Master Thesis

Political and Institutional Drivers of Business Enterprise R&D Expenditures in the Electrical Equipment Division of the Manufacturing Sector

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An industry-level empirical research on private-sector R&D Activity

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Abstract

This study empirically examines the political and institutional drivers of privately financed R&D investment behavior in the electrical equipment division of the manufacturing (EEM) sector with an emphasis on the roles of intellectual property protection, human capital formation, international trade openness, and direct government funding using rich unbalanced panel data of industry-specific business enterprise R&D expenditures of 12 OECD economies spanning the period 2000 to 2016. Unlike previous work, the effectiveness of a specific set of European Union (EU) policy initiatives targeted at the EEM-sector is also subject to investigation by applying a difference-in-differences approach. Consistent with theoretical predictions, empirical evidence advocates the conventional view that intellectual property rights protection, as well as human capital formation, have a spurring effect on business R&D intensity irrespective of the type of specification, thus, being important institutional predictors. Interestingly, the econometric analysis unambiguously indicates a significantly negative association of direct government funding with industry-specific R&D activity suggesting an inducement of crowding-out rather than additionality effects. Adding to this, no statistical confirmation has been found in terms of the difference-in-differences estimator providing no evidence in favor for a significant effect of the EU research funding initiatives on EEM sector business R&D spending. Against expectations, the research was incapable of drawing explicit conclusions on the relationship of international trade openness to R&D activity, and ultimately, to find empirical support for trade openness to be an essential and robust determinant.

Keywords

R&D, innovation, intellectual property protection, government support, trade openness, endogenous growth, national innovation systems, electrical equipment manufacturing sector

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1. Introduction

A notable acceleration of technological change characterizes recent times in modern economies. In light of increasing competitive pressure on the rate and scope of innovation, such dynamics cause economic activities to be more extensively focused on the creation and distribution of knowledge than ever before. In this context, business research and development (R&D) activity allows for strategic knowledge accumulation as well as systematic knowledge exploitation, and thus, is considered a key determinant of the aforementioned velocity of technological advance. As specified by the Organisation for Economic Co-operation and Development (OECD, 2015), R&D is defined as "creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of man, culture and society – and to devise new applications of available knowledge". R&D activity, therefore, is the sum of all these deliberate undertakings with each of them being classified into one of the three main sub-activities: basic research, applied research, and experimental development. Interestingly, not only the academic theory of mainstream economics indicates R&D to be an engine of economic growth, but also a growing body of recent empirical evidence confirms investment in R&D to be associated with economic prosperity (Coe & Helpman, 1995; Coe, Helpman & Hofmeister, 2009; O'Mahony & Vecchi, 2009; Bravo-Ortega & Martin, 2011; Kahn, 2015). Against this background, modern governments, highly valuing its effects, increasingly attempt to support (business) R&D investment by means of economic-political instruments in recent years (Belitz, 2016).

However, public policy establishment and funding directed towards encouraging private sector R&D activity is not only undertaken on the national level. That is, supra-national state actors like the European Commission take a pragmatic interest in R&D policy and investment priorities (European Commission, 2003, 2004, & 2010). In recent times, these become manifest in substantial research programs such as Horizon 2020 as part of the European Union's (EU) growth agenda Europe 2020. Aside from economic growth targets, initiatives of that kind are predominantly motivated by the need to face current structural and systemic weaknesses emerging as universal environmental sustainability challenges.

Rooted in the importance of R&D for innovation and sustainable growth, past decades have seen a growing body of empirical work within this field of research. Much of the existing literature deals with a theoretical and experiential debate about country-level differences in R&D intensity (Becker, 2015) in order to explore why some economies show more business R&D activity than others. Thus far, one of the main empirical concerns is a lacking consensus on the driving factors of private-sector R&D investment. Particularly, there is a scarcity of empirical knowledge about the determinants of R&D expenditure at the industry and national level (Becker & Pain, 2008). A reason for this might be the prevailing firm-level perspective taken by the majority of existing evidence. As a consequence of the deficient systematic understanding in this research area, national and supra-national policy actors are impeded in their attempt to effectively promote private R&D investment.

This being said, in-depth empirical exploration of specific R&D intensive industries that, next to their economic importance, have high strategic relevance in the context of sustainability is of high value from a political standpoint. Specifically, this applies to the electrical equipment manufacturing sector (EEM) which comprises product fabrication related to electrical power generation, distribution, and usage. Due to its diversified and heterogeneous nature, the industry encompasses a wide variety of manufacturing processes and products with electric motors, batteries, lighting equipment, and domestic appliances as the most visible. However, less visible products including wiring devices, electric generators, as well as distribution apparatus account for a considerable part of the market because of comparatively high product value. Showing large differences in business models and supply-side structure, the industry sub-sets cover different markets and thus customer bases causing demand to be driven by a multiplicity of factors (European Competitiveness and Sustainable Industrial Policy Consortium [ECSIP], 2013). Even though demand and production have their origins in mature markets of Western Europe and North America, past decades have shifted the industry focus to the Asia Pacific region. That is, as a result of increasing levels of industrialization and urbanization, electrical equipment companies have found an immense potential for growth in the emerging Asian markets. Evolving product market opportunities have also caused new competitive pressures within the industry which is why the sector is experiencing a continued momentum of mergers and acquisitions in recent times. Given this, there is a rising need for Western countries to stay on the leading edge of development, and thus relevant and competitive in times of the occurring transformation within this knowledge-intensive sector.

Next to the economic importance of recent developments, however, electrical equipment manufacturing is also characterized by an environmental pertinence in times of climate change, diminishing fossil fuels and changing consumer expectations. On the one side, this industry's waste has emerged as one of the most abundant waste streams worldwide with forecasts of more than 12 million tons by 2020 which can provoke environmentally harmful implications unless properly managed (European Commission, 2018). On the other side, the industry is an enabler to technical change and thus holds high potential for making a severe impact on sustainable advancement by developing and improving sector-specific core products and climate change technologies. As a consequence, the industry plays an essential role as a supplier of innovations for downstream industries (ECSIP, 2013). Rooted in the strategic importance as well as recent developments, the research program Horizon 2020 mentioned above is aimed at directly impacting several sub-sets of the electrical equipment manufacturing industry through numerous implemented EU research funding initiatives such as the European Green Vehicle Initiative, Photonics21, or Factories of the Future (ECSIP, 2013). For these reasons, not only understanding the driving forces of a country's business R&D intensity but also the effectiveness of specific policies targeted at the manufacturing sector of electrical equipment turns out to be highly valuable, notwithstanding that a scarcity of empirical work in this area is prevalent.

