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FROM ENTREPRENEURSHIP TO GREEN GROWTH: SUPPORTING SUSTAINABLE ECONOMIC DEVELOPMENT THROUGH ECO-INNOVATION

Master's thesis

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ABSTRACT

Entrepreneurship can be regarded as one of the key benefactors of eco-innovation and green growth. The study aims to investigate into the macro-economic factors that impact the cultivation of eco-innovative entrepreneurship, employing panel data comprising of 36 OECD countries over the period from 1995 to 2014. The focus is placed on business and trade freedom, although other attributes are examined as controls. The regression results corroborate the economic arguments in which higher business and trade freedom are supportive of eco-innovation and green growth. As these relationships are relatively generic, suggestions are shared for further research with more granular data.

Keywords: Eco-Innovation, Green Growth, Entrepreneurship

INTRODUCTION

The current linear economic system can be regarded as unsustainable, because it is focused on achieving unlimited growth while diminishing the fact that there is only a limited amount of resources available. Keeping this in mind more sustainable economic models such as circular economy and green growth have been developed. These approaches are often seen as some of the major remedies to this great 21st century challenge. Considering entrepreneurship is a supportive element in ensuring economic growth (e.g. Schumpeter 1911) this causal relationship could also be transferred to achieving greener economies, particularly when directing the focus of entrepreneurs onto eco-innovation. In this regard, entrepreneurship could play a special role in pushing eco-innovative products and services into the market as well as into the internal structures and processes of public institutions and private sector companies. The potential is as vast as the human society but has for the most part been left untapped. Therefore, ensuring its success and advancement demands special attention by policymakers and academic circles alike.

In this regard, although there exists some qualitative research examining the linkages between eco-innovation, entrepreneurship and green growth (e.g. Sarkar 2013) as well as several micro-level quantitative analyses (e.g. Marin, Lotti 2017), remarkably little has been done in providing extensive macro-level quantitative empirical evidence on these causal relationships. The few that exist focus largely on governmental policies, such as environmental regulations and subsidies (e.g. Triguero *et al.* 2015), but to a considerably lesser degree on other internal and external structural factors. This might partly be tied to the fact that eco-innovation is a subcategory of innovation, which has been covered for a much longer time period. Another major issue might be related to the lack of reliable data on the subject both on an aggregate and granular level. The given thesis aims to overcome some of these shortcomings by compiling a new dataset from Fraser Institute, Heritage Foundation, OECD and World Bank databanks forming a sizable sample of 36 OECD member countries over the period of 1995 to 2014.

The central logic of the study is that entrepreneurship is an important instrument in providing green innovation and economic growth, both through their linked causal relationship as well as separately. The thesis therefore aims to investigate into some of the key elements that further eco-innovative entrepreneurship, focusing on the impacts from business and trade freedom while also looking at the effect of domestic market size, consumer purchasing power, property rights, tax burden, government spending, foreign direct investment and gross capital formation. The objective of the study is in short to answer the following research question: *which supporting factors of entrepreneurship bring about eco-innovation?*

As the first step, an overview of previous research on the subject matter is shared, followed by the establishment of the analytical framework. These two are presented in unison based on the central logic of the research paper, dissecting the link between entrepreneurship, eco-innovation and green growth. The central hypotheses related to business and trade freedom are proposed in their respective sections within the analysis. Next, the research methodology subchapter will elaborate on the dataset, variables and methods employed. As these play a key role in assessing the proposed causal chains, special attention is placed on descriptive statistics of the variables and evaluating model robustness in the section for results. Only thereafter the findings from the model regression are thoroughly analysed and elaborated, while also offering preliminary, corroborative deductions. The conclusion will tie this work together and offer suggestions for further research.

1. LITERATURE REVIEW AND THEORY

The given chapter will commence with defining the theoretical concepts of eco-innovation, entrepreneurship and green growth. Thereafter, a theoretical framework is formed based on previous research on the subject matter, focusing on how entrepreneurship furthers green growth through eco-innovation. This link is examined through the various macroeconomic and other types of structural conditions which have an impact on the eco-innovative endeavours of enterprises. Finally, based on these contextual factors two hypotheses regarding business and trade freedom are proposed.

1.1. Definitions

Innovation can generally be regarded as any introduction of a new process or method (Schumpeter, 1911). Schumpeter (1911) in this regard, considered economic innovation to only be modifications in the way of the specific manufacturing method in a production process in which case entrepreneurs through “creative destruction” provide these improvements replacing the old methods. Modern theories tend to also account for the new product or service (e.g. Anderton 1999), or societal change innovation brings about (e.g. Kline, Rosenberg 2009; Sarkar 2013). The given short introduction leads us to investigate into and propose the definitions for eco-innovation and the two phenomena associated with it and studied in the given research paper – entrepreneurship and green growth.

1.1.1. Eco-Innovation

Eco-innovation conveys the same logic, only that it is aimed at either directly reducing negative environmental impacts or offering a more environmentally friendly alternative, i.e. taking a more indirect effect. To take a closer look, Schiederig *et al.* (2011) offer a relatively good system for analysing eco-innovation based on the following characteristics:

1) What is the object of eco-innovation? Is it a product, process, service or method?

2) Is the eco-innovation oriented towards earning profits, offering a public good or both?

3) What is the environmental impact of the eco-innovation? Does it decrease pollution, substitute for resource extraction, or offer other alternative measures?
4) What stage of the customer value chain does the eco-innovation cover? Is it focused on a specific section? Does it take into account the full life cycle of the product or service?
5) What type of motivational drive does it infuse? Is it economical or ecological?
6) Does it set or is it intended for complying with an innovation or green standard?

Considering the methodological aims and spatial limitations of this study, the thesis will incorporate these analytical questions into two main focal areas: objectives and systems of eco-innovation. For the former different aspects are often highlighted. For example, Weber and Hemmelskamp (2015) combine innovation and technology development with environmental protection, in which case by incorporating this concept into new products, processes or services it offers a way of contributing to economic growth while pursuing sustainability. Similarly, Fussler and James (1996) consider eco-innovation to be a "process of developing new products, processes or services which provide customer and business value but significantly decrease environmental impact". The importance of attracting green rents on the market has also been brought out as an important condition of eco-innovation (Andersen 2002). Even more generally, eco-innovation has been linked with the creation of new market space, products and services or processes which is driven by social, environmental and/or sustainability issues (Little 2005).

The systematic perspective attempts to describe internal and external structural factors of eco-innovation. For example, Charter and Clark (2007) consider eco-innovation to be a "process where sustainability considerations (environmental, social, financial) are integrated into company systems from idea generation through to research and development (R&D) and commercialisation" which can therefore apply to products, services and technologies, as well as new business and organisation models. The thesis will account for both of these focal areas, as they offer a complementary explanation to how entrepreneurship is tied with eco-innovation and green growth. One simply cannot be preferred over the other without losing some degree of analytical rigour, which includes examining and understanding the various supporting and hindering factors.

1.1.2. Entrepreneurship

Although there is no joint agreement on the definition of entrepreneurship either, there is a bit larger consensus on the conceptual meaning of the term which dates back to the 20th century, and historically even centuries earlier. In this regard, an entrepreneur is most often seen as a person in search of profit willing and able to convert a new idea or invention into a successful innovation (Schumpeter 1911). Knight (1921) distinguishes between measurable risks and unquantifiable uncertainty in which case entrepreneurs invest into innovations hoping to achieve profits in face of the former. The concept of entrepreneur has broadened to include other types of objectives as well, such as social entrepreneurship which is aimed at the non-profit tackling of societal challenges (e.g. Leadbeater 1996). In this light we also come to the "eco-entrepreneur", which focuses on issues related to the environment (e.g. Wagner 2009). These studies have also started to investigate into the larger effects eco-entrepreneurs play in the world. For example, Geyer and DuBuisson (2015) showcase how eco-entrepreneurs could also have a negative impact on the society, when they do not account for the innovation's full life cycle.

The given research paper will again take a broad generalist perspective, considering an entrepreneur or enterprise to be a person or a legal entity engaged in the development of new technologies in order to reap the rewards of such endeavours. Next to maintaining a wide conceptual framework which includes private and non-private entrepreneurs, this standpoint is also important because there is no good data available which distinguishes non-innovative enterprises from innovative enterprises and thus it is important to incorporate both of them under one denominator. Finally, the nature and degree of entrepreneurship is highly dependent on the political, economic, social and cultural environment of any given country. As taking all of these into consideration could lead the scope of the thesis to become too extensive, the study will only focus on politico-economic conditions which are related to governments, enterprises and market situations. Moreover, these factors have less methodological concerns in terms of scaling them internationally, because social and cultural conditions are considerably more relative and thus much harder to quantify and compare between nations.

