

Sun, Yang; Easaw, Joshy Z.; Logotheitis, Vassilis

Working Paper

Assessing the institutions-innovation channel within the inequality-growth nexus

Cardiff Economics Working Papers, No. E2023/21

Provided in Cooperation with:

Cardiff Business School, Cardiff University

Suggested Citation: Sun, Yang; Easaw, Joshy Z.; Logotheitis, Vassilis (2023) : Assessing the institutions-innovation channel within the inequality-growth nexus, Cardiff Economics Working Papers, No. E2023/21, Cardiff University, Cardiff Business School, Cardiff

This Version is available at:

<https://hdl.handle.net/10419/284183>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Cardiff Economics Working Papers



Working Paper No. E2023/21

Assessing the Institutions-Innovation Channel within the Inequality-Growth Nexus

Yang Sun, Joshy Easaw and Vassilis Logothetis

July 2023

ISSN 1749-6010

Cardiff Business School
Cardiff University
Colum Drive
Cardiff CF10 3EU
United Kingdom
t: +44 (0)29 2087 4000
f: +44 (0)29 2087 4419
business.cardiff.ac.uk

This working paper is produced for discussion purpose only. These working papers are expected to be published in due course, in revised form, and should not be quoted or cited without the author's written permission. Cardiff Economics Working Papers are available online from:
<http://econpapers.repec.org/paper/cdfwpaper/> and
business.cardiff.ac.uk/research/academic-sections/economics/working-papers
Enquiries: EconWP@cardiff.ac.uk

Assessing the Institutions-Innovation Channel within the Inequality-Growth Nexus

Yang Sun^{*}, †, Joshy Easaw[†], Vassilis Logothetis[‡]

May 2023

Abstract

The present paper assesses the interactions between innovation and economic institutions within the context of the inequality-growth nexus. By carrying out fixed effects estimations on a cross-country panel, we find that both institutional quality and innovations improve economic growth at the expense of income equality. We show that the marginal effects of innovations on growth and inequality diminish as institutions increase in quality, and the effects of institutions can be influenced by level of innovations. This indicates that while institutions and innovations can be inequality-inducing, their interactions dampen the effect. Similarly, both variables positively affect growth but their interactions are negative. More importantly, we note a series of transitory interactive effects on growth which show property right protection as the principal growth-enhancing institutions in earlier stages of development, and broader institutional quality in later stages. These results are verified and reinforced by GMM and IV estimations, the latter of which uses judicial independence as an instrument, as well as additional robustness tests.

JEL classification: C33, C36, D63, O33, O34, O43, O47.

Key words: income inequality, economic growth, institutions, entrepreneurship, innovation.

^{*}Corresponding author: suny64@cardiff.ac.uk

[†]Cardiff Business School, Cardiff University, UK

[‡]Department of Economics, University of Ioannina, Greece

1 Introduction

The study of how inequality affects growth in economics and inter-disciplinary research is a long-standing one¹. We contribute to the understanding of the inequality-growth nexus by establishing an important transmission channel, the innovation and institutional interaction channel. We, thereby, consolidate two well-established classical mechanisms: the saving-entrepreneurship channel and the economic roles of institutions.

In this paper, we consider the hypothesis that economic institutions in the form of the enforcement of property right protection and measures for innovation or other productivity indicators are growth-enhancing but induce inequality. A higher level of property right protection encourages economic activities as those who engage in such may be reinsured that the fruit of their labour can be safeguarded against expropriation. 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 would lead to the aforementioned growth and inequality effects. This hypothesis is in line with conventional belief regarding innovation, inequality and growth². One example of relevant study, Amendola et al. (2013), interacts political and economic institutions to examine their effects on redistribution. Yang et al (2021), on the other hand, 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 study³.

Illustrated in Figure 1, which plots inequality and growth figures against institutional quality, clear positive correlations can be observed for institutions and innovation, pointing towards their growth enhancing effects as well as their footprint in increasing inequality. However, innovation and economic institutions may interact and produce marginal effects on dependent variables. This is represented in our empirical models as an interaction term between variables of interest, which has not been explored in prior study. 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 innovation⁴ and the protection of property right is used to appropriate the quality of economic institutions. Using a fixed effects estimation framework and subsequently system-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 downward sloping, 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

¹Earlier works (e.g., Kuznets 1955) suggesting positive causal links between inequality and growth. Others have found contrary results and identified various novel transmission channels (e.g., Alesina & Rodrik 1994; Banerjee & Newman 1993; Deininger & Olinto 2000).

²See Banerjee & Newman 1993; Amendola et al. 2013 and Yang et al. 2021.

³Yang et al. constructed a DSGE model to capture household behaviours when given the agency of conducting entrepreneurial activities to innovate, then with a system of two representative agents, one rich and one poor, demonstrates the process of widening wealth gap that occur alongside with economic growth, simulated by entrepreneurship.

⁴Additional 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

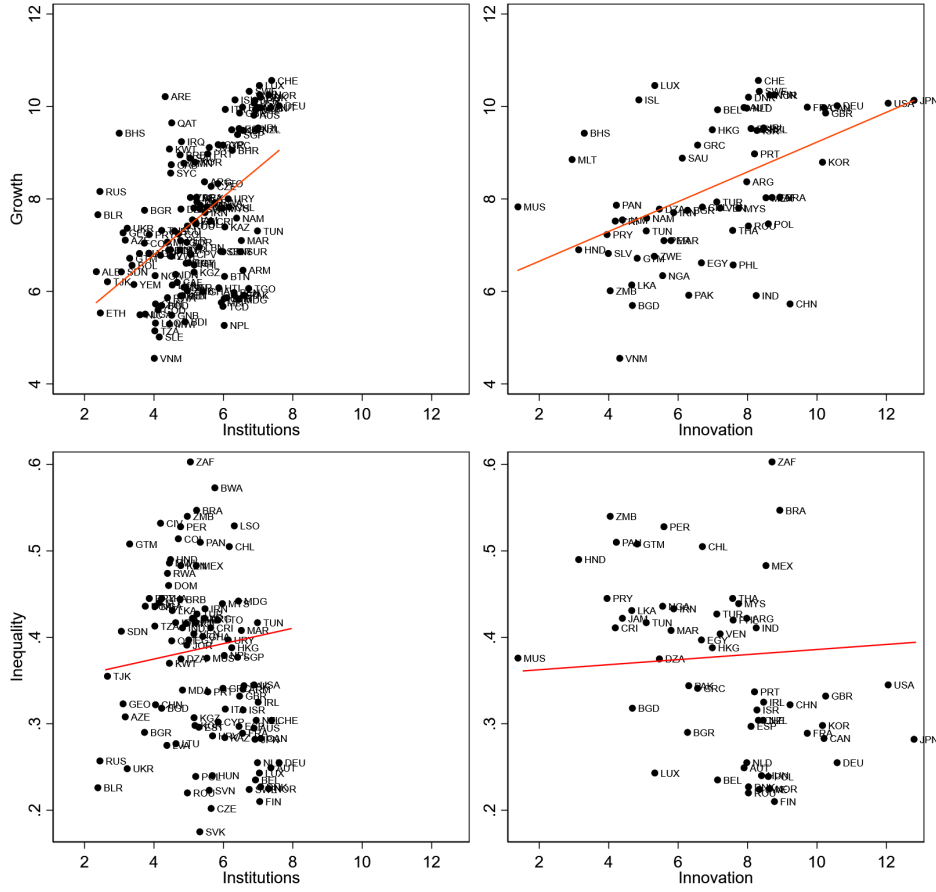


Figure 1: Growth and inequality effects of economic institutions and innovation, 1990

are distinguished in separate estimation attempts. Findings from these estimations further confirm our results as statistically significant. In addition to the novel transmission channel identified in this paper, our research fills a unique niche in the field by bridging the gap between two areas of studies that have seen limited interaction: the study of inequality-growth nexus, and the growth and inequality effects of innovation and various types of institutions. For the former, beside the classical theory such as the direct saving channel (Kuznets 1955; Kaldor 1956), later studies tend to be more elaborate, with some incorporating socio-economic components into the mechanism, such as socio-political instability⁵ (Alesina & Perotti 1996; Alesina et.al. 1996), redistribution⁶ (Alesina & Rodrik 1994; Persson & Tabellini 1994 and Perotti 1996) and innovation and entrepreneurship⁷ (Banerjee & Newman 1993 and Yang et al. 2021)