Following this, the purpose of this research is to empirically analyze the research question: what are the institutional and political drivers of a country's business R&D expenditure in the electrical equipment division of the manufacturing sector? Herewith, several contributions to existing literature that explores the driving forces of private R&D activity are made. First, analysis of more recent data allows for verification of findings from that of previous work. Second, contested variables, as well as measures used to operationalize theoretical concepts, are subject to evaluation. Third, the empirical exploration goes beyond the scope of previous research through the evaluation of a broad set of supra-national policies with the potential of spurring private R&D. Fourth, besides the innate theoretical and academic relevance, this study facilitates the understanding, coherence, and adjustment of an economy's institutional framework in its endeavor to promote private R&D activity from a political standpoint.

Therefore, the paper has been organized in the following way. In section 2, the conceptual framework of the study is set up that includes the provision of the theoretical foundations as well as an overview of previous literature in the field of research. Based on this, section 3 addresses the methodology used in this study, and hence, delineates the model specification, data, as well as econometric approach used. Hereupon, section 4 outlines obtained econometric results that are subject to discussion in section 5. Finally, section 6 comprehensively concludes with a recapitulation of main findings and their implications.

2. Conceptual Framework

2.1 Theoretical Background

What follows is an introduction of the underlying theories relevant to this study in order to set a clear theoretical foundation for the subsequent empirical work. By bringing the most critical elements of each theory regarding the research topic into focus, a thorough understanding of the logic and pertinence underpinning each theory is established. This, in turn, identifies and sets the boundary conditions needed to allow for the buildup of an explicit and logical argumentation in a subsequent step.

As one of the most critical components of macroeconomic theory, a body of literature has been published that theoretically intends to explain the existence of long-run economic growth. However, it was not until the mid-twentieth century that the theoretical discussion about the rationality for technological change as a key factor of the phenomenon gained momentum. More specifically, the development of this strand of literature has emerged with the pioneering works of Robert Solow and Trevor Swan in the context of neo-classical growth theory (Solow, 1956; Swan, 1956). In an endeavor to provide a theoretical foundation for understanding the growth of economic output and differences in per capita output, the Solow-Swan Model relies on the neoclassical aggregate production function (Acemoglu, 2008, p.26). Although accentuating the need for technological change, and thus research and development activities for long-term growth, the model generates per capita output and capital growth only by introducing exogenous technological progress. That is, by giving no explanation of how technological changes occur, the rate of growth is determined outside the model. As a consequence, the Solow-Swan Model does not allow to analyze the underlying determinants of technological progress.

In response to the aforementioned shortcomings of the neoclassical conceptualization, a set of literature has attempted to endogenously model the medium of technological discovery and progress in order to arrive at a more realistic depiction of the complex process of technological change (Romer, 1986, 1990; Grossman & Helpman, 1991; Aghion & Howitt, 1992). Known as endogenous growth theory, these conceptualizations of economic growth form the theoretical basis of the majority of empirical work on the determinants of R&D activity by reason of bringing R&D into the economic growth model. Crucial in these formulations is the fact that growth depends on investment decisions for R&D activity as well as the degree of monopolistic power while assuming a company's profit maximization intentions. This, in turn, means that endogenous growth theory, as opposed to its neoclassical predecessor, incorporates an imperfectly competitive framework into the production function within which the ability to commercialize innovation has an impact on the stimuli to invest in R&D. By doing so, endogenous growth theory stresses the importance of a country's institutional framework for encouraging deliberate R&D investment and, ultimately, technological progress. A crucial implication of this theory, therefore, is an assumed effect of government intervention meaning that economic policies and market structures influence the rate of growth. Explaining country-level variations in the ability to apply technological knowledge by actions of economic agents and policymakers, endogenous growth theory justifies an active role of the state in promoting private R&D activity.

Another strain of theoretical approaches that intends to break with the neoclassical orthodoxy in its attempt to explain the sources of technological progress emerged in the late nineteen-eighties and gathered momentum in the subsequent decade with scholarly work by Nelson (1993), Freeman (1995), Edquist (1997) and Lundvall (1992). Referring to national innovation system literature, these conceptualizations intend to provide an alternative framework to standard economics and its understanding of long-term growth through a more dynamic perspective on innovation processes. That is, the national innovation system is defined as a composition of constantly interacting institutions that play a decisive role in impacting innovative performance (Nelson, 1993, p.4). In turn, it means that innovation does not happen in isolation but rather by relationships and mechanisms that shape the interaction of different institutions at the regional, national, or supranational level. Justifying a general necessity for active government involvement, the most fundamental assumption underlying this approach is the fact that national institutional contexts matter in the attempt to analyze technological change. Since the approach gives some flexibility concerning the elements that should be included in the analysis as well as the setting in which the system is embedded (Lundvall, 2007), there is a general lack of common understanding on where to draw the lines of such a system. As a consequence, Edquist (2005) has proposed to define an innovation system by specific functions and factors impacting innovation rather than its organizations which have been elaborated by Lundvall (2007) two years later. Against this background and in accordance with Nelson (1993, p.20) as well as Lundvall (2007), this paper draws the lines around the role of the overall national policy environment in terms of the factors and functions of intellectual property protection, trade policy, higher education, and private R&D funding approaches. Delimiting a nation's institutional structure to these pillars causes the conceptual setting to be sharp enough to adequately guide the subsequent empirical work.

Given that there is considerable overlap between the concepts of endogenous growth theory and national innovation systems theory when it comes to the critical factors influencing technological change, this research bases the empirical exploration into the determinants of country-level differences in private R&D activity on both conceptualizations in this respect. This combination of insights of both theoretical strands strengthens the explanatory power of the subsequent argumentation with regard to the driving forces of private R&D investment. Next to the corroborative effect on account of the aforementioned parallels, both perspectives are joined and contribute to the research topic due to their complementary nature. That is, the concept of national innovation theory provides flexibility and power in the context of globalization and the focus on collective activities that stimulate technological progress on the supranational level. Consistent with Edquist (1997, p. 210), it is important to note that the ongoing trend of globalization is assumed to not making the concept of the national innovation system redundant. While maintaining the importance of national specificities, a more globalized world is expected to add more international linkages and cause more dynamic system interactions. As such, the rationale is seen as indispensable when examining the effect of supranational policy impacts.

