutions quality: Property right protection and the composite institutional index, and three measures for innovation and alternatives: logged total patent applications, logged total trademark applications, and TFP. Estimations are carried out with a mixed country panel, developed and developing country panels. Findings in this table are consistent with prior results from the fixed effects estimations as well as the GMM and IV estimations. Statistics included are sample size *N*, R-squared and adjusted R-squared, as well as degrees of freedom. The marginal effects of both institutions conditional on innovation, and innovation conditional on institutions are shown in stylised forms. The arrows represents the general slope of the effects (upwards, downwards or mostly flat), and statistical significance are coded. Refer to table 4.1 for a guide on how to interpret them.

Table 4.3: The simple growth model, 1990-2018

	Patent			TM			TFP			Patent			TM			TFP		
	Mixed	Dev	unDev	Mixed	Dev	unDev	Mixed	Dev	unDev	Mixed	Dev	unDev	Mixed	Dev	unDev	Mixed	Dev	unDev
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
PptyRgt	-0.039	0.191**	-0.244**	-0.186*	0.138	-0.318**	0.085**	0.048	0.058									
	(0.073)	(0.087)	(0.101)	(0.105)	(0.201)	(0.152)	(0.037)	(0.034)	(0.052)									
Inst										-0.094	0.077	-0.239	-0.338**	-0.226	-0.673***	0.024	0.123**	-0.017
										(0.101)	(0.090)	(0.148)	(0.139)	(0.149)	(0.190)	(0.042)	(0.046)	(0.039)
Patent	-0.119*	0.043	-0.234**							-0.092	-0.106	-0.142						
	(0.062)	(0.079)	(0.090)							(0.085)	(0.096)	(0.101)						
Trademark				-0.040	0.044	-0.077							-0.091	-0.271*	-0.226**			
				(0.048)	(0.137)	(0.065)							(0.073)	(0.133)	(0.090)			
TFP							0.909	2.401	0.603							0.465	2.834**	0.287
							(0.967)	(1.672)	(1.078)							(0.498)	(1.386)	(0.522)
PptyRgt*Patent	0.022**	-0.010	0.046***															
	(0.010)	(0.011)	(0.017)															
PptyRgt*TM				0.030**	-0.004	0.040**												
				(0.012)	(0.021)	(0.018)												
PptyRgt*TFP							-0.017	-0.193	0.044									
							(0.177)	(0.296)	(0.210)									
Inst*Patent										0.017	0.012	0.030						
										(0.014)	(0.013)	(0.022)						
Inst*TM													0.039**	0.042**	0.070***			
													(0.016)	(0.018)	(0.022)			
Inst*TFP																0.082	-0.224	0.121
																(0.095)	(0.208)	(0.112)
Partial effects: Inst cond. Inno	↗ *	↘ *	↗ !(4)	↗ !(2)	↘ *	↗ !(4)	→	↘	↗	↗	↗ *	↗	↗ !(4)	↗ !(2)	↗ !(4)	↗	↘ !(3)	↗
Partial effects: Inno cond. Inst	↗	↘	↗ !(4)	↗ *	↘	↗ *	→ !(3)	↘ !(3)	↗ !(3)	↗	↗	↗	↗ *	↗	↗ !(4)	↗ *	↘ *	↗ *
N	1601	647	954	1851	668	1183	1993	710	1283	1608	653	955	1858	674	1184	1999	716	1283
R-sqr	0.856	0.915	0.874	0.843	0.897	0.858	0.853	0.924	0.859	0.849	0.911	0.869	0.841	0.901	0.864	0.850	0.926	0.858
adjR-sqr	0.853	0.910	0.869	0.840	0.891	0.854	0.850	0.920	0.855	0.845	0.906	0.864	0.838	0.895	0.859	0.847	0.923	0.854
dfres	106	31	74	116	30	85	105	31	73	106	31	74	116	30	85	105	31	73

* $p<0.10$, ** $p<0.05$, *** $p<0.010$

This table shows the results from the estimations of the restricted growth model, with a medium time dimension, 1990-2018. Two measures for institutions quality: Property right protection and the composite institutional index, and three measures for innovation and alternatives: logged total patent applications, logged total trademark applications, and TFP. Estimations are carried out with a mixed country panel, developed and developing country panels. Findings in this table are consistent with prior results from the fixed effects estimations as well as the GMM and IV estimations. Statistics included are sample size N, R-squared and adjusted R-squared, as well as degrees of freedom. The marginal effects of both institutions conditional on innovation, and innovation conditional on institutions are shown in stylised forms. The arrows represents the general slope of the effects (upwards, downwards or mostly flat), and statistical significance are coded. Refer to table 4.1 for a guide on how to interpret them.

Table 4.4: The simple growth model, 2000-2018

	Patent			TM			TFP			Patent			TM			TFP		
	Mixed (1)	Dev (2)	unDev (3)	Mixed (4)	Dev (5)	unDev (6)	Mixed (7)	Dev (8)	unDev (9)	Mixed (10)	Dev (11)	unDev (12)	Mixed (13)	Dev (14)	unDev (15)	Mixed (16)	Dev (17)	unDev (18)
PptyRgt	0.040	0.142	-0.126	-0.148	0.170	-0.295*	0.071**	0.084**	-0.015									
	(0.098)	(0.093)	(0.149)	(0.138)	(0.183)	(0.164)	(0.034)	(0.031)	(0.040)									
Inst										-0.003	0.245	-0.102	-0.182	0.475	-0.371	0.058	0.168**	0.005
										(0.157)	(0.210)	(0.156)	(0.200)	(0.371)	(0.243)	(0.040)	(0.066)	(0.036)
Patent	-0.101	-0.002	-0.138							-0.106	-0.015	-0.100						
	(0.073)	(0.081)	(0.102)							(0.124)	(0.170)	(0.114)						
Trademark				-0.094	0.018	-0.130**							-0.107	0.189	-0.181			
				(0.062)	(0.126)	(0.064)							(0.103)	(0.250)	(0.115)			
TFP							-0.050	3.454***	-0.061							-0.638	5.301***	-0.188
							(0.652)	(1.137)	(0.726)							(0.520)	(1.902)	(0.575)
PptyRgt*Patent	0.012	-0.005	0.023															
	(0.011)	(0.011)	(0.018)															
PptyRgt*TM				0.027**	-0.007	0.034**												
				(0.013)	(0.019)	(0.016)												
PptyRgt*TFP							0.203	-0.373*	0.190									
							(0.125)	(0.194)	(0.153)									
Inst*Patent										0.012	-0.004	0.018						
										(0.020)	(0.022)	(0.021)						
Inst*TM													0.029	-0.028	0.043*			
													(0.020)	(0.035)	(0.025)			
Inst*TFP																0.314***	-0.581**	0.213
																(0.104)	(0.278)	(0.128)
Partial effects: Inst cond. Inno	↗ *	↘ !(3)	↗	↗ !(2)	↘ !(3)	↗ !(2)	↗ !(3)	↘ !(1)	↗	↗	↘ !(3)	↗	↗ !(2)	↘ !(3)	↗	↗ !(4)	↘ !(1)	↗
Partial effects: Inno cond. Inst	↗	↘	↗	↗	↘	↗	↗ *	↘ *	↗ *	↗	↘ !(3)	↗	↗	↘	↗	↗ *	↘ *	↗ *
N	1149	463	686	1333	479	854	1415	501	914	1150	463	687	1334	479	855	1415	501	914
R-sqr	0.834	0.921	0.860	0.820	0.905	0.848	0.857	0.928	0.877	0.828	0.922	0.858	0.815	0.905	0.847	0.858	0.931	0.878
adjR-sqr	0.831	0.916	0.854	0.816	0.900	0.843	0.854	0.924	0.874	0.824	0.918	0.853	0.812	0.900	0.842	0.855	0.928	0.874
dfres	102	30	71	113	30	82	105	31	73	102	30	71	113	30	82	105	31	73

* p<0.10, ** p<0.05, *** p<0.010

This table shows the results from the estimations of the restricted growth model, with the smallest possible time dimension, 2000-2018. Two measures for institutions quality: Property right protection and the composite institutional index, and three measures for innovation and alternatives: logged total patent applications, logged total trademark applications, and TFP. Estimations are carried out with a mixed country panel, developed and developing country panels. Findings in this table are consistent with prior results from the fixed effects estimations as well as the GMM and IV estimations. Statistics included are sample size *N*, R-squared and adjusted R-squared, as well as degrees of freedom. The marginal effects of both institutions conditional on innovation, and innovation conditional on institutions are shown in stylised forms. The arrows represents the general slope of the effects (upwards, downwards or mostly flat), and statistical significance are coded. Refer to table 4.1 for a guide on how to interpret them.

4.3 Further Robustness Checks

The results described in the previous chapter as well as the above section from the instrument variables, system-GMM estimations and the restricted growth model reinforce our findings on how innovation, institutions and their interactions behave under the context of an inequality and a growth model. Under both frameworks, innovation and institutions are found to be positively correlated with the dependent variables, thus confirming the previously proposed hypotheses of growth-enhancing and inequality worsening effects of innovation and institutions. The interaction terms between the key variables are shown to be significantly negative, indicating dampening partial effects on either growth or inequality. To gather additional evidence in support of our findings, a series of robustness checks are carried out on various specifications or using alternative analytical techniques. In this section we outline two major augmentations: an alternative measure for innovation, and multiple time dimensions.

Due to the amount of estimations shown in the following tables it is difficult to display all marginal effects diagrams for each estimation. To circumvent this and prevent the loss of information by simply omitting the marginal effects diagrams, we employ a stylised coding system to describe the significance and shapes of each marginal effects of innovation and institutions, conditional on the values of institutions and innovation, respectively. Table 4.1 provides a guide on how the stylised system can be interpreted.

4.3.1 Approximating Innovation with R&D Expenditure

Due to the majority of the observations being available after 2000 for most countries, share of R&D expenditure as a percentage of GDP is not included in the primary estimation results but are rather a part of the further robustness tests in smaller time dimensions. The variable captures the aggregate spending on research and development in public, private, non-profit and higher education sectors as a share of GDP. This covers expenditures on theoretical and applied research as well as experimental development. Including both public and private spending this variable not necessarily measures private R&D expenditure or those from foreign investors exclusively but also state investment in research and development. One may argue that this is an adequate approximation of innovation but is of a different calibre relative to total patent applications, which is used in the primary estimations, as a share of GDP captures the overall spending on innovation and technological advancement which may include failed or ineffective expenditure, whereas total patent applications measure the amount of concrete innovation being submitted for patenting. The observations are extracted from the World Development Indicators with the source being the UNESCO Institute for Statistics. For this round of robustness tests, we replace the previous measures of innovation with R&D expenditure and carry out all combinations of estimations with other specifications holding constant, but for two smaller time dimensions (1990 – 2018 and 2000 – 2018) due to availability of data. While the overall pattern of variables of interest shows consistency to the primary estimations, the level of statistical significance is relatively low. For the growth model, institutions, either property right protections or the composite index, are shown to possess positive and significant coefficients, reinforcing their growth enhancing effects. This is also observed in development groups where the positive growth effects of institutions can be seen to be applicable for both developing and developed countries. Innovations are shown to have positive effects on growth, though not significant. The interactions between the two variables are not significant, but the signs remain consistent and the marginal effects of innovations and institutions conditional on their counterparts show limited statistical significance at higher level. Similar outcomes are seen for the inequality model, with consistent coefficient signs but relatively low statistical significance for both variables of interest and their interactions. Stylised results are available.

4.3.2 Alternative Time Dimensions

Both the inequality and growth model are now estimated with an additional two sets of time dimensions. Recall that the primary estimations are carried out on a panel dataset containing data from 1970 to 2018. This is the largest possible time dimension we are able to obtain without making sacrifice in panel size, both in terms of countries and variables. With this time dimension and the fact that part of the estimations is on a mixture of developed and developing countries, an argument can be made that disparity in data availability between developed and developing countries could compromise the authenticity of the results, in the sense that with a large time dimension some developing countries may not share the extensive data availability relative to developed countries, and thus estimations carried out under this premise may be subject to potential bias. To address this valid concern, two additional time dimensions are used in this section: 1990 – 2018 and 2000 – 2018. The same estimations on an identical set of variables are carried out, all producing comparable results in terms of statistical significance and coefficient signs, with no notable shifts of outcomes for the variables of interest and their interactions. When distinguishing developmental status, the results are once again effectively identical to the primary results for both shorter time dimensions. This suggests that the concern regarding potential bias originate from an unbalanced panel set and uneven observation availability between developed and developing groups does not appear to manifest in a significant way that may compromise our findings. The results from these estimations are presented and described below.

4.3.3 Empirical Results

We now present the empirical results obtained from estimations under shorter time dimensions. The results are presented alongside with the initial estimation in its entirety with the best possible time coverage. The results from the growth model are shown as separate from those from the inequality model, while both contain the outcomes from estimations on developed countries, developing countries and a mixture of the two. Apart from the different time dimensions all other specifications are kept as constant. The new addition of R&D expenditure as an alternative measure for innovation is also included in these tables. Note that due to the data for R&D expenditure as a percentage of GDP is not available before 1990 it is not present in some tables.

Table 4.5 and 4.6 show the effects of institutions and innovation on inequality and growth, respectively, with the largest possible time dimension 1970-2018. One may take note that in table 4.5 the rare instances where the variables of interest display statistical significance are for developed countries, where both property right and composite institutions, and innovation under different measures have increasing effects on inequality (column 2, 5, 11 and 17). In these estimations the interaction terms between innovation and institutions are significantly negative, indicating a dampening marginal effects. As shown, the decreasing marginal effects indicate that the partial effects of both institutions and innovation at given level of their interacting counterparts are reducing. This means the positive inequality effects diminishes as a country improves in its institutions and progresses technologically. For developed countries, this behaviour can be observed when either patent, measuring innovation, or trademark, measuring entrepreneurship, are used. One notable outlying result can be seen in column 16 and 18, where TFP is interacting with the composite institutional index. In these instances TFP measuring productivity, has a positive effects on inequality for developing countries. This would suggest that at earlier stages of development, productivity gain, which is a key contributor of economic growth, increase inequality in less developed countries. The same effects can also be observed in developed countries, but at a reduced statistical significance (seen in column 17). This discovery is inline with conventional growth theory in the inequality-growth nexus, where developing countries are said to experience heightened productivity gain and economic growth at the expense of equality. The marginal effects from interacting the variables of interest are negative, implying diminishing returns as the conditional variables increases in value.

For results from the growth model, depicted in table 4.6, we see less symmetric outcomes across different specifications. For developed countries, property right protection is shown to have positive effects on growth, but is only significantly positive when interacted with logged patent application (observed in column 2). Apart from this instance neither property right nor institutions are seen to have a significant effect on growth, though coefficient signs are positive for developed countries. Similarly, measures for innovation also display no statistical significance for developed countries, apart from TFP, which has positive and significant effects on growth, when interacted with property right or the composite institutions (column 8 and 17). Overall institutions and property right does not demonstrate notable effects of statistical significance when estimated with data from developed countries, nor does the most measures of innovation apart from TFP. The marginal effects from interacting the variables of interest however, show partial significance. In column 2, The marginal effects of innovation is shown to be mostly significant at given level of institutions. Similar outcomes can be observed in column 3, where the effects of innovation are significant when institutions are at medium level. In column 11, 14 and 17 the partial effects of innovation on growth given the level of institutions are notably significant despite the coefficients being not so. The positive and significant effects of the interaction terms overtaking the negative the individual effects of property right and innovation on growth can once again be observed in developing countries. Said effects are very prominent, as observed in column 3, 6 and 15. Note that in these instances the marginal effects are shown to be significant towards the tail end, indicating that the positive marginal effects of innovation and institutions manifest when the given level of institutions and innovation, respectively, are very high.