1.1.2. Green Growth

Green growth in its essence is an economic model focused on achieving environmental sustainability in economic development (e.g. Ekins 1999). It does not deny a growth-based social system but aims to reduce environmental strain from both the production and consumption sides of economic growth (e.g. Hallegatte *et al.* 2011). Regarding the former, more sustainable use of resources and methods of manufacturing are advocated, which could for example include switching to renewable energy and more environmentally friendly materials among other factors. From a consumption perspective goods and services which cause a smaller environmental impact are recommended over ones with a larger ecological footprint. For example, changing from plastic packaging to reusables has been a common theme during the last decade.

Green growth is distinct from other types of alternatives to the current linear economic model. For example, degrowth is aimed at reducing the environmental impact of societies by slowing down economic development (e.g. Jakob, Edenhofer 2014). Another common theory which is advocated is the building a circular economy which strives to reduce waste in every phase of the product or service life cycle, while making the entire process as cost and material effective as possible. The key idea is to employ the limited resources available optimally, decreasing loss and re-processing the remains as well as final products. The easiest example is the establishment of networks of thrift shops, which take, sort and sell used clothing, furniture and accessories. If degrowth seems counterintuitive in terms of offering incentives for eco-innovation, then circular economy would narrow down the scope of eco-innovative products and services considerably as the market ecosystem in this field is at this point very small. The thesis therefore takes green growth as a basis for the analysis, due to the nature of the research question as well as the subsequent requirement to maintain the generic politico-economic framework of the current international economy. With the definitions in place it is time to move on to the analysis of the causal links between eco-innovation, entrepreneurship and green growth.

1.2. Entrepreneurship and Green Growth

Most famous theoretical framework on the role entrepreneurship plays in the growth of output is provided by Schumpeter (1911). The empirical side only started to expand in the last few decades which will be evaluated in this section. In this regard, the following analysis focuses on the structural factors which affect the cultivation of innovation while producing green growth, systematising these into internal and external factors. This categorisation will be helpful for understanding the underlying process and institutional structure which either supports or hinders eco-innovation.

1.2.1. Eco-innovation and internal factors

Internal factors refer to the organisational structure, capabilities and objectives-incentives of enterprises, entrepreneurs and innovators. Studies in this field are therefore largely focused on the micro-level of eco-innovation. Regarding the organisational attributes of companies, eco-innovation has been found to be more active and fruitful in larger firms, although this proposition is also strongly related with the age of the private entity, losing its spirit and edge with every passing year (Wagner 2015). The given notion is further confirmed by studies investigating into the time-scale of advancing and adopting eco-innovation, in which case smaller firms are often seen to be more environmentally lagging (Tilley 1999, 2000; Hillary 2000). This is likely due to the sizable upfront costs of innovation, deriving from insufficient knowledge and/or human and financial capital required for such a process.

Turning to the capabilities perspective, Scarpellini (2017) has argued that specialized human capital involved in the R&D and innovation activities, the environmental management of firms and the resources and energy management are relevant elements in the eco-innovation process, and as such they have to be specifically managed for the development of eco-innovations. Zaušková *et al.* (2015) make a case in which the stress the importance of marketing to cultivating successful eco-innovation, which involves reaching out to customers not only for sales, but also for feedback and market analysis as part of product development. The given strategy brings customers into the innovation process, which offers both new insights as well as supports the likelihood of the innovative products achieving business success, due to better solving customer “jobs-to-be-done” and pains (Levitt 1969).

The expansion of enterprises and their resources offers new opportunities for cultivating eco-innovation and productivity. However, this is constrained by numerous hurdles and challenges derived from increased complexity of effective management and growing financial risks among others. In this regard, R&D internationalization is found to have a U-curve in which the benefits eventually outweigh the costs after critical levels of intensity and diversity (Hsu *et al.* 2015). R&D internationalisation therefore has a positive moderating impact on the relationship between R&D internationalization and innovation performance, suggesting the effect is dependent on the firm's capability in dealing with the complexities and uncertainties inherent in international business (*Ibid.*). At the same time, R&D labour mobility increases total innovative activity in the firms witnessing such influx (Kaiser *et al.* 2015), indicating that the growth of companies brings in new ideas and talents.

Innovation could also be motivated in various ways, starting from creating such job roles and ending with salary bonuses. Profit-sharing is another interesting strategy allowing the employees of companies to participate in efficiency gain, although it is more effective in furthering product innovation but not process innovation (Aerts *et al.* 2015). The ultimate objective of eco-innovation by private enterprises is naturally to increase profits, either by reducing costs, or bringing additional value to the products and services offered in the market. The former also ties into governmental regulations regarding the production of waste, cost of energy and other external factors which will be covered in the next subsection. Interestingly enough, eco-innovation has been shown to increase labour productivity (e.g. Garcia-Pozo *et al.* 2018), meaning that it can make labour more cost effective. However, eco-innovation is also found to bring about lower productivity growth in comparison to other innovation, particularly for heavy polluting companies (Marin, Lotti 2017), as these are often tied to expensive investments into environmental efficiency.

1.2.2. Eco-innovation and external factors

To a large extent the external factors for eco-innovation and green growth can be categorised as market push and pull factors, in which case the former is related to bringing improved products and services to the market, whereas the latter is tied to consumers demanding greater environmental protection from the market side. Broadly speaking, theorists which emphasize the importance behind cultivating entrepreneurship as a method for green growth (e.g. Thurik, Wennekers 2004) belong under this category. As an example, green innovation has proven to have the potential to create more jobs in comparison to other types of innovations (Gagliardi *et al.* 2016) which means that next to increased green productivity it also expands the job market. This category also includes studies examining entrepreneurial sociology. For example, Hovne *et al.* (2014) were able to provide some quantitative evidence to the positive link between entrepreneurial training during and after schooling and higher degrees of innovation. In other words, entrepreneurial education plays a role in establishing and ensuring the scale and scope of innovation present in the society.

Regarding external structural factors, location has been linked with local firms being more open for developing eco-innovation due to closeness to the impacts of climate change as well as the companies' visibility within their local communities (Martin *et al.* 2013). However, due to globalisation firms will also be pushed to innovate by fierce international competition. This is because the development of new technologies and business models, such as peer-to-peer (P2P) businesses, could lead to more strain on existing companies to innovate (Stallibrass, Fingleton 2016). At the same time, globalisation offers increased opportunities for partnership, which includes sharing the R&D related costs, furthering human capital and many more options. In this regard, R&D collaboration with all types of partners improves enterprise performance through innovation, once firms persistently engage in collaborating with innovation-driven stakeholders and it is particularly strong when engaging with competitors (Belderbos *et al.* 2014). Although R&D cooperation with academic and research institutions is strongest in the beginning of the innovative process, it eventually fades out to the private sector (*Ibid.*). This appears to co-align with the typical innovative process of start-up companies in particular, in which case academic and research institutions are taken on board to help in the development of new products and services, but such partnerships are often left behind once the product or service is able to enter the market.

The majority of research on external factors behind entrepreneurial eco-innovation focuses on governmental policies and strategies. For example, Bailey *et al.* (2018) showcase the positive impact of adopting and implementing regional industrial strategies for capturing co-created value. This conclusion is further corroborated by studies investigating how clustering cultivates cooperation and eco-innovation (e.g. Heshmati, Lenz-Cesar 2013). Government policy are advised to target all aspects of innovation, which includes R&D, design, production, operations and marketing, while keeping up to date with the latest changes within firms and markets (Dogson 2017). Furthermore, Migendt *et al.* (2017) stress the importance of policymakers striking a fine balance between innovation and finance policy as part of the “finance-innovation-policy nexus”, one which would favour investments into cleantech. This is particularly important due to the fact one of the major external obstacles to cleantech entrepreneurs is access to finance (e.g. Stucki 2014). This in turn comes from the above average risks associated with eco-innovation, including greater technological uncertainty, higher policy dependency, asset heaviness, slower scalability and corresponding long payback periods (Foxon, Pearson 2008; Hockerts, Wüstenhagen 2010; Hargadon, Kenney 2012; Petkova *et al.* 2014; Polzin *et al.* 2016). The government’s entrepreneurial policy and its enforcement, depending on its degree of business freedom, also plays a major role in the costs associated with establishing and maintaining businesses. Higher regulation and tax burden among other factors will hinder the growth of businesses and eco-innovation simply due to investment capital being directed to upholding government institutions. This leads us to establish our first hypothesis.