⁵Inequality is theorised to cause socio-economic instability and class conflict, which diminish investor confidence and impose uncertainty.

⁶By 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.

⁷Where 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.

are some examples. Contemporary studies on the inequality-growth nexus focus either on the negative social-political implications (e.g., Deininger & Olinto 2000; Banerjee & Duflo 2003; Kolawole et al. 2015) or promote nonlinear relations between inequality and growth (e.g., Chen 2003; Voitchovsky 2005; Castello 2010, Halter et al. 2014 and Baek 2018).

While the study on the inequality-growth nexus has been extensive, how the effects of institutions contribute in a transmission channel between inequality and growth and how they interact with other key economic indicators have not been thoroughly examined. 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 effects⁸. 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), but the authors focus solely on the institutional aspects and do not account for innovation. Madsen and Murtin (2017) demonstrate insufficient evidence for consequential effects of property right protection on British economic growth. 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)⁹. 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 framework, 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 inequality¹⁰. To summarise, the study of the effects of innovation and institutions on in-

⁸i.e., higher innovation activities in terms of productivity gain reduces income inequality (e.g., Antonelli & Gehringer 2013; Benos & Tsiachtsiras 2019; Adrián Riso & Sánchez Carrera 2019; Santamaría 2019) while studies conducted in Europe or otherwise developed regions contest this finding (e.g., Aghion et al. 2018).

⁹These 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.

¹⁰e.g., Antonelli and Gehringer (2013) and Benos & Tsiachtsiras (2019)

equality does not present a consensus. Similar to the aforementioned studies, it presents opportunities for further investigations.

The rest of the paper is structured as follows. Section 2 introduces the empirical models and data used in this research. Section 3 presents the findings from the fixed effects estimations and the marginal effects between variables of interest. Section 4 addresses potential endogeneity concerns with IV and system GMM estimations; further robustness assessment is also included. Lastly, section 5 offers concluding remarks. A large suite of robustness estimations with different specifications are included in the appendix.

2 Empirical Framework

To outline the empirical strategy, one may consider the mechanisms outlined in the previous section, condensed into the following hypotheses:

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. At the same time, inequality can contribute to 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.

2.1 The Inequality Model

To analyse the above-proposed effect on inequality one considers a simple regression model, which tests the hypotheses with regards to innovation, institutional quality, and inequality:

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

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. $(inno_{i,t-1} \cdot inst_{i,t-1})$ 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.

The addition of i distinguish between countries for the estimation of a cross-country panel, as inequality measure for country i at the given time period t is dependent on the variable described above. Country and period specific fixed effects, α_i and δ_t and a series of control variables $\sum_{j=1}^p \mu_j X_{jt}$, are included.

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.

2.2 The Growth Model

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

$$y_t = \phi_0 + \phi_1 ineq_{i,t} + \phi_2 inno_{i,t-1} + \phi_3 inst_{i,t-1} + \phi_4 (inno_{i,t-1} \cdot inst_{i,t-1}) + \gamma_t + \gamma_i + \sum_{n=1}^q \mu_n X'_{nt} + \epsilon_{it} \quad (2)$$

where logged output is the dependent variable and innovation, institutions and a series of control variables in $\sum_{n=1}^q \mu_n X'_{nt}$ are the explanatory variables. In this model $\phi_1 ineq_{i,t-1}$ denotes inequality as an explanatory variable to capture the effects of inequality on growth. The control variables include key descriptive measures: investment, human capital in terms of education (enrolment), child mortality, financial flows, tax revenue, financial 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 provided in table(2). 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 interest¹¹.

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.

¹¹The growth and inequality models should be viewed as separate entities unless stated otherwise in specific context.

3 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 2017. Furthermore, as observations are unbalanced between countries and observation availability favouring recent years, as shown in Figure 2, subsequent estimations take three different time dimensions into account¹² 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 economic institutions:

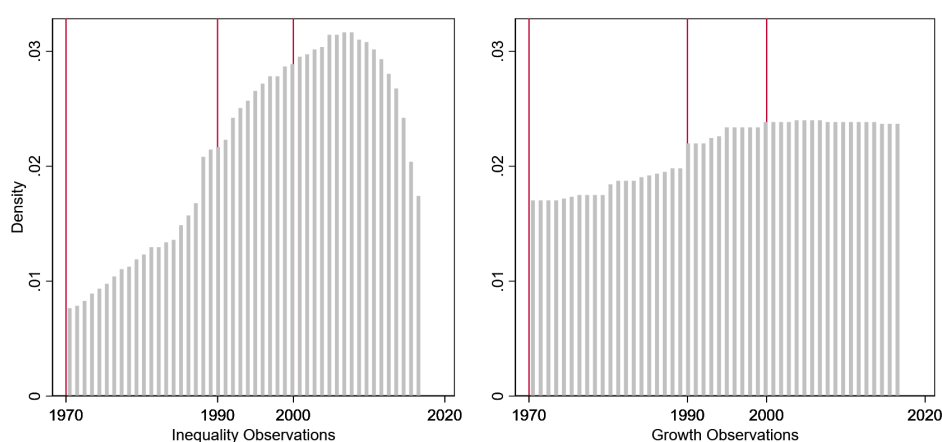


Figure 2: Dependent variables data availability, inequality and growth

protection of property rights index, and a composite index for legal system and property rights, data for both of which are extracted from the Fraser Institute Economic Freedom of the World Index 2020, which we judged to offer the best possible coverage in time dimension and number of countries. 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. 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 system¹³.

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 continuous 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

¹²1970-2018, 1990-2018 and 2000-2018

¹³Refer to Fike (2017) for methodological detail of the adjustment.

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 initial index for consistency in measures (Gwartney 2020).

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. 2011). 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 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 to test the robustness of our results. 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 institutions¹⁴.

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 & Gehring 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 innovation¹⁵ 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

¹⁴It 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. 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.

¹⁵As opposed to domestic and national

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 resident 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 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 productivity¹⁶, 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 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 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

¹⁶Which is typically measured by TFP, e.g. Minford et al. 2009; Le et al. 2016.

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.

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 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 2: Summary statistics: control variables

4 Empirical Results: Fixed Effects Estimations

4.1 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 displays an overview of the fixed effects estimations with robust standard error for the inequality model with a panel of developed and developing countries. 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.