Table 4.7 and 4.8 display the results for the inequality model and the growth model when a medium time dimension is used (1990-2018). In addition to the three measures for innovation used in the previous sets of estimations, logged R&D expenditure as a percentage of GDP is also included in this set going forward. We note that in table 4.7 no significant results can be observed when innovation interacts with property right protection, while the effects of innovation and institutions are positive towards inequality (inequality worsening), and their interactions having negative effects, which is consistent with early estimations. In column 12 R&D expenditure has a positive effect on inequality, indicating that an increase in R&D expenditure can increase inequality in developing countries. Meanwhile the interaction between R&D expenditure and property right protection negatively impact inequality. Both effects show statistical significance at 10% level. Comparatively, the effects of TFP and R&D expenditure interacting with the composite institutions index show more significance in the right half of table 4.7, with most of the significant effects occurring in developed countries. Column 17 shows that the effects of trademark applications and composite institutions increase inequality while their interactions dampens the overall effects. In other columns numerous interactions display partial statistical significance as shown by the marginal effects notations. Overall estimations carried out on the medium time dimension produce comparable results that are consistent with prior findings. The results from the growth model is shown in table 4.8. We see that most of the significant growth effects manifest in developing countries, a finding that possesses policy implication for economic development. Inequality is shown to have significant and positive effects on economic growth, supporting a positive inequality-growth transmission channel. The interactions between institutions and innovation approximated by all four variables are positive on economic growth in developing countries, as shown in column 3, 6, 18 and 21. This shows the importance of institutions, both property right protection and institutions in a broader sense, and innovation in promoting growth.

Table 4.5: The inequality model, 1970-2018

	Patent			TM			TFP			Patent			TM			TFP		
	Mixed (1)	Dev (2)	unDev (3)	Mixed (4)	Dev (5)	unDev (6)	Mixed (7)	Dev (8)	unDev (9)	Mixed (10)	Dev (11)	unDev (12)	Mixed (13)	Dev (14)	unDev (15)	Mixed (16)	Dev (17)	unDev (18)
PptyRgt	0.096	0.272**	0.054	-0.033	0.488*	-0.107	0.005	-0.014	0.005									
	(0.101)	(0.130)	(0.175)	(0.121)	(0.275)	(0.171)	(0.032)	(0.050)	(0.034)									
Inst										-0.002	0.493*	-0.113	-0.049	0.503	-0.108	0.017	-0.008	0.031
										(0.079)	(0.248)	(0.103)	(0.108)	(0.346)	(0.128)	(0.027)	(0.044)	(0.030)
Patent	0.112	0.298**	0.105							-0.030	0.376*	-0.096						
	(0.099)	(0.113)	(0.170)							(0.058)	(0.188)	(0.066)						
Trademark				0.035	0.397*	0.029							-0.020	0.325	-0.017			
				(0.072)	(0.210)	(0.097)							(0.056)	(0.257)	(0.062)			
TFP							0.382	-0.089	0.203							0.781**	1.278*	1.090***
							(0.442)	(2.617)	(0.326)							(0.312)	(0.635)	(0.402)
PptyRgt*Patent	-0.019	-0.038**	-0.015															
	(0.016)	(0.017)	(0.030)															
PptyRgt*TM				0.001	-0.053*	0.009												
				(0.014)	(0.028)	(0.021)												
PptyRgt*TFP							-0.069	-0.056	-0.049									
							(0.084)	(0.390)	(0.060)									
Inst*Patent										0.005	-0.046*	0.022						
										(0.009)	(0.025)	(0.014)						
Inst*TM													0.011	-0.040	0.018			
													(0.011)	(0.033)	(0.014)			
Inst*TFP																-0.158**	-0.270***	-0.265***
																(0.066)	(0.088)	(0.089)
Partial effects: Inno cond. Inst	↘	↘ !(1)	↘	→	↘	↗	↘	↘	↘	↗	↘ !(1)	↗ !(2)	↗ !(3)	↘	↗ !(2)	↘ !(4)	↘ !(1)	↘ !(4)
Partial effects: Inst cond. Inno	↘	↘ *	↘	→	↘	↗ !(3)	↘	↘	↘	↗	↘ *	↗	↗	↘	↗ *	↘ !(4)	↘ !(2)	↘ !(4)
N	2052	903	1149	2262	892	1370	2710	1096	1614	2052	903	1149	2262	892	1370	2710	1096	1614
R-sqr	0.971	0.962	0.978	0.973	0.959	0.980	0.976	0.966	0.983	0.971	0.962	0.978	0.974	0.959	0.981	0.977	0.966	0.983
adjR-sqr	0.970	0.960	0.977	0.973	0.957	0.980	0.976	0.964	0.982	0.970	0.960	0.977	0.973	0.957	0.980	0.976	0.964	0.983
dfres	106	32	73	117	30	86	106	32	73	106	32	73	117	30	86	106	32	73

* p<0.10, ** p<0.05, *** p<0.010

This table shows the results from the inequality effects estimations, with the largest possible time dimension 1970-2018. Two measures for institutions quality: Property right protection and the composite institutional index, and three measures for innovation and alternatives are included: total patent applications, total trademark applications and TFP. Due to no observations older than 1990 being available for R&D expenditure, estimations with R&D expenditure are not present. Estimations are carried out on a mixed country panel, developed and developing country panels. As shown multiple estimations show significance in variables of interest an0d their interaction terms, with significant marginal effects (e.g. column 2, 5, 11, 16, 17 and 18). It is notable that the inequality effects are significant for developed countries with various measures for innovation as well as institutions. Some marginal effects demonstrate partial significance where the coefficients do not (e.g. column 6, 12, 13 and 15), mostly for developing countries. Statistics including sample size, R square, adjusted R square are included. The marginal effects of both institutions conditional on innovation, and innovation conditional on institutions are shown in stylised forms. The arrows represents the general slope of the effects (upwards, downwards or mostly flat), and statistical significance are coded. Refer to table 4.1 for a guide on how to interpret them.

Table 4.6: The growth model, 1970-2018

	Patent			TM			TFP			Patent			TM			TFP		
	Mixed (1)	Dev (2)	unDev (3)	Mixed (4)	Dev (5)	unDev (6)	Mixed (7)	Dev (8)	unDev (9)	Mixed (10)	Dev (11)	unDev (12)	Mixed (13)	Dev (14)	unDev (15)	Mixed (16)	Dev (17)	unDev (18)
Ineq	0.008	0.006	0.026**	0.004	-0.012	0.024**	-0.009	-0.010	0.007	0.009	0.006	0.027**	0.004	-0.012	0.023**	-0.009	-0.009	0.007
	(0.012)	(0.010)	(0.012)	(0.011)	(0.014)	(0.011)	(0.010)	(0.010)	(0.011)	(0.013)	(0.010)	(0.013)	(0.011)	(0.013)	(0.011)	(0.010)	(0.010)	(0.012)
PptyRgt	0.029	0.217**	-0.155	-0.292**	0.230	-0.476***	0.021	-0.007	0.020									
	(0.082)	(0.090)	(0.116)	(0.140)	(0.221)	(0.162)	(0.032)	(0.038)	(0.042)									
Inst										-0.068	0.093	-0.155	-0.475***	-0.096	-0.647***	0.023	0.007	-0.036
										(0.089)	(0.145)	(0.120)	(0.114)	(0.202)	(0.145)	(0.032)	(0.036)	(0.033)
Patent	-0.010	0.060	-0.090							-0.067	-0.080	-0.026						
	(0.076)	(0.071)	(0.113)							(0.088)	(0.116)	(0.106)						
Trademark				-0.075	0.123	-0.149**							-0.174***	-0.170	-0.222***			
				(0.069)	(0.162)	(0.070)							(0.064)	(0.151)	(0.071)			
TFP							1.422**	2.645**	1.593**							1.299**	2.103***	0.568
							(0.706)	(1.238)	(0.610)							(0.586)	(0.553)	(0.457)
PptyRgt*Patent	0.013	-0.014	0.031*															
	(0.011)	(0.010)	(0.018)															
PptyRgt*TM				0.042***	-0.014	0.057***												
				(0.014)	(0.023)	(0.017)												
PptyRgt*TFP							-0.076	-0.193	-0.159									
							(0.135)	(0.198)	(0.121)									
Inst*Patent										0.021	0.007	0.022						
										(0.014)	(0.016)	(0.019)						
Inst*TM													0.059***	0.027	0.070***			
													(0.013)	(0.021)	(0.016)			
Inst*TFP																-0.061	-0.115	0.055
																(0.106)	(0.090)	(0.101)
Partial effects: Inno cond. Inst	↗ *	↘ *	↗	↗ !(4)	↘ !(3)	↗ !(4)	↘	↘	↘	↗ !(3)	↗ !(2)	↗	↗ !(4)	↗ !(2)	↗ !(4)	↘	↘	↗
Partial effects: Inst cond. Inno	↗ !(2)	↘	↗ !(2)	↗ *	↘	↗ *	↘ *	↘ *	↘ *	↗ !(2)	↗	↗ !(2)	↗ !(4)	↗	↗ !(4)	↘ *	↘ *	↗ *
N	1866	789	1077	2091	806	1285	2517	984	1533	1866	789	1077	2091	806	1285	2517	984	1533
R-sqr	0.880	0.956	0.890	0.871	0.945	0.878	0.913	0.974	0.898	0.879	0.955	0.889	0.874	0.946	0.882	0.913	0.975	0.897
adjR-sqr	0.877	0.953	0.885	0.868	0.941	0.874	0.911	0.973	0.894	0.876	0.952	0.884	0.871	0.943	0.878	0.911	0.973	0.893
dfres	101	31	69	112	30	81	103	31	71	101	31	69	112	30	81	103	31	71

* p<0.10, ** p<0.05, *** p<0.010

This table shows the results from the standard growth effects estimations, with the largest possible time dimension 1970-2018. Note that this set of regressions differ from those shown in table 4.2 which are a set of more restricted growth models. Two measures for institutions quality: Property right protection and the composite institutional index, and three measures for innovation and alternatives are included: total patent applications, total trademark applications and TFP. Due to no observations older than 1990 being available for R&D expenditure, estimations with R&D expenditure are not present. Estimations are carried out on a mixed country panel, developed and developing country panels. As shown multiple mixed country and developing countries display significant coefficients that are consistent with previously presented findings. In addition inequality is shown to be significantly and positively correlated to growth for developing countries, which confirms conventional wisdom. Multiple interaction terms across estimations are statistically significant, with partial effects overshadowing individual effects of variables of interest. Statistics included are sample size N, R-squared and adjusted R-squared, as well as degrees of freedom. The marginal effects of both institutions conditional on innovation, and innovation conditional on institutions are shown in stylised forms. The arrows represents the general slope of the effects (upwards, downwards or mostly flat), and statistical significance are coded. Refer to table 4.1 for a guide on how to interpret them.

Table 4.7: The inequality model, 1990-2018

	Patent			TM			TFP			R&D			Patent			TM			TFP			R&D		
	Mixed (1)	Dev (2)	unDev (3)	Mixed (4)	Dev (5)	unDev (6)	Mixed (7)	Dev (8)	unDev (9)	Mixed (10)	Dev (11)	unDev (12)	Mixed (13)	Dev (14)	unDev (15)	Mixed (16)	Dev (17)	unDev (18)	Mixed (19)	Dev (20)	unDev (21)	Mixed (22)	Dev (23)	unDev (24)
PptyRgt	0.100	0.213	0.163	0.053	0.294	0.037	0.011	0.048	0.015	-0.053	-0.054	-0.115												
	(0.118)	(0.135)	(0.195)	(0.117)	(0.298)	(0.173)	(0.028)	(0.047)	(0.038)	(0.041)	(0.055)	(0.083)												
Inst													0.104	0.676**	0.056	0.100	1.336***	0.005	0.080**	0.151	0.091***	0.047	0.016	0.062
													(0.098)	(0.314)	(0.141)	(0.152)	(0.453)	(0.184)	(0.032)	(0.117)	(0.034)	(0.055)	(0.103)	(0.104)
Patent	0.123	0.215	0.162										0.026	0.415*	-0.036									
	(0.115)	(0.138)	(0.182)										(0.079)	(0.238)	(0.091)									
Trademark				0.069	0.234	0.080										0.034	0.836**	-0.001						
				(0.063)	(0.255)	(0.088)										(0.079)	(0.333)	(0.081)						
TFP							-0.071	1.067	-0.155										0.453	4.291	0.359			
							(0.584)	(3.129)	(0.816)										(0.339)	(2.654)	(0.431)			
R&D										0.158	0.217	0.421*										0.028	0.556	0.108
										(0.141)	(0.325)	(0.236)										(0.159)	(0.615)	(0.217)
PptyRgt*Patent	-0.017	-0.020	-0.029																					
	(0.019)	(0.019)	(0.033)																					
PptyRgt*TM				-0.008	-0.027	-0.007																		
				(0.014)	(0.032)	(0.021)																		
PptyRgt*TFP							-0.032	-0.244	-0.027															
							(0.105)	(0.466)	(0.166)															
PptyRgt*R&D										-0.025	0.004	-0.085*												
										(0.026)	(0.056)	(0.047)												
Inst*Patent													0.001	-0.047	0.009									
													(0.012)	(0.030)	(0.018)									
Inst*TM																-0.002	-0.109**	0.010						
																(0.016)	(0.043)	(0.019)						
Inst*TFP																			-0.136*	-0.666*	-0.150			
																			(0.072)	(0.363)	(0.104)			
Inst*R&D																						0.000	-0.047	-0.019
																						(0.028)	(0.093)	(0.046)
Partial effects: Inno cond. Inst	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	→	↘	↗ !(3)	↘ *	↗ !(3)	→ !(3)	↘ *	↗ !(3)	→	↘	↘	↘ !(1)	↘ !(1)	↘ !(1)
Partial effects: Inst cond. Inno	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	→	↘	↗	↘	↗	→	↘ *	↗	→	↘ !(3)	↘	↘ !(2)	↘ !(2)	↘ !(3)
N	1721	738	983	1910	734	1176	2044	803	1241	1217	575	642	1721	738	983	1910	734	1176	2044	803	1241	1217	575	642
R-sqr	0.965	0.940	0.974	0.967	0.937	0.976	0.968	0.939	0.977	0.961	0.923	0.974	0.965	0.941	0.974	0.967	0.939	0.976	0.969	0.941	0.977	0.961	0.923	0.974
adjR-sqr	0.964	0.937	0.973	0.966	0.934	0.975	0.968	0.936	0.976	0.960	0.919	0.973	0.964	0.938	0.973	0.967	0.936	0.975	0.968	0.938	0.977	0.960	0.919	0.972
dfres	105	32	72	114	30	83	106	32	73	106	32	73	105	32	72	114	30	83	106	32	73	106	32	73

* p<0.10, ** p<0.05, *** p<0.010

This table shows the results from the inequality effects estimations, with a medium time dimension 1990-2018. Two measures for institutions quality: Property right protection and the composite institutional index, and four measures for innovation and alternatives are included: total patent applications, total trademark applications, TFP and logged R&D expenditure as a percentage of GDP. Estimations are carried out on a mixed country panel, developed and developing country panels. Overall the coefficients for variables of interest and their interactions are mostly insignificant when property right protection is used as the measure for institutions from column 1 to 12, with only column 12 displaying statistical significance for innovation and the interaction term, with signs being consistent with prior findings. When the composite institutional index is used, statistical significance for the variables of interest can be observed in column 14, 17, 19 and 21, with consistent coefficient signs and significant partial effects. Statistics included are sample size *N*, R-squared and adjusted R-squared, as well as degrees of freedom. The marginal effects of both institutions conditional on innovation, and innovation conditional on institutions are shown in stylised forms. The arrows represents the general slope of the effects (upwards, downwards or mostly flat), and statistical significance are coded. Refer to table 4.1 for a guide on how to interpret them.

