The impact of business regulations on innovation: An analysis of the Ease of Doing Business index on patent applications in the OESO countries

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Abstract: This research examines the effects of national regulations on the innovative output of countries by studying the effects of the indicators of the Ease of Doing business index on the yearly patent applications. The research focuses on 30 OESO countries in a 10-year span (2009-2019). The analysis is performed through a Fixed Effects model. This thesis finds that an increase in the Ease of Doing business score has a positive effect on yearly patent applications. When examining what kind of business regulations can improve innovation the most, the study finds that dealing with construction permits, registering property, paying taxes, trading across borders, and enforcing contracts significantly impact the yearly patent applications. This research therefore provides evidence that business regulations can have a positive effect on innovation.

Key words: regulation, innovation, Ease of Doing Business, Patents

Contents

1 Introduction

1.1 Background on Innovation

As explained by economists, such as Schumpeter (1911), Solow (1957) and Porter (1992), innovation plays an important role in the economic development of countries and the long-term success of businesses. Innovation provides the basis for creative destruction, which refers to the process of old products and processes being replaced by newer, higher quality or more efficient ones, as a result of constant innovation. Consequently, firms must innovate their products or processes to be able to compete in the market and stay relevant for consumers. Furthermore, innovative products fuel the economy by creating new or expanding existent markets and thereby enhancing job creation and productivity. Not to mention that advancements in current products may improve our daily life, especially advancements in the security and health care sector.

The strand of literature on innovation has therefore always remained an extensive one and continues to pique the interest of researchers today. He and Tian (2020) conclude that the recent availability of high-quality data on patent applications resulted in a fast-growing strand of literature that aims to understand the factors that influence innovation. There are various institutions that are found to be relevant determinants of innovation activities, such as social and corporate culture, demographic factors, market development, policies, and regulation. To better understand the underlying determinants of innovation, this paper focuses specifically on the governmental regulations that encourage or hamper with innovation of firms.

First and foremost, a relevant definition of innovation ought to be made. However, as innovation is a rather complex set of activities, describing such a vague phenomenon is easier said than done. When looking at the innovation chain in a broader sense, innovation can be divided into a few stages. In its early stage, innovation can be classified as an idea about an improvement of existing ideas or products, or as a completely new idea about non-existing ideas or products. In this stage, a measurement for these ideas is hard to find. However, the second stage is more tangible and economically relevant. In this second stage, these ideas are exploited in the form of a patent. Patents are a form of legal protection which provides security to firms to solely produce and distribute a product or use a certain production process. Mostly during a specific time-period, competitors are not allowed to produce or use the patented good or process without authorization by the patent holder. This allows firms to financially exploit their innovative output. In the literature, the number of patent applications has become a general way to measure innovation. As patenting your innovation is an understandable consequence of innovating, the number of patent applications form a good first approximation of innovation. For the sake of this thesis, the number of yearly patent applications is used to indicate innovation.

However, using the number of patent applications as a measure of innovation comes with some limitations. Firstly, and most importantly, not every country's definition of what a patentable invention is, is equal. As Moser (2005) exhibits as an example, in the US only the 'first' inventions of something new were capable of being patented. In contrast, in France, any person who discovered or imported a new technology was capable of patenting this technology. Secondly, applying for a patent is only the first step in the actual innovation. Meinhardt (1946) concludes that only a small percentage (between 5 and 20) percent of patented ideas and products make their way to the market. However, the number of patent applications is still a widely used measure of innovation as no new measure is found to be a suitable alternative.

1.2 Background on Regulation

Economic regulation and governmental influence on the economy has always remained a broad topic of discussion, as it affects economies at regional, national, and international levels. As unregulated markets often result in market failures and inefficiencies, economic regulation often functions as a possible and necessary solution. For the sake of economic growth, governments seek ways to intervene in the markets where optimal outcomes are not realized. Market regulation comes in various forms, shapes, and colors. Governments can affect the economy and firms through various laws, health and safety measures, environmental policies, and subsidies, just to name a few. There are thus multiple definitions of regulation. For the sake of this thesis, the definition of the OECD is used. The OECD (2021) qualifies a regulation as 'an implementation of rules by public authorities and governmental bodies to influence market activity and the behavior of private actors in the economy'.

Under this definition, regulation still covers a wide array of ways governments can intervene with firms. The Ease of Doing Business (EoDB) index focusses on a particular set of regulations which are found to influence business practices. Established in 2003, the EoDB report aims to measure the ease of starting, operating and dissolving a business. In this annual assessment, the EoDB studies the way regulations interact with entrepreneurs. The EoDB consists of 10 indicators: 'starting a business', 'dealing with construction permits', 'getting electricity', 'registering property', 'getting credit', 'protection of minority investors', 'paying taxes', 'trading across borders', 'enforcing contracts' and 'resolving insolvency'. Regulation on these indicators affects businesses in various ways. For example, proper regulation for getting credit and protection of minority investors might improve the accessibility of financial aid, which is beneficial for funding innovational practices. The ease of dealing with permits and paying taxes might save time and lower operational cost, which also benefits the firm's ability to innovate. Furthermore, regulation which facilitates new entrepreneurs to start their business might lead to stronger competition and may oppose a threat to existing firms. In line with the creative destruction theory of Schumpeter (1911), this can improve the overall innovational output of countries, as the older products and processes are replaced by newer and higher quality ones. Secondly, the threat of newcomers in the market might motivate and drive the incumbent firms to innovate in order to stay relevant for their customers. These examples show that regulation on the indicators can differ in their effects.

The Ease of Doing Business is calculated as follows. Each of the 190 countries is investigated and given a score for each of the indicators. After that, the EoDB score is generated by aggregating and weighing these scores. Eventually, the ease of which entrepreneurs can set up, operate, and close their business is captured in a final country score. The score ranges from 0 to 100 with 100 being the most business friendly. Over the last few years, New Zealand has scored the best. Countries can be compared on their EoDB score and on the indicators separately. This enables governments and policy makers to identify shortcomings in their regulative behavior and implement changes, in order to stimulate economic growth. Since its establishment in 2003, nearly 5,000 regulatory reforms were recorded by the EoDB report.

1.3 Aim of Research

This paper aims to assess the effect of national regulations on the innovation output of countries by examining the effect of the EoDB index on patent applications. The data consists of panel data for 30 OESO countries over a time period of 10 years (2009-2019). The analysis is done through a *Fixed Effects Model*, as it is necessary to control for country and time invariant

factors. Furthermore, to account for endogeneity in the regression analysis, control variables such as R&D expenditures, GDP and population are added to the model.

From the results, it can be concluded that an increase in the EoDB score has a positive significant effect on the number of yearly patent applications. Most of the indicators provide a positive effect on the innovation output. In particular, the model highlights significant effects for the 'dealing with construction permits', 'registering property', 'paying taxes', 'trading across borders', and 'enforcing contracts' indicators. However, the magnitude is small, and the other indicators are not significant. Nonetheless, in the case the assumptions of the model will hold, this study provides evidence that firm regulations can offer a positive effect on innovation.

2 Literature Review

2.1 Existing Research

2.1.1 Public Interest Theory

Research on the effects of national regulations on economic outcomes and public welfare can be traced back to Pigou's (1921) public interest theory of regulation. Pigou theorized that unregulated markets could lead to market failures, such as monopolies, missing markets, and externalities. When markets are unregulated and competition can freely develop, it is often said that a pareto optimal equilibrium can be achieved. However, various circumstances can interfere with the creation of this equilibrium. These so-called market failures often serve as a justification for economic regulation.

These market failures come in various flavors, as indicated by Parker (2002). The first one, significant externalities, occurs when all relevant costs are not captured by the price of goods. External costs, such as environmental damages, are not accounted for, resulting in a lower price than desired. Another market failure refers to a situation where market participants do not possess over complete information. These information imperfections might lead to an inefficient allocation of resources. A famous example would be where people tend to underestimate their chances of health complications and therefore underinvest in their health insurance. Extending this idea, Akerlof (1970) concluded that incomplete information might even result in adverse selection and moral hazard by market participants. In this case, the 'bads' drive out the 'goods'. In the health insurance example and imagining a country without obligatory health insurance, unhealthy individuals tend to insure themselves due to the high cost they expect to bear. Meanwhile, healthier individuals might refrain from health insurance. In this scenario, insurance companies end up with unhealthy individuals, causing them to raise their prices. This might push out the healthy people even further, ending up with a selected group of unhealthy and costly individuals. This process is called adverse selection. Moral hazard occurs when insured individuals behave riskier or unhealthier than without insurance as their costs will be covered. This situation can become very costly for the public and is therefore seen as socially inefficient.