H1: Higher level of business freedom will lead to increased eco-innovation

Although eco-innovation can come in many shapes and sizes, when focusing on product or process innovation by private enterprises, then another key element is its ability to succeed in the market.

This means that new products are influenced by the ease of accessing both domestic and foreign markets as well as their prices deriving from production as well as trade and marketing costs. The simple economic logic is that an enterprise is not sustainable and cannot survive unless it is able to generate revenue by making sales. In this regard, factors that improve market performance of eco-innovative products are found to be cross-functional coordination between new product development professionals and environmental specialists; supplier involvement in the process; focus on target market and product life cycle analysis (Pujari 2006). The importance of trade is strongly influenced by the size of the domestic market and its purchasing power, but the common postulate is that the larger the total market of sales – domestic and foreign – the more likely an entrepreneur is able to garner success. Furthermore, next to the initial upfront costs, the access to these markets is dependent on trade barriers and regulations, meaning that the same as with ordinary products and services globalisation and trade freedom are able to support increased eco-innovation and proliferation of green products and services. This study will now propose its second hypothesis.

H2: Increased trade opportunities and capabilities will support the cultivation of eco-innovation.

1.2.3. Entrepreneurship, eco-innovation and green growth

The interrelation between entrepreneurship, eco-innovation and green growth is relatively straightforward, but for analytical clarity it is best to sum up what has been discussed regarding these causal relationships before moving on to the research design chapter. Starting with the first link, entrepreneurs bring new eco-innovations and other types of technological developments to the market, as they are constantly searching for ways to make profits or other gains (e.g. Schumpeter 1911). As the level of entrepreneurial activity, which includes the number, scale and activeness of enterprises in the market depends on a number of structural factors, which either support or hinder eco-innovation (e.g. Tilley 1999, 2000; Hillary 2000; Wagner 2015), the same attributes are likely to have a direct and indirect impact on the development of environmentally friendly technologies. More innovation brought into the market and/or public space can increase growth in a number of ways. Based on the perspective of consumption and expenditure, eco-innovation as with innovation in general can bring economic growth through value added from new products and services offered in the market, additional investments into fixed assets and inventories, increased government spending on environmentally friendly technologies and greater net trade of such products and services. It could also provide new jobs and income to the labour force working in the given sector (e.g. Gagliardi *et al.* 2016) as well as decrease production cost with certain types of technologies (e.g. Garcia-Pozo *et al.* 2018). Net positive changes in these attributes in turn increase capital available for additional spending.

The given causal chain is presented based on a linear perspective. In reality all of these phenomena are however strongly interlinked as the economy can rather be seen as a web of causes and effects. For example, green growth which is created from an expanding market of environmentally friendly products and services will naturally pull and push more entrepreneurs to bring their own eco-innovations to the fore. In other words, improvement in one link in the chain will likely positively impact the others and vice versa. This does not however, stop us from estimating the linear one-way relationship as the various factors have a different effect on each other which are formed through changing conditions. Furthermore, the objective of this study is to examine the impact factors conducive for entrepreneurship have on eco-innovation, thereby narrowing down and giving a deeper insight into the relationship. However, as the thesis looks at main concepts, then certain types of relationships will unfortunately remain unverified and uncorroborated. For example, Jänicke (2012) has distinguished that environmentally sustainable growth could be rapid in green sectors while producing degrowth in others. The analytical framework of this thesis is tied to the macroeconomic data available for empirical analysis, and because of the lack of such a distinction in the database, these conundrums are overlooked and must be left for future researchers to solve.

1.2.4. Previous Empirical Research and Methodology

The objective of this subchapter is to complement the theoretical framework by sharing relevant examples of the methodologies of some of the major research performed regarding eco-innovation as well as innovation as a whole. This and other related publications are then used to develop and elaborate on the empirical concepts underlying the research design and methodology section. In other words, Table 1 allows us to have a short overview of the data, methods and variables previously employed. However, focus is notably placed on analytical studies which examine similar research gaps as the body of research in the field of innovation is quite substantial. Furthermore, qualitative studies are excluded as these fall out of the current scope. In this regard, d'Agostino and Scarlato (2019) in particular provide the empirical framework for using innovation as an intermediary for growth, while all of the mentioned studies offer support in choosing the measured variables and statistical methods to be employed.

Table 1. Overview of Selected Empirical Research

Authors	Objective	Method	Variables
d'Agostino, Scarlato (2019)	Provide an empirical analysis of the linkages between institutions and economic growth in the European context, highlighting innovation as the intermediate variable that drives the given interplay.	Panel data of 15 EU Member States, time period 1960–2010. Fixed effects with robust standard errors accounting for heteroscedasticity and autocorrelation. Shock in stock of knowledge lagged.	DV – Growth rate of technologies, GDP growth rate; IV – Shock in stock of knowledge, democratic accountability, law and order, socioeconomic conditions, ethnic tensions, corruption, investment profile
Moro *et al.* (2019)	Examine indicators that govern water sector's innovative capacity in a comparative analysis of Europe and China, including the assessment of the evolution of the development of water technologies.	Panel data of EU member states and China (People's Republic of), time frame 1990–2013. Comparison of pooled OLS, fixed effects and random effects. No time adjustments added to variables.	DV – Water patents, water patents per capita; IV – GDP per capita, stock of international water patents, protection for international property, aggregate R&D expenditures, aggregate employed scientific and technological (S&T) personnel and labour force, share of government expenditure on higher education, specialization degree, environmental policy stringency index, water

			dependency ration, drinking water availability, water pollution levels, collaboration, governance.
Noni *et al.* (2018)	Measure and evaluate the capacity of local innovative organisations in lagging-behind European regions to develop internal and external regional inventors' networks, which is performed by exploring the collaborative patenting processes of these organisations.	Panel data of 269 European regions, time period 2002–2008. Time-fixed effects with robust standard errors to control for heteroscedasticity. No time adjustment added to variables.	DV – Logged division of patents over three-year periods and million habitants; IV – Collaborative networks, local collaboration, external collaboration, knowledge-intensive collaboration; CV – Business density, GDP per capita, R&D expenditures, technological diversification, human capital

Source: Shared under Authors' column

2. RESEARCH DESIGN AND METHODOLOGY

The objective of the present chapter is to shed light onto the methodological framework of the thesis. Firstly, the nature of the sample is elaborated which includes describing the number of objects, time frame and sources. The next step involves the presentation of the dependent, independent and control variables, indicating their strengths and weaknesses. Thereafter, a number of regression methods are introduced which is followed by the elaboration on the methodological path for its final selection.

2.1. Dataset

This is a quantitative study employing panel data from multiple sources. Information on environmental patents are taken from OECD (2018) which is the most comprehensive dataset on the subject matter. Data related to entrepreneurship is based on the Index of Economic Freedom provided by Heritage Foundation (2018) and Fraser Institute (2018), both of which are well-regarded systems of indicators covering the entire world and as such are often used in these types of analyses (Li 2008). Control variables are taken from the World Bank's renown World Development Indicators databank (2018). In this regard, combining three different datasets could bring its challenges as they use different methodological frameworks. However, this is mostly a problem in instances in which the methods employed are not robust. This is fortunately not the case with these four institutions as they are generally considered as reliable sources.

Another issue lies in avoiding gaps in the data which sets restrictions on the number of countries and years available for analysis. Although, one could evaluate up to 196 states and autonomous regions there are considerable gaps and other types of restrictions for a large number of them. As OECD countries are generally regarded to have the highest standard in data collection, then for the sake of statistical rigour the 36 members of the OECD are chosen as a basis for the analysis. Regarding the time period, due to the OECD (2018) missing data from 2015 onwards the latest date is set at year 2014. The lower bound is placed at the year 1995 which is chosen for two reasons: firstly, there is no data or there are larger gaps in the Heritage Foundation (2018) and

Fraser Institute (2018) databases in prior years; and secondly, to mark a 20-year-long period for the empirical analysis. Furthermore, to be able to assess any impacts from lagged effects the entire dataset is extended where possible on both sides of the given period forming altogether a timeframe of 1990–2018. Lastly, a minor problem is related to these four sources having some country names which differ due to political and historical reasons. In such scenarios the country names employed by World Bank are preferred as this institution could be regarded as the most representative and politically correct. In short, the renamed and combined dataset consists of 36 OECD members covering the time period of 1995–2014, with a maximum analytical range of 1990–2018. Overall, given the scope of the formed dataset it offers an extensive and scalable basis to test the research question and hypotheses presented in the study. More insight into the variables and data are shared in the following subheadings.