2.2 Literature Review and Hypotheses Development

The subsequent section intends to systematically develop and ground the hypotheses critical for the research problem by building a compelling argumentation based on explanatory logic and persuasive empirical evidence from previous literature. Establishing coherence in the relationships, logical arguments are stated that explain why the core variables are related in the proposed manner. In order to position the hypotheses in relation to related research, a collated and integrated summary of the key drivers emerging from previous literature on the determinants of R&D activity as well as a critical analysis of the underlying empirical work is provided. By pulling disparate strands of ideas and empirical evidence together, important findings and relevant contradictions are highlighted in order to contextually embed the current study and put the proposed research problem into perspective.

In a first step, clear boundaries of literature relevant to the study are set as there is a broad scope of R&D literature causing a large body of academic work addressing the effects and relationships of R&D activity and innovation. As such, this study does not intend to directly contribute to the vast literature with regard to the endogeneity of patents to R&D that has devoted its attention to the relationship between R&D investments and the generation of knowledge. This set of empirical studies focuses on the output dimension of the innovation process and thus goes beyond the scope of this work which is devoted to the input measures of business R&D activity by focusing on R&D expenditure or R&D intensity. Interestingly, past literature, however, has found R&D input and output variables to be correlated in practice (Acs & Audretsch, 1988; Bottazzi & Peri, 1999). Neither does it add to the strand of literature on the determinants of the location of overseas R&D that has proposed several schemes for systematizing different approaches and patterns of multinational corporations with regard to the internationalization of R&D activity. Another strain of literature has concentrated on the internal motivation of corporate R&D activity by exploring the effect of principal firm characteristics. The discussion of this literature is avoided inasmuch as specific firm-level factors are merely incorporated into the model specification as control variables. In contrast, a majority of literature that has emerged essentially intends to empirically verify the impact of external factors on business R&D expenditures. Overall, two distinct but interconnected strands of literature are distinguished in this field of research. The first strand relates to empirical work that seeks to relate country-specific macroeconomic factors to business R&D activity and is not subject to comparative analysis. Nevertheless, the set of control variables defined in the model specification covers some of the variables under investigation in this field of research. To focus on distinct studies relevant to this paper, the subsequent discussion is limited to the second strand which relates to the causality relation between political/institutional factors and private R&D activity. Here, the contribution is made to the academic work that has revealed the emergence of several distinct themes and points to the importance of a country's legal system and property rights, openness of the economy, human capital, as well as government R&D policy. By doing so, a systematic distinction between these sub-strands is specified.

2.2.1 Legal System and Intellectual Property Protection

Existing empirical work investigating the effects of political and institutional variables predominantly focus on intellectual property (IP) protection. Here, theoretical arguments are drawn upon endogenous growth as well as national innovation systems literature since both strands deem patents a means to foster innovation. That is, patent laws and other protection measures pertaining to IP rights decrease uncertainty about possibilities of appropriation and simultaneously function as stimuli since they allow to capture temporary technological rents (Edquist, 1997, p.52-53). Through the implementation of a patent protection framework, governments assume a safeguarding and market interfering role that provides innovators with protection from imitation by competitors and temporary monopolization of their research outcomes. In an attempt to create excess economic returns, the monopolistic advantage and the possibility of its exploitation are decisive when it comes to an innovator's R&D decision as the higher this power is, the higher the expected returns are. A strong IP rights regime not only prohibits the entrance of imitators but also enhances the market share of the innovator by giving the opportunity for monopolistic power exploitation. In turn, this makes businesses undertaking R&D in order to increase market coverage and capitalize on their monopolistic advantage. This rationale is used as the foundation by a number of authors empirically investigating the effect of IP protection on private R&D activity (Varsakelis, 2001; Furman, Porter, & Stern, 2002; Kanwar & Evenson, 2003; Falk, 2006; Wu, Popp, & Bretschneider 2007; Wang, 2010; Garcia & Mohnen, 2010; Brown, Martinsson, & Petersen, 2017).

Furman, Porter, and Stern (2002) construct their theoretical framework by drawing upon argumentations from both endogenous growth and national innovation system theory. They measure a country's strength of IP protection on a 1-10 Likert Scale drawn from a survey instrument and conclude this factor to be an important and robust determinant. Stressing the importance of monopolistic power in their argumentation in favor of strong property protection, Kanwar and Evenson (2003) are in accordance with this finding since their investigation shows similar results. Making use of the Ginarte-Park Index, the authors find strong significance for IP protection being a critical incentive for stimulating innovation and technological change. In this regard, technological change is measured by R&D expenditure. Also, appropriation difficulty is the underlying theoretical problem being addressed in the work of Brown, Martinsson, and Petersen (2017). The authors argue that a firm's inability to appropriate technological rents is caused by weak or incomplete property rights protection, that in turn, is the reason for underinvestment in R&D. Employing a difference-in-differences approach, the authors assess the relative effectiveness of IP protection at promoting R&D activity in industries with different innovative intensity by analyzing data from a broad sample of OECD countries. The regression model confirms the conclusion drawn by Kanwar and Evenson (2003) by using the same index as a proxy for the strength of property rights. Through their difference-in-differences regressions, the authors further find an unambiguous positive differential association of stronger IP protection with business R&D expenditures in more innovative sectors. This, in turn, corroborates the relevance of an IP protection regime within the electrical equipment manufacturing sector. Similarly, the property protection rationale is also in line with the argumentation of Varsakelis (2001) who views R&D as an economic decision that is dependent on the expected profits of the innovator and its ability to exploit the established monopolistic advantage. The empirical investigation finds patent protection using the Ginarte-Park Index as a proxy to significantly impact R&D investment in their cross-country analysis for 50 countries. In his empirical research, the author makes use of an index from UNESCO to measure R&D intensity which is used as the dependent variable within his estimation model. Taking into account nine OECD countries, results of Wu, Popp, and Bretschneider (2007) also confirm previous findings relating to the Ginarte-Park Index by showing that patent protection as one of the major national innovation policies plays a significant role in promoting business R&D. Interestingly, the authors not only argue strong IP rights to stimulate R&D investment due to the increase of expected returns but also because of provoking rushed R&D in a race of filing patents first. However, the investigation from that of Falk (2006), does not conclude consistent findings in this regard when using a panel of OECD countries to empirically examine potential driving forces of business-sector R&D intensity. By using different estimation methods, Falk has not been able to uniformly show patent protection to significantly increase