The existence of a monopoly is also seen as publicly inefficient. This market failure occurs when markets are not as competitive as they are intended to be. Instead, markets are dominated by a singular market player, who has the individual ability to raise prices and even offer low quality products. Another example of a market failure is when market simply do not exist, even when they are desired. These missing or incomplete markets occur when resources are not correctly distributed due to market barriers. The fifth example of a market failure is the existence of public goods. This special kind of goods, such as street lighting, are non-excludable and non-rival goods. Consumers cannot be excluded from the utilization of the products or services, which tends to lead to freeriding behavior and underinvestment from consumers. Another type of goods, called merit and demerit goods, are referred to as goods that are found to be under- or subsequently overconsumed. These products or services tend to be encouraged or discouraged through subsidies or regulations. Finally, market may also fail when unregulated markets result in an unequal distribution of resources and income. This inequality among market participants offers a justification for redistribution, in both developed and developing countries.

The public interest theory suggests that governments are able to intervene in these markets and thereby protect the public. For example, to protect consumers from high prices, low quality and cartel behavior, the EU competition law is established to regulate undertakings with a strong market power.

2.1.2 Public Choice Theory

However, contrary to Pigou's theory, the public choice theory, as popularized by Stigler (1971), holds that governments ought to refrain from regulation, as it's seen as socially inefficient. Governments suffer, just as individuals, from biases which influence state decisions. Regulative measures can therefore be stained by biases or imperfect information. Public choice theory focuses on the government agents and how they can be influenced by their own self-interest and biases. The theory of regulatory capture, for example, theorizes that the policymakers can essentially biased in favor of a particular area, industry, or group. This special priority can lead to inefficient outcomes and a net loss for the general public when interest groups are favored over the rest of society. These groups are often politically more powerful or more incentivized to lobby and can therefore influence governmental agents. The second strand focuses more on corruption as a possible outcome of regulation. When heavy regulation is in place, the tollbooth theory suggests that politicians and regulators are able to collect bribes in exchange for release of regulation. In line with this theory, Djankov et al. (2002) concluded that countries with heavier regulation of entry show higher levels of corruption and larger unofficial economies. Both the theory of regulatory capture, as the tollbooth theory suggest that regulation is seen as socially inefficient. Thus, it is good to keep in mind that although regulation is often justified by the elimination of market failures, regulating industries can result in other negative side effects, such as corruption or rent seeking behavior. However, it still remains the case that countries regulate particular industries and businesses.

2.1.3 Ease of Doing Business Indicators

When focusing on the effects of the Doing Business indicators specifically, Djankov et al. (2002) start off by examining the effects of regulation on the entry of new firms. Countries vary in the way they regulate entrepreneurs who aim to start a business. When considering the number of procedures, time and costs needed to set up a firm, the authors found that heavier regulation led to higher corruption levels and larger unofficial economies. Meanwhile, the quality of goods did not necessarily increase. In this case, regulation on entry of new firms does not seem to be benevolent for economic outcomes. Registering property and enforcing contracts are also studied by Djankov et al. (2003) by examining the level of formalism of national courts. Higher procedural formalism can be seen as regulative and are found to be determinant for lengthy dispute settlements, higher corruption levels, and lower enforceability of contracts. For these indicators, stronger regulation also seems to affect economic outcomes in a negative way. However, institutions and regulations on creditor-rights do have a strong effect on the development of private credit, as concluded by Djankov et al. (2007). Especially for poorer countries, the authors found that governments can play an important role in easing the access to credit for firms. Lastly, when looking at the closure of a firm, Djankov et al. (2008) found that the regulations concerning the insolvency of a business are economically inefficient. Just as with starting a business, the procedures are lengthy, time-consuming, and costly. As these studies show, regulations affect firms and economic activity in various ways. Studying the effects of these regulations on economic outcomes can therefore offer more guidance as to how these regulations should be shaped and how the institutions surrounding them should be formed.

2.2 Research Question

By examining the EoDB score and the effect on patent output, the following main research question is to be answered:

What is the effect of regulations on innovation?

The innovation output of countries is measured by the number of yearly patent applications, as this provides a general valid impression of innovation capabilities. The regulations studied are based on the Ease of Doing Business (EoDB) index. This set of regulations is found to influence economic outcomes and firms and covers various areas of business regulation. The index includes starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protection minority investors, paying taxes, trading across borders, enforcing contracts and resolving insolvency.

Secondly, to better understand the mechanisms that drive innovation, the indicators and their effects on patent applications are investigated separately. By doing so, the following sub question of this research is to be answered:

What kind of business regulations can improve innovation output?

2.3 Contribution to Literature

This paper builds on the research of national regulations on economic outcomes by extending its research to innovation. The majority of the research on the Ease of Doing Business indicators neglect the effects on innovation. Instead, most of the research focuses on the effects of the indicators on other economic outcomes such as economic growth and FDI inflows (Djankov et al, 2006.; Corcoran and Gillanders, 2015). Therefore, this thesis adds to the literature surrounding the effects of the EoDB indicators by expanding its analysis to the area of innovation.

This thesis is organized as follows. Chapter 2 provides a literary overview of the effects of regulation on economic outcomes and previous research on the Ease of Doing Business indicators. Secondly, this chapter covers the contribution to and gap in this literature. In chapter 3 the data, methodology and the assumptions and limitations thereof are explained. Chapter 4 conveys the results of the statistical regression and the main findings of the research. The research is concluded in chapter 5 with some final conclusions and discussions of the study.

3 Data and Methodology

3.1 Data Description

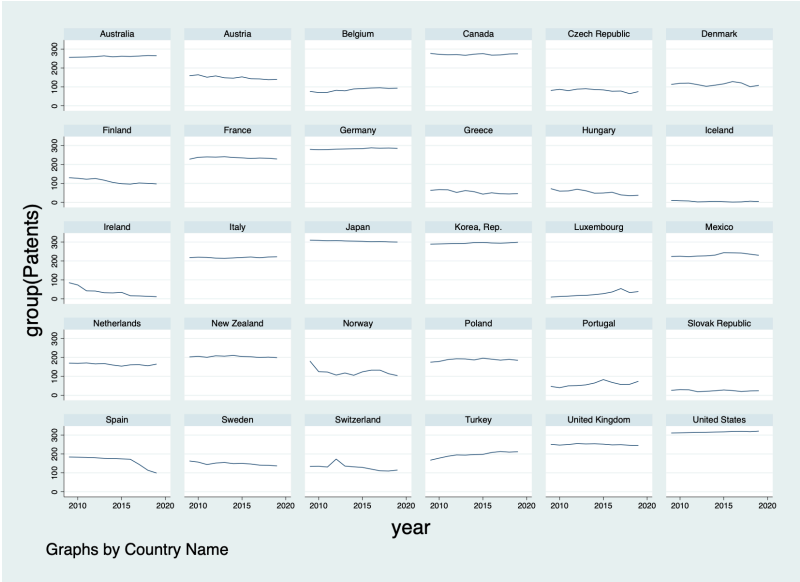
To delineate the research and to deal with missing data on control variables for the majority of the countries in the world, the study will focus on 30 of the OECD countries. The full list of countries is found in Appendix A. Furthermore, the studied period consists of 10 years (2009-2019), as the available data for the Ease of Doing Business (EoDB) index starts here for most of the countries. This leaves us with a maximum of 330 observations. This range provides enough data points to make valid conclusions. Appendix B provides a description of all the variables, as well as their sources.

Dependent Variable: Patents

To approximate the innovation output in a country, the number of yearly patent applications is used. The data on patent applications are found at the World Bank and is composed by the World Intellectual Property Organization (WIPO). To count as a patent application, these applications must be filed through the Patent Cooperation Treaty procedure or with a national patent office which provides exclusive rights for an invention. Such invention must be classified as "a product or process that provides a new way of doing something or offers a new technical solution to a problem" (WorldBank, 2023a). This patent then provides exclusive rights for generally 20 years. Patent data from the World Bank are divided into patents registered by residents and patents registered by non-residents. Therefore, to provide the complete view of worldwide patent applications, a new variable (*Patents*) is generated which combines the two variables.