Table 4.8: The growth model, 1990-2018

	Patent			TM			TFP			R&D			Patent			TM			TFP			R&D		
	Mixed (1)	Dev (2)	unDev (3)	Mixed (4)	Dev (5)	unDev (6)	Mixed (7)	Dev (8)	unDev (9)	Mixed (10)	Dev (11)	unDev (12)	Mixed (13)	Dev (14)	unDev (15)	Mixed (16)	Dev (17)	unDev (18)	Mixed (19)	Dev (20)	unDev (21)	Mixed (22)	Dev (23)	unDev (24)
gini100	0.011	0.005	0.027**	0.005	-0.015	0.021*	-0.003	-0.012	0.015	-0.008	-0.001	0.009	0.010	0.001	0.030**	0.006	-0.016	0.023**	-0.003	-0.010	0.015	-0.013	-0.004	0.010
	(0.013)	(0.014)	(0.013)	(0.012)	(0.021)	(0.011)	(0.011)	(0.018)	(0.012)	(0.010)	(0.014)	(0.011)	(0.014)	(0.015)	(0.014)	(0.012)	(0.020)	(0.011)	(0.012)	(0.017)	(0.012)	(0.011)	(0.013)	(0.012)
PptyRgt	-0.011	0.175*	-0.168	-0.236*	0.104	-0.418**	0.048	0.040	-0.013	0.156***	0.100***	0.110*												
	(0.093)	(0.099)	(0.123)	(0.131)	(0.219)	(0.170)	(0.035)	(0.035)	(0.047)	(0.036)	(0.035)	(0.060)												
Inst													-0.145	-0.050	-0.211	-0.362**	-0.196	-0.642***	0.001	0.136**	-0.050	0.153***	0.150**	0.002
													(0.123)	(0.225)	(0.149)	(0.140)	(0.264)	(0.173)	(0.042)	(0.052)	(0.035)	(0.058)	(0.059)	(0.066)
Patent	-0.100	0.028	-0.157										-0.125	-0.194	-0.098									
	(0.073)	(0.085)	(0.103)										(0.103)	(0.181)	(0.112)									
Trademark				-0.067	0.035	-0.119*										-0.100	-0.241	-0.201**						
				(0.058)	(0.143)	(0.069)										(0.073)	(0.195)	(0.078)						
TFP							1.749*	2.539	1.941*										0.316	2.702*	-0.002			
							(0.903)	(1.560)	(1.021)										(0.497)	(1.376)	(0.497)			
R&D										0.021	0.135	-0.038										-0.170	-0.537	0.128
										(0.101)	(0.261)	(0.142)										(0.140)	(0.499)	(0.130)
PptyRgt*Patent	0.018*	-0.008	0.033*																					
	(0.011)	(0.012)	(0.018)																					
PptyRgt*TM				0.036***	-0.001	0.049***																		
				(0.013)	(0.022)	(0.018)																		
PptyRgt*TFP							-0.168	-0.217	-0.241															
							(0.174)	(0.275)	(0.208)															
PptyRgt*R&D										-0.013	-0.035	-0.004												
										(0.022)	(0.041)	(0.033)												
Inst*Patent													0.022	0.024	0.024									
													(0.016)	(0.024)	(0.022)									
Inst*TM																0.041***	0.039	0.065***						
																(0.016)	(0.028)	(0.020)						
Inst*TFP																			0.125	-0.206	0.178*			
																			(0.096)	(0.205)	(0.106)			
Inst*R&D																						0.027	0.065	-0.039
																						(0.030)	(0.070)	(0.031)
Partial effects: Inno cond. Inst	↗ *	↘ !(3)	↗	↗ !(2)	→ !(3)	↗ !(4)	↘	↘	↘	↘ *	↘ !(3)	→ !(3)	↗	↗ !(2)	↗	↗ !(4)	↗ !(2)	↗ !(4)	↗	↘ !(3)	↗ !(3)	↗ !(2)	↗ !(2)	↘
Partial effects: Inst cond. Inno	↗	↘	↗	↗ *	→	↗ *	↘ *	↘ *	↘ *	↘	↘	→	↗	↗	↗	↗ *	↗	↗ !(4)	↗ *	↘ *	↗ *	↗	↗	↘
N	1553	642	911	1764	663	1101	1870	705	1165	1106	516	590	1553	642	911	1764	663	1101	1870	705	1165	1106	516	590
R-sqr	0.855	0.914	0.879	0.842	0.897	0.867	0.863	0.924	0.878	0.852	0.910	0.887	0.848	0.912	0.877	0.839	0.899	0.870	0.862	0.926	0.879	0.844	0.910	0.884
adjR-sqr	0.851	0.909	0.873	0.839	0.891	0.862	0.860	0.920	0.874	0.847	0.904	0.881	0.844	0.906	0.872	0.835	0.893	0.865	0.859	0.922	0.876	0.839	0.905	0.878
dfres	101	31	69	112	30	81	103	31	71	102	31	70	101	31	69	112	30	81	103	31	71	102	31	70

* $p<0.10$, ** $p<0.05$, *** $p<0.010$

This table shows the results from the growth effects estimations, with a medium time dimension 1990-2018. Two measures for institutions quality: Property right protection and the composite institutional index, and four measures for innovation and alternatives are included: total patent applications, total trademark applications, TFP and logged R&D expenditure as a percentage of GDP. Estimations are carried out on a mixed country panel, developed and developing country panels. One can observe that the growth effects of the variables of interest are more pronounced in developed countries and in the mixed panel. It is worth noting that inequality is shown to be positively and significantly correlated to growth, thus confirming a positive inequality-growth effect for developing countries. Furthermore, the interaction terms, which captures the partial effects of institutions and innovation, have a greater footprint in developing countries, with their effects overtaking the individual effects of either innovation or institutions, indicating an upwards sloping relation between the variables of interest. The same can be observed in the mixed panel to a lesser extend. Statistics included are sample size N, R-squared and adjusted R-squared, as well as degrees of freedom. The marginal effects of both institutions conditional on innovation, and innovation conditional on institutions are shown in stylised forms. The arrows represents the general slope of the effects (upwards, downwards or mostly flat), and statistical significance are coded. Refer to table 4.1 for a guide on how to interpret them.

Table 4.9: The inequality model, 2000-2018

	Patent			TM			TFP			R&D			Patent			TM			TFP			R&D		
	Mixed	Dev	unDev	Mixed	Dev	unDev	Mixed	Dev	unDev	Mixed	Dev	unDev	Mixed	Dev	unDev	Mixed	Dev	unDev	Mixed	Dev	unDev	Mixed	Dev	unDev
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
PptyRgt	0.113	0.029	0.216*	0.158	0.027	0.165	-0.008	-0.018	-0.002	-0.032	-0.020	-0.118												
	(0.087)	(0.151)	(0.116)	(0.126)	(0.357)	(0.182)	(0.027)	(0.045)	(0.036)	(0.041)	(0.056)	(0.077)												
Inst													0.183*	0.303	0.317*	0.269	0.473	0.204	0.053	0.017	0.059	0.066	0.012	0.064
													(0.109)	(0.310)	(0.184)	(0.189)	(0.471)	(0.268)	(0.037)	(0.093)	(0.044)	(0.059)	(0.094)	(0.116)
Patent	0.144*	0.123	0.197**										0.109	0.238	0.167									
	(0.075)	(0.145)	(0.081)										(0.083)	(0.263)	(0.120)									
Trademark				0.113*	0.102	0.122										0.127	0.306	0.100						
				(0.067)	(0.302)	(0.074)										(0.103)	(0.367)	(0.122)						
TFP							-1.106	-2.044	-1.103										0.120	-1.465	0.722			
							(0.985)	(4.226)	(1.337)										(0.533)	(4.431)	(0.771)			
R&D										0.057	-0.095	0.368										-0.041	0.116	0.078
										(0.146)	(0.342)	(0.239)										(0.157)	(0.660)	(0.244)
PptyRgt*Patent	-0.021*	-0.006	-0.037**																					
	(0.012)	(0.020)	(0.015)																					
PptyRgt*TM				-0.021	-0.007	-0.020																		
				(0.013)	(0.037)	(0.019)																		
PptyRgt*TFP							0.098	0.165	0.118															
							(0.185)	(0.627)	(0.282)															
PptyRgt*R&D										-0.009	0.050	-0.081*												
										(0.027)	(0.055)	(0.048)												
Inst*Patent													-0.014	-0.023	-0.032									
													(0.014)	(0.033)	(0.024)									
Inst*TM																-0.022	-0.034	-0.014						
																(0.019)	(0.044)	(0.028)						
Inst*TFP																			-0.148	0.065	-0.283			
																			(0.105)	(0.599)	(0.190)			
Inst*R&D																						0.010	0.010	-0.020
																						(0.029)	(0.093)	(0.051)
Partial effects: Inno cond. Inst	↘	↘	↘ !(2)	↘	↘	↘	↗	↗	↗	↘	↗	↘	↘ !(3)	↘	↘	↘	↘	↘	↘ !(3)	↗	↘	↗	↗	↘
Partial effects: Inst cond. Inno	↘	↘	↘ !(1)	↘	↘	↘	↗ !(3)	↗	↗ !(3)	↘	↗	↘	↘	↘	↘	↘	↘	↘	↘ *	↗	↘ !(3)	↗	↗	↘
N	1224	510	714	1382	508	874	1450	549	901	1099	511	588	1224	510	714	1382	508	874	1450	549	901	1099	511	588
R-sqr	0.958	0.915	0.970	0.963	0.910	0.973	0.964	0.915	0.975	0.956	0.912	0.970	0.958	0.916	0.970	0.963	0.911	0.973	0.965	0.915	0.975	0.956	0.911	0.970
adjR-sqr	0.957	0.911	0.969	0.962	0.905	0.972	0.964	0.911	0.974	0.955	0.907	0.969	0.957	0.911	0.969	0.962	0.906	0.972	0.964	0.911	0.974	0.955	0.907	0.969
dfres	101	32	68	112	30	81	105	32	72	104	32	71	101	32	68	112	30	81	105	32	72	104	32	71

* p<0.10, ** p<0.05, *** p<0.010

This table shows the results from the inequality effects estimations, with the smallest time dimension 2000-2018. Two measures for institutions quality: Property right protection and the composite institutional index, and four measures for innovation and alternatives are included: total patent applications, total trademark applications, TFP and logged R&D expenditure as a percentage of GDP. Estimations are carried out on a mixed country panel, developed and developing country panels. Overall the findings in this table are mostly consistent with other results, confirming the positive (inequality-inducing) effects institutions and innovation as well as other measures on inequality. The interactions are shown to be negative, meaning that the adverse impact is reduced by the partial effects. Statistics included are sample size *N*, R-squared and adjusted R-squared, as well as degrees of freedom. The marginal effects of both institutions conditional on innovation, and innovation conditional on institutions are shown in stylised forms. The arrows represents the general slope of the effects (upwards, downwards or mostly flat), and statistical significance are coded. Refer to table 4.1 for a guide on how to interpret them.

Table 4.10: The growth model, 2000-2018

	Patent			TM			TFP			R&D			Patent			TM			TFP			R&D		
	Mixed (1)	Dev (2)	unDev (3)	Mixed (4)	Dev (5)	unDev (6)	Mixed (7)	Dev (8)	unDev (9)	Mixed (10)	Dev (11)	unDev (12)	Mixed (13)	Dev (14)	unDev (15)	Mixed (16)	Dev (17)	unDev (18)	Mixed (19)	Dev (20)	unDev (21)	Mixed (22)	Dev (23)	unDev (24)
gini100	-0.012	0.010	0.006	-0.014	0.004	-0.002	-0.019*	0.008	-0.007	-0.017	0.000	0.002	-0.017	0.006	0.007	-0.018	-0.001	-0.003	-0.021*	0.004	-0.008	-0.024**	-0.004	0.003
	(0.013)	(0.016)	(0.014)	(0.012)	(0.015)	(0.012)	(0.011)	(0.015)	(0.012)	(0.011)	(0.015)	(0.012)	(0.012)	(0.016)	(0.014)	(0.012)	(0.013)	(0.012)	(0.011)	(0.013)	(0.012)	(0.012)	(0.014)	(0.012)
PptyRgt	0.016	0.145	-0.150	-0.127	0.177	-0.290	0.055	0.087***	-0.027	0.155***	0.103***	0.104*												
	(0.107)	(0.091)	(0.158)	(0.151)	(0.193)	(0.186)	(0.034)	(0.031)	(0.041)	(0.038)	(0.034)	(0.054)												
Inst													-0.022	0.251	-0.104	-0.079	0.478	-0.240	0.080*	0.168**	0.023	0.163***	0.139**	-0.006
													(0.163)	(0.213)	(0.175)	(0.203)	(0.370)	(0.240)	(0.045)	(0.066)	(0.041)	(0.062)	(0.059)	(0.070)
Patent	-0.117	-0.008	-0.155										-0.131	-0.012	-0.102									
	(0.077)	(0.077)	(0.108)										(0.124)	(0.172)	(0.126)									
Trademark				-0.087	0.023	-0.122										-0.065	0.192	-0.117						
				(0.066)	(0.132)	(0.073)										(0.103)	(0.249)	(0.113)						
TFP							0.563	3.339***	0.662										-0.682	5.249**	-0.547			
							(0.765)	(1.157)	(0.959)										(0.568)	(1.941)	(0.691)			
R&D										0.026	0.165	-0.093										-0.144	-0.414	0.147
										(0.108)	(0.255)	(0.138)										(0.147)	(0.535)	(0.134)
PptyRgt*Patent	0.015	-0.006	0.026																					
	(0.012)	(0.011)	(0.019)																					
PptyRgt*TM				0.026*	-0.007	0.035*																		
				(0.014)	(0.019)	(0.018)																		
PptyRgt*TFP							0.105	-0.351*	0.045															
							(0.147)	(0.196)	(0.204)															
PptyRgt*R&D										-0.012	-0.036	0.006												
										(0.023)	(0.040)	(0.032)												
Inst*Patent													0.017	-0.005	0.018									
													(0.020)	(0.022)	(0.023)									
Inst*TM																0.022	-0.028	0.031						
																(0.020)	(0.035)	(0.025)						
Inst*TFP																			0.349***	-0.572*	0.302*			
																			(0.109)	(0.285)	(0.153)			
Inst*R&D																						0.025	0.052	-0.045
																						(0.032)	(0.076)	(0.030)
Partial effects: Inno cond. Inst	↗ *	↘ !(3)	↗	↗ !(2)	↘ !(3)	↗ !(2)	↗	↘ !(1)	↗	↘ !(2)	↘ !(3)	↗ !(3)	↗	↘ !(3)	↗	↗ !(2)	↘ !(3)	↗	↗ !(4)	↘ !(1)	↗	↗ !(2)	↗ !(3)	↘
Partial effects: Inst cond. Inno	↗	↘	↗	↗	↘	↗	↗ *	↘ *	↗ !(3)	↘	↘	↗ !(3)	↗	↘	↗	↗	↘	↗	↗ *	↘ *	↗ *	↗	↗	↘
N	1122	463	659	1290	479	811	1345	501	844	1008	469	539	1122	463	659	1290	479	811	1345	501	844	1008	469	539
R-sqr	0.836	0.921	0.862	0.823	0.905	0.852	0.861	0.929	0.879	0.839	0.908	0.879	0.831	0.922	0.860	0.819	0.905	0.850	0.866	0.931	0.881	0.831	0.906	0.877
adjR-sqr	0.832	0.916	0.856	0.819	0.900	0.846	0.858	0.925	0.875	0.835	0.903	0.873	0.827	0.918	0.854	0.815	0.899	0.845	0.863	0.927	0.877	0.826	0.900	0.870
dfres	97	30	66	110	30	79	102	31	70	100	31	68	97	30	66	110	30	79	102	31	70	100	31	68