R&D intensities. Even stronger controversial results compared to the aforementioned studies are prevalent. The Ginarte-Park Index is also used in the work of Wang (2010) which examines the driving forces of R&D investment at the national level and signals statistical insignificance in its association with R&D activity so that IP protection is not found to be a robust determinant. Supporting this, Garcia and Mohnen (2010) examine the effect of government support on R&D expenditure at the firm-level in Australia and infer that appropriation problems measured by the perceived importance of economic risk do not significantly affect R&D.

Even though characterized by a lacking consistency and mixed results, the majority of empirical findings produced within the field of IP protection support the theoretical argumentation previously outlined. Given the relevance of this study in light of the growing controversy and in order to investigate the effect of the property rights regime on private R&D investment, the following hypothesis is posited:

Hypothesis 1. *The stronger the patent rights protection framework in a country is the higher its R&D investment intensity.*

2.2.2 Openness of an Economy and International Trade

As an institutional factor, the degree of an economy's openness in terms of international trade is affected by a government's aggregate policy choices and a highly discussed determinant in the vast majority of publications. While considering the role of trade openness, the relevance of foreign knowledge spillovers is stressed in the context of R&D activity. Because knowledge spillovers lead to innovation and growth, it is emphasized by endogenous growth literature that economic prosperity is directly related to the strength of knowledge dissemination (Romer, 1990). That is, using available knowledge as input for own operations and R&D projects, businesses benefit from knowledge transfers in the form of positive technological externalities that in turn lead to higher economic returns. The same is true when it comes to foreign knowledge spillovers as several empirical studies have found significant positive effects of foreign R&D spillovers on national productivity (Coe & Helpman, 1995; Guellec & van Pottelsberghe De La Potterie, 2004). International trade is considered an important channel for foreign R&D spillovers that allow for greater access to foreign technology. Resulting in a stimulating effect on domestic business R&D investment, it is assumed that domestic R&D stands to benefit from foreign knowledge assimilation for two reasons. First, there is a direct learning effect from foreign technological knowledge. Second, domestic businesses can make use of advanced intermediate products developed outside of domestic boundaries (Keller, 2004).

The strain of empirical literature is characterized by contradictory empirical findings making the generalizability of much of the published work problematic. More specifically, Bebczuk (2002) not only bases his work on the theoretical assumption with regard to a favorable knowledge spillover effect of trade openness on domestic R&D investment. Additionally, the author argues for a second, yet opposing, effect in that international trade is expected to decrease R&D investment due to disadvantages in the production of new knowledge. Macroeconomic determinants of R&D expenditures, as well as the role of the government against the background of endogenous growth theory, are investigated and trade openness is found to have a significant and negative effect on business R&D. Using exports and imports as percentage of GDP as a measure for the degree of openness, findings provide support for the latter argumentation and further indicate foreign technology inflow to be a substitute for domestic R&D. Nonetheless, the effects of disadvantage in knowledge creation are difficult to disentangle from spillover effects, causing findings to not weaken the theoretical strength of the knowledge spillover argument. Also, the disadvantage in knowledge creation is considered to be rooted in a lack of human capital whose effects are subsequently subject to an individual investigation. In a similar vein, Wang (2010) finds evidence for international technology flows to impact R&D investment decisions. While arguing for the technology transfer hypothesis, the author further brings forward the argument of R&D spurring competition effects resulting from international trade. That is, international trade is expected to increase competitive pressures of domestic companies due to imports and operations of foreign businesses within domestic boundaries. As a response, domestic companies are forced to increase the possibility of innovation, and thus the rate of R&D investment in order to stay competitive. Therefore, import enlargement is seen to have spurring effects on private R&D activity which is justified by a challenge-response mechanism (Wang, 2010). Here, the author makes use of two separate and individually construed measures that mirror the important role played by a country's extent of trade openness. First, the ratio of the sum of imports and foreign direct investment inflows to a country's gross domestic product aims at indicating market penetration. Second, the ratio of an economy's import value of machinery, apparatus, and equipment to total imports measures the importance of R&D related capital import. Supporting Wang's conclusion, identical results have been reported by literature taking different foci. That is, in their attempt to investigate the determinants of country-level production of international patents, Furman, Porter, and Stern (2002) find an economy's degree of trade openness, measured on a 1-10 Likert Scale, to be an important determining factor positively influencing R&D productivity. Interestingly, the authors examine the effect on patents in the role of the dependent variable whereas R&D expenditure is seen as a capital resource and as part of the innovation structure. Nevertheless, their work identifies the importance of trade openness that should be considered when not only regarding the output side of the innovation process in terms of R&D productivity but also the association with R&D capital expenses. Also, Wu, Popp, and Bretschneider (2007) investigate the effect of trade openness in their empirical model by incorporating the ratio of total imports and exports over GDP. The empirical investigation is not only based on the theoretical argumentation that advantages from R&D activities transmitted through international trade increase R&D investments. A second argument for the spurring effect of trade openness on R&D expenditure is related to the previously outlined appropriability problems in the context of patent right protection. International trade holds the potential to open up new markets in terms of exports. Access to a larger market, in turn, enlarges the demand side and results in higher R&D investment (David, Hall, & Toole, 2000). This line of reasoning emphasizes the export side of trade openness in spurring R&D investment by enhancing the appropriability of innovation outputs. In line with Falk (2006) who includes equal measures for operationalizing trade openness, however, findings suggest only modest empirical support for trade openness to stimulate business R&D spending within the estimation methods applied. Nonetheless, empirical support for the relevance of the export argument is provided by Yang and Chen (2012). Examining the impacts of competition in foreign markets, findings of the regression-based estimation method suggest export intensity, measured by the ratio of exports to output, to be a significant predictor of R&D intensity. This conclusion is in agreement with that of Lee (2008), although results only reveal a statistical significance at the ten-percent significance level. Contrasting conclusions are drawn in the work of Girma, Görg, and Hanley (2008) who investigate a two-way relationship between R&D expenditures and export activity in Great Britain and Ireland using micro-data at the firm-level. Findings specify significant results for Irish firms whereas insignificant inferences are made for British companies. Even stronger controversial results have been found by Varsakelis (2001) who corroborates the knowledge assimilation hypothesis. It is argued that an open economy increases the marginal productivity of the stock of knowledge, in turn leading to a higher inclination to private R&D investment. Contrary to previous findings against the background of this line of argumentation, findings indicate that the degree of openness to an economy does not significantly affect R&D expenditures. Nonetheless, this study differentiates itself from previous empirical work by utilizing the black-market exchange rate premium as a measure of trade openness. While similarly operationalizing trade openness through a dummy variable based on black market exchange rate premia, Kanwar and Evenson (2003) reached different conclusions and reported significant results.