	Patent		TM		TFP		Patent		TM		TFP	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Property Right	-0.033 (0.040)	0.096 (0.101)	-0.027 (0.035)	-0.033 (0.121)	0.003 (0.031)	0.005 (0.032)						
Institutions							0.039 (0.033)	-0.002 (0.079)	0.049* (0.029)	-0.049 (0.108)	0.022 (0.025)	0.017 (0.027)
Patent	0.004 (0.021)	0.112 (0.099)					0.003 (0.020)	-0.030 (0.058)				
Trademark			0.039 (0.029)	0.035 (0.072)					0.036 (0.028)	-0.020 (0.056)		
TFP					0.007 (0.111)	0.382 (0.442)					-0.008 (0.114)	0.781** (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 (0.627)	-0.324 (0.807)	-0.004 (0.518)	0.029 (0.796)	0.091 (0.511)	0.099 (0.510)	0.232 (0.627)	0.522 (0.841)	-0.242 (0.493)	0.370 (0.832)	-0.016 (0.495)	0.007 (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: 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 interest¹⁷, the marginal effects of both institutions and innovation on the dependent variable are plotted. Figure (1) 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 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. As shown, the inequality model does not offer concrete findings supporting the significance of the variables of interest when tested in a mixed panel containing both developed and developing countries. We answer the question of if the condition of

¹⁷Following conventional practices set by prior studies(e.g., Brambor et al. 2006, Amendola et al. 2013, Aghion et al. 2018).

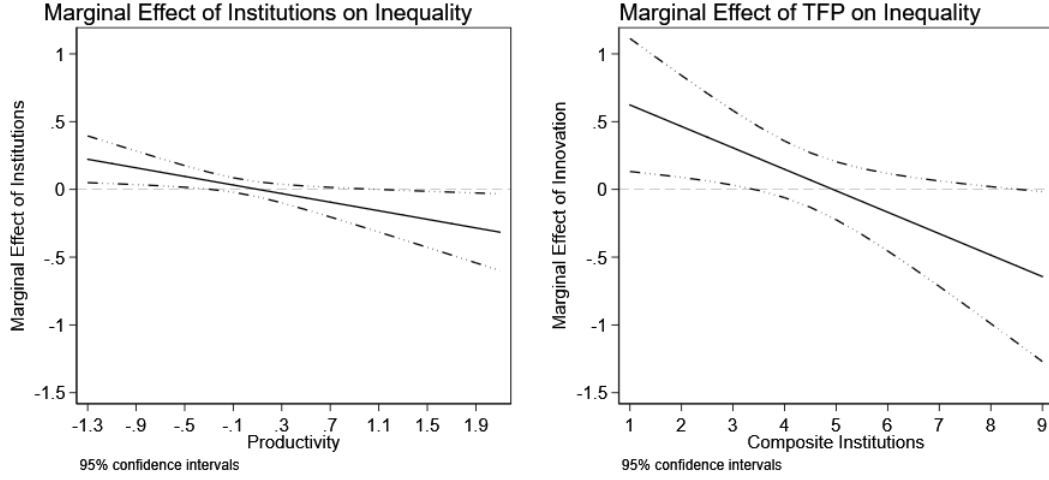


Figure 3: Marginal effects of variables of interest on inequality

development stages can be applied to extract more meaningful results by further testing the model while distinguishing developed countries from developing countries. The results are displayed in table 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. 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 countries¹⁸, 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.

In terms of economic implication, this relation can be explained as follows. Better institutions in the form of property right enforcement against expropriation and unlawful redistribution, as well as more complex institutional operations 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

¹⁸Shown 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 Appendix for an outline of these estimations.

	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)
Property Right	0.272** (0.130)	0.054 (0.175)	0.488* (0.275)	-0.107 (0.171)	-0.014 (0.050)	0.005 (0.034)						
Institutions							0.493* (0.248)	-0.113 (0.103)	0.503 (0.346)	-0.108 (0.128)	-0.008 (0.044)	0.031 (0.030)
Patent	0.298** (0.113)	0.105 (0.170)					0.376* (0.188)	-0.096 (0.066)				
Trademark			0.397* (0.210)	0.029 (0.097)					0.325 (0.257)	-0.017 (0.062)		
TFP					-0.089 (2.617)	0.203 (0.326)					1.278* (0.635)	1.090*** (0.402)
Property Right*Patent	-0.038** (0.017)	-0.015 (0.030)										
Property Right*TM			-0.053* (0.028)	0.009 (0.021)								
Property Right*TFP					-0.056 (0.390)	-0.049 (0.060)						
Institutions Patent							-0.046* (0.025)	0.022 (0.014)				
Institutions TM									-0.040 (0.033)	0.018 (0.014)		
Institutions TFP											-0.270*** (0.088)	-0.265*** (0.089)
Constant	-0.611 (1.503)	-0.207 (1.240)	-1.126 (2.312)	-0.095 (1.042)	0.866 (1.418)	-0.239 (0.544)	-2.259 (2.260)	1.092 (0.923)	-1.391 (3.426)	0.116 (0.915)	0.858 (1.327)	-0.397 (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 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.