2.2. Variables

The study will focus on the following three main variables:

- **Patents in Environment-Related Technologies (DV)** encompass a broad spectrum of technologies related to environmental pollution, water scarcity and climate change mitigation which is formed based on the analysis and evaluation by OECD (2018). The pros of employing patents as a measure of innovation is its relatively reliable link with officially declared technological developments and as such have been used extensively in measuring innovation the output of R&D, its productivity, structure and the development of specific technologies or industries (*Ibid.*). The major drawback is that patents do not necessarily mean the presence of innovation, as it is dependent on many methodological conundrums. For example, the registration and enforcement of patents is a complicated international system which for the most part depends on national regulations and assessments. The rigor of the process and subject matter coverage could therefore be highly biased (Pavitt 1988). Significant policy differences among countries also make it difficult to compare globally (OECD 2018). Additional weaknesses are tied to the innovative value of patents which at this point is extremely difficult to measure due to lack of detailed data on the matter. Certain inventor activities and motivations, such as hiding, secrecy or stalling, could also influence the number of patents registered, generating a varied and complex lagged effect which unfortunately cannot be controlled for. However, considering the extent and scale of the data available on patents in environment-related technologies the author argues that such macro level studies minimize these challenges. Finally, although some studies recommend categorising patents into smaller groups (e.g. Kleinknecht, Reinders 2012) then accounting for the economic and political differences of the various nations in the dataset as well as methodological issues mentioned above, aggregation could instead offer more reliable results than the more detailed alternative.

- **Business Freedom (IV)** is a quantitative measure which showcases the “ability to start, operate, and close a business that represents the overall burden of regulation as well as the efficiency of government in the regulatory process” (Heritage Foundation 2018). In other words, it is a generic indicator encompassing the main enterprise-related attributes of any given country which support or deter the establishment of businesses. In this regard, the Fraser Institute (2018) indicator is chosen as it has a greater variability and encompasses a larger number of relevant factors, which include credit, labour and business regulations. Its strength lies in its methodological robustness which includes having very few missing values. However, conceptually it is only able to give a general overview of the business environment and reaching more specific conclusions would need to involve testing the Fraser Institute’s disaggregated sub-indicators. The latter therefore offers opportunities to compare the various regulations and their impact on eco-innovation. This would however escape the scope of this thesis and is thus recommended for future research. As the last remark, the index falls between the range of 0 and 10, with 10 referring to the freest business environment.
- **Trade Freedom (IV)** is a composite measure which marks “the absence of tariff and non-tariff barriers that affect imports and exports of goods and services” (Heritage Foundation 2018.). The indicator therefore offers an overview of obstacles set in place for entrepreneurial trade to flourish. Considering the trade freedom score is based on two inputs, i.e. trade-weighted average tariff rate and non-tariff barriers, it is considerably less aggregated as the business freedom index and thus carries a smaller degree of the same methodological and theoretical constraints. The drawback of the indicator is its focus on foreign trade, leaving out domestic trade altogether which in countries of large populations could have a major impact on the inventors’ sales strategies. This issue could however be alleviated by using a suitable control factor, e.g. in this case domestic market size. The index values cover the range from 0 to 100, with 100 indicating the largest degree of trade freedom.

Control variables employed are the following:

- **Property Rights** is an "assessment of the ability of individuals to accumulate private property, secured by clear laws that are fully enforced by the state" (*Ibid.*), showcasing the degree to which a country's laws protect private property rights and the degree to which its government enforces those laws. This is generally regarded as one of the central pillars of liberal economics which are essential structural motivators for both innovators and entrepreneurs hoping to reap the benefits of their pursuits. The composite measure is however based on the Fraser Institute (2018) methodology, as it has greater variability in accounting for the legal framework of private property rights and its enforcement by the government. Although one could argue intellectual property rights specifically are more important for innovation as they ensure a direct reward for the technological development, this would not account the rights for assets required to undertake research and development as well as entrepreneurship. Therefore, the latter is considered to be a more important control factor than intellectual property by itself.
- **Government Spending** is measured as the level of government expenditures as a percentage of GDP, which includes consumption and transfers (Heritage Foundation 2018). Government spending often plays an important role in the level of funding attributed to country's research and development as well as social benefits required for ensuring higher worker productivity. The indicator is also used in the calculation of the gross domestic product and will therefore have a direct impact on economic growth. Based on economic intuition one could therefore assume that increased spending could lead to higher levels of innovation in environmentally-related technologies.
- **Tax Burden** is a measure of the tax rates imposed by government, encompassing "both the direct tax burden in terms of the top tax rates on individual and corporate incomes and the overall amount of tax revenue as a percentage of GDP" (*Ibid.*). Higher tax rates would arguably lead to decreased innovation and entrepreneurship as they increase the cost of starting as well as managing such endeavours. Lower tax rates would have the opposite effect. This could be offset by the nature of the taxes, for example in cases where taxes on environmental pollution are directed to eco-innovation, but this would require further study of more disaggregated data. However, due to data limitations of the Heritage Foundation (2018) variable the study will instead use **Taxes on Goods and Services** as a proxy which will allow to evaluate the impact these costs have on consumption. In this regard, higher tax rate will ultimately decrease the amount of goods and services purchased, which will increase opportunity costs and financial risks for entrepreneurs to eco-innovate.

- **Total Labour Force** comprises of people ages 15 and older who supply labour for the production of goods and services during a specified period, including people who are employed, people who are unemployed but seeking work and first-time job-seekers (World Bank 2018). The measure indicated the labour pool available for undertaking entrepreneurial activity as well as could be seen as a proxy for the relative size of the domestic market, i.e. number of consumers. One would therefore expect a considerable positive effect from this indicator.
- **FDI Inflow** refers to direct investment equity flows in the reporting economy, forming the sum of equity capital, reinvestment of earnings, and other capital (*Ibid.*). High levels of foreign direct investment inflow could be regarded as an important factor in cultivating innovation and entrepreneurial activity, as they provide the capital required to take on such objectives. The variable is based on net inflow of FDI, with the assumption that net positive gains in foreign investments will produce higher levels of eco-innovation. This would however not be the case in states where there is a higher outflow than inflow of investments, as this would mark the diversion of capital into foreign countries.
- **GDP per Capita** based on purchasing power parity (PPP) is the "sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products" (*Ibid.*). PPP is used to account for wealth differences among the world economies while employing constant 2011 international dollars allows to maintain an equal value standard for the entire modelling period. The indicator controls for the potential purchasing power of domestic consumers, with higher GDP per capita increasing consumer opportunity and ability to purchase technologically advanced goods.
- **Gross Capital Formation** (formerly gross domestic investment) consists of "outlays on additions to the fixed assets of the economy plus net changes in the level of inventories" (*Ibid.*). The fixed assets include all kinds of land improvements; purchases of plant, machinery, and equipment; the construction of private and public buildings and infrastructure. Inventories are considered to be stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales (*Ibid.*). The indicator would therefore be supportive of entrepreneurial and eco-innovation activities in cases in which it marks the improvement and increase of the capital structure available in the country's economy.

2.3. Methodology

The study will employ the Stata software package for the statistical analysis. Three main methodologies are considered to examine the proposed hypotheses and causal relationships as well as determine the highest model goodness-of-fit which are based on the assumptions presented in the study: pooled ordinary least squares (OLS), fixed effects and random effects. All of these models are commonly employed in panel data analysis. Considering the named methodologies have their own restrictions which among other factors depends on the nature and scope of the variables in the dataset then choosing the regression model for empirical analysis is performed with a commonly employed step-by-step process.

The preliminary analysis involves evaluating for any restrictions in the data which would either support or deny the use of any of the given models. Thereafter, one can begin with the first methodological phase aimed at running an F-test to decide between pooled OLS or fixed effects. Notably, the F-test is often employed to determine the most appropriate statistical model and therefore demands little additional justification. In this regard, if the results of the F-test show that the individual effects are zero then the null hypothesis is approved and employing a fixed effects method is more suitable. In the opposite instance a pooled OLS model is deemed more appropriate. When the fixed effects methodology is favoured, a Hausman test is performed in order to ascertain whether the slope coefficients of the two models being compared do not differ significantly. If the estimates are found to be considerably different, then fixed effects would be the final choice to perform the regression analysis, but in the alternative case it would be the random effects method. As the Hausman test is generally considered a reliable indicator then this too does not need further explanation.

After selecting the most appropriate statistical model based on the named tests the last step in the methodological process is to assess whether the findings of the chosen model can be deemed reliable and valid. This involves performing several robustness checks which are partially dependent on the limitations and assumptions of the respective model. However, it is a common academic practice to check the statistical model against multicollinearity, autocorrelation, heteroscedasticity and stationarity. Failure in any of these tests indicates to various challenges within the dataset which need to be tackled before one could move on to regression analysis. Such a scenario would therefore involve making amendments to the data and rerunning the model until the named robustness checks are successfully passed.