Although theoretical argumentations explaining the effect of trade openness on private business R&D investment in recent literature are diverse in nature, the majority of rationale still collectively points to a spurring impact. In conclusion, it is assumed that international trade, manifested in both exports and imports, has positive effects on R&D investment. Therefore, the following hypothesis is postulated:

Hypothesis 2: *The higher the degree of an economy's international trade the higher its R&D investment intensity.*

2.2.3 Human Capital / Resource-endowment-related Factors

A growing body of literature investigates the effect of resource-endowment-related factors such as country-level differences in human capital stock and indicates resource endowments to be critical determinants of the pattern of business R&D expenditures across countries. The underlying rationale is rooted in theoretical argumentations of endogenous growth as well as national innovation systems literature both which stress the relevance of human capital in the context of R&D activity and economic growth. (Romer, 1990; Nelson, 1993; Edquist, 1997). That is, given the scientific nature of R&D, human capital by means of education and knowledge creation is seen as critical input and a central prerequisite for the research sector and thus innovation activity. It is argued that a strong human capital formation in terms of qualification and skills enhances a firm's innovation capability. Augmented through a country's education system (Edquist, 1997, p.191), increases in human capital enable an expansion of R&D activity that in turn raises a company's inclination to invest in R&D due to an accompanying reduction in research costs (Grossman & Helpman, 1993, p.130). Additionally, by referring to the argumentation in 2.2.2 when it comes to international trade, human capital impacts the ability to adapt to and make use of foreign technological advances (Badinger & Tondl, 2002). More educated workers can drive firms to adopt advanced technologies within their research operations, and thus, cause increased willingness to invest in R&D. That is, governments invest in human capital by means of s strong education policy that enlarges the stock of people being capable of undertaking sophisticated research as well as applying research results and technological advances stemming from external R&D activity (Nelson, 1993, p.393).

In opposition to research undertaken on trade openness and intellectual property protection, this strand of research underlies a general consistency in its conclusions. In this context, the majority of literature points to the importance of this factor by focusing on either educational attainment and human capital formation variables or differential access to scientific human resources. More specifically, Bebczuk (2002), Falk (2006) and Wang (2010) examine the effects of human capital stock across countries by considering the ratio of people having tertiary education and find supporting results for a significant association. Both Wang and Falk argue that the need for R&D investment increases as the number of people with tertiary education, and hence the number of scientists in a country rises. In the same vein, Kanwar and Evenson (2003) conclude human capital stock to be a robust determinant of R&D by using the number of years of formal schooling of the population as a proxy. The authors agree with the previously outlined rational of increased human capital formation to be a stimulating factor of increased R&D investment. Also assuming a facilitating effect of skilled and qualified workers influencing the success of a firm's innovation process, this view finds further support in the empirical outcomes of the research undertaken by Garcia and Mohnen (2010). The authors argue a firm's human capital resource to be a robust predictor on the basis of analyzing the ratio of the number of workers with higher education to the number of the total company workforce. Going even more into depth in terms of human capital within the context of R&D, Wang (2010) further studies the proportion of scientific researches in the total population and finds significant associations. Likewise, Becker and Pain (2008) focus on the number of scientists and engineers employed in R&D and ultimately find this proxy to be a driving factor of business R&D investment. Similar conclusions were previously drawn by Furman, Porter, and Stern (2002) who inferred R&D related human capital, measured by the size of the R&D workforce, to be an important predictor of innovation intensity and R&D productivity.

Taken together, these studies collectively provide consistent evidence for human capital to be a catalyst for private R&D investments and support the macro-approach taken towards the effect of resource endowments on business R&D expenditure in this research which assumes human capital to be an integral part of the innovation process. For this reason, the following hypothesis is postulated:

Hypothesis 3: *The stronger the human capital formation in a country is the higher its R&D investment intensity.*

2.2.4 Government R&D Policy

Using firm-level or more aggregative datasets, two additional key strands of R&D literature addressing the effect of government policies on private R&D exist. More precisely, one set of empirical studies assesses the impact of government subsidies, and thus explores whether public subsidization is a substitute or complement for corporate R&D while another focuses on the influence of fiscal R&D incentives. The underlying theoretical reasoning of this research rests upon a firm's appropriability problem of R&D investments. Referring to the previous argumentation in 2.2.1, even if intellectual property protection frameworks are effectively enforced by the government, private R&D activity creates knowledge externalities and thus beneficial spillovers for other economic actors and the economy in general. Being aware of the fact that knowledge is not entirely excludable and that other companies appropriate parts of the returns, private R&D investors thus tend to make fewer R&D investments than socially optimal (David et al., 2000). More specifically, companies invest to the level where the marginal private rate of return equals the marginal cost of capital instead to the point where marginal social returns equal marginal social costs. Even though estimates of the social rate of return are found to be imprecise, in general, they tend to be higher than private returns indicating an actual potential of welfare enhancement (Hall, Mairesse, & Mohnen, 2009). In order to fill the resulting gap between private and social returns to R&D caused by private underinvestment governments assume an intervening role in the market through incentives that shift the intersection of marginal private returns and costs towards the intersection of marginal social returns and costs (Leyden & Link, 1992; David et al., 2000). Against this background, national innovation systems literature has emphasized the role of direct R&D subsidies as well as tax incentives as mechanisms for funding private R&D (Nelson, 1993, p.372). As one of the most popular innovation policy instruments, tax incentives reduce the tax liability of firms when undertaking R&D. More precisely, this is done by allowing investors to expense rather than capitalize R&D investments, to make use of depreciation allowance for R&D capital investments, as well as to deduct a share of R&D expenditures by means of R&D tax credits. Being part of the broader public research policy, these incentives have a spurring effect on business R&D activity by shifting the marginal costs curve of such activities downward (Hall & van Reenen, 2000). In addition, as an alternative innovation policy tool, business R&D subsidies not only minimize private R&D costs but also augment the profitability of R&D investments (Girma, Gong, & Görg, 2009). Direct public funding is composed of grants directly targeted on companies applying for financial support of a predefined R&D project. Because funding results in lower joint costs of R&D activity that have to be borne by the investing company itself, the private marginal cost curve is shifted downwards, thus spurring R&D investment. In accordance with David et al. (2000), direct grants further hold the potential to increase the marginal private rate of returns through government contracts for business performed R&D. Even though it is generally more complex to examine the effect on marginal returns than on marginal costs, public policy in terms of direct funding contributes to an enhanced inclination of private R&D effort through impacting both a company's costs and returns (Callejón & García-Quevedo, 2005).