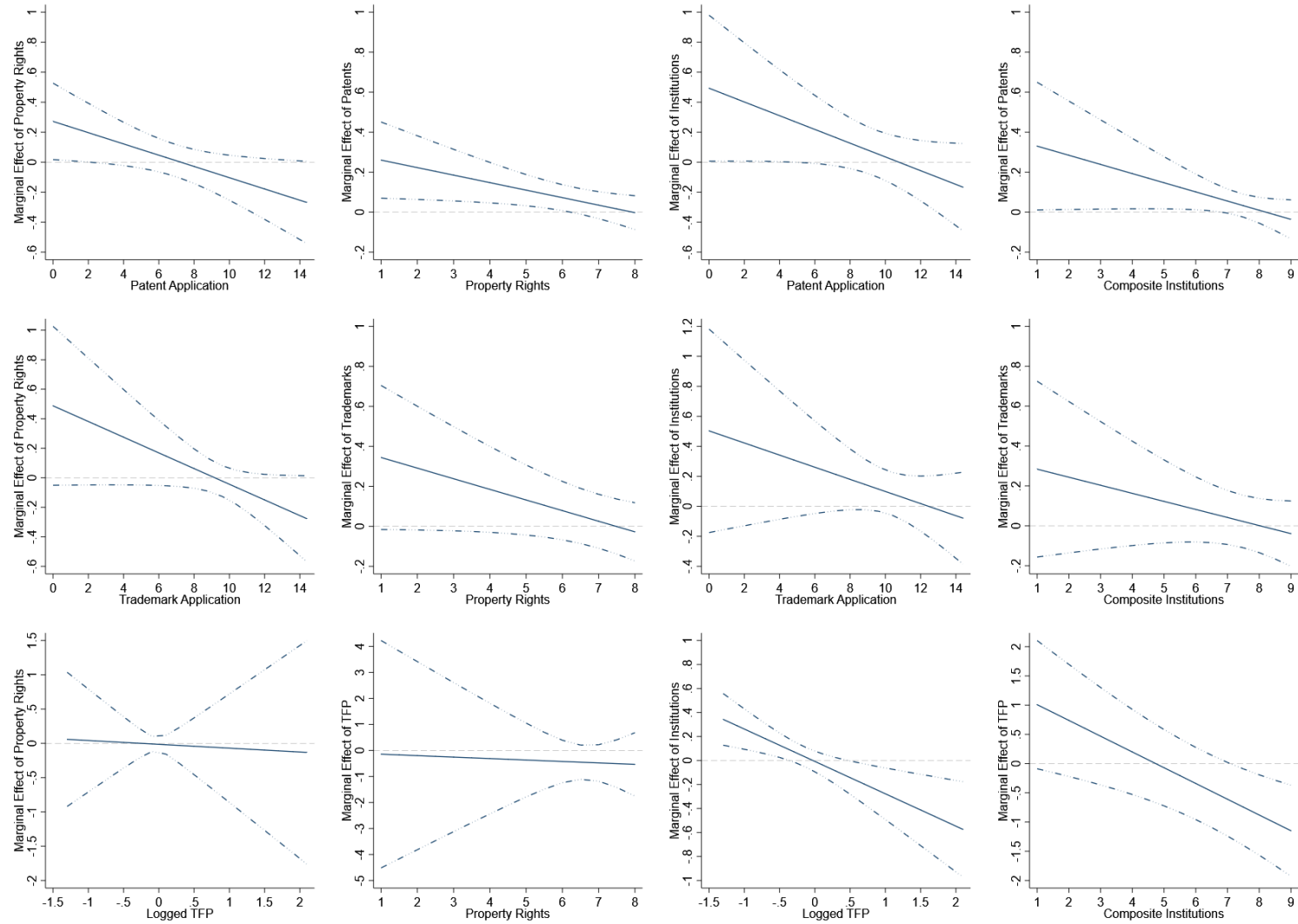


Figure 4: This matrix of diagrams shows the marginal effects of either institutions or innovation on inequality conditional on their interacting counterparts. The estimations are carried out on developed countries. Each row shows the results of a measure of innovation: row 1 uses total patent application, 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.

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 ¹⁹ are shown in figure (4). Each row of figure (4) 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.

4.2 The Growth Model

Table 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 ²⁰. 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 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 further investigate the particular effects of trademark application and how it interacts with institutional

¹⁹As seen in 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.

²⁰Please refer to model and data description for details and justifications.

measures, the marginal effects of their interaction are plotted, presented in figure 5. 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 ²¹. 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 (0.012)	0.008 (0.012)	0.006 (0.012)	0.004 (0.011)	-0.009 (0.010)	-0.009 (0.010)	0.011 (0.013)	0.009 (0.013)	0.007 (0.012)	0.004 (0.011)	-0.009 (0.010)	-0.009 (0.010)
Property Right	0.117*** (0.029)	0.029 (0.082)	0.091*** (0.032)	-0.292** (0.140)	0.019 (0.031)	0.021 (0.032)						
Institutions							0.088** (0.042)	-0.068 (0.089)	0.065 (0.046)	-0.475*** (0.114)	0.024 (0.034)	0.023 (0.032)
Patent	0.062** (0.031)	-0.010 (0.076)					0.058** (0.028)	-0.067 (0.088)				
Trademark			0.128*** (0.042)	-0.075 (0.069)					0.128*** (0.042)	-0.174*** (0.064)		
TFP					1.011*** (0.164)	1.422** (0.706)					1.007*** (0.147)	1.299** (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 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.

To follow 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. The results of these estimations are shown in table 6.

Similar to the setup in table 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;

²¹ The partial effects of institutions conditional on the value of logged total trademark application are also significantly positive and upwards sloping. 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 Appendix.

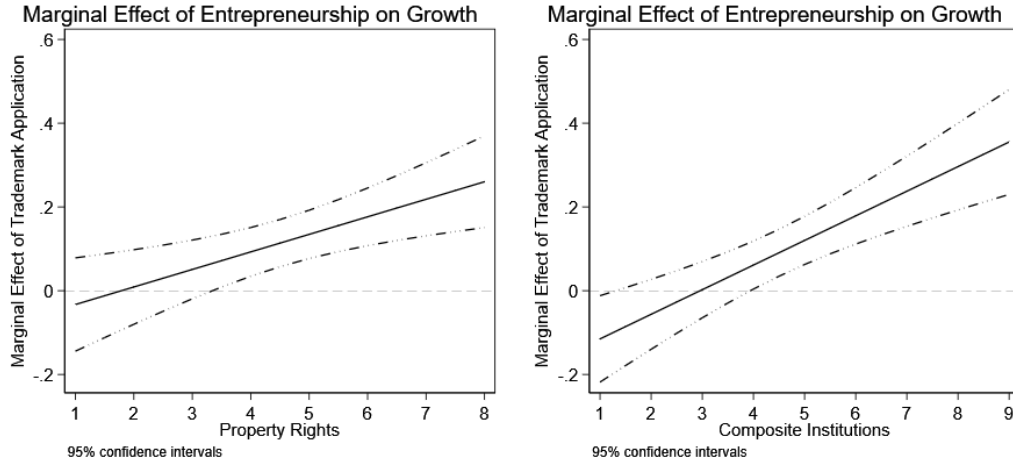


Figure 5: Marginal effects of variables of interest on growth

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 value²².

We then look at the marginal growth effects of the interacting variables at given values of their counterpart. Figure 6 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 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 6 a contradicting behaviour can be noted in the first and third diagrams on the first row.

²²The 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 (0.010)	0.026** (0.012)	-0.012 (0.014)	0.024** (0.011)	-0.010 (0.010)	0.007 (0.011)	0.006 (0.010)	0.027** (0.013)	-0.012 (0.013)	0.023** (0.011)	-0.009 (0.010)	0.007 (0.012)
Property Right	0.217** (0.090)	-0.155 (0.116)	0.230 (0.221)	-0.476*** (0.162)	-0.007 (0.038)	0.020 (0.042)						
Institutions							0.093 (0.145)	-0.155 (0.120)	-0.096 (0.202)	-0.647*** (0.145)	0.007 (0.036)	-0.036 (0.033)
Patent	0.060 (0.071)	-0.090 (0.113)					-0.080 (0.116)	-0.026 (0.106)				
Trademark			0.123 (0.162)	-0.149** (0.070)					-0.170 (0.151)	-0.222*** (0.071)		
TFP					2.645** (1.238)	1.593** (0.610)					2.103*** (0.553)	0.568 (0.457)
Property Right *Patent	-0.014 (0.010)	0.031* (0.018)										
Property Right*TM			-0.014 (0.023)	0.057*** (0.017)								
Property Right*TFP					-0.193 (0.198)	-0.159 (0.121)						
Institutions *Patent							0.007 (0.016)	0.022 (0.019)				
Institutions *TM									0.027 (0.021)	0.070*** (0.016)		
Institutions *TFP											-0.115 (0.090)	0.055 (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 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.