When comparing the *Patents* data across countries, Japan, Korea and the United States significantly produce the most patents, as seen in graph 1. In graph 1, countries are ranked according to their output of yearly patent applications, as a graph covering the total patent applications does not provide a clear and understandable view. Iceland, Greece, Luxembourg, and the Slovak Republic are among the 'worst' countries when it comes to patent applications. Comparing the best and worst performing countries, the size of the country seems to matter. This claim is also supported by a high correlation of 0.868 between *Patents* and *Population*. Countries vary substantially in patent output. To account for this variation in the data, a new variable *ln_Patents* is created which describes the natural logarithm of *Patents*. This eases causal inference.

Graph 1. Ranked yearly patent applications per country

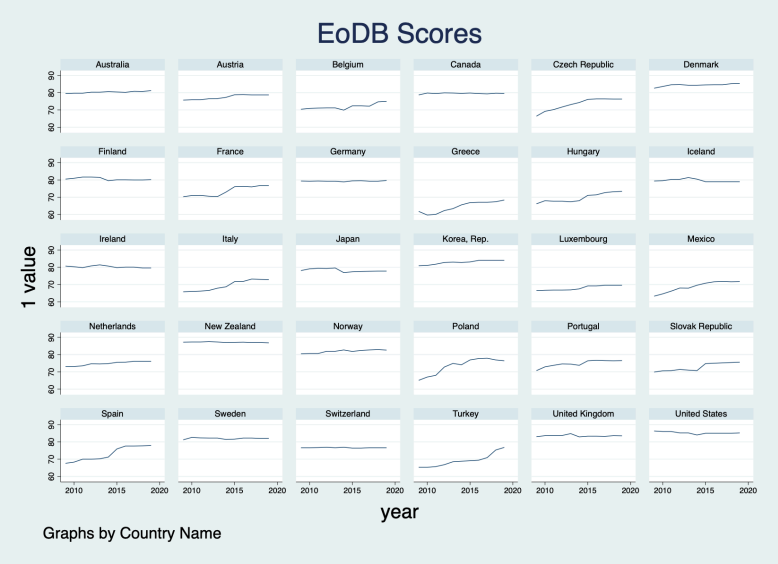


Variable of interest: EoDB

To analyze the effect of regulations on innovation, the Ease of Doing Business Index is used to indicate the ease of regulations. The data on the Ease of Doing Business indicators are also found at the World Bank. The data reflect the global distance to frontier (DTF) score for ease of doing business using different methodologies. DB10-14 refers to the methodology used in the years 2009 until 2013, DB15 for the year 2013 and 2014 and DB17-20 for the years 2016-2019. Finally, the EoDB20 refers also to the year 2019. However, in this methodology countries were given a rank instead of scores. As this methodology differs significantly in comparison with other years, this year will be disregarded in the analysis. The changes made to the methodologies do not significantly impact the results, as every year, the scores were highly correlated with previous years (WorldBank, 2023b). In 2011 getting electricity was added as an indicator. Previously, however, obtaining electricity was part of the dealing with construction permits indicator and therefore does not significantly alter results. Therefore, the EoDB scores can be compared over the years and still provide valid results. On a final note, for the year 2013, the EoDB is calculated by two different methodologies (EoDB1014 and EoDB15). To be more consistent with previous years, the scores of the DB10-14 methodology is used for the year 2013 in the final analysis.

The 30 OESO countries selected perform generally well on the EoDB indicators, with an average score of 76.55 and a minimum score of 59.7 (Table 1). Overall, the EoDB scores do not seem to alter much over the years for most countries. Among the best scores are New Zealand, United States and the United Kingdom, as seen in graph 2. Comparing the EoDB scores of countries with the amount of yearly patent applications, countries who score relatively beter on the EoDB indicators also seem to rank higher on the patent applications. The US, Australia and Korea provide evidence for this. Also, countries who score relatively lower on the EoDB indicators are also underperforming when it comes to patent applications, as supported by Greece and Luxembourg. However, in contrast, Iceland's low output of patent applications are not supported by low EoDB scores. The same goes for Denmark and Norway.

Graph 2. Yearly Ease of Doing Business scores per country



Variables of interest: EoDB Indicators

To better understand the influence of the regulations on the innovation output of countries, the EoDB indicators are separated in their own variables. Descriptive statistics on each of the indicators is found in Table 1. The overall score for *Starting a business* is not available in the dataset. Instead, only the sub indicators for this indicator, such as number of procedures, time and costs, appear. As this methodology substantially differs from the other EoDB indicators, this indicator is omitted from the general analysis and regressed separately. Secondly, for the *Protecting minority Investors* indicator, the data from 2009 until 2012 are missing for all the selected countries. When running the regression, including this indicator would result in an exclusion of these years, also for the other indicators. This would then result in insufficient years for causal inference. Therefore, this indicator is excluded from the analysis. Instead, this indicator is regressed separately, keeping the limitations in mind.

Control variables: R&D expenditures, Population and GDP

To control for endogeneity in the regression, three control variables are added to the analysis. As previously stated, size matters. Countries with a large population seem to put out significantly more patent applications that smaller countries. Unsurprisingly, a larger population generates more businesses which can apply for a patent registration. Since the *Patents* variable is a total of the number of applications and does not consider the size of the country, it is logical to add *Population* as a control variable. As this variable consists of large values and countries vary noticeably in size, the data for *Population* are extremely skewed to the left. To deal with this, the logarithm of the population is generated and used in the regression. The second control variable concerns *GDP*, which denotes the value of all the final goods and services produced in a country. This variable serves as an indicator for the economic activity in a particular country. Just as *Population*, the values of the *GDP* are highly skewed. The logarithm of *GDP* is therefore included in the analysis. Data on the population and the GDP of countries are derived from the World Bank. The last control variable added in the regression concerns *RDexp*, which indicates the expenditures to research and development (R&D) in a country. Just as the previous control variables, the logarithm of *RDexp* is used as the values are skewed to the left. For this variable, data are derived from the OECD database and includes all

expenditures towards R&D in a country, carried out by businesses, universities, research facilities and governments (OECD, 2023). Research and development expenditures are highly correlated with patent applications for OESO countries (Prodan, 2005). This is backed up by the high correlation of 0.942 between *RDexp* and *Patents* in the dataset. This is unsurprising, as R&D is a logical pre-step and foundation for generating innovative ideas. So, R&D expenditures will most probably explain a substantial part of the amount of patent applications and is, because of this, relevant to include in the analysis.

Table 1. Descriptive statistics.

Variable	Observations	Mean	Standard Deviation	Min	Max
Patents	329	43,978.81	117,758.1	38	621,453
EoDB	330	76.55	6.07	59.7	87.5
RDexp	311	42,759.41	96,705.79	259	631,845
Population	330	41,263,413.75	61,995,771.03	318,041	328,329,953
GDP	330	1,596,403,192,793.98	3,238,453,965,871.89	13,154,416,196.75	21,380,976,119,000
Starting_B	330	5.7	2.362	1	15
D_Permits	330	73.905	8.609	51.5	91.6
G_Electricity	330	81.134	12.389	42	99.9
R_Property	330	75.770	12.567	39.8	97.1
E_Contracts	330	68.656	9.144	40.6	85.7

G_Credit	330	67.383	17.757	15	100
P_Taxes	330	81.228	8.179	53.3	95.3
Trading_B	330	89.815	7.913	70.3	100
P_Investors	210	67.4	9.237	40	86
R_Insolvency	330	74.677	13.611	33.3	93.9

Note: Table 1 denotes descriptive statistics. In the table, for each variable the number of observations, the mean, the standard deviation, the minimum and maximum value is given.

3.2 Methodology

To analyze the effects of regulations on innovation *Fixed Effects Model* is used. Firstly, the following regression is tested:

$$ln\_Y_{it} = \alpha + \gamma_i + \zeta_t + \rho T_{it} + \beta_1(RDexp_{it}) + \beta_2(ln\_Population_{it}) + \beta_3(ln\_GDP_{it}) + \varepsilon$$

Y_{it} represents the number of patent applications for a given country *i* and year *t*. α denotes the constant. T_{it} is the independent variable of interest, representing the Ease of Doing Business (EoDB) score for country *i* at time *t.* The effect of the EoDB score will be represented by ρ. To decrease endogeneity in the regression $RDexp_{it}$, $ln\_Population_{it}$, and ln_GDP_{it} represent the control variables for country *i* at time *t* and β_1, β_2 and $\beta_3$represent the coefficient associated with these variables. To control for country and time invariant factors which can affect the outcome variable, *country fixed effect* (γ_i) and *time fixed effect* (ζ_t) have been added to the regression. The fixed effects model can account for all time-invariant factors influencing the outcome variable, even unobserved factors. Certain country specific characteristics influencing the patent output, such as national institutions or cultural values are captured by the country fixed effect. The country fixed effects also account for the differences in patent definitions, as indicated by Moser (2005). The time fixed effect controls for time specific characteristics which affect the innovation of a country, such as trends over time.