Against this background, tax incentive literature is characterized by the construction of a basic model that predicts the level of business R&D spending as a function of the user cost of R&D. Bloom, Griffith, and van Reenen (2002) discuss the sensitivity of R&D to changes in its user cost and construct a variable by collecting information about the tax system in operation for nine countries with regard to tax rates, depreciation allowance, and integration of personal and corporate income taxes. Findings indicate changes in fiscal provisions to significantly impact the level of private R&D, and thus tax incentives to be effective in increasing R&D activity. In contrast, employing the B-Index is a more common approach to operationalize the user cost of R&D in recent literature. Wu, Popp, and Bretschneider (2007) as well as Falk (2006) make use of this composite index as a measure of R&D tax policy in their cross-national studies and verify the significant role played by tax incentives. Both empirical works support the marginal private cost reduction rationale with regards to tax incentives previously outlined. Additionally, both studies further explore the relationship between direct government funding of R&D performed by the corporate sector on business R&D and also find significant results with regard to a positive impact. Here, government subsidies are measured by means of government-funded business R&D and as the percentage of GDP. Predominantly, this strain of literature draws on cross-country instead of firm-level data for several reasons. On the one hand, it is problematic to separate out the real effect of the tax credit from other coexistent macroeconomic events as its variability is essentially macroeconomic. On the other hand, variations of tax credit effectiveness between companies are firm-specific and likely to be highly endogenous due to the impact of a company's individual tax positions and expectations of future R&D spending.
Nevertheless, a set of work is concerned with the examination of microdata within a specific country (Görg & Strobl, 2007; Hussinger, 2008; Bérubé & Mohnen, 2009; Lokshin & Mohnen, 2012; Mulkay & Mairesse, 2013). While using a plant-level data set of the Irish manufacturing

sector, Görg and Strobl (2007) investigate whether government funding has a stimulating or crowding-out effect on private R&D investment. Assuming investments to be under the socially optimal level because of aforementioned appropriability problems, the examination shows that effects are funding-size dependent, hence non-linear. That is, small grants are associated with spurring impacts while larger support is likely to substitute private R&D. While acting on identical assumptions, however, linear and significantly positive associations have been found in the work of Hussinger (2008) who explores the effects of federal support in German manufacturing. As a consequence, a crowding-out effect of government funding is not supported and gives reason to assume a complementary rather than a substitutional impact of government subsidies on privately financed R&D investment behavior. Bérubé and Mohnen (2009) draw on an extensive range of firm-level data from Canada to assess the relationship between public funding and a firm's innovativeness when already benefitting from fiscal incentives. Empirical findings complement previous studies in that firm innovativeness, measured by three different outcome variables, is found to be significantly higher for companies benefitting from both direct subsidies and fiscal incentives than enterprises benefitting from fiscal incentives only.

Mirrored in its focal point of interest, Bérubé and Mohnen's work identifies a relevant aspect that should be considered when researching the effectiveness of these government R&D policies on an industry level. That is, unlike tax incentives which provide a general boost of private R&D, direct subsidies to business R&D enable governments to channel public support into particular industries and thus, to direct corporate research investments into specific areas of interest such as sustainability mission objectives (OECD, 2002). The primary importance attached to R&D subsidies in the authors' investigation gives reason for the relevance of industry level grant-based mechanisms in this study. More precisely, holding the potential to influence the nature of R&D, public funding and its specific effect on private research investment when directed to the electrical equipment manufacturing sector is brought into focus in terms of the European Union's research program Horizon 2020. Given the general agreement in the aforementioned literature with spurring effects of direct funding on R&D activity, the following hypothesis is posited:

Hypothesis 4: *Direct government funding of business R&D in a country is a complement for private R&D intensity.*

3. Methodology

So far, this paper has focused on the theoretical foundation of as well as existing empirical research on the institutional/political determinants of private R&D investment activity. The following section aims at specifying the empirical strategy pursued in order to specifically examine the driving factors in the electrical equipment division of the manufacturing sector. For this purpose, the econometric model specification will be subject to delineation in a first step. Second, the data used for estimation as well as the appropriate estimation procedure relevant to this cross-national research is discussed.

3.1 Model Specification

Based on the discussion of the previous section, the following equation is derived to initially model the effect of political and institutional factors of EEM sector-based business R&D investment behaviour:

$$logRDI_{ijt} = \beta_0 + \beta_1 IPRP_{jt} + \beta_2 OPEN_{jt} + \beta_3 logHUMAN_{jt} + \beta_4 logGFRD_{jt} + \varepsilon_{ijt}, \quad (1)$$

where *i* indexes firm, *j* indexes country, and *t* indexes year. The dependent variable *RDI* refers to private R&D intensity within the EEM sector calculated by industry-level business R&D expenditures as percentage of gross value added. Furthermore, the strength of the intellectual property protection regime (I*PRP),* the degree of openness to international trade (*OPEN*), human capital endowment (*logHUMAN*) as well as government funding of business R&D (*logGFRD*) are included as policy variables in the model whose β-coefficients are the parameters of interest in this research. Given the preceding outline of the underlying rationale for each variable, the expected signs of the coefficients are derived from the discussion of the previous section and are summarized in Table 1.