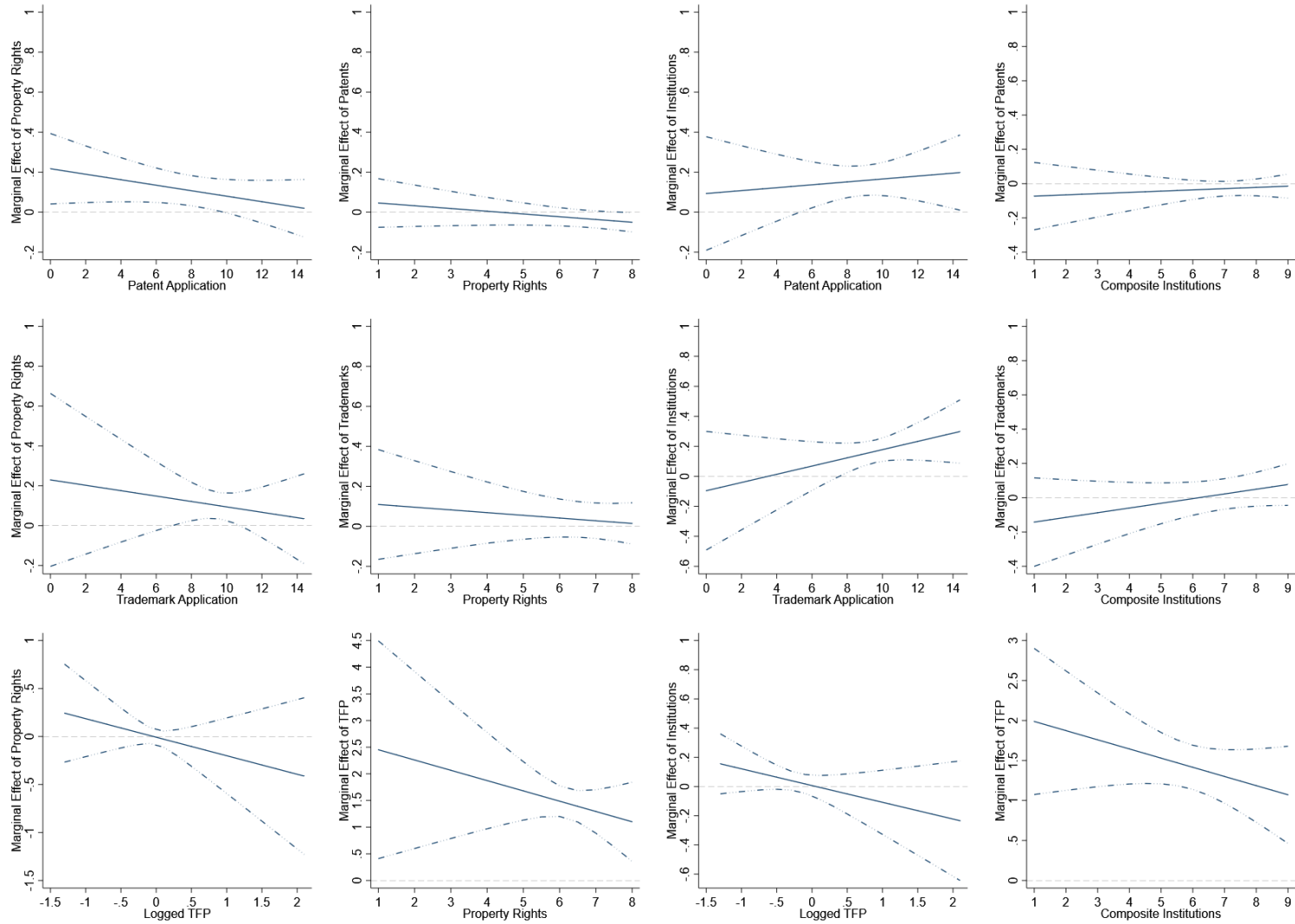


Figure 6: This matrix of diagrams shows the marginal effects of either institutions or innovation on growth conditional on their interacting counterparts. The estimations are carried out on developed countries. Each row shows the results of a measure of innovation: row 1 uses total patent application, 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.

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.²³ 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 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 innovative²⁴.

5 GMM & IV Estimations and Further Robustness Checks

5.1 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

²³An 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: courtrooms and judges to settle dispute, patent offices and clerks 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.

²⁴The results of the additional estimations are available upon request.

a series of instrumental variable (IV) estimations to assess the robustness of the 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. Following the advise by Roodman (2009) we elect to address this issue 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; 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. 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).

5.2 The Inequality Model

Table 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 statis-

tics 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.

	GMM						IV Estimations		
	Base (1)	2 Lags (2)	3-Way Interact (3)	Both (4)	Developed (5)	Developing (6)	Mixed (7)	Developed (8)	Developing (9)
Property Right	1.022** (0.518)	0.296 (0.208)	1.662* (0.928)	1.237* (0.722)	1.140* (0.625)	2.077* (1.152)	0.062 (0.057)	0.003 (0.098)	0.189** (0.075)
Patent	0.836** (0.376)	0.290** (0.142)	1.317** (0.627)	0.978* (0.533)	1.096** (0.546)	1.531* (0.795)	0.112** (0.050)	0.104 (0.089)	0.191*** (0.063)
Property Right *Patent	-0.127* (0.070)	-0.042 (0.027)	-0.234** (0.119)	-0.177* (0.103)	-0.130 (0.081)	-0.276* (0.164)	-0.016** (0.008)	-0.004 (0.013)	-0.037*** (0.011)
Development			13.689 (9.119)	10.819* (6.216)					
Development *Property Right			-2.268 (1.610)	-1.878* (1.086)					
Development *Patents			-1.839 (1.192)	-1.574* (0.888)					
Three-way Interaction			0.327 (0.200)	0.271* (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 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.

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 interaction 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 consistent signs and improved statistical significance which provide further support for the findings.

5.3 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 8.

	GMM				IV Estimations		
	Base (1)	1 Lag (2)	Developed (3)	Developing (4)	Mixed (5)	Developed (6)	Developing (7)
Ineq	-0.060* (0.036)	-0.002 (0.030)	-0.055 (0.054)	-0.028 (0.026)	-0.043*** (0.009)	0.037*** (0.012)	-0.068*** (0.010)
Ppty Rgt	1.197** (0.601)	0.750* (0.394)	0.361 (0.612)	0.776 (1.020)	0.349*** (0.075)	0.285*** (0.083)	-0.100 (0.107)
Patent	1.081** (0.516)	0.619* (0.331)	0.299 (0.617)	0.890 (0.755)	0.043 (0.065)	0.108* (0.059)	-0.326*** (0.090)
Ppty Rgt *Patent	-0.157* (0.083)	-0.106* (0.054)	-0.027 (0.090)	-0.155 (0.139)	-0.019* (0.011)	-0.029*** (0.009)	0.049*** (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 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.

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 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.

6 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 inequality persist in the analysis of developed and developing countries. We then test the robustness of the 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 producing comparable results.