Evaluating the impact of the separate indicators on the patent applications, the following regression is tested:

$$\begin{aligned} ln\_Y_{it} = \alpha + \gamma_i + \zeta_t + \rho_1(D\_Permits_{it}) \\ + \rho_2(G\_Electricity_{it}) + \rho_3(R\_Property_{it}) + \rho_4(G\_Credit_{it}) + \rho_5(P\_Investors_{it}) \\ + \rho_6(P\_Taxes_{it}) + \rho_7(Trading\_B_{it}) + \rho_8(E\_Contracts_{it}) + \rho_9(R\_Insolvency_{it}) \\ + \beta_1(RDexp_{it}) + \beta_2(ln\_Population_{it}) + \beta_3(ln\_GDP_{it}) + \varepsilon \end{aligned}$$

ρ_i represents the relevant coefficient for the given indicator i. Considering the omitted years as a result of adding $P\_Investors_{it}$ in the regression, this regression is also performed without this indicator. Also, to deal with the dissimilarity of the methodology for the $S\_Business_{it}$ with the other indicators, the following regression is also tested, which singles out the indicator:

$$ln\_Y_{it} = \alpha + \gamma_i + \zeta_t + \rho_1(S\_Business_{it}) + \beta_1(RDexp_{it}) + \beta_2(ln\_Population_{it}) + \beta_3(ln\_GDP_{it}) + \varepsilon$$

3.3 Assumptions and Limitations

The fixed effects model relies on a few assumptions. To decrease the possibility of omitted variable bias (OVB), the fixed effects model uses each country as their own control. By using data of the country in a previous time period, the model controls for all observed and unobserved characteristics that do not vary over time. It is therefore assumed that unobserved characteristics that are correlated with the independent variable are time-invariant. Observed characteristics may vary over time, on the condition that they are controlled for by a control variable. Secondly, the fixed effects model cannot account for 'shocks' in the omitted variables. In other words, the model cannot deal with variables that experience a one-time increase in value and afterwards remain constant. They must remain constant over time. The fixed effects model used in this research can still be subject to endogeneity if these assumptions do not hold, which invalidates the estimated effects.

A possible cause for endogeneity in the model is due to omitted variables that may still exist after the introduction of the control variables. In this case, certain relevant variables which influence both the patent outcome (Y) and the Ease of Doing business indicator (T) are still not controlled for in the model. This may lead to a biased estimator of the effect of the EoDB indicator, which can then be over- or underestimated. It is unlikely that all relevant variables are controlled for in the model. There is no statistical test which indicates the relevant control variables. Secondly, some (control)variables are simply not possible to measure and can therefore not be included.

Selection bias might also appear in the case of reverse causality. In this case, the dependent variable (*Patents*) might also influence the independent variable (*EoDB*), which biases the estimators. It is possible that the number of patents affects one or more indicators of the Ease of Doing business. For example, possessing over high value patents might increase the possibility of getting credit. This is because a patent might offer protection for the product or service which can strengthen the position in the market and eases getting credit.

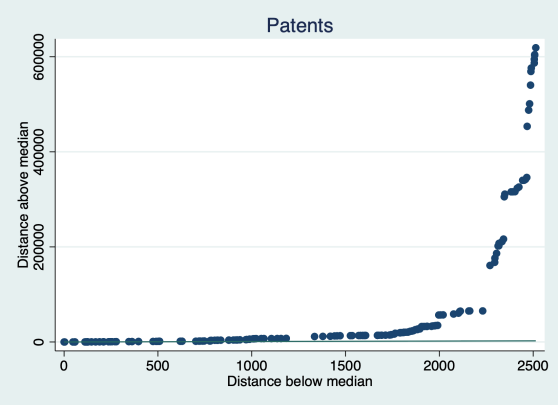
A third limitation of the model and a reason for endogeneity is the possibility of data irregularities. As most of the data is published by reliable research institutions, such as the World Data Bank and the OESO, this would originally not be a major issue. However, after a series of audits and reports on manipulation scandals and data controversies, the World Bank decided to discontinue the Doing Business report in September of 2021. Pressure by the Chinese government on the methodology, serious score inaccuracies for Saudi Arabia, United Arab Emirates and Azerbaijan during 2017 until 2020, combined with a toxic working environment marked the downfall of the Doing Business Report (Machen et al, 2021). Although these countries are not included in the analysis, the reliability of the data is still affected. This forms a major limitation of the research, and the results should therefore be interpreted with caution.

4 Results

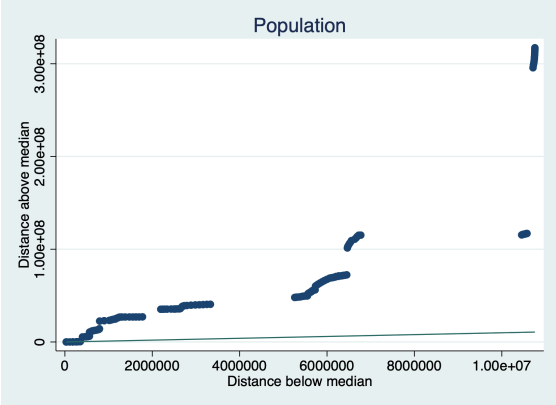
4.1 Results for the Ease of Doing Business index

Firstly, as shown in graph 3, 4, 5 and 6, the values of *Patents*, *Population*, *GDP* and *RDexp* are left skewed and high in value. To account for this, the logarithm of these variables is used instead. Supported by the graphs, the usage of the logarithms of these variables is thereby justified.

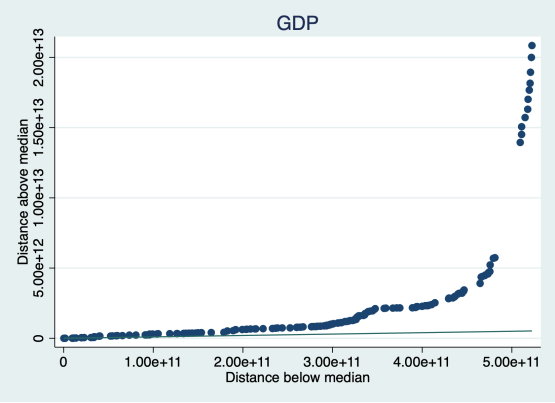
Graph 3. Patent value distribution



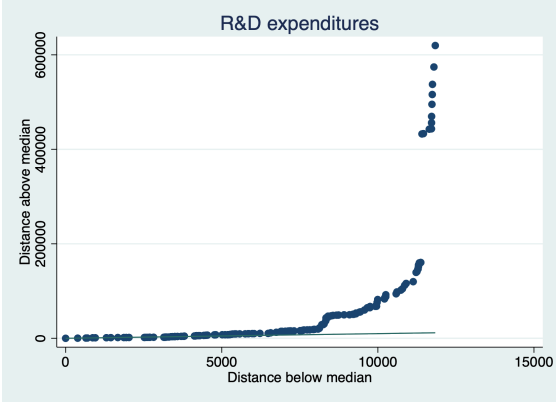
Graph 4. Population value distribution



Graph 5. GDP value distribution



Graph 6. RDexp value distribution



The results of the analysis on the effects of the EoDB on patent output are shown in Table 2. In the first column, the results for the fixed effects regression are presented. To check for robustness of the results, the same analysis is performed under a random effects model. The results of the random effects model are shown in column (2). Under a random effects model, factors that may impact the number of patents may vary randomly across countries or time. In the fixed effects model, we assume that these factors do not change over time, whereas the random effects are allowed to vary as long as they follow a normal distribution. To assess whether a fixed effects or a random effects model should be used to examine the effects of the EoDB on Patents, the Hausman (1987) test is performed. The results of this test are shown in Table 3. As indicated by the low p-value (< 0.05) of the Hausman specification test in Table 3, a fixed effects model is more appropriate to study the effects of the EoDB scores on the

innovative output of countries. This is most likely due to the fact that the country effects are not randomly distributed, which is an assumption the random effects model builds on. In Appendix C, the country and time fixed effects are presented for the model.

Table 2. OLS regression estimates for relation between Ease of Doing Business Index and Patent output.