2.4. Econometric Model

Overall we can showcase the following model for the regression:

$$y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \beta_5 X_{5it} + \beta_6 X_{6it} + \beta_7 X_{7it} + \beta_8 X_{8it} + \beta_9 X_{9it} + \varepsilon_{it} \quad (1)$$

The variables which correspond to these indicators are

y_{it} – Patents in Environmentally-Related Technologies
β_0 – Intercept
X_1 – Trade Freedom
X_2 – Business Freedom
X_3 – Property Rights
X_4 – Government Spending
X_5 – Taxes on Goods and Services
X_6 – Total Labour Force
X_7 – GDP per Capita
X_8 – FDI Net Inflow
X_9 – Gross Capital Formation
ε – Residual
Indices *i* and *t* mark a specific country and time period (year), respectively.

Taxes on goods and services and gross capital formation are indicators which are percentage based, while the rest are denominate figures. Notably, some indicators could be transformed in order to accommodate for any irregularities in the variable distribution and allow for easier interpretation of results, most importantly the dependent variable. Furthermore, it is important to note the caveat deriving from the presented data and methodologies that in the ensuing interpretation and discussion of results it is only possible to make deductions about relationships between the studied phenomena but not direct causality as such analytical conclusions have not been proven for these methodologies. The thesis can now turn to the subchapter on empirical analysis where the given methodological framework is applied and assessed, which includes examining summary statistics, model regressions, robustness tests and the interpretation of results.

3. RESULTS AND DISCUSSION

In this chapter an overview is shared on the data employed in the study, which is followed by the comparison of the results by the pooled OLS, fixed effects and random effects models. After choosing the model with the best goodness-of-fit, including explanatory power, robustness checks are performed to assess the validity and reliability of the results delivered by the chosen model. The last subsection will present an analysis of the findings derived from the regression.

3.1. Summary Statistics

Looking at the data one can see that the number of observations per variable falls into the range of 679 and 1008 which gives a good baseline for taking up the task at hand (see Table 2). For analytical purposes it is useful to make a distinction between time-invariant, panel-invariant and generally variant variables which places restrictions on the models. Accordingly, within variation is time-variant or panel-invariant marking the variation over time, between variation is time-invariant or panel-variant indicating variation across individuals and overall variation depicting variation over time and individuals. A variable is time-invariant when its within standard deviation is zero and panel-invariant when its between standard deviation is zero. Looking at Table 2 it appears that all of the variables are neither, as they vary over time and across panels. Therefore, limitations from these variables do not apply. Another factor to investigate is whether there are any anomalies in the standard deviations of between and within values as well as minimum and maximum values of the between values. Between value in this regard is the estimation of unit-level averages for every unit of the variable, calculating the standard deviation for these means, while within value can be seen as the variation of a variable within units leaving out all variation between units. Looking at the standard deviations for the variables presented, they appear to be systematic and orderly. The minimum and maximum of between values of the variables are also in line with the overall values which points to a likely lack of any statistical issues in the variation of these variables. Notably, Table 2 already holds variables which have been transformed so some of the problems which occurred during data analysis have already been corrected. The challenges faced in the data are explained more thoroughly below in which regard special focus will be placed on the independent and dependent variables.

Table 2. Summary Statistics

Variable	Variation	Mean	Std. Dev.	Min	Max	Observations
Logged Environmental Patents	overall	4.65	2.13	-1.11	9.65	N = 900
	between		2.03	0.84	8.92	n = 36
	within		0.74	0.97	6.85	T = 25
Trade Freedom	overall	82.09	5.97	49.60	90.00	N = 803
	between		2.16	76.60	85.73	n = 34
	within		5.58	53.01	93.49	T-bar = 23.62
Business Freedom	overall	7.39	0.91	2.03	9.16	N = 679
	between		0.71	5.93	8.77	n = 36
	within		0.58	2.73	8.71	T = 18.86
Property Rights	overall	7.26	1.19	3.98	9.28	N = 679
	between		1.14	4.76	8.91	n = 36
	within		0.38	5.53	9.59	T = 18.86
Government Spending	overall	43.01	20.19	0.10	93.10	N = 773
	between		18.90	10.19	85.19	n = 34
	within		8.41	4.61	63.28	T-bar = 22.74
Taxes on Goods and Services	overall	31.81	8.94	2.44	62.13	N = 879
	between		7.83	3.23	45.07	n = 35
	within		4.32	11.64	52.36	T = 25.11
Logged Total Labour	overall	15.58	1.51	11.86	18.91	N = 1008
	between		1.52	12.06	18.81	n = 36
	within		0.10	15.14	15.91	T = 28
Logged GDP per Capita	overall	10.31	0.44	9.02	11.49	N = 979
	between		0.40	9.63	11.30	n = 36
	within		0.19	9.64	10.87	T = 27.19
Logged FDI Net Inflow	overall	22.52	1.92	12.26	27.32	N = 917
	between		1.53	19.29	25.77	n = 36
	within		1.20	15.49	25.88	T = 25.47
Gross Capital Formation	overall	23.47	4.37	9.82	41.54	N = 983
	between		3.03	17.70	33.30	n = 36
	within		3.20	12.08	38.79	T = 27.31

Source: Author’s calculations

The dependent variable Patents in Environment-Related Technologies and control variables Total Labour Force, FDI Inflow and GDP per Capita did not follow normal distribution. As this could interfere with the results with some methodologies, they were logged which solved the issue to an acceptable degree. Doing this for the dependent variable for example decreased its skewness from

4 to 0.1 and kurtosis from 20.1 to 2.78 (Table 3). Notably, in cases where there was only zero patents in any country in any given year the natural logarithm was taken as x + 1 to accommodate for the mathematical restriction. This is a common practice which is important to maintain the robustness of the dataset. The other reason for transforming variables is to allow for easier explanation of any impact, particularly in cases where the original variable has a wide range of values. Entrepreneurship related indicators derived from the Heritage Foundation and Fraser Institute database (2018) were not subjected to the challenge of shifting from normal distribution to such a problematic extent and thus demanded no intervention. Table 4 gives a more detailed overview of the independent variables. All variables are continuous which allows to carry on with employing the pooled OLS, fixed effects and random effects models.

Table 3. Summary Statistics: Dependent Variable (Detailed)

Logged Environmental Patents				
	Percentiles	Smallest		
1%	0.00	-1.11		
5%	1.31	-0.69		
10%	2.01	-0.69	Obs	900
25%	3.04	-0.69	Sum of Wgt.	900
50%		4.73	Mean	4.65
		Largest	Std. Dev.	2.13
75%	5.92	9.59		
90%	7.79	9.60	Variance	4.55
95%	8.63	9.61	Skewness	0.10
99%	9.46	9.65	Kurtosis	2.78

Source: Author's calculations

The dependent variable has a substantial 900 observations falling into the upper range of the maximum range of observations. This also means there are zero missing values for the dependent variable which is a positive sign regarding the variable robustness. The independent variables cover a smaller range of data the reasons for which have already been explained in the 2.1. Dataset subchapter. At the same time, it is notable that their mean, standard deviation and value range differ considerably. This is due to having different methodologies for their calculation. Out of the control variables, Gross Capital Formation, GDP per Capita and Labour Force Total have the highest number of observations, which largely due to the focus they receive by economists and therefore is also essential in the World Bank data collection process (2018).

Table 4. Summary Statistics: Independent Variables (Detailed)

Trade Freedom				
	Percentiles	Smallest		
1%	59.00	49.60		
5%	73.00	55.00		
10%	77.00	57.00	Obs	803
25%	78.60	57.00	Sum of Wgt.	803
50%	82.40		Mean	82.09
		Largest	Std. Dev.	5.97
75%	86.90	90.00		
90%	87.90	90.00	Variance	35.62
95%	88.00	90.00	Skewness	-1.63
99%	90.00	90.00	Kurtosis	7.09
Business Freedom				
	Percentiles	Smallest		
1%	4.53	2.03		
5%	5.74	3.42		
10%	6.22	3.58	Obs	679
25%	6.89	4.22	Sum of Wgt.	679
50%	7.49		Mean	7.39
		Largest	Std. Dev.	0.91
75%	8.04	9.07		
90%	8.49	9.11	Variance	0.84
95%	8.66	9.11	Skewness	-1.06
99%	8.92	9.16	Kurtosis	5.55

Source: Author’s calculations

Considering that after a few transformations the data appears to be robust, the thesis can move on with the regression analysis.