* p<0.10, ** p<0.05, *** p<0.010

This table shows the results from the growth effects estimations, with the smallest dimension 2000-2018. Two measures for institutions quality: Property right protection and the composite institutional index, and four measures for innovation and alternatives are included: total patent applications, total trademark applications, TFP and logged R&D expenditure as a percentage of GDP. Estimations are carried out on a mixed country panel, developed and developing country panels. Findings in this table are mostly consistent with prior results from the fixed effects estimations and the GMM and IV estimations. Statistics included are sample size *N*, R-squared and adjusted R-squared, as well as degrees of freedom. The marginal effects of both institutions conditional on innovation, and innovation conditional on institutions are shown in stylised forms. The arrows represents the general slope of the effects (upwards, downwards or mostly flat), and statistical significance are coded. Refer to table 4.1 for a guide on how to interpret them.

Lastly, the results from using the shortest time dimension, 2000-2018 are displayed in table 4.9 and 4.10 for the inequality and the growth model, respectively. Once again we note comparable and consistent effects with previous estimations on growth and inequality from the variables of interest and their interactions, with developing countries displaying more statistical significance while maintaining consistency of the effects on the dependent variables. In terms of inequality effects, both institutions and innovation individually increase inequality when the interactions between them reduces the overall impact. We also note that in column 8 and 20 in table 4.10 both TFP and R&D expenditure have strong and statistically significant effects on growth in developed countries but not in developing countries. The positive growth effects of institutions are more pronounced in developed countries relative to developing countries. Lastly, we identify that inequality has a weak but statistically significant negative impact on economic growth in developed countries. Comparing to the positive inequality-growth effects identified in previous estimations for developing countries, one may argue that the overall inequality-growth effect may manifest differently depending on the level of development. This finding is supported by some of the non-linear transmission channels identified in existing studies.

Furthermore, we note the addition of evidence on the transitional institutional effects originated from the interaction terms within the growth models (e.g., column 1 through 3 in table 4.2 and table 4.3). As shown by the encoded marginal effects, the partial effects of property right protections are strongly positive but diminishing in developing countries when the level of innovation is increasing from a low initial stage. At the same time the marginal effects of the composite institutions are shown to be increasing to the point where they overtakes the effects of property right and become the dominant growth enhancing institutional effects. This transition of institutional-growth effect from property right protection to institutions in a broader sense reinforce our previous findings, as similar observations can be made in the remaining robustness estimations.

4.4 Quantile Regression

4.4.1 An Introduction to MMQR

In this section we employ a novel variant of the quantile regression technique for panel data to assess the robustness of the findings. Introduced in the work of Silva and Machado (2019) this method-of-moment quantile approach (MMQR) allows the estimations of panel datasets with individual fixed effects and potentially endogenous explanatory variables and capture the effects that might be active in specific quantiles. The additional information that can be extracted with such an approach represents a distinctive advantage that MMQR possesses. Furthermore, as explained by Fitzenberger et al. (2022), conventional regression techniques focus on capturing the effects of explanatory variables on the conditional means of the dependent variable, which may be affected by outliers or specific patterns that are otherwise covered up during estimations. The MMQR approach is able to examine the overall effects in stages and thus take the outlying influences into account as well as address any potential unobserved heterogeneity problems with the consideration of individual effects. However, one may note that MMQR serves as an additional layer of robustness tests that does not replace the primary findings obtained from conventional estimations. Furthermore, while conventional quantile estimation technique is robust to outliers, it does not consider individual heterogeneity within a panel dataset, an issue that is addressed via the MMQR approach as it allows the identification of conditional heterogeneous covariance effects of explanatory variables as the individual effects can influence the entire distribution in quantile, rather than simply changing means. Such technique despite its novelty is of notable relevance in panel analysis where individual effects are theorised to exist and when endogeneity is present. In addition, MMQR also offers an intuitive view to the proposed effects as the estimations of regression quantiles can provide additional information that would supplement some of the previous findings.

The justification for the employment of the MMQR technique to carry out the estimation of both the inequality and growth model is twofold. First, as previously described, quantile regression technique offers an unique approach for the estimation of the growth and the inequality effects with the largest panel possible and extract information that would otherwise be difficult to obtain with conventional estimation techniques, without having to resort to distinguishing developed and developing countries. By carrying out quantile regression on the combined panel dataset we are able to identify specific effects of innovation and institutions, as well as the partial effects from their interactions, on different quantiles of growth and inequality. The estimation results can also help identify the levels of significance in observation groups at different levels of growth and inequality[3]. Second, the method-of-moment quantile regression (MMQR) technique we cite is a relatively novel approach and represents a new development in the school of quantile regression. Developed by Silva and Machado (2019) this new approach adds to the well-established estimation method of quantile regression by utilising moment conditions. As previously described, the MMQR works particularly well with panel with individual fixed effects and endogenous variables, two properties that may be present in our panel.

To better illustrate the concept, one may consider the following function, based on which the estimation of the conditional quantiles takes form:

$$Y_{it} = \alpha_i + X_{it}'\beta + (\delta_i + Z_{it}'\gamma)U_{it} \tag{4.2}$$

Where α, β, δ, γ are parameters and the probability $P(\delta_i + Z_{it}'\gamma > 0) = 1$. The individual fixed effects are denoted as α_i and δ_i. X_{it} is independently and identically distributed for fixed i, whereas U_{it} is independently and identically distributed for any individuals across time and orthogonal to X_{it}. In Silva and Machado (2019) this is to set to satisfy moment conditions and does not imply exogeneity. With this in mind the following function can be derived:

$$Q_Y(\tau|X_{it}) = (\alpha_i + \delta_i q(\tau)) + X_{it}'\beta + Z_{it}'\gamma q(\tau) \tag{4.3}$$

X_{it} is a vector of explanatory variables, featuring the variables described in model description. $Q_Y(\tau|X_{it})$ denotes the dependent variables and the quantile distribution of them. $q(\tau)$ is the τ^{th} quantile of the sample. To maintain consistent theoretical frameworks with preivous estimations, lagged dependent variables are included for the inequality model, alongside with an identical set of control variables.

The proposed methodology is applied to identical specifications from prior regressions with fixed effects and robust standard error applied. The panel is of the smallest time dimension to maintain consistency. The results demonstrate consistent coefficient signs and level of statistical significance for the growth model, where both institutions and innovations are shown to positively affect inequality (higher values increase inequality) while the interaction of the two reduces the overall impact in the second, fourth and sixth quantile, suggesting that the hypothesised effects of institutions and innovation are more prominent

[3]For instance, the innovation effects on growth may be significant in certain growth quantiles, thus signalling significant effects during specific stages of economic development. Similarly, the effects of institutions on inequality may only manifest in either highly unequal societies. Such information may not be apparent when the model is estimated using conventional estimation techniques.

in countries with higher degree of inequality. The first quantile, representing countries with low level of inequality, does not display any significant effects from the variables of interest. Similar results can be observed in both the inequality and growth model, echoing the findings obtained via fixed effects estimation and the subsequent IV and GMM estimations.

4.4.2 Empirical Results

In this section we present the results from two sets of quantile estimations. Table 4.11 shows the results for the inequality model with the shortest time dimension. Explanatory variables include a lagged dependent variable [4], level of education, approximated by secondary school enrolment, child mortality, government expenditure and money growth. We observe that property right protection significantly increase inequality at the 40% quantile. Innovation approximated with logged patent application has a significant and positive effect on inequality in countries with high inequality (40% quantile and upwards), while the interactions between inequality and innovation are negative and significant in countries with medium level of inequality. The results from MMQR estimations support our previous findings. In terms of control variables, we note that the lagged dependent variables occupy a majority of the effects and are highly significant, which is expected due to the slow-changing nature of inequality. Education has a negative impact on inequality that is statistically significant at the 60% quantile, meaning that improving education can reduce inequality, though the effect is not significant in countries with very high inequality.

Table 4.12 gives an overview of the growth effects of innovation and institutions when the model is estimated using the MMQR technique. We note that at higher quantile both patent application and the interactions between innovation and institutions have positive and significant effects on growth, but the individual effects of property right, though positive, are not significant. This indicates that the effects of innovation and its interaction with institutions are more pronounced in developed countries, a findings that was noted in previous chapters.

4.5 Concluding Remarks

In this chapter we carry out a series of additional estimations of the growth and inequality model to assess the robustness of our principal findings on the effects of institutions and innovation and their interactions, outlined in Chapter III. These includes the estimations of an alternative approximation of innovation in the form of R&D expenditure as share of GDP, multiple time dimensions, and the novel method of moments quantile regression technique. We demonstrate that under different specifications our hypotheses maintain the robustness. Our findings which indicate that innovation and institutions can significantly increase economic growth at the cost of equality, though the overall effects are reduced by the interactions between the two variables of interest. We further identify that when entrepreneurship is included in place of innovation, approximated by logged trademark application, the interaction effects it generate with property right protection as well as composite institutions become significantly positive on economic growth. This would suggest that the positive growth effects of entrepreneurship can be further enhanced by the interaction with economic institutions, a finding that may carry policy implication. Lastly, by employing MMQR we find consistent and comparable results in the effects of innovation and institutions on inequality and economic growth. To summarise, the results outlined in this chapter serve as reinforcement

[4] The justifications for the lagged dependent variables can be found in the theoretical outline in Chapter 3.

Table 4.11: The inequality model, 2000-2018

	20% (1)	40% (2)	60% (3)	80% (4)
Lagged Inequality	0.978***	0.980***	0.981***	0.983***
	(0.012)	(0.009)	(0.010)	(0.014)
Education	-0.397**	-0.336**	-0.264*	-0.197
	(0.187)	(0.142)	(0.159)	(0.227)
Child Mortality	0.002	0.003	0.004*	0.005*
	(0.002)	(0.002)	(0.002)	(0.003)
Gov Consumption	0.008	0.009**	0.010**	0.011*
	(0.005)	(0.004)	(0.005)	(0.006)
Money Growth	-0.518***	-0.541***	-0.568***	-0.593***
	(0.180)	(0.137)	(0.153)	(0.220)
PptyRgt	0.110	0.112*	0.114	0.116
	(0.086)	(0.065)	(0.073)	(0.105)
Patent	0.120	0.135**	0.152**	0.168*
	(0.074)	(0.056)	(0.063)	(0.090)
PptyRgt*Patent	-0.019	-0.020**	-0.022**	-0.024
	(0.012)	(0.009)	(0.010)	(0.015)
Observations	1224	1224	1224	1224

* $p<0.10$, ** $p<0.05$, *** $p<0.010$

This table shows the results from estimating the inequality model using the MMQR method. We set 4 quantiles of inequality, with group countries based on their level of inequality. Innovation is measured by logged patent application, and institutions measured by property right protection. Control variables used in the estimations are inequality from the previous period, level of education, approximated by secondary school enrolment, child mortality, government expenditure and money growth. The MMQR toolkit currently does not produce test statistics.

Table 4.12: The growth model, 2000-2018

	20% (1)	40% (2)	60% (3)	80% (4)
Inequality	0.005	0.009	0.013**	0.016**
	(0.011)	(0.007)	(0.006)	(0.008)
Education	0.194	0.163	0.136	0.115
	(0.157)	(0.100)	(0.089)	(0.114)
Trade Exposure	-0.425***	-0.439***	-0.451***	-0.461***
	(0.111)	(0.071)	(0.063)	(0.081)
Child Mortality	-0.006***	-0.006***	-0.006***	-0.006***
	(0.002)	(0.001)	(0.001)	(0.002)
Agricultural Land	-0.063	-0.181	-0.284	-0.364
	(0.548)	(0.349)	(0.308)	(0.397)
Gov Consumption	0.008	0.005	0.003	0.001
	(0.006)	(0.004)	(0.003)	(0.004)
Money Growth	-0.080	-0.049	-0.022	-0.001
	(0.092)	(0.059)	(0.052)	(0.067)
Financial Openness	0.026***	0.024***	0.023***	0.021***
	(0.009)	(0.006)	(0.005)	(0.007)
PptyRgt	0.066	0.007	-0.045	-0.086
	(0.109)	(0.070)	(0.061)	(0.079)
Patent	-0.059	-0.091	0.119**	0.140**
	(0.090)	(0.057)	(0.051)	(0.065)
PptyRgt*Patent	0.010	0.016*	0.022***	0.026**
	(0.015)	(0.009)	(0.008)	(0.011)
Observations	1553	1553	1553	1553

* p<0.10, ** p<0.05, *** p<0.010

This table shows the results from estimating the growth model using the MMQR method. We set 4 quantiles of growth, with group countries based on their level of GDP per capita. Innovation is measured by logged patent application, and institutions measured by property right protection. Control variables used in the estimations are inequality from the previous period, level of education approximated by secondary school enrolment, trade exposure, child mortality, share of agricultural land, government expenditure and money growth and financial openness. The current MMQR toolkit does not produce test statistics so none are included.

to our main findings in determining the roles of institutions, innovation and their interactions play in the inequality-growth nexus.