Variable	***ln_Patents (FE)***	***ln_Patents (RE)***
EoDB	0.024**	0.028**
	(0.008)	(0.009)
ln_RDexp	0.240*	0.223
	(0.105)	(0.114)
ln_Population	5.842***	1.284***
	(1.011)	(0.175)
ln_GDP	-0.725***	-0.202
	(0.223)	(0.154)
constant	-72.742***	-11.603***
	(10.962)	(3.128)
N	310	310
R-squared	0.709	0.773

Note: Table 2 denotes the regression results of the Ease of Doing Business Index on Patents. The dependent variable is ln_Patents and the variable of interest is EoDB (marked grey). In column (1) the coefficients for the regression with country and time fixed effects is given. In column (2) the coefficients for the regression with random effects is given. The standard errors are given between the brackets. *p < 0,05, **p < 0,01, ***p < 0,001.

Table 3. Hausman (1978) specification test

	Coef.
Chi-square test value	85.59
P-value	0.000

When interpreting the results, we should consider that the dependent variable is a logarithm of patents. This indicates that an increase in the EoDB score with 1 point, leads to an increase in the patent output with 2.4% (as $e^{0.024}$=1.024). All the variables are significant under a 5 percent significance level, with the control variables being even significant under a 0.1% significance level. If all the assumptions of the model hold, we can conclude a positive effect of the EoDB score on patent output. The 95% confidence interval of this regression is between 0.007 and 0.041. Although this bandwidth is relatively large, the effect remains positive.

Although this study focuses more on the EoDB indicators, from the control variables we can conclude some valuable facts. Firstly, the expenditures towards R&D seem to have a positive effect on innovation. A 1% increase in R&D expenditures would in the model only lead to a 0.24% ($1.01^{0.240} = 1.0024$) increase in patent applications. Secondly, as stated before, size seem to matter. A 1% increase of a countries' population would increase patent output with almost 6% ($1.01^{5.842} = 1.0599$). Remarkably, GDP seems to have a negative effect on the patent applications of a country.

As shown in Appendix C, most of the country fixed effects are highly significant. The effects vary in their magnitude and whether they are positive or negative. Especially for smaller countries such as Iceland and Luxembourg, these country fixed effects are relatively large. Indicated by their significance, it can be concluded that, to a certain extent, the innovation output can be explained by country time-invariant factors. These (time-invariant) factors are not captured by one of the control variables in the model or by the Ease of Doing business index. Based on this model, there are various factors that influence innovation that are country specific and are not captured by regulation. This might suggest that regulation is less relevant in explaining the innovation of a country than other factors. Secondly, all the time fixed effects have a negative effect, with the effect of the last years being significant. This might be evidence for a downwards trend of innovation in the OESO countries.

4.2 Results for the Indicators of the Ease of Doing Business

Since the Ease of Doing Business index is an aggregate score of multiple sub indicators, investigating the effects of the indicators on innovation separately is a lot more interesting. In Table 4 the relevant coefficients are presented for each of the indicators, as well as the control variables. Again, the same analysis is also performed under a random effects model in column (2) and (4). In Table 6 and Table 7, the outcomes of the relevant Hausman test are shown. Furthermore, the variable *P_Investors* misses data for multiple years. Including this indicator leads to an omission of data for these years, also for the other indicator. This leads to insufficient datapoints for causal inference. Therefore, only in column (3) and (4) of Table 4, *P_Investors* is added. The outcomes for variable *Starting_B* and the relevant Hausman test is listed in Table 5 and Table 8, respectively, as the methodology for this indicator differs significantly with the other indicators. The coefficients for the country and time fixed effects are presented in Appendix D and Appendix E.

Table 4. OLS regression estimates for relation between Ease of Doing Business Indicators and Patent output.

Variable	***ln_Patents (FE)***	***ln_Patents (RE)***	***ln_Patents (FE)***	***ln_Patents (RE)***
D_Permits	-0.008*	-0.000	-0.011	0.002
	(0.004)	(0.005)	(0.008)	(0.008)
G_Electricity	-0.007	-0.008*	-0.005	-0.009
	(0.004)	(0.004)	(0.005)	(0.005)
R_Property	0.012**	0.011**	0.012*	0.019*
	(0.004)	(0.004)	(0.006)	(0.006)
E_Contracts	0.013***	0.010**	0.003	0.006
	(0.003)	(0.003)	(0.004)	(0.004)
G_Credit	0.004	0.008**	0.001	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
P_Taxes	0.009*	-0.004	-0.001	-0.005
	(0.004)	(0.005)	(0.006)	(0.006)
Trading_B	0.013***	0.009*	0.008	0.002
	(0.003)	(0.004)	(0.004)	(0.004)
R_Insolvency	-0.007	-0.001	-0.004	-0.000
	(0.005)	(0.005)	(0.008)	(0.008)
P_Investors	.	.	0.005	0.010

	.	.	(0.018)	(0.145)
ln_RDexp	0.121	0.179	0.117	0.387*
	(0.110)	(0.117)	(0.159)	(0.153)
ln_Population	7.051***	1.108***	4.192***	1.140***
	(0.733)	(0.177)	(1.050)	(0.215)
ln_GDP	-0.550***	0.036	-0.704**	-0.257
	(0.156)	(0.160)	(0.220)	(0.209)
constant	-97.430***	-14.489***	-44.043*	-9.107*
	(11.525)	(3.115)	(18.343)	(3.955)
N	310	310	199	199
R-squared	0.703	0.767	0.672	0.758

Note: Table 4 denotes the regression results of the Ease of Doing Business indicators on Patents. The dependent variable is ln_Patents and the variables of interest are the first 10 variables. In column (1) the coefficients for the regression with country and time fixed effects is given. In column (2) the coefficients for the regression with random effects is given. In column (3) the variable *P_Investor* is added to the regression in column (1) and the coefficients for the regression with country and time fixed effects is given. In column (4) the coefficients for the regression with random effects is given. The standard errors are given between the brackets. *p < 0,05, **p < 0,01, ***p < 0,001.

Table 5. OLS regression estimates for relation between 'Starting a Business' indicator and Patent output.

Variable	***ln_Patents (FE)***	***ln_Patents (RE)***
Starting_B	0.027	0.025
	(0.014)	(0.015)
ln_RDexp	0.377***	0.412***
	(0.116)	(0.116)
ln_Population	5.460***	1.246***
	(0.689)	(0.176)
ln_GDP	-0.925***	0.387*
	(0.160)	(0.158)
constant	-61.173***	-14.489*
	(10.899)	(2.957)
N	310	310
R-squared	0.695	0.734

Note: Table 5 denotes the regression results of the Ease of Doing Business indicator for Starting a Business on Patents. The dependent variable is ln_Patents and the variable of interest is Starting_B. In column (1) the coefficients for the regression with country and time fixed effects is given. In column (2) the coefficients for the regression with random effects is given. The standard errors are given between the brackets. *p < 0,05, **p < 0,01, ***p < 0,001.

Table 6. Hausman (1978) specification test

	Coef.
Chi-square test value	135.67
P-value	0.000

Note: Table 6 denotes the results for the Hausman (1978) specification test for column (1) and (2) of Table 4

Table 7. Hausman (1978) specification test

	Coef.
Chi-square test value	47.82
P-value	0.000

Note: Table 7 denotes the results for the Hausman (1978) specification test for column (3) and (4) of Table 4

Table 8. Hausman (1978) specification test

	Coef.
Chi-square test value	90.40
P-value	0.000

Note: Table 8 denotes the results for the Hausman (1978) specification test for column (1) and (2) of Table 5

Firstly, indicated by the low p-value (<0.05) in Table 6, Table 7 and Table 8, the fixed effects model is more suitable to study the effects of the indicators on innovation in all cases. When comparing the fixed effects model with the random effects model of Table 4, multiple indicators and the control variable for GDP lose their significance. When adding the *P_Investors* variable in column (3), only the indicator for Registering Property remains significant. This is most probably due to the loss of relevant datapoints, as explained before. Lastly, in Table 5, the *Starting_B* indicator does not seem significant in explaining innovation output for countries. Therefore, the analysis is focused on column (1) of Table 4.