7 References

- Abdulahi, M.E., Shu, Y. and Khan, M.A., 2019. Resource rents, economic growth, and the role of institutional quality: A panel threshold analysis. *Resources Policy*, 61, pp.293-303.
- Adrián Risso, W. and Sánchez Carrera, E.J., 2019. On the impact of innovation and inequality in economic growth. *Economics of innovation and new technology*, 28(1), pp.64-81.
- Adrián Risso, W. and Sánchez Carrera, E.J., 2019. On the impact of innovation and inequality in economic growth. *Economics of innovation and new technology*, 28(1), pp.64-81.
- Aghion, P., Akcigit, U., Bergeaud, A., Blundell, R. and Hémous, D., 2019. Innovation and top income inequality. *The Review of Economic Studies*, 86(1), pp.1-45.
- Alesina, A. and Perotti, R., 1996. Income distribution, political instability, and investment. *European economic review*, 40(6), pp.1203-1228.
- Alesina, A. and Rodrik, D., 1994. Distributive politics and economic growth. *The quarterly journal of economics*, 109(2), pp.465-490.
- Alesina, A., Özler, S., Roubini, N. and Swagel, P., 1996. Political instability and economic growth. *Journal of Economic growth*, 1(2), pp.189-211.
- Aluko, O.A. and Ibrahim, M., 2020. Institutions and the financial development–economic growth nexus in sub-Saharan Africa. *Economic Notes*, 49(3), p.e12163.
- Amendola, A., Easaw, J. and Savoia, A., 2013. Inequality in developing economies: the role of institutional development. *Public Choice*, 155(1), pp.43-60.
- Antonelli, C. and Gehringer, A., 2013. Innovation and income inequality (No. 201324). University of Turin.
- Antonelli, C. and Gehringer, A., 2017. Technological change, rent and income inequalities: A Schumpeterian approach. *Technological Forecasting and Social Change*, 115, pp.85-98.
- Baek, S.H. and Kim, K.T., 2018. Retesting the income inequality hypothesis: Pooled time-series–cross-section regression with a new statistical case selection method. *Asian Social Work and Policy Review*, 12(3), pp.191-199.
- Banerjee, A.V. and Duflo, E., 2003. Inequality and growth: What can the data say?. *Journal of economic growth*, 8(3), pp.267-299.
- Banerjee, A.V. and Newman, A.F., 1993. Occupational choice and the process of development. *Journal of political economy*, 101(2), pp.274-298.
- Benos, N. and Tsiachtsiras, G., 2019. Innovation and income inequality: World evidence.
- Biurrun-Santamaria, A., 2019. New empirics about innovation and inequality in Europe.
- Boudreaux, C.J., 2019. Entrepreneurship, institutions, and economic growth: Does the level of development matter?. *arXiv preprint arXiv:1903.02934*.

- Bosma, N., Sanders, M. and Stam, E., 2018. Institutions, entrepreneurship, and economic growth in Europe. *Small Business Economics*, 51(2), pp.483-499.
- Brambor, T., Clark, W.R. and Golder, M., 2006. Understanding interaction models: Improving empirical analyses. *Political analysis*, 14(1), pp.63-82.
- Castelló-Climent, A., 2010. Inequality and growth in advanced economies: an empirical investigation. *The Journal of Economic Inequality*, 8(3), pp.293-321.
- Cheema, A.R. and Sial, M.H., 2012. Poverty, income inequality, and growth in Pakistan: A pooled regression analysis. *The Lahore Journal of Economics*, 17(2), p.137.
- Chen, B.L., 2003. An inverted-U relationship between inequality and long-run growth. *Economics Letters*, 78(2), pp.205-212.
- Chinn, M.D. and Ito, H., 2008. A new measure of financial openness. *Journal of comparative policy analysis*, 10(3), pp.309-322.
- Cook, K.S., 2014. Social capital and inequality: the significance of social connections. *Handbook of the social psychology of inequality*, pp.207-227.
- Deininger, K., Olinto, P. and Maertens, M., 2000. Redistribution, investment, and human capital accumulation: the case of agrarian reform in the Philippines.
- Fitzenberger, B., Koenker, R., Machado, J. and Melly, B., 2021. Economic applications of quantile regression 2.0. *Empirical Economics*, pp.1-6.
- Galindo-Martín, M.A., Méndez-Picazo, M.T. and Castaño-Martínez, M.S., 2019. The role of innovation and institutions in entrepreneurship and economic growth in two groups of countries. *International Journal of Entrepreneurial Behavior & Research*.
- Gwartney, J., Lawson, R., Hall, J. and Murphy, R., 2020. *Economic Freedom of the World: 2020 Annual Report-executive summary*.
- Hall, B.H., 2011. Innovation and productivity (No. w17178). National bureau of economic research.
- Halter, D., Oechslin, M. and Zweimüller, J., 2014. Inequality and growth: the neglected time dimension. *Journal of economic growth*, 19(1), pp.81-104.
- Isaksson, A.S., 2011. *Essays on Institutions. Inequality and Development*.
- Kaldor, N., 1955. Alternative theories of distribution. *The review of economic studies*, 23(2), pp.83-100.
- Kolawole, B.O., Omobitan, O.A. and Yaqub, J.O., 2015. Poverty, inequality and rising growth in Nigeria: Further empirical evidence. *International Journal of Economics and Finance*, 7(2), pp.51-62.
- Kurokawa, Y., 2014. A survey of trade and wage inequality: anomalies, resolutions and new trends. *Journal of Economic Surveys*, 28(1), pp.169-193.
- Kuznets, S., 1955. Economic growth and income inequality. *The American economic review*, 45(1), pp.1-28.

- Lawrence, R.Z., Slaughter, M.J., Hall, R.E., Davis, S.J. and Topel, R.H., 1993. International trade and American wages in the 1980s: giant sucking sound or small hiccup?. *Brookings papers on economic activity. Microeconomics*, 1993(2), pp.161-226.
- Linzer, D.A. and Staton, J.K., 2015. A global measure of judicial independence, 1948–2012. *Journal of Law and Courts*, 3(2), pp.223-256.
- Long, A. and Ascent, D., 2020. World economic outlook. International Monetary Fund.
- Machado, J.A. and Silva, J.S., 2019. Quantiles via moments. *Journal of Econometrics*, 213(1), pp.145-173.
- Madsen, J.B. and Murin, F., 2017. British economic growth since 1270: the role of education. *Journal of Economic Growth*, 22(3), pp.229-272.
- Ouattara, B. and Standaert, S., 2020. Property rights revisited. *European Journal of Political Economy*, 64, p.101895.
- Perotti, R., 1996. Growth, income distribution, and democracy: What the data say. *Journal of Economic growth*, 1(2), pp.149-187.
- Persson, T. and Tabellini, G., 1994. Representative democracy and capital taxation. *Journal of Public Economics*, 55(1), pp.53-70.
- Roodman, D., 2009. A note on the theme of too many instruments. *Oxford Bulletin of Economics and statistics*, 71(1), pp.135-158.
- Ruiz, J.L., 2018. Financial development, institutional investors, and economic growth. *International Review of Economics & Finance*, 54, pp.218-224.
- Solt, F., 2016. Using the SWIID in Stata. Unpublished manuscript, University of Iowa.
- Tselios, V., 2011. Is inequality good for innovation?. *International Regional Science Review*, 34(1), pp.75-101.
- Voitchovsky, S., 2005. Does the profile of income inequality matter for economic growth?. *Journal of Economic growth*, 10(3), pp.273-296.
- Yang, X., Minford, P. and Meenagh, D., 2021. Inequality and economic growth in the UK. *Open Economies Review*, 32(1), pp.37-69.

8 Appendix

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 9: Country list and developed countries designation. All countries are included in the initial estimations. Countries that are designated as developed countries are labelled as D in the second column. In total the database covers 155 countries for 1970-2018, 35 of which are developed countries. See Data Description for designation criteria.

8.1 Further Robustness Checks

The above-described results from the instrument variables and system-GMM estimations reinforce our findings on how innovation and institutions as well as 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, confirming the previously proposed hypotheses. The interaction terms between key variables are negative, indicating a dampening partial effect. To gather additional evidence in support of our findings a series of robustness checks are carried out with varying specifications or analytical techniques.