Chapter 5

A Voter-driven Policy Model for the Inequality-Growth Trade-off

5.1 Introduction

In this chapter we expand on the trade-off relations between inequality and innovation, entrepreneurship-driven economic growth discovered in previous chapters and reinforced by existing studies (e.g., Banerjee and Newman 1993; Bosma et al. 2018; Galindo-Martín et al. 2019; Yang et al. 2021). This exercise is to further explore such dynamics and assemble a tool to reflect potential policy implications that may provide additional insight into policies that carry out redistribution at the expense of economic activities.

As it has been well-established, the entrepreneurship transmission channel, as well as the innovation-inequality transmission channel discovered in our previous chapters, describe the positive effects high inequality can have on economic growth. Within such frameworks, high concentration of wealth is said to be held by the wealthy of the society, who then possess the mean to engage in entrepreneurial and innovative activities which enhance productivities and innovation, ultimately creating momentum for economic growth. Our previous empirical explorations show that such effects are in fact statistically significant and can be observed in developed and developing countries alike. While the negative effects on equality can be reduced by the improvement of institutional quality, such effects on growth can also be reduced. This now begs the question: what policy implications can be derived from such an inequality-growth relations, and how does one impose such policies to address the trade-off between inequality and economic growth?

To answer these questions, we propose the assembly of a theoretical framework that examines the viewpoint of a median voter, who is capable of influencing policymakers by the nature and the political position of being the median voter. Such a median voter would then carefully consider their political preference that balances between the positives from economic growth and the negatives from high level of inequality. A redistributive policy could then be inserted into these dynamics so that the median voter is now given the agency to tune the level of growth and inequality by adjusting the rate of redistribution, which is levied on the innovation and entrepreneurship-driving rich for the purpose of reducing inequality. Naturally, the redistributive policy has the function of lowering inequality at the cost of economic growth, as imposing such policy would reduce the incentives and the capacities for the rich to continuously innovate and engage in entrepreneurial activities. By constructing such a theoretical framework, we can then task the median voter to maximise their utility by using the aforementioned policy tool to adjust the utility gained from economic growth and the disutility gained from inequality, thus producing an optimised, voter-driven rate of redistribution. Such a political-economics model can be empirically examined, and its validity assessed, to offer policy implementation in addressing the inequality-growth effects with voter-driven policies.

The remaining chapter is organised as such. Section two introduces the model setup. It contains two stages: the entrepreneurship-growth mechanics and the voter-driven policy mechanics. Section three outlines the process and techniques used in the empirical estimation and testing. Section four describes the data. Section five discusses the findings obtained from empirical estimation. Section six offers concluding remarks.

5.2 Model Setup

5.2.1 Stage I

First, we build on the theoretical framework developed by Yang et.al (2021). The model was developed with a structured agent behaviour in mind and is based on microeconomic foundation. This allows us to circumvent some of the disadvantages of ad hoc macroeconomic models. One key issue that is avoided with such modelling technique is the Lucas Critique (Lucas 1976)[1]. The household problem outlined in the model is shown as below:

$$U(C_{i,t}, N_{i,t}, Z_{i,t}) = \Phi \frac{(C_{i,t})^{1-\Psi_1}}{1-\Psi_1} + (1-\Phi)\frac{(1-N_{i,t}-Z_{i,t})^{1-\Psi_2}}{1-\Psi_2} \tag{5.1}$$

Equation 5.1 shows the reasoning for the proposed utility function to capture agent behaviour. Consistent with standard DSGE modelling techniques, agent i's utility is comprised of utility gained from consumption and utility gained from leisure. Leisure is assumed to be the "leftover time" when time spent on other activities has been allocated, the allocation of which are dependent on the optimisation process. C_t denotes consumption, N_t labour input, and Z_t entrepreneurial effort. Z_t is assumed to have a cost so that it could be incorporated into the agent's budget constraint. $1-\Psi_1$ and $1-\Psi_2$ are utility elasticity of consumption and leisure respectively, they are also implemented to simplify the model solving process when computing the first order conditions.

Idiosyncratic shocks are later added to consumption and labour input to kickstart the inequality generation process. We assume there are two distinct types of households. The utility function is subject to the budget constraint:

[1]The Lucas Critique states that ad hoc empirical models rely on the analysis of prior data and base the economic theories solely on said analyses. This, while a valid estimation approach, leaves room for potential bias as there is no structural components that defines key economic activities or other behavioural patterns. One example of this can be seen in the defence of Fort Knox. Ad hoc model may determine that because Fort Knox has never been robbed, which is in accordance to historical data, the level of defence is not needed. This line of argument obviously does not consider the fact that robbers are deterred by the level of defence and security at Fort Knox, a fact that could be overlooked without structural component during economic modelling.

$$(1-\tau)Y_{i,t} + (1+r_{t-1})b_{i,t} - \pi_t Z_{i,t} = C_{i,t} + b_{i,t+1} + K_{i,t} - (1-\delta)K_{i,t-1} \tag{5.2}$$

Most components within the budget constraint shown in equation 5.2 follow that of Minford et al. (2009), where the left hand side of the equation are the income for the current period t, with Y_t denoting output and $(1+r_{t-1})b_{i,t}$ being bond yielding. On the right hand side are the expenditure. $b_{i,t+1}$ denotes bond purchase, $K_{i,t} - (1-\delta)K_{i,t-1}$ being the capital investment process and $C_{i,t}$ is the consumption choice. Bonds are assumed to be a type of risk-free enrichment avenue through which the agent can obtain added wealth through bond purchase. We propose to augment this component with market instability caused by institutional deficiencies in future iteration of the model. For the sake of simplicity this element will not be present in the current iteration, which is set up for demonstration purpose only. $\pi_t Z_{i,t}$ is the total cost of agent's effort into entrepreneurship. $Z_{i,t}$ is assumed to carry a per unit cost, π_t. This is to incorporate them into the budget constraint and by extension the optimisation process. In the current stage the costs are assumed to be fixed per unit of effort spent, future iteration may include dynamic costs dependent on how much effort spent. This latter is logical as economies of scale may affect cost of entrepreneurship whereas institutionalisation process may encounter diminished return. However, for this earliest iteration of the model the researcher is content with fixed costs for these choices. τ denotes the transfer rate, which is levied on the rich for the purpose of redistribution. The income $Y_{i,t}$, or output, is derived from a standard Cobb-Douglas production function:

$$Y_{i,t} = A_{i,t}(K_{i,t-1})^{\alpha}(N_{i,t})^{1-\alpha} \tag{5.3}$$

$K_{i,t-1}$ is the capital stock from previous period. Lagged capital stock is used to capture the delay in the implementation of capital, which would typically include factory, heavy machinery or other hard-to-implement equipment. $N_{i,t}$ denotes labour input from the representative agent. α is the share of capital stock in the factors of production. The output is augmented by productivity, $A_{i,t}$, which is determined by an endogenous, non-stationary stochastic growth path that follows the expression shown below.

$$\frac{A_{i,t+1}}{A_{i,t}} = \theta_1 + \theta_2 Z_{i,t} + \upsilon_{A,t} \tag{5.4}$$

θ_1 is the natural rate for productivity gain, or technological progress whereas θ_2 is the coefficient for entrepreneurial input and is influenced by agent decision driven by the utility function and the agent's utility maximisation problem. The agent optimises by considering an infinite-horizon problem, where they take into account the sum of utility from all periods starting from period t, with subsequent periods being discounted by the discount factor δ^t. Solving the model is a straight-forward process, which provides the following first order condition:

$$C_{i,t}^{-\Psi_1} = \beta(1+r_t)E_t\left[C_{i,t+1}^{-\Psi_1}\right] \tag{5.5}$$

$$C_{i,t}^{-\Psi_1} = \beta\left\{E_t\left[C_{i,t+1}^{-\Psi_1}\right]\left[(1-\delta) + \alpha(1-\tau)\frac{Y_{i,t+1}}{K_{i,t}}\right]\right\} \tag{5.6}$$

$$(1-\Phi)(1-N_{i,t}-Z_{i,t})^{-\Psi_2} = \Phi C_{i,t}^{-\Psi_1}(1-\alpha)(1-\tau)\frac{Y_{i,t}}{N_{i,t}} \tag{5.7}$$

$$(1-\alpha)(1-\tau)\frac{Y_{i,t}}{N_{i,t}}\frac{1}{C_{i,t}^{\Psi_1}}+\pi_t\frac{1}{C_{i,t}^{\Psi_1}}=\theta_2\frac{A_{i,t+1}}{A_{i,t}}E_t\left[\sum_{s=1}^{\infty}\beta^s(1-\tau)\frac{Y_{i,t+s}}{C_{i,t+1}^{\Psi_1}}\right] \tag{5.8}$$

We follow Yang et al. (2021) in simplifying equation 5.8 by approximating $\frac{Y_{i,t+s}}{C_{i,t+1}}$ as a random walk before the steady state. Ψ_1 is set to unity. The resulting function is equation 5.9:

$$(1-\alpha)(1-\tau)\frac{Y_{i,t}}{N_{i,t}}+\pi_t=\beta\theta_2(1-\tau)\frac{1}{1-\beta}\frac{A_{i,t}}{A_{i,t+1}}Y_{i,t} \tag{5.9}$$

We then define π_t as an individualised term with the expression:

$$\pi_t=\pi_t'w_{i,t} \tag{5.10}$$

And define wage $w_{i,t}$ by making the assumption that it follows the real wage rate under the perfect labour market assumption:

$$w_{i,t}=(1-\alpha)\frac{Y_{i,t}}{N_{i,t}} \tag{5.11}$$

One may now choose to substitute equation 5.10 and 5.11 into equation 5.9 and rearrange to obtain a function for productivity growth, which is also the optimal rule for entrepreneurial input:

$$\frac{A_{i,t+1}}{A_{i,t}}=\frac{(1-\tau)\beta\theta_2\frac{Y_{i,t}}{w_{i,t}}}{(1-\beta)\left(1-\tau+\pi_{i,t}'\right)} \tag{5.12}$$

By linearising the above first order conditions alongside with those of the aggregate economy that accommodate for the two households, model testing and parameter estimation can be carried out via indirect inference. The model setting was not rejected and demonstrates a significant trade-off between economic growth and inequality, which points towards positive inequality-growth effects. Further exploration into the topic by Yang et al. (2021) shows the simulated trade-off induced by redistribution policy by setting values of the transfer rate τ to 0.1, 0.2 and 0.3, which channel wealth from the rich household to the poor. The results from different levels of transfer rates manifest in changes in growth and inequality, which forms the basis of the second stage.

5.2.2 Stage II

It has been well established from the empirical findings in previous chapters, there exists a trade-off between inequality and innovation-led economic growth. Through this channel, high inequality translates to enhanced growth momentum as the rich engage in entrepreneurial or innovative activities by bringing their concentrated wealth to bear, which boosts productivity and contributes to economic growth. Efforts for redistribution diminish such momentum to improve equality. With this in mind, we now turn to the policy implication that can come into play within such dynamics by examining how targeted policies can affect the trade-off and to what extent such policies can be effective or preferred. The objective of the model is quite straightforward: to set up a social planner who is capable of determining redistributive policies that address the trade-off between the growth and inequality effects. The policies should be designed as a rate of transfer levied on the rich which has the sole purpose of redistribution to reduce inequality. The social planner, representing households, values economic growth but shuns inequality, which provides them with utility and disutility, respectively. To construct the utility function of such a planner, who weighs the utility gained from economic growth against the disutility gained from inequality, one considers a simple set up:

$$u = G_t - Q_t \tag{5.13}$$

G_t denotes the utility gained from growth in period t, and Q_t denotes the disutility gained from inequality in the same period. The social planner, who may also represent the median voter, as such function determines redistributive policies, maximise their utility as such. We then expand equation 5.13 to accommodate an infinite horizon and attach parameters and preference shocks:

$$u = \frac{1}{1-\sigma_g} G_t^{1-\sigma_g} - \frac{1}{1-\sigma_q} \gamma_{q,t} Q_t^{1-\sigma_q} \tag{5.14}$$

Where voter utility is gained from economic growth, G_t, subject to the exponent $1-\sigma_g$. Inequality Q_t has the exponent $1-\sigma_q$ and is attached to an inequality preference shock $\gamma_{q,t}$. The exponents $1-\sigma_g$ and $1-\sigma_q$ represent the utility elasticity of growth and inequality, respectively. The preference shock captures voter preference changes likely induced by shifts in political landscape or voter composition which drives the median voter's weighing of the importance of inequality. Lastly, we impose the assumption that inequality preference shock $\gamma_{q,t}$ is sufficient in capturing voter preference change and omit a potential growth preference shock. $\gamma_{q,t}$ follows a standard first order autoregressive process, AR(1) with *i.i.d* distribution:

$$\gamma_{i,t} = \varphi \gamma_{i,t-1} + \alpha_t + \xi_t \tag{5.15}$$

We include a exogenous terms in the function α_t to bridge the gap between empirical data and our preference shock equations due to the presence of deterministic trend in simplicial observations. The deterministic trend observed in empirical data is discussed in greater detail in the following sections.

With the utility functions and the associated expressions established, one would then need to expand growth, G_t and inequality Q_t as functions of transfer rate denoted as T_t, so that $G_t = g(T_t)$ and $Q_t = q(T_t)$. To approximate these functions, we cite empirical behaviour from Yang et al. (2021), where transfer rate under the setup of the stage I model displays diminishing return on growth and inequality. We call for a system of second-degree polynomials. Growth and inequality as functions of the transfer rate for such are:

$$G_t = g(T_t) = g_1 T_t^2 + g_2 T_t + \varepsilon_{g,t} \tag{5.16}$$

$$Q_t = q(T_t) = q_1 T_t^2 + q_2 T_t + \varepsilon_{q,t} \tag{5.17}$$

g_i and q_i[2] are coefficients for the transfer rates in the growth and inequality function, respectively. $\varepsilon_{i,t}$ is the error term. By approximating functions of growth and inequality as polynomials we can capture some forms of diminishing return of the transfer rate would inflict on the growth and inequality effects, as higher transfer rate would logically reduce growth and inequality at a reducing rate. At this point one may substitute G_t and Q_t in function 5.13 with their respective functions, equation 5.16 and 5.17 and obtain the utility maximisation problem for the median voter:

$$u = \frac{1}{1-\sigma_g}(g_1 T_t^2 + g_2 T_t + \varepsilon_{g,t})^{1-\sigma_g} - \frac{1}{1-\sigma_q}\gamma_{q,t}(q_1 T_t^2 + q_2 T_t + \varepsilon_{q,t})^{1-\sigma_q}$$

We normalise $1-\sigma_q$ to unity and compute the first order conditions to acquire the optimal transfer rate perceived by the median voter, which would maximise their utility by balancing between growth and inequality.

$$\frac{2g_1 T_t + g_2}{(g_1 T_t^2 + g_2 T_t + \varepsilon_{g,t})^{\sigma_g}} = \gamma_{q,t}(2q_1 T_t + q_2) \tag{5.18}$$

Equation 5.18 shows the optimal condition for transfer rate, optimised by the median voter. As it includes time-dependent variables in the form of the preference shocks, its value is subject to the shock and is therefore non-constant. The coefficients g_j and q_j for transfer rate are calibrated to the implication of the first stage model by Yang et al. (2021)[3] . The resulting function for transfer rate T_t shows that both the calibrated components, which measure the innate voter preference with regard to the inequality-growth trade-off and the shock components, which captures shifts in voter demographics or the political landscape, can cause changes in the median voter's policy preference with regards to growth and inequality and thus affect redistribution policies. Equation 5.18 can thus be log linearised:

$$\hat{T}_t = \phi_1 \hat{\gamma}_{q,t} + \varepsilon_t \tag{5.19}$$

Equation 5.19 shows that the optimal transfer rate obtained from the median voter's utility maximisation problem is determined by the value of the preference shock, where shifts in political standpoints, either due to would events, domestic or international shocks or some other factors, affects the median voter's weighing between the importance of growth and inequality, and such shifts would lead to a change in policy preferences regarding redistributions.