When comparing the indicators, the indicators do not seem to vary substantially in their magnitude. The effects of the variables are mostly small and do not exceed a 2% increase (or decrease) in patent applications following an increase of 1 point in the indicator score. Most of the indicators have a positive effect, while *D_Permits, G_Electricity* and *R_Insolvency* have a negative effect. However, these negative effects are small in magnitude. Secondly, not all the indicators have a significant effect. Only the indicators *D_Permits, R_Property, E_Contracts, P_Taxes,* and *Trading_B* have significant effects for explaining the number of patents. Remarkedbly, *G_Credit* does not seem to have a significant effect in the fixed effects model. This is surprising, as innovation and R&D often requires funding. This insignificant effect might be related to the fact that *ln_RDexp* is also not significant. If all the assumptions would hold, we might conclude that acquiring and spending funds for and towards R&D does not influence the innovational output as much as we would initially expect. *E_Contracts* and *Trading_B* do seem to have a positive significant effect, highlighting the importance of legal protection of the patent applications and the availability of international trade.
Just as the analysis of the overall EoDB score, most of the country fixed effects are highly significant. This suggests that other (country-specific) time-invariant factors that are not captured by the variables in the model might be relevant determinants of innovation. Also, the coefficients for the last few years are negative, suggesting a downward trend in patent applications.

5 Conclusion and Discussion

This thesis focused on the effects of business regulations on innovation. This study aims to estimate these effects by examining the effects of the Ease of Doing Business indicators on the number of patent applications for 30 OESO countries during the time period of 2009-2019. For the analysis, a *Fixed effects model* with country and time fixed effects is used. The model controls for the expenditures towards R&D, population, and the GDP of a country. If the assumptions of the model hold, we can conclude a positive significant effect of the EoDB score on the amount of patent applications. An increase in the EoDB score with 1 point would, ceteris paribus, lead to an increase in the yearly patent output with around 2.4%. In that line of thought, we can conclude positive effects of better regulations on innovation. When going more in debt into what kind of regulations have a positive effect on innovation, we can find that the indicators *dealing with permits, registering property, enforcing contracts, paying taxes* and *trading across borders* are significant in explaining the yearly patent output. Except for the negative coefficient for dealing with permits, these indicators have a positive effect on the innovation output. This means that a higher score on these indicators is beneficial for the number of patent application in a country. Improving regulations on these indicators is therefore expected to be favorable for the innovative output of a country if the assumptions were to hold. Improving on the *dealing with permits, registering property,* and *paying taxes* indicators will most likely lead to lower operational costs for firms and time savings, which can be beneficial for the innovation practices. *Enforcing contracts* highlights the importance of legal protection. Especially for the protection of patent rights, a strong legal enforcement will be favorable for firms. *Trading across borders,* on the other hand, highlights the importance of the availability international trade for businesses. Remarkably, the *getting credit* indicator and the control variable for R&D expenditures do not seem to be significant factors for innovation. This might suggest that innovation is not very much driven by capital.

However, the study is subject to some substantial limitations. Firstly, from a methodological point of view, the assumptions of the fixed effects model are unlikely to hold. Although the country and time fixed effects aim to account for all time-invariant variables that affect innovation, there may still be omitted variables that are unaccounted for and bias the estimates. Also, indicated by the magnitude and significance of the country fixed effects, it is likely that the most important determinants of innovation are not captured by the model. Instead, they are captured by the country fixed effects. This provides evidence that regulation is not the most explanatory factor of innovation and that other factors may be more relevant in explaining the innovative output of countries. Secondly, the fixed effects model cannot account for time-varying omitted variables and shocks in the time-invariant variables, which also contributes to endogeneity in the model. Therefore, the fixed effects model might not be able to produce valid results.

The main limitation of the research, however, is the usage of the Ease of Doing Business index as a proxy for regulation. Firstly, due to the controversies and scandals around the data production, the EoDB has been discontinued since 2021. The data has therefore become somewhat unreliable due to data irregularities for some countries and methodologies of the indicators. Furthermore, the EoDB is also subject to some limitations internally. Most of the indicators are calculated by data for businesses in the largest business city. This city might not be representative of regulation in other parts of the country, especially when the countries are larger in size. These regulations might also not affect every company or entrepreneur in the same way, as the indicators do not control for the size of the firm. A smaller firm might experience the regulation in a different way than a multinational corporation and, thus, may

form a different perceived barrier. Lastly, the indicators are very general, and they might not represent the full set of problems or advantages regulation offers to the firms. It does not account for all the relevant regulations that affect firms and their innovation, as local regulations which are specific to a certain area are not accounted for. Furthermore, regulation on environment and intellectual property are also not considered in the index. Especially the strength of intellectual property rights might be an extremely relevant determinant of innovation, as it can offer protection for new ideas and products. The overall score of the EoDB and the indicators might therefore not provide a good approximation for the regulations which affect a business and their innovation output.

Lastly, using the number of yearly patent applications might also not be the most suitable measure of innovation. As explained before, defining innovation is not an easy task, as it covers a broad set of activities. Patenting the idea or product is just one stage in the innovation cycle and might not fully represent the innovational output of a country. Especially since only a small percentage of patents actually makes it to the market, as concluded by Meinhardt (1946). The yearly patent applications might therefore not be able to function as a suitable approximation of innovation.

References

Akerlof, G. A. (1970). The Market for "Lemons": Quality Uncertainty and the Market Mechanism. *The Quarterly Journal of Economics*, *84*(3), 488–500. https://doi.org/10.2307/1879431

Corcoran, A., & Gillanders, R. (2014). Foreign direct investment and the ease of doing business. *Review of World Economics, 151*(1), 103–126. https://doi.org/10.1007/s10290-014-0194-5

Djankov, S., La Porta, R., Florencio Lopez-de-Silanes, & Shleifer, A. (2002). The Regulation of Entry. *The Quarterly Journal of Economics*, *117*(1), 1–37.

Djankov, S., La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (2003). Courts. *The Quarterly Journal of Economics*, *118*(2), 453–517.

Djankov, S., McLiesh, C., & Ramalho, R.M., (2006). Regulation and growth. *Economic Letters, 92*(3), 395-401. https://doi.org/10.1016/j.econlet.2006.03.021

Djankov, S., McLiesh, C., & Shleifer, A (2007). Private credit in 129 countries. *Journal of Financial Economics, 84*(2), 299-329. https://doi.org/10.1016/j.jfineco.2006.03.004

Djankov, S., Hart, O., McLiesh, C., & Shleifer, A. (2008). Debt Enforcement around the World. *Journal of Political Economy*, *116*(6), 1105–1149. https://doi.org/10.1086/595015

Hausman, J. A. (1978). Specification Tests in Econometrics. *Econometrica*, *46*(6), 1251–1271. https://doi.org/10.2307/1913827

He, J., & Tian, X. (2020). Institutions and Innovation. *Annual Review of Financial Economics, 12*, 377-398. https://doi.org/10.1146/annurev-financial-032820- 083433

Machen, R., Jones, M., Varghese, G., & Stark, E. (2021). *Investigation of Data Irregularities in Doing Business 2018 and Doing Business 2020*. WilmerHale

Meinhardt, P. (1946). *Inventions, patents and monopoly.* London: Stevens & Sons, Ltd

Moser, P. (2005). How do patent laws influence innovation? evidence from nineteenth-century world's fairs. *American Economic Review*, *95*(4), 1214–1236. https://doi.org/10.1257/0002828054825501

OECD (2021). *OECD Regulatory Policy Outlook 2021*. OECD Publishing, Paris

OECD (2023). Gross domestic spending on R&D (indicator). https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm#indicator-chart

Parker, D. (2002). Economic Regulation: A Review of Issues. *Annals of Public and Cooperative Economics, 73*, 493-519. https://doi.org/10.1111/1467-8292.00202

Pigou, A.C. (1921) The Economics of Welfare. *The Economic Journal*, *31*(122), 206-213, https://doi.org/10.2307/2222816

Porter, M.E. (1992). Capital disadvantage: America's failing capital investment system. *Harvard Business Review, 70*(5), 65-82.

Prodan, I. (2005). Influence of Research and Development Expenditures on Number of Patent Applications: Selected Case Studies in OECD Countries and Central Europe, 1981-2001. *Applied Econometrics and International Development. 5(*4), 5-22.