3.2. Regression Analysis

To choose between fixed effects or pooled OLS one should start with the F-test, which assesses the joint significance of the fixed effects intercepts. As a reminder, the null hypothesis states that all of the fixed effects intercepts are zero which would deny the need for fixed effects. After running the F-test the results indicated the alternative premise holds and thus fixed effect has a better methodological fit vis-à-vis the pooled OLS model (see Appendix 1). Next the Hausman test is performed to compare the slope coefficients of the fixed and random effects models. As these figures do not differ significantly fixed effects will be chosen to proceed with the analysis. These deductions are further corroborated by the relatively adequate goodness-of-fit and strong preliminary results of the fixed effects model (see Appendix 1). Notably, GDP per Capita and

Government Spending did not come into the fixed effects model and as they weakened the model results and stats they were taken out from the presented regression results.

The within R-squared of the model is 0.57 (see Appendix 1) which indicate a moderately good representation of the variance of the dependent variable caused by the independent and control variables. There are some explanatory factors missing but considering the number of various indicators that determine eco-innovation, the lack of more appropriate data and the diversity of the sample then this could be considered acceptable. Notably, the F-test which is a division between the model Mean Square and residual Mean Square has the value 81.77 which is statistically significant at more than 99%. The model and residual degrees of freedom visible in the F-statistic parentheses, with the values 7 and 428 respectively, are also a cause for no alarm. This provides additional support for choosing the fixed effects method for our empirical analysis.

3.2.1. Robustness Checks

To ensure the reliability and validity of these results one must also check for multicollinearity, heteroscedasticity, autocorrelation and stationarity. Multicollinearity is a situation where there is a high level of inter-correlation between the independent variables, which could give inaccurate coefficients, inflated standard errors and ultimately skewed results. For this purpose, normally we calculate the variance inflation factor (VIF), which showcases the degree collinearity increases variance of the coefficients for the independent and control variables. However, due to limitations of the methodology this test cannot be used on fixed effects models. This issue is usually bypassed by a correlation matrix of the variables, which gives a tentative overview of any problems that might occur. The correlation matrix reveals that there might be a small multicollinearity problem with the Property Rights and Business Freedom as well as logged FDI Inflow and Total Labour Force variables (see Appendix 2). However, as the significance levels of these variables are high and the fixed effects smooths out smaller multicollinearity issues then this is nothing major to be concerned about.

Heteroscedasticity is a circumstance in which the residuals spread systematically over the range of measured values. As one of the assumptions of the fixed effects methodology is that residuals have constant variance, then the lack of homoscedasticity would diminish the validity and reliability of the regression results. Unfortunately, the heteroscedasticity test with over a 99% significance accepts the null hypothesis of the residuals being heteroscedastic (see Appendix 3). This issue can either be overcome by adding any missing variables which influence the degree of eco-innovation into the model and would thus eliminate the current heteroscedasticity, or diminished greatly by employing robust standard errors in the regression calculations. As the data available does not allow a lot of flexibility in including other variables then the latter option is taken.

Autocorrelation is the systematic effect random errors have over time, indicating whether there are any time factors missing from the model. This is another important criterion for ensuring the independence of the model results. By running the Woolridge test, which is suitable for employing in case of panel data, one can see that the F-values fall between the necessary criteria range, while it has a statistical significance of over 99%. This however means the alternative hypothesis of the model having autocorrelation is confirmed (see Appendix 4). The remedy for this situation is similar to the one with the heteroscedasticity issue, while there is an additional caveat that one should employ clustered robust standard errors. The final test to take up is to ensure the model variables are stationary.

Panel data as with other types of time series data needs to be stationary. This is a condition in which the mean, variance and autocorrelation structure remain the same over time. Stationary data lacks any type of periodic fluctuations or trends in the given attributes. This is usually tested using the Levin–Lin–Chu or Harris–Tzavalis test. This can be done for the dependent and control variables, but unfortunately not with the independent variables, because it appears the latter data is unfortunately not strongly balanced. For these variables Fisher-type or Im–Pesaran–Shin test is recommended as these also allow the dataset to be unbalanced. Taking a closer look at the unit-root test results for dependent variable it is clear there are no issues for the given variable as the null hypothesis is rejected (see Appendix 5). The independent variables also reject the null hypothesis of the Im–Pesaran–Shin tests and the control variables do the same in their respective tests. The conclusion of these unit-root checks therefore is that the data is stationary. No intervention with a time-corrective variable, such as trend or ramp, is thus required. This includes lagging some of the variables which together with findings from many previous empirical studies (e.g. Moro *et al.* 2019) appears to be methodologically unnecessary.

3.2.1. Models and Results

The last step is to now use the methodological findings to provide a new model taking into account for the shortcomings of the preliminary model and data, while offering a test of robustness for the independent variables by examining whether the results hold for their respective models. One can see in Table 5 that the relationship for the independent variables remain, despite employing clustered robust standard errors. Furthermore, the main results of the fixed effects models 1 and 2 are consistent with the random effects models 3 and 4 which are included in order to provide more reliability to the findings. This observation excludes two control variables out of which Property Rights became statistically insignificant, whereas Taxes on Goods and Services remained significant at the confidence level 90% only in the Business Freedom random effects model 4. Considering the results of the methodological and robustness checks, the following analysis will take the fixed effects model as the basis of analysis. Overall, while keeping in mind the models' limitations one can find that the models have an acceptable degree of the validity and reliability and therefore proceed with the analysis of the findings.

Table 5. Regression Comparison

	Model 1 – FE	Model 2 – FE	Model 3 – RE	Model 4 – RE
tradefree	0.0321***		0.0513***	
	(0.00696)		(0.00892)	
busfreedom		0.223**		0.352***
		(0.0739)		(0.0730)
legalsysproprights	0.0784	0.149	0.101	0.150
	(0.0835)	(0.109)	(0.0912)	(0.123)
taxgoodsserv	-0.00792	-0.0133	-0.0117	-0.0230*
	(0.00601)	(0.00724)	(0.00797)	(0.0106)
ln_labtot	3.625***	4.462***	1.149***	1.379***
	(0.626)	(0.653)	(0.117)	(0.176)
ln_fdinetinflow	0.0713**	0.0743**	0.0947***	0.134***
	(0.0232)	(0.0242)	(0.0236)	(0.0321)
grosscapform_pct	-0.0347**	-0.0459***	-0.0318**	-0.0505***
	(0.0116)	(0.00856)	(0.0111)	(0.00744)
Constant	-55.30***	-67.49***	-19.01***	-21.39***
	(9.736)	(10.80)	(2.512)	(3.678)
Observations	468	530	468	530
Adjusted R^2	0.553	0.595		

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Source: Author's calculations

3.4. Interpretation and Discussion of Results

The model indicates a positive relationship between entrepreneurship and eco-innovation. Although the impact might seem small at first glance then the logic behind the figures proves otherwise. Namely, a unit increase of business freedom and a unit increase of trade freedom will respectively lead to an approximately 25% and 3.3% increase in the number of patents in environmentally-related technologies in any random country in any given year[1]. Both hypotheses have thus been confirmed albeit the effect by the former appears to be much stronger. This is due to the business freedom variable having a ten times smaller scale than the trade freedom variable, so the taking this into consideration the overall impact is in much closer range. Business freedom supports eco-innovation and thereby green growth, as it is one of the key elements in the current capitalist society. This is to be expected as the ease of doing business, including opening, managing and closing enterprises will reduce the costs of running a company as well as reduces risks associated with bringing new innovations to the market. As access to capital plays a major role, while depending on the country's political and economic model these financial and human resources for the most part belong to the private sector (e.g. Piketty 2014), then government regulation and enforcement of laws plays a supervisory and distributional role. In other words, the less there is government involvement in business affairs the easier it is for entrepreneurs to eco-innovate, although this also depends on the number and quality of public goods the government provides, such as infrastructure, rule of law, educated workforce among others. From a negative side, the level of corruption will hinder the entrepreneurial spirit to innovate, because it increases monitoring and transaction costs which restrict trade opportunities (Anokhin, Schulze 2009).