Having used equation (1) to estimate the primary elements of the model, the specification is expanded in order to account for other variables that are likely to affect EEM sector-based private R&D intensity. This is rooted in the fact that solely accounting for the factors under primary investigation is not sufficient for clearly estimating the relationship between the variables of interest and the dependent variable. As such, there is a need to control for additional macroeconomic as well as firm-specific influences. Therefore, the focus variables I*PRP*, *OPEN*, *HUMAN*, and *GFRD* are consolidated and enter into model (2) in vector form. Then, the extended specification can be written as:

$$logRDI_{ijt} = \alpha + \beta_x X_{jt} + \mu_N N_{jt} + \gamma_M M_{ijt} + \varepsilon_{ijt}, \quad (2)$$

where *X* is the vector of the variables of interest, *M* is a vector of firm-level control variables including firm size, financial performance, as well as capital structure, and *N* is a subset of variables chosen from a pool of macroeconomic variables that are considered to possibly have explanatory power in addition to the factors consolidated in the *X*-variable. More precisely, the *N*-vector accounts for economic prosperity, inflation, cost of lending, and unemployment. A constant, as well as an error term, is incorporated into both, equation (1) and equation (2), in order to allow for unobserved firm-fixed effects that remain constant over the whole of the sample period and all additional effects, respectively. A linear functional form for both models is assumed.

As previously outlined, the paper aims for evaluating the effectiveness of a set of specific research funding initiatives targeted at the EEM-sector within the European Union's research program Horizon 2020. For this reason, a difference-in-differences approach is used in order to evaluate the causal effects of policy interventions. As a final exercise, thus, an extended estimation model can be expressed as:

$$logRDI_{ijt} = \alpha + \beta_x X_{jt} + \mu_N N_{jt} + \gamma_M M_{ijt} + \lambda_0 dEU + \delta_0 d2 + \delta_1 EU \cdot d2 + \varepsilon_{ijt}, \quad (3)$$

where two dummy variables *dEU* and *d2*, as well as their interaction, have been added to the model. Controlling for possible differences between the treatment and control groups, *dEU* is a treatment indicator that takes the value one if firm *i* is based in an EU member state, thus is part of the treatment group, at time *t* and zero otherwise. Accounting for aggregate factors that would cause changes in the dependent variable even in the absence of the Horizon 2020 initiatives, *d2* serves as time period dummy which is equal to 1 for the years in which the initiatives were active and zero otherwise. In this difference-in-differences regression, the focal point is considered to be the interaction term $EU \cdot d2$ as its coefficient is the difference-in-differences estimator. This is rooted in the properties of the interaction term as it factors out common trends influencing both firms of EU and non-EU member states as well as permanent differences between these two groups. A positive coefficient on the interaction term indicates funding initiatives in the context of Horizon 2020 to be associated with a larger positive difference in the level of R&D intensity for EU member states compared to other non-EU OECD member states that are not affected by the program.

In conclusion, equations (2) and (3) are the specified models under consideration in this research. Equation (2) incorporates not only the macroeconomic variables of primary interest but also necessary control variables needed in order to account for additional macroeconomic as well as relevant firm-specific factors possibly affecting R&D investment behaviour. Especially, government funding is considered as a focal point of interest in order to investigate the predicted complementary effect on private R&D investment. Given this, equation (3) places further emphasis in this respect by including a difference-in-differences estimation that evaluates the effect of specific EU funding initiatives targeted at the electrical equipment division of the manufacturing sector. The variables *RDI*, *HUMAN*, *GFRD*, as well as specific control variables enter into the specifications in logarithmic form with the intention of scaling down raw data and taking a step towards compliance with the underlying normality assumption.

3.2 Data Description

As quantitative research, the proposed study utilizes an unbalanced panel that was obtained by merging an individually constructed dataset consisting of macroeconomic data of 18 OECD countries spanning the years between 2000 and 2016 with micro-level data from Compustat Global. The major constraining factor for the sample period was the short series of industry-level private R&D expenditure which was available for an adequate number of countries only from 2000 to 2016. The datasets have been merged based on years and ISO country codes. Since firm-level data is not observed with regard to six of the 18 countries within the Compustat body of information, only observations for twelve countries are ultimately kept in the merged dataset. A listing of the specific countries under investigation can be found in Appendix A. Given the EEM as the sector under investigation, the dataset has been filtered in terms of companies within section 36 of the Standard Industry Classification (SIC). Additionally, further adjustment of the data has been made in that duplicates were removed from the sample in order to take account for repeated time values within the panel. Similarly, the sample was reduced by companies having their headquarters in a country other than the country of incorporation. The reason for this is the assumption that a majority of a company's R&D expenditure is made at the headquarter due to scale and agglomeration economies, coordination cost savings, as well as firm-specific technology protection (Kumar, 2001). Ultimately, this results in a total of 4207 firm-year observations for 439 firms in the sample. Reflecting the previously stated shift of industry focus of the EEM sector to the Asia Pacific region, more than 50% of the micro-level observations are covering firms incorporated in Korea. Further data concentrations can be found with regard to Germany (13%) and Australia (9%). A majority of firms under investigation have operations in EEM sub-sectors such as electronic components and accessories (47,16%), communication- (17,8%), and household equipment (6,75%).