5.3 Estimation Techniques

In this section we state the procedure of model testing and parameter estimation using the indirect inference technique, following a long line of established theoretical studies on the economy of the UK

[2] i=1,2
[3] j=1,2

(Minford et al. 2009; Le et al. 2011; Chou et al. 2017; Yang et al. 2021). We employ this method over the alternatives such as Bayesian estimation or the maximum likelihood (also known as direct inference) as it is believed to be the best suited tool for addressing policy questions under such a setup, as demonstrated by Minford and Xu (2018). Furthermore, the indirect inference technique shows sufficient power when testing CGE models with UK data. The concept was first brought forth by Smith (1990) and later can be seen in the work of Monfort and Renault (1993), Gallant and Tauchen (1996) and others, providing a valid alternative to the Bayesian approach in estimating structure parameters that may otherwise be difficult to directly estimate.

The indirect inference procedure implemented in this study, utilised by Minford et al. (2009) and later expanded upon by Le et al. (2011) and Calvet & Czellar (2015), works by contrasting the moments computed via data simulated from the model against actual observation, to evaluate a calibrated or estimated (or partly estimated) model. The model estimated based on the actual data shall be referred to as the auxiliary model, which is set up to capture key macroeconomic information from the real-world data, which the simulated model based on constructed theoretical framework should aim to match. The auxiliary model would in this case act as the basis for a 'closeness of fit' evaluation, where the difference between the simulated data and its actual counterpart is compared through some metric to determine the fitness of the theoretical model, and whether it should be rejected.

5.3.1 The Indirect Inference Method

As described in the work of Le et al. (2016), the working of the indirect inference technique is to first describe the actual data with some time series not based on the theoretical framework being tested, referred to as the auxiliary model. Then we set the parameters of the theoretical model so that the estimates generated from simulating the theoretical model can be as close to those obtained from the atheoretical auxiliary model as possible so that the model would fit the data. We employ the Wald statistic to determine the distance between simulated and actual data to assess model fitness. Upon successfully passing the Wald test it would indicates that the model is capable of generating simulated data that sufficiently fits actual data in key information and the model itself should sufficiently represent real world macroeconomic behaviour. It can then be used to discuss policy implications concerning the components in the model or predict future trends or movements with a certain degree of confidence. It would also be within expectations that the theoretical model with calibrated initial parameters fails to pass the Wald test, as calibration would only produce parameters that are roughly around true values, especially with the political economics model presented here due to novelty of the model and the lack of prior knowledge in existing studies. When this occurs, we implement the Simulated Annealing algorithm to minimise the difference between generated and actual data via repeated indirect inference around the calibrated parameters until a sufficient set is located. To provide an in-depth outline of an II procedure, we explain it in three steps:

Step 1: Calculate the theoretical model's shock process conditional on data and parameters and acquire the residuals and innovations (of shocks). We achieve this by backing out structural residuals using actual data and model parameters. As the structural errors are the difference between the actual data and the calculated values using model parameters, subtracting the latter from the former would produce the results. As the model assembled in the previous section is not forward looking, we do not need to work with expectations. After acquiring the residuals, we can compute the corresponding autoregressive (AR) coefficients and shock innovations via OLS estimations. We define our auxiliary model as a representative of the log-linearised optimised conditions from the Stage II model, which takes the form of a VAR(1) model with stationary shocks and three principal variables: growth rate, inequality and transfer rate.

Step 2: Generate simulated data by bootstrapping innovations. With the shock process mapped out in step 1, we can carry out data simulation with randomness. The bootstrapping procedure allows random drawing of shock innovations in accordance with the method described in Minford et al. (1984) and solve the resulting model using computational programme. This process is repeated a desirable number of times to generate a large set of simulated data.

Step 3: Compute the Wald statistic. The metric through which we evaluate the theoretical model's goodness of fit against the auxiliary model is the indirect inference Wald (IIW) test. The Wald test is carried out to evaluate model performance in imitating real-world macroeconomic behaviour, with the null hypothesis being that the theoretically constructed structural model is true. To carry out this procedure, OLS is used to estimate the auxiliary model's parameter vector using both the simulated data from previous step and actual data to obtain their distribution. We can subsequently acquire the corresponding estimated coefficients $\hat{\theta}$, which denotes data descriptors estimated from actual data and $\theta_s(\beta)$, which denotes distribution mean based on simulated data. The Wald statistic can then be defined as follows:

$$W = (\hat{\theta} - \overline{\theta_s(\beta)})'\Omega(\beta)^{-1}(\hat{\theta} - \overline{\theta_s(\beta)}) \tag{5.20}$$

$\Omega(\beta)^{-1}$ denotes the inverse variance covariance matrix of $(\hat{\theta} - \overline{\theta_s(\beta)})$, the distribution of simulated estimates and is used to measure the distance between actual and mean of the simulated data descriptors. The Wald statistic is then transformed to a normalised t-statistic at 95% confidence level via the transformed Mahalanobis distance:

$$W_T = \left(\frac{\sqrt{2W^{\alpha}} - \sqrt{2k-1}}{\sqrt{2W^{0.95}} - \sqrt{2k-1}} \right) * 1.648 \tag{5.21}$$

W^{α} is the Wald statistic on the actual data, $W^{0.95}$ denotes the Wald statistic based on 95% of the simulated data. For the model to pass the test by not rejecting the null hypothesis, the t-statistic is required to be no greater than 1.648, which would also indicate a p-value of less than 0.05 for a more familiar test indicator.

5.4 Data and Calibration

To maintain consistency with the stage 1 model and its empirical testing and estimation, we collect annual data for the same period of 1870-2016 for the UK. We elect to use raw observations without processing them for stationarity, as the preference shock for inequality $\hat{\gamma}_{q,t}$ is backed out of the model, and it is necessary to preserve shocks. We use logged GDP output with base year 2012 to measure growth, for which there are available observations for the UK extracted from *'A Millennium of Macroeconomic Data'* database, also known as the *'Three Centuries of Macroeconomic Data'* (2016). For inequality, we splice the WDI Gini coefficient for the UK with the historical Gini coefficient from 1870 to 2011 extracted from the OECD database assembled by Madsen et al. (2018). While the alternatives for measuring inequality are numerous, we use the Gini coefficient for the ease of accessibility. We also extract the top 10% income share, which displays comparable behaviour to the Gini coefficient but at diminished availability.

To obtain observations of the government transfer rate as a measure of redistribution, we calculate the rate by dividing the sum of transfers by total household wealth before taxation and transfer. Three variables are involved in this process: total household disposable income, total government transfer to households and NPISH sectors as a means of redistribution, and total tax on income and wealth. The latter two are spliced using historical data extracted from the *'A Millennium of Macroeconomic Data'* database, and observations for total household disposable income are extracted with no further processing. Lastly, we back out preference shocks from the model using existing data.

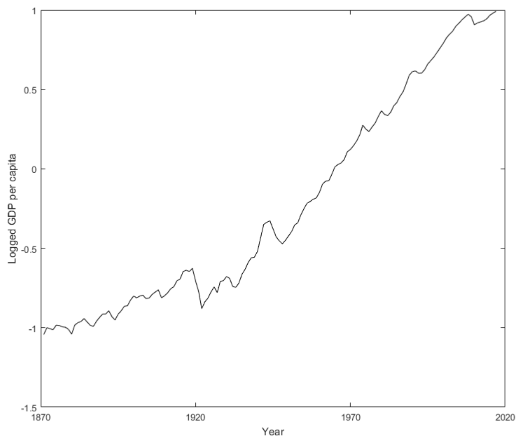
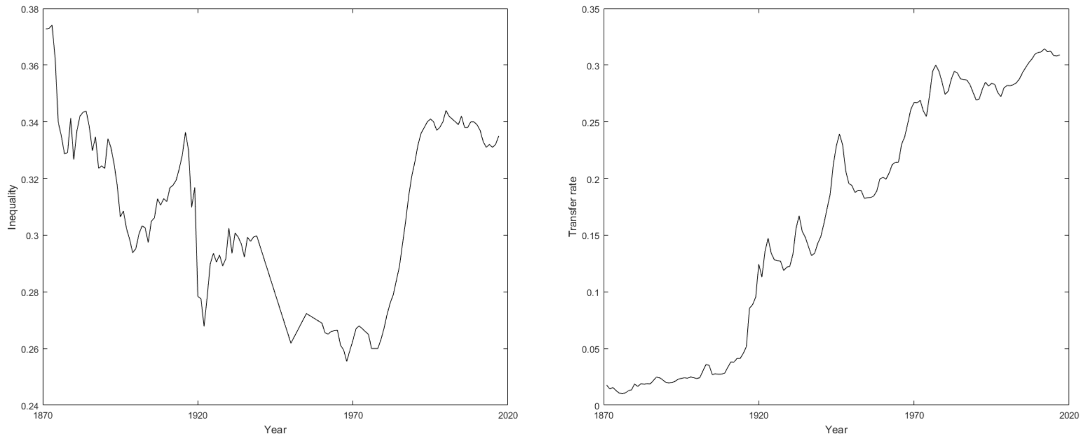


Figure 5.1: Data trend, logged GDP per capita, UK 1870-2018

Figure 5.1 shows the logged GDP per capita for the UK from 1870 to 2016, which remained stable prior to the first world war, during and immediately after which a large dip can be seen. Similarly, another drop can be observed during WWII. Post-war growth is shown to be quite robust, and the trend continued until the turn of the century. Growth data is available in its entirety from 'A millennium of macroeconomic data'. As for data for inequality we employ the Gini coefficient for the UK. Due to the impossibility of obtaining continuous historical inequality data, we splice two series of the Gini coefficient: the Gini coefficient observations for the UK, which is available for the year 1970 onward, extracted from the WDI, and the data from the historical OECD database by Madsen et al. (2018), which is available in annual observations for years from 1870 to 2011.

We use the WDI measure as the baseline to splice the historical data. The detail is shown in figure 5.2a. We can observe that inequality is notably high initially in 1870 during the latter half of the Victorian era after the Industrial Revolution. Inequality then drops sharply in a continuous trend until the beginning of the 20th century, where it bounces back to a local peak of 0.34 towards the end of the first World War. This uptick in inequality is immediately followed by a sharp decline between 1918 and 1920. The inequality level maintains its lowest point in recorded data between 1950 and 1975, shoots up substantially in the 80s and remains high till the present. We compute the transfer rate in the procedure described before, the resulting data is shown in figure 5.2b. One can note the upwards trend of the rate of transfer after the relatively stable period starting in 1870 when data became available. The upward trend initiates in 1910 and sees several temporary surges in 1925, 1932 and 1950 and continues to rise till present day. The surges roughly correlate to economic downturns where presumably the median voter, due to economic hardships, shifts from favouring growth to equality, resulting in more aggressive redistributive policies and higher transfer rate. Note that similar behaviour can also be observed albeit at a lesser extend during the Financial Crisis of 2008 where the transfer rate increases and remains at the highest point.



(a) Data trend, logged inequality, UK 1870-2018 (b) Data trend, transfer rate, UK 1870-2018

Figure 5.2: Data trend, UK 1870-2018

5.4.1 Calibration

For simplicity the weight the median voter assigns to growth and inequality in their utility function, σ_g and σ_q are set to unity to reflect on an equal importance of utility gained from growth and utility lost in inequality. We acknowledge that assigning difference weights for growth and inequality preference may be a direction for future investigation, as political landscape and voter preference may lead to the populace valuing growth and inequality unequally beyond the preference shock. We calibrate the remaining parameters of the model using existing studies as reference. One refers to the simulated outcome from the baseline model, depicted in Figure 4. Due to the components constructed for stage 2 are not present in the first stage of the model, transfer rate is mechanically set to three values, 0.1, 0.2 and 0.3 for the simulations to carry out. This is represented in the figure as the tri-coloured lines. As shown from simulating the stage 1 model, higher transfer rate leads to lowered inequality at the cost of growth reduction. The effects on both at a given rate of transfer show evidence for diminishing returns, which the second stage of the model described in previous chapters is set out to capture. To approximate the described systems, one extracts the following information on the effects of the transfer on growth and inequality respectively, from figure 5.3:

Using this information one can substitute the observations into equation 5.16 and equation 5.17 to obtain two systems of three equations with three unknowns, which can then be used to calculate the parameters. The results give g_1 as 3, g_2 -1.9; q_1 as 0.25 and q_2 as -0.075. The constants can also be obtained but are interpreted as the residuals and are omitted. To summarise, table 5.1 displays the calibrate parameter values.

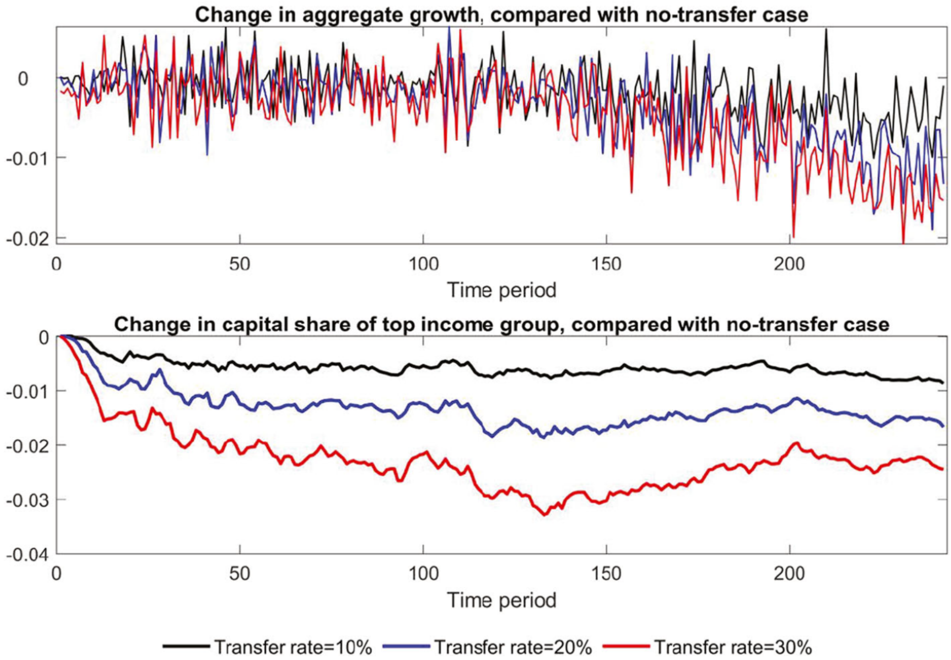


Figure 5.3: Simulated growth and inequality effects from pre-determined transfer rates, UK 1870-2018

Parameter 1, growth equation	g_1	3
Parameter 2, growth equation	g_2	-1.9
Parameter 1, inequality equation	q_1	0.25
Parameter 2, inequality equation	q_2	-0.075
Growth preference	σ_g	1
Inequality preference	σ_q	1

Table 5.1: Calibrated parameter values

5.5 Empirical Results

5.5.1 Indirect Inference Estimations and Tests

Following the method described in previous section we now conduct the indirect inference estimation to acquire the structural parameters to minimise the difference between actual data and simulated data. Initial estimations show that the calibrated parameters fail to produce a satisfactory Wald statistic and therefore the model with calibrated parameters do not fit actual data. We carry out the Simulated Annealing algorithm to search for a set of suitable parameters in a pre-specified range determined by the starting parameter values, which we set as the calibrated values. The annealing is able to produce a series of parameters that was not rejected by the Wald test. The resulting parameters and test statistics are shown in table 5.2 alongside with those of the calibrated parameters.