Trade freedom furthers eco-innovation as increases the market size of the entrepreneurs and sometimes even allows to establish new markets. As backed by the regression results, lower tariff rates and non-tariff barriers will make it easier to trade goods and services, which includes both imports and exports. More specifically, higher trade freedom opens the door for more innovation entering the domestic market through goods and services imported as well as opportunities to export products and services produced in the country. As the entire process is made easier it would also lower the cost of bringing new products and services to the domestic market, as it reduces the risks associated with being handicapped by domestic demand while increased competition pushes entrepreneurs to constantly develop new products and services and improve those already in the market. Given the numerous positive effects of trade freedom one should not disregard the

[1] Percentages are calculated based on exponentials $e^{0,223}$ and $e^{0,0321}$ for business and trade freedom, respectively.

challenges and reasons behind why the impact in the regression results could be seen moderate. Higher trade freedom could also bring cheap alternatives to the domestic market, making it harder for eco-innovative products and services to compete as well as increasing the cost of developing green innovation. These products also often have a larger ecological footprint offsetting the positive role trade freedom plays in furthering green growth, not to mention the environmental damage caused by the transport and logistics sector among other factors.

As to be expected, out of the control variables total labour force had the strongest positive impact in advancing eco-innovation in the sample countries during any given year. Total labour force is a measure of the size of the labour pool available for entrepreneurial activity. It comprises of both the number of workers in the job market which are required to produce goods and offer services as well as the potential number of entrepreneurs pursuing personal gains through developing new innovations. Total labour force is also a good proxy for understanding the size of the domestic consumption market, as people in the employment age bracket are for the most part also the largest consumers in society. Although there could be exceptions, in most cases children younger than 15 are unlikely to produce the bulk of consumption. The regression results could not be disaggregated to which sub-elements specifically total labour force supportive role falls, but in either case it is a strong prerequisite for entrepreneurial success. GDP per capita (PPP) which arguably gives an overview of the importance of domestic purchasing power, where wealthier nations are more inclined to cultivate eco-innovation, did not come up in the model. This is because it was correlated with the independent variables and took out the relevant regression results. Considering that innovation has high upfront costs, then we would have expected it to follow previous research on the matter (e.g. Sierzchula *et al.* 2014), because wealthier consumers will be able to cover the initial higher cost of the innovative products and service. Once the eco-innovative product and/or service is put into mass production and/or offering, then the cost of it will naturally go down and will become affordable to a wider range of consumers. In short, this relationship remains uncorroborated likely due to limitations and peculiarities of the data on the independent variables, as well as the effect they had on the model. Taking all of the above into consideration, the variables of Trade Freedom, Total Labour Force and GDP per Capita can be seen as hard to compare because of their different sources and methodologies. However, based on previous research and current findings one could tentatively propose that the size and purchasing power of the domestic market could in average be more important than access to foreign markets. This does however make sense from the perspective and potential of having lower transportation costs.

Foreign direct investment appears to have a positive role in furthering eco-innovation. As FDI is often regarded an important element in ensuring production growth (e.g. Iamsiraroj, Ulubaşoğlu 2015) this result corroborates the same economic logic. However, one should note the strength of this relationship could be somewhat diminished by two reasons. Firstly, the variable is in essence the net inflow of FDI meaning it is the difference between capital invested abroad by domestic investors and in the target country by foreign investors. In cases where the capital inflow and outflow are extensive, net inflow of FDI could be low or even negative, which does not necessary mean that the value of investment is such as well. Secondly and lastly, the impact of FDI net inflow could be reduced by effects from other investments such as government spending or gross capital formation. This could particularly be the case for countries with large domestic markets as well as those in which entrepreneurs are more dependent on investments by their constituent government and local investors than FDI inflow.

The study's prediction of the increase in gross capital formation to advance eco-innovation due to the latter being dependent on the country's capital structure has proven to have the opposite effect. As a reminder, gross capital formation comprises of the development of fixed assets as well as net changes in the level of inventories (World Bank 2018). The former includes improvements to the country's infrastructure, but also investment into land, equipment and buildings, which in other words also leads to capital being placed into large-scale projects. This in turn could be seen as a competition ground between existing technologies and innovation, in which case the negative impact indicates that the larger share of capital being expended on the former, diminishing its full potential for eco-innovation and green growth. This marks an opportunity cost and an opportunity lost to furthering eco-innovation in the land, construction, infrastructure and machinery sectors, while it would have less and indirectly relevant to other segments of the economy. At the same time, net changes in the level of inventories arguably has had a smaller effect on eco-innovation, but the direction of the effect remains unknown due to limitations of the variable. However, this could be more impactful for eco-innovative products related to certain types of manufacturing, such as electric cars. Overall, this distinction between fixed assets and inventories in comparing the effect it has on eco-innovation and green growth is a notion which should of course be investigated and tested in future research.

Property rights is a much-studied field in patent-related research and one would have expected to receive results which corroborate the usual underlying prerequisite for innovation (e.g. Chen, Puttitanum 2005). The insignificant model results are likely caused by the variable which differs from the commonly studied protection of intellectual property provided by the World Intellectual Property Organization. This data was however not employed due to it being restricted to the public. The main idea behind the expected impact lies in the fact that the right for private property and its enforcement by the government will give incentives to entrepreneurs and innovators to develop new inventions in order to obtain profits and other gains. When entrepreneurs are awarded with payments from the fruit of their innovation, they will naturally strive to bring such creations into fruition. From another perspective, property rights also help to ensure security for the investments made into innovative endeavours, which involves all of its typical stages including placing financial capital in an enterprise, construction of infrastructure for production and securing returns among other factors. Lack of private property could be replaced by gains given by the state. However, many examples in history have shown, including the Union of Soviet Socialist Republics, such a model cannot compete with the free-market capitalist system. Overall, it is recommended to continue studying this causal relationship to test the given economic logic.

Tax burden using the Heritage Foundation (2018) data was excluded from the model due to unreliable results deriving from data limitations. The economic logic is that higher tax rates on corporate incomes will increase the cost of developing eco-innovative products and services, while also providing incentives to turn to other sources of revenue. In other words, entrepreneurs are less likely to place time, energy and capital into pursuing profits through innovation in cases where the tax rate will start to diminish their returns. From a consumer standpoint, the impact from the proxy taxes on goods and services remains uncorroborated, though it showed weak significance in random effects Model 4. As in accordance with microeconomic principles, higher tax rates on goods and services will increase the price of these goods and services while simultaneously decreasing consumer purchasing power, which in turn shrinks the potential market for eco-innovative products. This means that it will become more costly, difficult and risky for enterprises to invest in innovation and therefore one would expect to see a negative impact. As eco-innovation is generally more expensive than other types of innovations due to a smaller market size, then increased tax burden will hurt this segment more than others which will ultimately have a negative effect on green growth as well. However, this negative externality could be offset by the structure of the tax system in which case special deductions on environmentally friendly goods and services vis-a-vis others could have the opposite effect. The original tax burden variable also accounts for the percentage tax revenue forms of the GDP in which case similar logical links could be deduced. The caveat being that higher degree of tax revenue could direct capital away from private markets into providing public goods (or in worse cases lost to corruption) which could potentially mark a lost opportunity in terms of investments into eco-innovation. Tax burden in short is another aspect that should be examined further from a more disaggregated perspective.

Government spending was taken out of the model, due to its destabilising impact on the independent variables and very high p-value in the final model. This has likely been caused by the nature and structure of the aggregated variable provided by the Heritage Foundation (2018) and more disaggregated data is likely to provide more valuable insights. Interestingly, in all of the tested models the impact of government spending was negative which seems a bit counterintuitive at first, considering that academia and research play an important role supporting all types of innovation (e.g. Guo *et al.*, 2016). However, as with tax burden the key lies in how the government coffers are employed. If the bulk of the government spending goes for example into providing social safety nets, including retirement and healthcare, then this is less effective for furthering both entrepreneurship and eco-innovation. In other words, many of the government spending articles could be seen as an alternative cost to investments into innovation and green growth. Another issue is related to how effectively government resources are used, which includes capital lost into upholding large bureaucratic machines, corruption inside institutions, ineffective investment programmes and other financial pits. However, as with other deductions in the study which are based on aggregates this should be investigated further with more granular data.

CONCLUSION

The objective of the study was to examine which economic factors of entrepreneurship support eco-innovation and green growth. The focus was placed onto business and trade freedom, investigating into how these contribute to the number of patents filed in environmentally-related technologies. The regression results confirmed the positive impact these two attributes have on increasing eco-innovation in the sample countries. The thesis proposed that the role played by business freedom ties into the ease of doing business and costs associated with opening, managing and closing enterprises. When entrepreneurship, i.e. running a business, is supported within societies, it increases opportunities for entrepreneurs to bring new innovative products and services to the market. It also cultivates process-based eco-innovation by lowering costs to existing businesses to follow government regulations on safety and other elements. Furthermore, it increases competition in the market which is beneficial for both consumers and businesses, in which case the latter needs to account for the price and quality demands of the former. Trade freedom in turn increases the size of the market available for entrepreneurs, which lowers the financial risks and capital costs of producing eco-innovative products and/or services. The impact of free trade could be offset by the relatively large and wealthy domestic markets, in which case entrepreneurs could be covered by the demand of domestic consumers. However, in light of increasing globalisation and international competition one could argue that by the end of the day a larger market will still offer a higher cost-benefit ratio as well as more secure source of revenue. This also includes the fact that the eco-market in particular is still relatively small in comparison to the general market, but also about entrepreneurs being prepared and accustomed to market pulls and pushes caused by consumer demands and competitor activities.