Alternative time dimensions

First, we estimate both inequality and growth model under different time dimensions. Recall that the primary estimations are carried out with the largest time coverage possible, that being between 1970 and 2018. With this time dimension and the fact that part of the estimations is on mixed development groups, 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 concern two additional time dimensions are used in this check: 1990 – 2018 and 2000 – 2018. The same estimations on the identical sets 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. When distinguishing developmental status, the results are once again effectively identical to the primary results under for both shorter time dimensions. This may suggest that the concern regarding potential bias originate from unbalanced observation availability between developed and developing groups does not appear to manifest in a significant way. The results from these estimations are available in this section.

R&D expenditure as innovation

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 rather 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 experiential 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 apply 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 interaction. Stylised results are available.

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.	

Table 10: Notation guide for the appendix estimation tables.

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 10 provides a guide on how the stylised system can be interpreted.

Table 11: 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 (0.101)	0.272** (0.130)	0.054 (0.175)	-0.033 (0.121)	0.488* (0.275)	-0.107 (0.171)	0.005 (0.032)	-0.014 (0.050)	0.005 (0.034)									
Inst										-0.002 (0.079)	0.493* (0.248)	-0.113 (0.103)	-0.049 (0.108)	0.503 (0.346)	-0.108 (0.128)	0.017 (0.027)	-0.008 (0.044)	0.031 (0.030)
Patent	0.112 (0.099)	0.298** (0.113)	0.105 (0.170)							-0.030 (0.058)	0.376* (0.188)	-0.096 (0.066)						
Trademark				0.035 (0.072)	0.397* (0.210)	0.029 (0.097)							-0.020 (0.056)	0.325 (0.257)	-0.017 (0.062)			
TFP							0.382 (0.442)	-0.089 (2.617)	0.203 (0.326)							0.781** (0.312)	1.278* (0.635)	1.090*** (0.402)
PptyRgt*Patent	-0.019 (0.016)	-0.038** (0.017)	-0.015 (0.030)															
PptyRgt*TM				0.001 (0.014)	-0.053* (0.028)	0.009 (0.021)												
PptyRgt*TFP							-0.069 (0.084)	-0.056 (0.390)	-0.049 (0.060)									
Inst*Patent										0.005 (0.009)	-0.046* (0.025)	0.022 (0.014)						
Inst*TM													0.011 (0.011)	-0.040 (0.033)	0.018 (0.014)			
Inst*TFP																-0.158** (0.066)	-0.270*** (0.088)	-0.265*** (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 and 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 10 for a guide on how to interpret them.

Table 12: 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 (0.012)	0.006 (0.010)	0.026** (0.012)	0.004 (0.011)	-0.012 (0.014)	0.024** (0.011)	-0.009 (0.010)	-0.010 (0.010)	0.007 (0.011)	0.009 (0.013)	0.006 (0.010)	0.027** (0.013)	0.004 (0.011)	-0.012 (0.013)	0.023** (0.011)	-0.009 (0.010)	-0.009 (0.010)	0.007 (0.012)
PptyRgt	0.029 (0.082)	0.217** (0.090)	-0.155 (0.116)	-0.292** (0.140)	0.230 (0.221)	-0.476*** (0.162)	0.021 (0.032)	-0.007 (0.038)	0.020 (0.042)									
Inst										-0.068 (0.089)	0.093 (0.145)	-0.155 (0.120)	-0.475*** (0.114)	-0.096 (0.202)	-0.647*** (0.145)	0.023 (0.032)	0.007 (0.036)	-0.036 (0.033)
Patent	-0.010 (0.076)	0.060 (0.071)	-0.090 (0.113)							-0.067 (0.088)	-0.080 (0.116)	-0.026 (0.106)						
Trademark				-0.075 (0.069)	0.123 (0.162)	-0.149** (0.070)							-0.174*** (0.064)	-0.170 (0.151)	-0.222*** (0.071)			
TFP							1.422** (0.706)	2.645** (1.238)	1.593** (0.610)							1.299** (0.586)	2.103*** (0.553)	0.568 (0.457)
PptyRgt*Patent	0.013 (0.011)	-0.014 (0.010)	0.031* (0.018)															
PptyRgt*TM				0.042*** (0.014)	-0.014 (0.023)	0.057*** (0.017)												
PptyRgt*TFP							-0.076 (0.135)	-0.193 (0.198)	-0.159 (0.121)									
Inst*Patent										0.021 (0.014)	0.007 (0.016)	0.022 (0.019)						
Inst*TM													0.059*** (0.013)	0.027 (0.021)	0.070*** (0.016)			
Inst*TFP																-0.061 (0.106)	-0.115 (0.090)	0.055 (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 ?? 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 10 for a guide on how to interpret them.

Table 13: 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 (0.118)	0.213 (0.135)	0.163 (0.195)	0.053 (0.117)	0.294 (0.298)	0.037 (0.173)	0.011 (0.028)	0.048 (0.047)	0.015 (0.038)	-0.053 (0.041)	-0.054 (0.055)	-0.115 (0.083)												
Inst													0.104 (0.098)	0.676** (0.314)	0.056 (0.141)	0.100 (0.152)	1.336*** (0.453)	0.005 (0.184)	0.080** (0.032)	0.151 (0.117)	0.091*** (0.034)	0.047 (0.055)	0.016 (0.103)	0.062 (0.104)
Patent	0.123 (0.115)	0.215 (0.138)	0.162 (0.182)										0.026 (0.079)	0.415* (0.238)	-0.036 (0.091)									
Trademark				0.069 (0.063)	0.234 (0.255)	0.080 (0.088)										0.034 (0.079)	0.836** (0.333)	-0.001 (0.081)						
TFP							-0.071 (0.584)	1.067 (3.129)	-0.155 (0.816)										0.453 (0.339)	4.291 (2.654)	0.359 (0.431)			
R&D										0.158 (0.141)	0.217 (0.325)	0.421* (0.236)										0.028 (0.159)	0.556 (0.615)	0.108 (0.217)
PptyRgt*Patent	-0.017 (0.019)	-0.020 (0.019)	-0.029 (0.033)																					
PptyRgt*TM				-0.008 (0.014)	-0.027 (0.032)	-0.007 (0.021)																		
PptyRgt*TFP							-0.032 (0.105)	-0.244 (0.466)	-0.027 (0.166)															
PptyRgt*R&D										-0.025 (0.026)	0.004 (0.056)	-0.085* (0.047)												
Inst*Patent													0.001 (0.012)	-0.047 (0.030)	0.009 (0.018)									
Inst*TM																-0.002 (0.016)	-0.109** (0.043)	0.010 (0.019)						
Inst*TFP																			-0.136* (0.072)	-0.666* (0.363)	-0.150 (0.104)			
Inst*R&D																						0.000 (0.028)	-0.047 (0.093)	-0.019 (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 10 for a guide on how to interpret them.