The estimated coefficient for the growth equation g_1 is quite similar to the calibrated results while g_2 is notably smaller in estimated results than its calibrated counterpart, making the utility polynomial for

Parameter	Description	Calibrated	Estimated
g_1	Parameter 1, growth equation	3.0000	2.8295
g_2	Parameter 2, growth equation	-1.9000	-3.9189
q_1	Parameter 1, inequality equation	0.2500	0.5884
q_2	Parameter 2, inequality equation	-0.0750	-0.7527
ϕ_1	Inequality preference shock parameter	0.25000	0.2553

Variables		Description	Trans-W	p-value
Calibrated	G_t Q_t T_t	Growth, Inequality, Transfer rate	2.8220	0.0050
Estimated	G_t Q_t T_t	Growth, Inequality, Transfer rate	1.2588	0.0860

Table 5.2: Estimation results of the structural model

growth $2.8295T_t^2 - 3.9189T_t + \varepsilon_{g,t}$, which is considerably lower than the calibrated function $3T_t^2 - 1.9T_t + \varepsilon_{g,t}$ with a smaller minimum at a higher transfer rate. This implies that for the UK where the actual data is collected for, the median voter appears to have much less tolerance to growth stunting policies, as by increasing the transfer rate T, The reduction in utility is much greater than what is suggested by the calibrated iteration.

Turning to inequality, the estimated parameters q_1 and q_2 for the inequality polynomial utility function are shown to be 0.5884 and -0.7527 respectively, as opposed to the calibrated 0.25 and -0.075. By plotting the functions for comparison one can note that the estimated parameters produce a relatively lower and steeper function, implying that the UK has a similarly lower tolerance to inequality, with overall more severe impact on median voter utility. Lastly, we show that the estimated parameter for the inequality preference shock is similar to the calibrated value.

Subsequent testing after the indirect inference estimation shows that the set of variables, namely growth, inequality and the transfer rate demonstrates statistical significance. The Trans-Wald statistics for the estimated model is shown to be 1.2588 with the p-value being 0.086. The Wald statistic is smaller than the critical value of 1.645 at 5% significance, indicating that the estimated model cannot be rejected by the null hypothesis, meaning the model sufficiently fits actual data. For the calibrated model, the Wald statistic is 2.8220, which is larger than the critical value at 5% significance level, thus rejecting the null hypothesis. The implication of rejecting the null hypothesis is that the calibrated model cannot explain the behaviour of actual data. To summarise, while the calibrated parameters offer a poorer performance in fitting the actual data for the UK, the estimated model is shown to capable in explaining the transfer policy trade-off between inequality and growth according to a hypothetical median voter.

5.5.2 Steady State Analysis and Policy Implication

Due to the simplicity of the model setup, we can predict the optimal rate of transfer that satisfies the median voter's estimated preference. In this section we compare the steady state transfer rates of the calibrated and estimated models and discuss the policy implications that are associated with them. As noted in the description of the theoretical framework, the median voter utility problem solves for transfer rate T_t that maximises the net utility gained from growth and lost from inequality. This reflects the median voter's preference on the two variables and the resulting transfer rate is voter-driven and optimal to voter preference. To assess the optimal rate at some steady state, we recall both the growth and inequality functions, and adjust them to represent a steady state position where no shock is present:

Model property	Optimal rate of transfer, T^*
Calibrated	0.3318
Estimated	0.7064

Table 5.3: Optimal transfer rate from calibrated and estimated models

$$g(T) = g_1 T^2 + g_2 T \tag{5.22}$$

$$q(T) = q_1 T^2 + q_2 T \tag{5.23}$$

And the utility function of the median voter:

$$u = \sigma_g G - \sigma_q Q \tag{5.24}$$

We then assign parameters obtained from calibration and estimation under separate instances to compute the optimal rates of transfer. The results are shown in table 5.3. Under the supposed steady state, the voter-driven transfer rates from the calibrated and estimated models fitted to the UK data are 0.3318 and 0.7064, respectively. We note that the estimated model produces a much higher voter-driven transfer rate than the calibrated model. This implies that for a median voter in the UK, they appear to value a much higher redistributive transfer rate to reduce inequality, than a lower transfer rate which sacrifice less growth. Such median voter would have a higher preference towards economic equality than economic growth, as such mentality manifests in policy preference. One may recall from previous sections that while the estimated model is shown to fit the actual data for the UK sufficiently well, the calibrated model fails to do so. We can then conclude that from a model that adequately matches actual data behaviour for the UK, the resulting optimal transfer rate produced by the voter-driven utility function that balances between inequality and economic growth is in fact, considerably high.

Several economic and political implications can be drawn from such conclusion. Firstly, as previously noted the model does not assign a weight to either growth or inequality in the median voter utility function, where $simga_g$ and $simga_q$ in equation 5.14 are set to unity. The median voter is therefore designed to view the utility gained in growth and lost in inequality naturally without any theoretically assigned preferential bias. Under such naturality the estimated results show the voter preferring a high level of transfer rate, which intuitively takes away growth and redistribute wealth to reduce inequality to a considerable extend. This suggests that empirically the UK has a naturally high tendency of valuing economic equality over high growth rate. One may attribute this to the well-developed sense of institutional or societal values, which warrants further investigation. Secondly, the optimal transfer rates are calculated under a steady state without the influence of any shocks. As demonstrated in the previous section, we show that any shocks to such preference are capable of having long lasting impact. This could suggest that while the median voter is shown to have a preference for high redistribution to reduce inequality at the expense of economic growth, such preference can be easily affected by preference shocks or external ones, which would significantly change voter preference and therefore alter the optimal transfer rate. Examples of such shocks may be shifts in political landscape either caused by change in administration, geopolitical events or adjustments in social values.

5.5.3 Shock and Residual Properties

We carry out residual stationarity tests to assess the properties of the shock processes present in the theoretical framework. The structural errors, introduced as the inequality preference shock, growth residual, inequality residual and the transfer rate residual, are computed during the estimation process from the estimated coefficients via indirect inference and then fitted into actual data, which is non-stationary. To test for stationarity the augmented Dickey–Fuller test (ADF) is selected for the task. The AFT test has the null hypothesis of unit root (implying non-stationarity). The results show that the residuals are in fact, trend stationary or stationary. Figures 5.4 shows the model residuals and the innovations of shocks, respectively. The top row shows the residuals, and the bottom row shock innovations.

One may observe that the model residuals depicted in the top row see trendy behaviours from growth, inequality and transfer rate, which are consistent with previous assessment of trend-stationarity, as per the ADF test results.

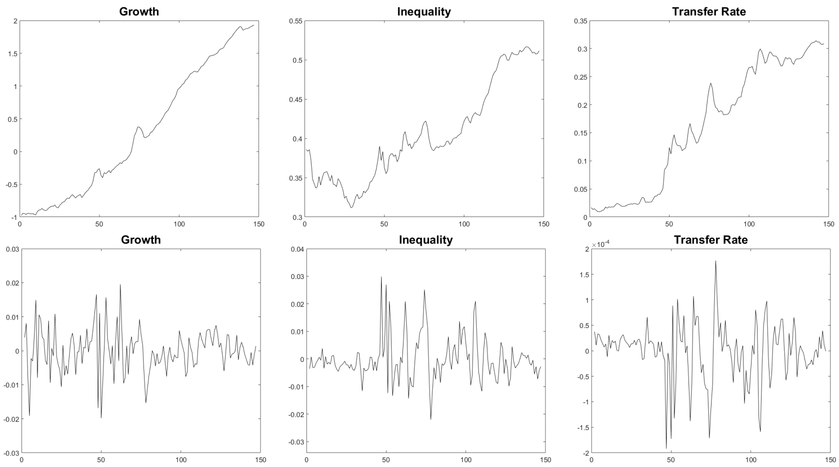


Figure 5.4: Residuals and innovations of shocks

5.5.4 Impulse Response

As the model has been estimated and tested to sufficient results, this section presents the impulse response functions of key variables in the model for the evaluation of empirical behaviours. The impulse response functions describe the movements in the variables following a one-off increase in key variables. Such functions can help visualise the effects of a shock or structural change as the dynamics of the model adjusts to said changes and transition towards its steady state(s). Due to the political nature of the model presented, the impulse response to shocks or structural changes allows us to evaluate shifts in political preference and how they would impact the median voter's preference towards redistributive policies in balancing the trade-off between growth and inequality. This process introduces a change in one or many of the variables, then compares the altered evolutions of the other variables to their previous trajectories. Both inequality and growth are exogenous variables and are not influenced in the model processes they are not featured.

Figure 5.5 plots the responses to shocks in inequality preference and transfer rate. Diagrams in the top row are the growth, inequality and transfer rate responses to a 10% positive inequality preference shock, and the bottom row the responses a 10% positive transfer rate shock. The positive shocks to both inequality preference and transfer rate initially have a negative impact on growth and inequality, as the median voter reacts to the change of their preference by shifting towards favouring redistribution. The positive voter preference shock on inequality means that when considering the median voter utility function, the disutility from inequality is now larger due to the shock. This would lead to the voter valuing equality more than economic growth. As a result, transfer rate would be increased for the duration of the shock, resulting in lowered growth and inequality. The effects of the shock dissipate relatively slowly. Both growth and inequality can be seen to gradually move back to their equilibrium position while the uptick in transfer rate slowly drops down. For the transfer rate shock, an increase in transfer means higher level of redistribution, which redistributes wealth from the rich to the poor, lowering wealth concentration and reduce growth. At the same time, inequality is lowered in accordance with the redistribution efforts. One may take note that the effect on inequality is much lower than the effects on growth while both are very long lasting, suggesting that to achieve a higher level of redistribution to ease inequality, much growth will have to be sacrificed.

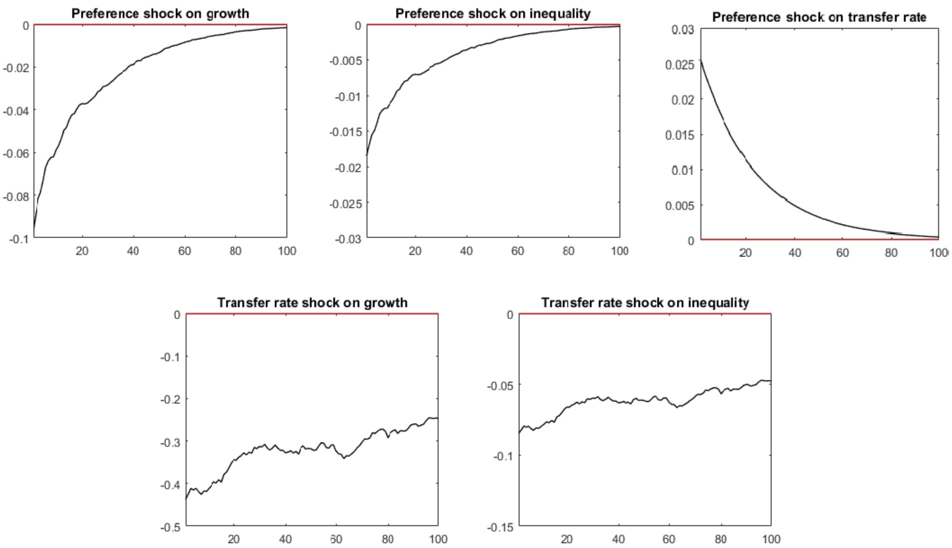
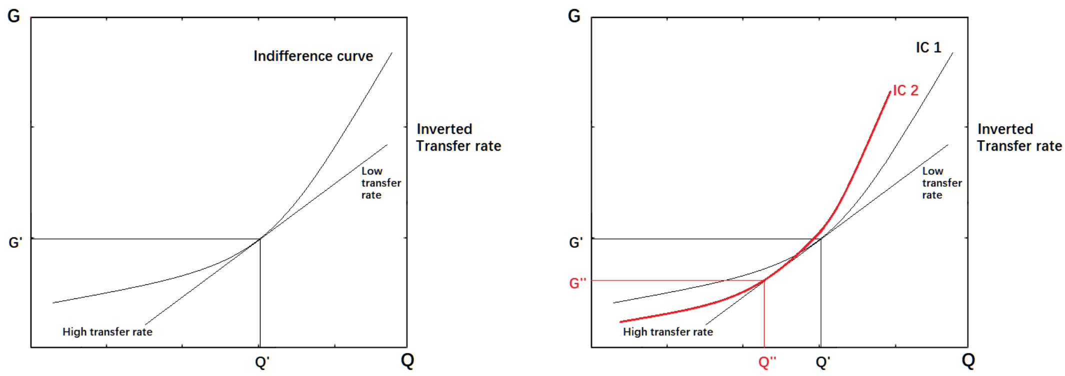


Figure 5.5: Inpulse Response

5.5.5 Intuitive Exposition

In this section we describe the working of the theoretical model after the estimation is complete, and the subsequent test having proved the fitness of the model to empirical observations collected for the UK. The final stage of the model initiates on two parallel premises: firstly, we establish that there exists a trade-off between inequality and innovation/entrepreneurship-driven economic growth. Under such context economic growth is achieved via the innovative and entrepreneurial activities made possible by a high concentration of wealth, at a cost to equality. This transmission channel between inequality and growth has been well-documented and tested both empirically and theoretically. Secondly, we now establish a representative median voter who consider their utility by expressing their preference between utility gained from economic growth, and utility lost from inequality. They would then maximise their net utility by employing a policy tool of transfer rate, which they use to adjust the trade-off between inequality



(a) Equilibrium transfer rate

(b) Shock response

Figure 5.6: Median voter indifference curve and the transfer rate "constraint"

and growth. Transfer rate is levied on those who posses a high concentration of wealth and the source of innovation and entrepreneurship for redistribution, which reduces inequality but also the incentive and capabilities for innovation and entrepreneurship. By balancing between inequality and growth via the policy tool, the median voter can therefore derive an optimal rate of transfer which can generate the highest possible utility for themselves. To illustrates this, suppose the median voter's preference is represented by an indifference curve shown in figure 5.6a. The indifference curve is accompanied by a function of transfer rate. Under the described setup, the marginal utility for economic growth is positive, while the marginal utility for inequality is negative. Accordingly, the rate of substitution, which is depicted as the slope of the indifference curve, is positive and upwards slopping. G denotes growth and Q denotes level of inequality, with larger values indicating more severe inequality. The diagram show that high economic growth is associated with high inequality and vice versa.