Schumpeter, J.A. (1911). *The Theory of Economic Development*. Cambridge, UK: Harvard University Press

Solow, R.M. (1957). Technological change and the aggregate production function. *The Review of Economics and Statistics, 39*(3), 313-320. https://doi.org/10.2307/1926047

Stigler, G. J. (1971). The Theory of Economic Regulation. *The Bell Journal of Economics and Management Science*, *2*(1), 3–21. https://doi.org/10.2307/3003160

World Bank (2023a). Patent applications, residents. https://data.worldbank.org/indicator/IP.PAT.RESD

World Bank (2023b). Changes to the methodology. https://archive.doingbusiness.org/en/methodology/changes-to-the-methodology

6 Appendix

Appendix A: list of OESO countries selected

1. *Australia*
2. *Austria*
3. *Belgium*
4. *Canada*
5. *Denmark*
6. *Germany*
7. *Finland*
8. *France*
9. *Greece*
10. *Hungary*
11. *Ireland*
12. *Iceland*
13. *Italy*
14. *Japan*
15. *Korea, rep.*
16. *Luxembourg*
17. *Mexico*
18. *Netherlands*
19. *New Zealand*
20. *Norway*
21. *Poland*
22. *Portugal*
23. *Slovak Republic*
24. *Spain*
25. *Czech Republic*
26. *Turkey*
27. *United Kingdom*
28. *United States*
29. *Sweden*
30. *Switzerland*

Appendix B: description and source of variables

Variable	Description	Source
Patents	Total of yearly patent applications (by residents and non-residents), filed through the Patent Cooperation Treaty procedure or with a national patent office	World Data Bank
EoDB	Final score for the Ease of Doing Business index (0 = lowest performance, 100 = best performance)	World Data Bank

RDexp	Expenditures towards Research and Development, carried out by businesses, universities, research facilities and governments	OECD Database
Population	Total population in a country	World Data Bank
GDP	value of all the final goods and services produced in a country	World Data Bank
Starting_B	Number of total procedures needed to set up a business	World Data Bank
D_Permits	Score for *Dealing with Construction Permits* indicator (0 = lowest performance, 100 = best performance)	World Data Bank
G_Electricity	Score for *Getting Electricity* indicator (0 = lowest performance, 100 = best performance)	World Data Bank
R_Property	Score for *Registering Property* indicator (0 = lowest performance, 100 = best performance)	World Data Bank
E_Contracts	Score for *Enforcing Contracts* indicator (0 = lowest performance, 100 = best performance)	World Data Bank
G_Credit	Score for *Getting Credit* indicator (0 = lowest performance, 100 = best performance)	World Data Bank
P_Taxes	Score for *Paying Taxes* indicator (0 = lowest performance, 100 = best performance)	World Data Bank
Trading_B	Score for *Trading across Borders* indicator (0 = lowest performance, 100 = best performance)	World Data Bank
P_Investors	Score for *Protecting Minority Investors* indicator (0 = lowest performance, 100 = best performance)	World Data Bank
R_Insolvency	Score for *Resolving Insolvency* indicator (0 = lowest performance, 100 = best performance)	World Data Bank

Appendix C: EoDB country + time fixed effects

Variable	*ln_Patents (FE)*	*ln_Patents (RE)*
YEAR		
2010	-0.048 (0.061)	-0.048 (0.061)
2011	-0.025 (0.063)	-0.025 (0.063)
2012	-0.079 (0.064)	-0.079 (0.064)
2013	-0.114 (0.066)	-0.114 (0.066)
2014	-0.146 (0.069)	-0.146 (0.069)
2015	-0.261*** (0.071)	-0.261*** (0.071)
2016	-0.325*** (0.075)	-0.325*** (0.075)
2017	-0.352*** (0.079)	-0.352*** (0.079)
2018	-0.400*** (0.085)	-0.400*** (0.085)
2019	-0.467*** (0.088)	-0.467*** (0.088)
COUNTRY		
Austria	2.771** (0.968)	2.771*** (0.670)
Belgium	0.589 (0.723)	0.589 (0.515)
Canada	-2.051*** (0.404)	-2.051*** (0.298)
Czech Republic	0.388 (0.791)	0.388 (0.573)
Denmark	4.608** (1.363)	4.608*** (0.938)
Finland	4.733** (1.400)	4.733*** (0.965)
France	-6.170*** (1.002)	-6.170*** (0.704)
Germany	-6.106*** (1.214)	-6.106*** (0.856)
Greece	0.330 (0.793)	0.330 (0.604)
Hungary	0.305 (0.878)	0.305 (0.649)
Iceland	16.573*** (4.103)	16.573*** (2.834)
Ireland	4.170** (1.581)	4.170*** (1.081)
Italy	-6.045*** (0.906)	-6.045*** (0.631)

Japan	-6.862*** (1.645)	-6.862*** (1.148)
Korea, Rep.	-2.874*** (0.797)	-2.874*** (0.571)
Luxembourg	15.925*** (3.657)	15.925*** (2.518)
Mexico	-9.720*** (1.640)	-9.720*** (1.111)
Netherlands	-0.573 (0.329)	-0.573* (0.254)
New Zealand	6.980*** (1.571)	6.980*** (1.103)
Norway	5.667*** (1.472)	5.667*** (1.025)
Poland	-5.073*** (0.585)	-5.073*** (0.418)
Portugal	0.278 (0.811)	0.278 (0.586)
Slovak Republic	2.735 (1.435)	2.735** (1.031)
Spain	-6.114*** (0.694)	-6.114*** (0.478)
Sweden	2.057** (0.843)	2.057*** (0.582)
Switzerland	3.181** (1.032)	3.181*** (0.714)
Turkey	-8.646*** (1.227)	-8.646*** (0.841)
United Kingdom	-5.935*** (0.992)	-5.935*** (0.694)
United States	-11.244*** (2.529)	-11.244*** (1.763)
VARIABLES		
EoDB	0.024** (0.008)	0.028** (0.009)
ln_RDexp	0.240* (0.105)	0.223 (0.114)
ln_Population	5.842*** (1.011)	1.284*** (0.175)
ln_GDP	-0.725*** (0.223)	-0.202 (0.154)
constant	-72.742*** (10.962)	-11.603*** (3.128)
N	310	310
R-squared	0.709	0.773

Note: This table denotes the regression results of the Ease of Doing Business Index on Patents. The dependent variable is ln_Patents and the variable of interest is EoDB (marked grey). In column (1) the coefficients for the regression with country and time fixed effects is given. In column (2) the coefficients for the regression with random effects is given. The standard errors are given between the brackets. *p < 0,05, **p < 0,01, ***p < 0,001.

Appendix D: indicators country + time fixed effects

Variable	*ln_Patents (FE)*	*ln_Patents (RE)*	*ln_Patents (FE)*	*ln_Patents (RE)*
YEAR				
2010	-0.066	-0.066	.	.
	(0.078)	(0.057)	.	.
2011	-0.052	-0.052	.	.
	(0.073)	(0.059)	.	.
2012	-0,093	-0,093	.	.
	(0.075)	(0.062)	.	.
2013	-0.120	-0.120	.	.
	(0.076)	(0.062)	.	.
2014	-0.229*	-0.229**	-0.074	-0.074
	(0.098)	(0.081)	(0.072)	(0.072)
2015	-0.279*	-0.279**	-0.132	-0.132
	(0.107)	(0.081)	(0.089)	(0.076)
2016	-0.349**	-0.349***	-0.179*	-0.179*
	(0.110)	(0.085)	(0.088)	(0.081)
2017	-0.399***	-0.399***	-0.180*	-0.180*
	(0.107)	(0.086)	(0.086)	(0.080)
2018	-0.430***	-0.430***	-0.188	-0.188
	(0.118)	(0.091)	(0.105)	(0.089)
2019	-0.501***	-0.501***	-0.228*	-0.228*
	(0.126)	(0.094)	(0.113)	(0.095)
COUNTRY				
Austria	3.888***	3.888***	0.650	0.650
	(1.001)	(0.691)	(1.452)	(1.083)
Belgium	1.630*	1.630**	-0.794	-0.794
	(0.757)	(0.552)	(1.117)	(0.869)
Canada	-2.793***	-2.793***	-1.799	-1.799
	(0.515)	(0.338)	(0.918)	(0.571)
Czech Republic	1.324	1.324*	-1.590	-1.590
	(0.779)	(0.587)	(1.297)	(0.973)
Denmark	6.398***	6.398***	2.015	2.015
	(1.471)	(0.983)	(2.080)	(1.529)
Finland	6.689***	6.689***	2.085	2.085
	(1.505)	(1.011)	(2.184)	(1.562)
France	-7.469***	-7.469***	-4.611**	-4.611**
	(1.203)	(0.775)	(1.688)	(1.132)
Germany	-7.335***	-7.335***	-3.706	-3.706
	(1.375)	(0.909)	(1.964)	(1.369)
Greece	1.428	1.428*	-1.542	-1.542
	(0.763)	(0.601)	(1.239)	(1.044)
Hungary	0.943	0.943	-2.091	-2.091
	(0.841)	(0.640)	(1.499)	(1.090)
Iceland	21.911***	21.911***	8.795	8.795
	(4.498)	(2.970)	(6.383)	(4.536)