Table 14: 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 (0.013)	0.005 (0.014)	0.027** (0.013)	0.005 (0.012)	-0.015 (0.021)	0.021* (0.011)	-0.003 (0.011)	-0.012 (0.018)	0.015 (0.012)	-0.008 (0.010)	-0.001 (0.014)	0.009 (0.011)	0.010 (0.014)	0.001 (0.015)	0.030** (0.014)	0.006 (0.012)	-0.016 (0.020)	0.023** (0.011)	-0.003 (0.012)	-0.010 (0.017)	0.015 (0.012)	-0.013 (0.011)	-0.004 (0.013)	0.010 (0.012)
PptyRgt	-0.011 (0.093)	0.175* (0.099)	-0.168 (0.123)	-0.236* (0.131)	0.104 (0.219)	-0.418** (0.170)	0.048 (0.035)	0.040 (0.035)	-0.013 (0.047)	0.156*** (0.036)	0.100*** (0.035)	0.110* (0.060)	-0.145 (0.123)	-0.050 (0.225)	-0.211 (0.149)	-0.362** (0.140)	-0.196 (0.264)	-0.642*** (0.173)	0.001 (0.042)	0.136** (0.052)	-0.050 (0.035)	0.153*** (0.058)	0.150** (0.059)	0.002 (0.066)
Inst																								
Patent	-0.100 (0.073)	0.028 (0.085)	-0.157 (0.103)													-0.100 (0.073)	-0.241 (0.195)	-0.201** (0.078)						
Trademark				-0.067 (0.058)	0.035 (0.143)	-0.119* (0.069)																		
TFP							1.749* (0.903)	2.539 (1.560)	1.941* (1.021)										0.316 (0.497)	2.702* (1.376)	-0.002 (0.497)			
R&D										0.021 (0.101)	0.135 (0.261)	-0.038 (0.142)										-0.170 (0.140)	-0.537 (0.499)	0.128 (0.130)
PptyRgt*Patent	0.018* (0.011)	-0.008 (0.012)	0.033* (0.018)																					
PptyRgt*TM				0.036*** (0.013)	-0.001 (0.022)	0.049*** (0.018)																		
PptyRgt*TFP							-0.168 (0.174)	-0.217 (0.275)	-0.241 (0.208)															
PptyRgt*R&D										-0.013 (0.022)	-0.035 (0.041)	-0.004 (0.033)												
Inst*Patent													0.022 (0.016)	0.024 (0.024)	0.024 (0.022)									
Inst*TM																0.041*** (0.016)	0.039 (0.028)	0.065*** (0.020)						
Inst*TFP																			0.125 (0.096)	-0.206 (0.205)	0.178* (0.106)			
Inst*R&D																						0.027 (0.030)	0.065 (0.070)	-0.039 (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 10 for a guide on how to interpret them.

Table 15: The inequality 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)
PptyRgt	0.113 (0.087)	0.029 (0.151)	0.216* (0.116)	0.158 (0.126)	0.027 (0.357)	0.165 (0.182)	-0.008 (0.027)	-0.018 (0.045)	-0.002 (0.036)	-0.032 (0.041)	-0.020 (0.056)	-0.118 (0.077)	0.183* (0.109) 0.109 (0.083) 0.303 (0.310) 0.238 (0.263) 0.317* (0.184) 0.167 (0.120)	0.269 (0.189)	0.473 (0.471)	0.204 (0.268)	0.053 (0.037)	0.017 (0.093)	0.059 (0.044)	0.066 (0.059)	0.012 (0.094)	0.064 (0.116)		
Inst																								
Patent	0.144* (0.075)	0.123 (0.145)	0.197** (0.081)																					
Trademark				0.113* (0.067)	0.102 (0.302)	0.122 (0.074)																		
TFP							-1.106 (0.985)	-2.044 (4.226)	-1.103 (1.337)															
R&D										0.057 (0.146)	-0.095 (0.342)	0.368 (0.239)							0.120 (0.533)	-1.465 (4.431)	0.722 (0.771)	-0.041 (0.157)	0.116 (0.660)	0.078 (0.244)
PptyRgt*Patent	-0.021* (0.012)	-0.006 (0.020)	-0.037** (0.015)										0.183* (0.109) 0.109 (0.083) 0.303 (0.310) 0.238 (0.263) 0.317* (0.184) 0.167 (0.120)	0.269 (0.189)	0.473 (0.471)	0.204 (0.268)	0.053 (0.037)	0.017 (0.093)	0.059 (0.044)	0.066 (0.059)	0.012 (0.094)	0.064 (0.116)		
PptyRgt*TM				-0.021 (0.013)	-0.007 (0.037)	-0.020 (0.019)																		
PptyRgt*TFP							0.098 (0.185)	0.165 (0.627)	0.118 (0.282)															
PptyRgt*R&D										-0.009 (0.027)	0.050 (0.055)	-0.081* (0.048)												
Inst*Patent																								
Inst*TM													-0.014 (0.014)	-0.023 (0.033)	-0.032 (0.024)									
Inst*TFP																-0.022 (0.019)	-0.034 (0.044)	-0.014 (0.028)						
Inst*R&D																			-0.148 (0.105)	0.065 (0.599)	-0.283 (0.190)	0.010 (0.029)	0.010 (0.093)	-0.020 (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 10 for a guide on how to interpret them.

Table 16: 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 (0.013)	0.010 (0.016)	0.006 (0.014)	-0.014 (0.012)	0.004 (0.015)	-0.002 (0.012)	-0.019* (0.011)	0.008 (0.015)	-0.007 (0.012)	-0.017 (0.011)	0.000 (0.015)	0.002 (0.012)	-0.017 (0.012)	0.006 (0.016)	0.007 (0.014)	-0.018 (0.012)	-0.001 (0.013)	-0.003 (0.012)	-0.021* (0.011)	0.004 (0.013)	-0.008 (0.012)	-0.024** (0.012)	-0.004 (0.014)	0.003 (0.012)
PptyRgt	0.016 (0.107)	0.145 (0.091)	-0.150 (0.158)	-0.127 (0.151)	0.177 (0.193)	-0.290 (0.186)	0.055 (0.034)	0.087*** (0.031)	-0.027 (0.041)	0.155*** (0.038)	0.103*** (0.034)	0.104* (0.054)	-0.022 (0.163)	0.251 (0.213)	-0.104 (0.175)	-0.079 (0.203)	0.478 (0.370)	-0.240 (0.240)	0.080* (0.045)	0.168** (0.066)	0.023 (0.041)	0.163*** (0.062)	0.139** (0.059)	-0.006 (0.070)
Inst													-0.131 (0.124)	-0.012 (0.172)	-0.102 (0.126)									
Patent	-0.117 (0.077)	-0.008 (0.077)	-0.155 (0.108)																					
Trademark				-0.087 (0.066)	0.023 (0.132)	-0.122 (0.073)																		
TFP							0.563 (0.765)	3.339*** (1.157)	0.662 (0.959)															
R&D										0.026 (0.108)	0.165 (0.255)	-0.093 (0.138)												
PptyRgt*Patent	0.015 (0.012)	-0.006 (0.011)	0.026 (0.019)																					
PptyRgt*TM				0.026* (0.014)	-0.007 (0.019)	0.035* (0.018)																		
PptyRgt*TFP							0.105 (0.147)	-0.351* (0.196)	0.045 (0.204)															
PptyRgt*R&D										-0.012 (0.023)	-0.036 (0.040)	0.006 (0.032)												
Inst*Patent													0.017 (0.020)	-0.005 (0.022)	0.018 (0.023)									
Inst*TM																0.022 (0.020)	-0.028 (0.035)	0.031 (0.025)						
Inst*TFP																			0.349*** (0.109)	-0.572* (0.285)	0.302* (0.153)			
Inst*R&D																						0.025 (0.032)	0.052 (0.076)	-0.045 (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 10 for a guide on how to interpret them.