The study also corroborated the positive impact of total labour force and FDI net inflow have on eco-innovation. Total labour force marks the relative size of the domestic job and consumer markets, while GDP per capita indicates the purchasing power of the nation at hand. Although the latter was excluded from the model due its destabilising effect on the independent variables, based on previous research and current results one could deduce that both of these attributes decrease the risks associated with eco-innovative entrepreneurship, most importantly by driving down costs and ensuring confidence in the consumer market. FDI net inflow marks the importance of investment into eco-innovative ventures, as investment capital plays an important role in financing the development of new products and services. The model results indicate that eco-innovation is negatively affected by gross capital formation, which is linked with investments into fixed assets and changes in net inventories. Out of these the former is likely to have a more important role in directing capital into other types of technologies and practices, while the latter could be a marking of the current and potential market share for eco-innovative products and services.

Property rights and tax burden produced inconclusive results, while government spending was excluded from the model due to its destabilising impact. Property rights arguably offers security for establishing and maintaining enterprises, investing into new ventures and collecting the gains derived from technological improvements. Higher tax burden would theoretically increase the costs of doing business, including investing into innovation, while higher taxes on goods and services would also decreasing consumer purchasing power and therefore market potential. The impact of government spending depends on the target of the expenditure, in which case investing into sustainable energy sources and research would likely increase eco-innovation, but in general higher government spending could be seen as an alternative cost to such investments. These relationships in short demand further attention by future scholars with more granular data.

As concluding remarks, the thesis could be considered as one of the first large-scale quantitative studies on the topic of entrepreneurship, eco-innovation and green growth, covering a considerable research gap. At the same time, the thesis is only able to provide theoretical explanations and empirical evidence to the relatively generic relationships found between entrepreneurship and eco-innovation. Further research on more disaggregated data is strongly advised on all of the covered independent and control variables. Considering that the main hurdle for the given inquiries is the absence of this type of reliable data, then future researchers are advised to start by overcoming this challenge.

KOKKUVÕTE

ETTEVÕTLUSE KAUDU ROHELISE KASVUNI: KESTLIK MAJANDUSARENG LÄBI ÖKOINNOVATSIOONI

Riho Palis

Valitsev lineaarse majanduskasvu mudel ei ole jätkusuutlik, sest eeldab piiramatute ressursside olemasolu ja ei arvesta piisaval määral keskkonnakahjusid. Sellega seoses on välja pakutud alternatiivseid lähenemisi nagu näiteks ringmajandus. Samal ajal on oluline roll ka ettevõtlusel, mis on suunatud ökoinnovatsioonile ja rohelisele kasvule. Seda valdkonda on mõnikümmend aastat uuritud, kuid ometi esineb antud teemal vähe globaalseid kvantitatiivseid analüüse. Käesoleva magistritöö eesmärk on see puudujääk katta, keskendudes ettevõtlust toetavatele tingimustele, mis edendaksid ökoinnovatsiooni ja rohelist majanduskasvu. Täpsemalt hinnatakse ettevõtlus- ja kaubandusvabaduse taseme mõju, kuid analüüsitakse ka muude strukturaalsete tegurite tähtsust.

Püstitatud eesmärgi täitmiseks kasutatakse uurimuses Fraser Instituudi, Heritage Fondi, Maailmapanga ning Majanduskoostöö ja Arengu Organisatsiooni andmeid. Koostatud andmebaas hõlmab 36-t OECD liikmesriiki, andmed on pärit ajavahemikust 1995–2014. Sõltuvaks muutujaks on valitud keskkonnateemaliste tehnoloogiate patentide arv ning sõltumatuteks muutujateks ettevõtlus- ja kaubandusvabaduse tase. Töös kasutatakse paneelandmete hindamisel kolme peamist mudelit: ühendatud vähimruutude meetodit, fikseeritud mõjude hinnangut ja juhuslike mõjude hinnangut. Selleks viiakse läbi mudeli usaldusväärsuse ja täpsuse testid, mille tulemusena valitakse välja fikseeritud mõjude hinnang.

Regressiooni tulemused kinnitavad püstitatud hüpoteese – nii kõrgem ettevõtlus- kui ka kaubandusvabadus toetavad ökoinnovatsiooni ja seeläbi rohelist majanduskasvu. Lisaks tuvastab uurimistöö positiivset mõju järgmiste kontrollmuutujate poolt: tööjõud ja välisinvesteeringud. Negatiivselt toimib kapitali kogumahutus. Kinnitamata jääb maksukoormuse ja omandiõiguste

suhe ökoinnovatsiooniga. Mudelist jäävad välja riigi kulutused ja SKP elaniku kohta. Kuna antud suhted põhinevad agregeeritud andmetel, saab käesolevaga tuvastada ja esitada ainult üldisemaid seaduspärasusi. Sellest tulenevalt soovitab uurimistöö järgnevateks analüüsideks keskenduda suurema eristatavusega andmete kogumisele ning hindamisele.

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APPENDICES

Appendix 1. Fixed Effects Model and F-test

```
Fixed-effects (within) regression               Number of obs      =       468
Group variable: id                              Number of groups   =        33

R-sq:  within  = 0.5722                         Obs per group: min =         8
       between = 0.6888                                        avg =      14.2
       overall = 0.7049                                        max =        16

                                                F(7,428)           =     81.77
corr(u_i, Xb)  = -0.9665                        Prob > F           =    0.0000
```

ln_envpat	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
tradefree	.0259441	.0049433	5.25	0.000	.0162279	.0356602
busfreedom	.1625031	.0449722	3.61	0.000	.0741093	.2508969
legalsysproprights	.113862	.0539144	2.11	0.035	.0078921	.219832
taxgoodsserv	-.0109019	.0054012	-2.02	0.044	-.0215181	-.0002858
ln_labtot	3.639049	.3267546	11.14	0.000	2.996806	4.281293
ln_fdinetinflow	.0625093	.0171149	3.65	0.000	.0288696	.096149
grosscapform_pct	-.0355515	.0055968	-6.35	0.000	-.046552	-.0245509
_cons	-56.1567	4.948331	-11.35	0.000	-65.88275	-46.43064
sigma_u	4.2538037					
sigma_e	.35337203					
rho	.99314634	(fraction of variance due to u_i)				

```
F test that all u_i=0:     F(32, 428) =     67.66             Prob > F = 0.0000
```

Source: Author's calculations

Appendix 2. Correlation Matrix

	Trade Freedom	Business Freedom	Property Rights	Taxes on Goods and Services, Percentage	Logged Total Labour	Logged FDI Net Inflow	Gross Capital Formation, Percentage
Trade Freedom	1.00						
Business Freedom	0.34	1.00					
Legal System & Property Rights	0.15	0.51	1.00				
Taxes on Goods and Services	-0.13	-0.17	-0.17	1.00			
Logged Total Labour	-0.09	-0.04	-0.19	-0.43	1.00		
Logged FDI Net Inflow	0.13	0.26	0.19	-0.43	0.58	1.00	
Gross Capital Formation, Percentage	-0.17	-0.01	-0.06	0.15	-0.14	-0.13	1.00

Source: Author's calculations

Appendix 3. Modified Wald Test for Groupwise Heteroscedasticity in FE Regression

```
H0: sigma(i)^2 = sigma^2 for all i

chi2 (33)  =    4839.82
Prob>chi2 =      0.0000
```

Source: Author’s calculations

Appendix 4. Wooldridge Autocorrelation Test in Panel Data

```
H0: no first-order autocorrelation
    F(  1,       32) =     12.136
           Prob > F =      0.0015
```

Source: Author's calculations

Appendix 5. Levin-Lin-Chu Unit-Root Test

```
Ho: Panels contain unit roots                Number of panels  =     36
Ha: Panels are stationary                    Number of periods =     25

AR parameter: Common                         Asymptotics: N/T -> 0
Panel means:  Included
Time trend:   Not included

ADF regressions: 1 lag
LR variance:     Bartlett kernel, 9.00 lags average (chosen by LLC)
```

	Statistic	p-value
Unadjusted t	-8.6394	
Adjusted t*	-5.8572	0.0000

Source: Author's calculations