Ireland	5.945***	5.945***	0.701	0.701
	(1.656)	(1.114)	(2.416)	(1.776)
Italy	-7.123***	-7.123***	-5.062**	-5.062**
	(1.094)	(0.684)	(1.495)	(0.992)
Japan	-8.628***	-8.628***	-3.870	-3.870
	(1.847)	(1.207)	(2.598)	(1.795)
Korea, Rep.	-3.584***	-3.584***	-1.332	-1.332
	(0.932)	(0.622)	(1.334)	(0.886)
Luxembourg	20.233***	20.233***	9.412	9.412
	(3.950)	(2.591)	(5.453)	(3.886)
Mexico	-11.900***	-11.900***	-7.515**	-7.515**
	(1.930)	(1.190)	(2.448)	(1.716)
Netherlands	-0.351	-0.351	-1.546**	-1.546**
	(0.286)	(0.263)	(0.512)	(0.428)
New Zealand	8.775***	8.775***	3.786	3.786
	(1.698)	(1.151)	(2.531)	(1.862)
Norway	7.370***	7.370***	2.599	2.599
	(1.584)	(1.065)	(2.212)	(1.628)
Poland	-5.768***	-5.768***	-4.687***	-4.687***
	(0.722)	(0.441)	(0.847)	(0.582)
Portugal	1.275	1.275*	-1.483	-1.483
	(0.775)	(0.593)	(1.269)	(0.981)
Slovak Republic	4.209**	4.209***	-0.721	-0.721
	(1.472)	(1.059)	(2.326)	(1.675)
Spain	-7.216***	-7.216***	-5.579***	-5.579***
	(0.876)	(0.538)	(1.131)	(0.751)
Sweden	3.166***	3.166***	0.275	0.275
	(0.892)	(0.613)	(1.259)	(0.958)
Switzerland	4.192***	4.192***	0.925	0.925
	(1.093)	(0.738)	(1.597)	(1.111)
Turkey	-10.492***	-10.492***	-7.261***	-7.261***
	(1.510)	(0.962)	(1.986)	(1.329)
United Kingdom	-7.083***	-7.083***	-4.254*	-4.254*
	(1.139)	(0.739)	(1.762)	(1.120)
United States	-14.450***	-14.450***	-6.554	-6.554
	(2.809)	(1.841)	(4.004)	(2.791)
INDICATORS				
D_Permits	-0.008*	-0.000	-0.011	0.002
	(0.004)	(0.005)	(0.008)	(0.008)
G_Electricity	-0.007	-0.008*	-0.005	-0.009
	(0.004)	(0.004)	(0.005)	(0.005)
R_Property	0.012**	0.011**	0.012*	0.019*
	(0.004)	(0.004)	(0.006)	(0.006)
E_Contracts	0.013***	0.010**	0.003	0.006
	(0.003)	(0.003)	(0.004)	(0.004)

G_Credit	0.004	0.008**	0.001	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
P_Taxes	0.009*	-0.004	-0.001	-0.005
	(0.004)	(0.005)	(0.006)	(0.006)
Trading_B	0.013***	0.009*	0.008	0.002
	(0.003)	(0.004)	(0.004)	(0.004)
R_Insolvency	-0.007	-0.001	-0.004	-0.000
	(0.005)	(0.005)	(0.008)	(0.008)
P_Investors	.	.	0.005	0.010
	.	.	(0.018)	(0.145)
CONTROL VARIABLES				
ln_RDexp	0.121	0.179	0.117	0.387*
	(0.110)	(0.117)	(0.159)	(0.153)
ln_Population	7.051***	1.108***	4.192***	1.140***
	(0.733)	(0.177)	(1.050)	(0.215)
ln_GDP	-0.550***	0.036	-0.704**	-0.257
	(0.156)	(0.160)	(0.220)	(0.209)
constant	-97.430***	-14.489***	-44.043*	-9.107*
	(11.525)	(3.115)	(18.343)	(3.955)
N	310	310	199	199
R-squared	0.703	0.767	0.672	0.758

Note: This table denotes the regression results of the Ease of Doing Business indicators on Patents. The dependent variable is ln_Patents and the variables of interest are the first 10 variables. In column (1) the coefficients for the regression with country and time fixed effects is given. In column (2) the coefficients for the regression with random effects is given. In column (3) the variable *P_Investor* is added to the regression in column (1) and the coefficients for the regression with country and time fixed effects is given. In column (4) the coefficients for the regression with random effects is given. The standard errors are given between the brackets. *p < 0,05, **p < 0,01, ***p < 0,001.

Appendix E: Starting_B + time fixed effects

Variable	***ln_Patents (FE)***	***ln_Patents (RE)***
YEAR		
2010	-0.028	-0.066
	(0.061)	(0.057)
2011	0.025	-0.052
	(0.062)	(0.059)
2012	-0,020	-0,093
	(0.063)	(0.062)
2013	-0.032	-0.120
	(0.064)	(0.062)
2014	-0.063	-0.229**
	(0.068)	(0.081)
2015	-0.173*	-0.279**
	(0.068)	(0.081)
2016	-0.220**	-0.349***
	(0.071)	(0.085)

2017	-0.236**	-0.399***
	(0.074)	(0.086)
2018	-0.264**	-0.430***
	(0.079)	(0.091)
2019	-0.335***	-0.501***
	(0.083)	(0.094)
COUNTRY		
Austria	2.023*	2.023**
	(1.026)	(0.688)
Belgium	-0.067	-0.067
	(0.751)	(0.508)
Canada	-1.877***	-1.877***
	(0.420)	(0.303)
Czech Republic	-0.419	-0.419
	(0.864)	(0.583)
Denmark	3.960**	3.960***
	(1.426)	(0.956)
Finland	3.998**	3.998***
	(1.456)	(0.974)
France	-5.994***	-5.994***
	(1.036)	(0.711)
Germany	-5.841***	-5.841***
	(1.236)	(0.858)
Greece	-0.521	-0.521
	(0.825)	(0.586)
Hungary	-0.550	-0.550
	(0.937)	(0.639)
Iceland	14.585**	14.585***
	(4.245)	(2.860)
Ireland	3.452*	3.452**
	(1.638)	(1.091)
Italy	-6.029***	-6.029***
	(0.943)	(0.636)
Japan	-6.407***	-6.407***
	(1.680)	(1.153)
Korea, Rep.	-2.725**	-2.725***
	(0.809)	(0.573)
Luxembourg	13.997***	13.997***
	(3.751)	(2.525)
Mexico	-9.394***	-9.394***
	(1.709)	(1.123)
Netherlands	-0.932**	-0.932***
	(0.341)	(0.250)
New Zealand	6.483***	6.483***
	(1.625)	(1.114)
Norway	5.040**	5.040***

	(1.523)	(1.038)
Poland	-5.204*** (0.626)	-5.204*** (0.419)
Portugal	-0.377 (0.862)	-0.377 (0.588)
Slovak Republic	1.727 (1.507)	1.727 (1.040)
Spain	-6.166*** (0.720)	-6.166*** (0.482)
Sweden	1.618 (0.883)	1.618** (0.590)
Switzerland	2.501* (1.065)	2.501** (0.722)
Turkey	-8.692*** (1.287)	-8.692*** (0.848)
United Kingdom	-5.516*** (1.010)	-5.516*** (0.692)
United States	-10.133*** (2.589)	-10.133*** (1.765)
INDICATOR		
Starting_B	0.027 (0.014)	0.025 (0.015)
CONTROL VARIABLES		
ln_RDexp	0.377*** (0.116)	0.412*** (0.116)
ln_Population	5.460*** (0.689)	1.246*** (0.176)
ln_GDP	-0.925*** (0.160)	0.387* (0.158)
constant	-61.173*** (10.899)	-14.489* (2.957)
N	310	310
R-squared	0.695	0.991

Note: This table denotes the regression results of the Ease of Doing Business indicator for Starting a Business on Patents. The dependent variable is ln_Patents and the variable of interest is Starting_B. In column (1) the coefficients for the regression with country and time fixed effects is given. In column (2) the coefficients for the regression with random effects is given. The standard errors are given between the brackets. *p < 0,05, **p < 0,01, ***p < 0,001.