We now consider the actions of the median voter and the policy tool available to them. The transfer rate is represented by the budget line. At the vertical intercept the highest possible growth is achieved with no transfer being levied. Similarly, at horizontal intercept a high rate of transfer is imposed, reducing growth considerably while allowing maximum redistribution. The median then set the transfer rate to maximise their utility where the highest possible indifference curve is tangential to the transfer rate line constraining it, settling the trade-off with an optimised transfer rate and producing a set of growth rate and level of inequality. This is shown in figure 5.6a as G' and Q' respectively. The optimal level of transfer rate depends on how inequality and growth are perceived by the median voter. Should a median voter favours equality more so than economic growth, a preference that could be induced in a more progressive context, such preference would translate into a higher transfer rate, resulting in lower economic growth but a more robust redistribution effort to reduce inequality. To put it in other words, the more reduction in inequality Q is desired, the greater the loss will be imposed on growth G. Inversely, should such preference be reversed and the median voter weighs growth more heavily than economic inequality, which would likely to occur under a different set of socio-economic and political conditions, the preference would lead to policies favourable to growth, instead of equality.

The latter of the two dynamics plays out when a positive preference shock to inequality occurs. During the shock process, the indifference curve shifts downwards along the transfer rate constraint, signalling that the median voter, for the duration of the preference shock, has a newfound focus towards economic equality, thus shifting their preference away from growth and towards reducing inequality. Consequently, the optimal rate of transfer according to the median voter is increased per the optimisation process, further hindering economic growth while increasing redistribution to lower inequality. This process is shown in figure 5.6b as the optimal rate of transfer causes the set of growth and inequality rate to move from the pre-shock G' and Q', to G'' and Q''. Growth is reduced by the new voter-driven transfer rate and inequality is reduced as well. When the shock dissipates, the new indifference curve would then gradually move back to the equilibrium position as the median voter's attention on inequality slowly subside. It is then during this post-shock phase does the transfer rate reduce, resulting in a slow recovery in economic growth and a gradual incline in inequality as innovation and entrepreneurial activities resume as the economy reinvigorates.

5.6 Conclusions

The study of the inequality-growth nexus is a long-lasting endeavour with many theories and empirical work emerging for more than half a century. In this chapter we add to this field by assembling a two-stage theoretical framework that captures the entrepreneurship transmission channel and evaluating the policy trade-off between enhancing economic growth and alleviating inequality, from the already-established positive inequality-growth relations. Built on top of the empirically proven entrepreneurship channel, where inequality is said to increase economic growth through the concentration of wealth the wealth holders' willingness to innovate and engage in entrepreneurial activities, we examine the trade-off between growth and inequality from a political economics perspective. This is achieved through a theoretical model of a median voter, who favours growth and shuns inequality. We set up a utility function to capture such behaviour by assigning positive utility for growth and negative utility for inequality, both are adjustable by a policy variable that transfers wealth for redistribution, lowering growth as a result. By solving the model, we obtain an optimal solution for transfer rate that is preferred by the median voter and subsequently testing it using the indirect inference technique. The model was described as sufficiently fitting for actual data for the UK as it is not rejected by Wald test. We further analysis the results by presenting shock innovations and responses, the optimal rate of policy under steady states and the associated economic and political implications. We add to the literature with a novel political economics framework that brings a voter driven policy tool into the discussion of the inequality-growth nexus.

We identify several aspects present in this study that could be expanded upon or adjusted in a direct continuation of the research or follow-up studies. Firstly, the Stage II model is based on a simple principle of linear trade-off between inequality and growth as perceived by a median voter. We acknowledge that this assumption may be a simplification of realistic political consideration. Future work could implement non-linear, diminishing return on utility or better incorporate the political aspect within the micro-founded structural economic framework. Secondly, the elasticities of both growth and inequality in the utility function is assumed to be fixed, which may be considered as strongly restrictive, as it would imply the median voter's perception regarding inequality and growth is constant. Such restriction that may be loosened to allow floating parameters during estimation which may provide additional insight into the political-economic dynamics. Lastly, as previously noted the model is fitted for the UK, a country with stable and well-established institutions and long tradition of political participations. Future work may expand upon this and estimate the model under countries in various degrees of development and political freedom.

Chapter 6

Appendix

Table 6.1: Descriptive information, empirical studies

Researcher & year	Sample	Data type	Estimation	Conclusion
Kaldor 1956	Micro data	N/A	N/A; OLS	Positive
Houthakker 1961	Micro data	N/A	N/A; OLS	Positive
Kelly & Williamson 1968	Micro data	Cross-section	OLS	Positive
Alesina & Rodrik 1994	56 countries, 25 years	Cross-section	OLS & 2SLS	Negative
Persson & Tabellini 1994	56 countries, 25 years	Cross-section	OLS & 2SLS	Negative
Cook 1995	49 countries	Cross-section	OLS	Positive
Perotti 1996	67 countries, 25 years	Cross-section	OLS	Negative
Alesina & Perotti 1996	71 countries	Cross-section	OLS	Negative
Deininger & Squire 1998	87 countries, 32 years	Cross-section	OLS	Negative for income, Inconclusive with land distribution
Li & Zhou 1998	46 countries, 30 years	Panel	Fixed & random effects	Positive
Ali & Tahir 1999	Pakistan	Panel	OLS	Positive
Wodon 1999	Bangladesh	Panel	N/A	Negative
Forbes 2000	45 countries	Panel	GMM	Positive for high-income countries
Barro 2000	84 countries, 30 years	Panel	3SLS	Positive for high-income countries, inconclusive otherwise
Deininger & Olinto 2000	60 countries	Panel	GMM	Positive for income, negative for income & land

Castelló & Domenéch 2002	67 countries, 30 years	Cross-section	OLS	Negative, inconclusive when region dummies were added
Deolalikar 2002	Thailand	Panel	N/A	Positive, higher effect in urban areas
Chen 2003	43 countries	Cross-section	OLS	Inverted U-shaped
Banerjee & Duflo 2003	45 countries, 30 years	Panel	N/A	Negative
Bleaney & Nishyama 2003	42 countries, 25 years	Cross-section	OLS	Negative
Knowles 2005	40 countries	Cross-section	OLS	Negative overall, inconclusive for high-income countries, negative for low-income countries
Voitchovsky 2005	21 high-income countries	Panel	GMM	Positive for high-income population, negative otherwise
Bengoa & Robles 2005	19 countries	Cross-section	OLS & fixed effects	Positive for high-income countries, U-shaped otherwise
Castelló 2010	102 countries	Panel	GMM	Negative overall, inconclusive for high-income countries using human capital as distribution
Chambers & Krause 2010	54 countries, 40 years	Panel	N/A	Negative
Herzer & Vollmer 2012	46 countries, 35 years	Panel	N/A	Negative
Cheema & Sial 2012	Pakistain	Panel	N/A	Positive
Ncube et al. 2014	ME & North Africa	Cross-section	OLS	Negative overall, Positive under certain channels
Halter et al. 2014	106 countries, 5 years	Cross-section	GMM	Short term positive, long term negative
Kolawole et al. 2015	Nigeria, 32 years	Time series	OLS	Positive
Bagchi & Svejnar 2015	26 countries, 15 years	Panel	IV	Negative
Kennedy et al. 2017	Australia, 71 years	Panel	OLS & GMM	Lagged negative
Yang, 2018	UK, 37 years	N/A	N/A	Positive
Iyke & Ho 2017	Italy, 45 years	Time series	IV	Lagged negative
Baek 2018	Clustered data	Cross-section	N/A	N-shaped curve

This table displays summative information of the reviewed empirical studies, including author(s) and year of publication, panel size and property, analytical techniques and conclusions. N/A denotes unavailable information or inapplicable items.

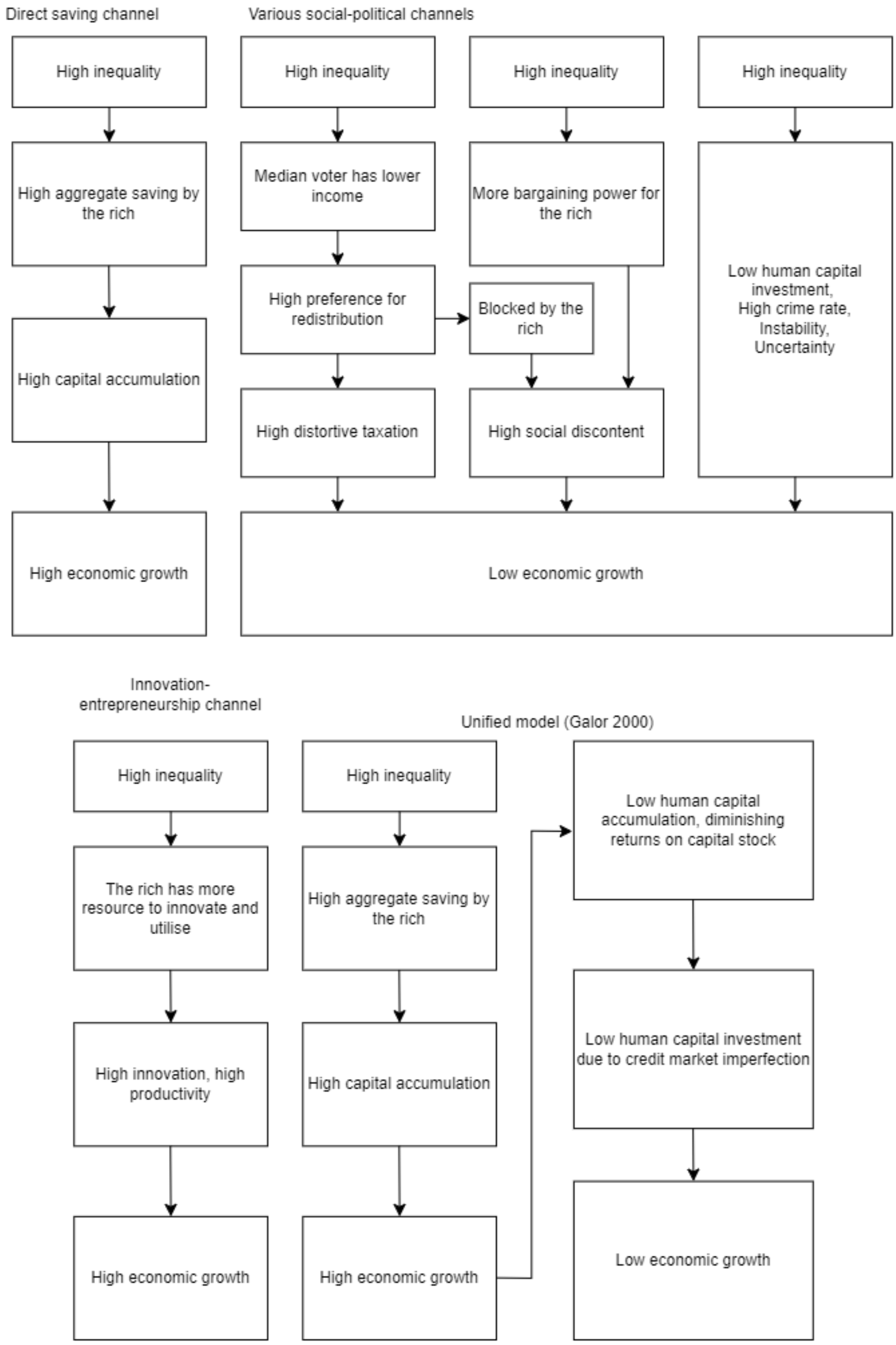


Figure 6.1: This figure shows 6 transmission channels in the inequality-growth nexus. The top left column shows the traditional direct saving channel, one of the first theoretical framework on the inequality-growth nexus (Kaldor 1955). The second column shows the median voter political channel by Alesina and Rodrik (1994). The last two columns are the socio-economic channel and the human capital channel. The bottom half displays two transmission channels: the novel innovation & entrepreneurship channel by Banerjee and Newman (1993) and Yang et al. (2021), and the unified model by Galor (2000).

Country		Country		Country		Country	
Albania		Denmark	D	Lebanon		Serbia	
Algeria		Dominican Republic		Lesotho		Seychelles	
Angola		Ecuador		Liberia		Sierra Leone	
Argentina		Egypt, Arab Rep.		Lithuania	D	Singapore	D
Armenia		El Salvador		Luxembourg	D	Slovak Republic	D
Australia	D	Estonia	D	Madagascar		Slovenia	D
Austria	D	Ethiopia		Malawi		South Africa	
Azerbaijan		Fiji		Malaysia		Spain	D
Bahamas, The		Finland	D	Mali		Sri Lanka	
Bahrain		France	D	Malta	D	Sudan	
Bangladesh		Gabon		Mauritania		Suriname	
Barbados		Gambia, The		Mauritius		Sweden	D
Belarus		Georgia		Mexico		Switzerland	D
Belgium	D	Germany	D	Moldova		Syrian Arab Republic	
Belize		Ghana		Mongolia		Tajikistan	
Benin		Greece	D	Montenegro		Tanzania	
Bhutan		Guatemala		Morocco		Thailand	
Bolivia		Guinea		Mozambique		Togo	
Bosnia and Herzegovina		Guinea-Bissau		Myanmar		Trinidad and Tobago	
Botswana		Haiti		Namibia		Tunisia	
Brazil		Honduras		Nepal		Turkey	
Brunei Darussalam		Hong Kong SAR, China	D	Netherlands	D	Uganda	
Bulgaria		Hungary		New Zealand	D	Ukraine	
Burkina Faso		Iceland	D	Nicaragua		United Arab Emirates	
Burundi		India		Niger		United Kingdom	D
Cabo Verde		Indonesia		Nigeria		United States	D
Cambodia		Iran, Islamic Rep.		Norway	D	Uruguay	
Cameroon		Iraq		Oman		Venezuela, RB	
Canada	D	Ireland	D	Pakistan		Vietnam	
Central African Republic		Israel	D	Panama		Yemen, Rep.	
Chad		Italy	D	Paraguay		Zambia	
Chile		Jamaica		Peru		Zimbabwe	
China		Japan	D	Philippines			
Colombia		Jordan		Poland			
Congo, Dem. Rep.		Kazakhstan		Portugal	D		
Congo, Rep.		Kenya		Qatar			
Costa Rica		Korea, Rep.	D	Romania			
Cote d'Ivoire		Kuwait		Russian Federation			
Croatia		Kyrgyz Republic		Rwanda			
Cyprus	D	Lao PDR		Saudi Arabia			
Czech Republic	D	Latvia	D	Senegal		155	35

Table 6.2: All countries are included in the initial estimations. Countries that are designated as developed countries are labelled as D. In total our dataset contains observations covering 155 countries for 1970-2018, 35 of which are developed countries. See Data Description for designation criteria.

Chapter 7

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