3.2.1 Dependent Variable

As discussed by Becker (2015), there are two ways with regard to the measurement of R&D activity. On the one side, output measures such as patents and innovation counts serve as means for operationalization. On the other side, input variables such as R&D expenditures and R&D intensity are used to proxy the phenomenon under investigation. Availing itself of the latter measurement option, this research makes use of R&D intensity for the sake of investigation for the following reasons. First, output measures such as patent-based indicators are associated with an inherent heterogeneity of their economic value prohibiting an inaccurate basis for comparison (OECD, 2012). R&D expenditures, in contrast, are characterized by an innate homogeneous nature with regard to their economic value, hence, build a more appropriate alternative in this context. Second, many OECD member states have implemented growth targets with regard to this input variable, acting as innovation indicator, in the interest of tightening policy decisions and government funding strategies (OECD, 2011). In view of this, it is crucial to base the investigation of the driving forces on exactly this input measure for the sake of consistency, and thus to assure the value this research intends to create for policymakers in their pursuit of spurring innovation. In general, the ratio of expenditures to output (predominantly GDP on country level) is defined as R&D intensity in a set of literature that employs this proxy as dependent variable within the estimation models in its attempt to investigate the determinants of R&D investment activity (Varsakelis, 2001; Bebczuk, 2002; Bloom, Griffith, & van Reenen, 2002; Falk, 2006; Wang, 2010; Yang & Chen, 2012). Being the dependent variable, in this study, R&D intensity is defined as the ratio of a country's EEM sector-based R&D expenditures to the industry's gross value added (GVA) (Galindo-Rueda & Verger, 2016). More specifically, being an industry-level output variable, GVA allows to measure the EEM industry contribution to a country's gross domestic product (GDP), and as such, puts the absolute industry's R&D activity in relation to industry size. It is assumed that this definition of the dependent variable at the industry level makes a valuable contribution to the research field given the adolescent nature of investigation at this level.

Therefore, comprehensive data on EEM sector-based business R&D expenditures is retrieved from the OECD's Analytical Business Enterprise Research and Development (ANBERD) database which breaks down a country's private R&D activity across a number of manufacturing and service industry groups. As the most trustworthy source with respect to this data, the ANBERD database allows to purposefully conduct an investigation on the electrical and equipment division of the manufacturing sector by following Revision 4 of the International Standard Industrial Classification (ISIC Rev. 4). Data on GVA is obtained from two separate versions of the OECD's Structural Analysis (STAN) database that both follow ISIC Rev. 4 but differ in the underlying accounting framework in its provision of a statistical standard for national accounts. That is, the version of STAN with regard to data between 2000 and 2004 is based on the System of National Accounts 1993 (SNA93) whereas the version for information covering the period 2005 to 2016 is relying on its update, the System of National Accounts 2008 (SNA08).

3.2.2 Independent Variables

In the course of panel creation, data with regard to the aforementioned focus variables of this study is retrieved from various sources. In order to measure the strength of a country's intellectual property rights regime, the Property Rights Index as a part of the overall index of Economic Freedom published by The Heritage Foundation is adopted. More specifically, the index is a component of the Rule of Law category and grades the extent to which governments protect private property on a scale of zero to 100. Corresponding data is retrieved from the organization's public database. As opposed to previous literature, this research does deliberately not refer to the Ginarte-Park Index as a surrogate (Varsakelis, 2001; Kanwar & Evenson, 2003; Falk, 2006; Wu, Popp, & Bretschneider, 2007; Wang, 2010; Brown, Martinsson, & Petersen, 2013). This decision is motivated by the intention to contribute to the lacking empirical consistency in the context of the property rights determinant with the help of a newly adopted surrogate.

In accordance with Bebczuk (2002), the degree of a country's openness to international trade is proxied by the sum of exports and imports as percentage of GDP instead of using black market exchange rate premia such as Varsakelis (2001) and Kanwar and Evenson (2003). This is a consequence of the hypothesized effect of both, the export as well as the input side of international trade, on private R&D investment. More precisely, black market exchange rate premia, according to Sachs and Warner (1995), are deemed to be a form of imports' control, and hence primarily allow to draw conclusions on the import side. Beside insufficient data availability, it causes black market exchange rate premia to be a less appropriate surrogate in this research. On the contrary, exports and imports in relation to GDP have the potential to capture the hypothesized positive effects of trade openness on both sides. Corresponding data has been obtained from The World Bank database which is considered as one of the most reliable and consistent public sources accessible.

The surrogate for human capital formation has been chosen to be the number of total researchers in full-time equivalent (FTE) and represents a standard measure in empirical research (Becker, 2015). The underlying purpose is to bring access to scientific human resources rather than educational attainment into focus. Empirical proxies such as the ratio of people having tertiary education or years of formal schooling as used by Bebczuk (2002), Kanwar and Evenson (2003), and Falk (2006) are less appropriate in this context since they act as more general measures of highly skilled human capital. Corresponding data has been collected from the OECD's Main Science and Technology Indicators (MSTI) database.

Following Wu, Popp, and Bretschneider (2007), government funding of business R&D in constant 2010 USD is utilized for the purpose of operationalizing direct government subsidies, and thus business R&D conducted by firms but funded by government. The variable has been specifically constructed. That is, the OECD's MSTI database is employed as it allows to disaggregate business R&D data by source of finance. Two sub-components have been sourced that form the basis of the surrogate at hand: total business enterprise R&D expenditure (BERD) in constant 2010 USD and the percentage of government-financed BERD. The product of these indicators is the value of government-funded business R&D.

3.2.3 Control Variables

It is assumed that private R&D activity, just as other significant business expenses, may be impacted by the overall economic condition as well as the business cycle of a country (Wang, 2010). In total, four macroeconomic control variables have been incorporated in the empirical investigation and are part of model (2) and (3) to control for these effects. Thus, GDP per capita in constant 2010 USD has been incorporated into the empirical specifications as a surrogate for economic prosperity, and associated data has been retrieved from The World Bank database. Additionally, specification (2) and (3) control for inflation by using the annual growth rate of the consumer price index. In agreement with Bloom (2007), Funk and Kromen (2010), and Costamagna (2015), inflation is expected to have negative effects on privately financed business R&D activity due to associated price instabilities causing uncertainties in future pay-offs. The effect of unemployment is also accounted for by utilizing annual unemployment rates with regard to population aged between 25 and 64. Lastly, the cost of lending is considered by employing the long-term interest rate which refers to government bonds maturing in ten years. Following Becker and Pain (2008), high interest rates are considered to negatively influence R&D investment as a result of higher financing cost of R&D projects. Data with respect to the three control variables described above has been collected from the OECD's Economic Indicators database.

Moreover, specific firm-level control variables have been employed in order to account for additional micro-level effects. That is, firm size, financial performance as well as capital structure are assumed to have an impact on a company's inclination to innovate. Here, firm size is measured by total assets. This is in agreement with Dang, Li, and Yang (2018) who consider firm assets, measuring a company's total resources, as one of the most common proxies of firm size. In this context, total sales are not an appropriate surrogate as the metric does not provide sufficient constancy due to its relation to the product market. When entering into the specification in logarithmic form, the variable is calculated by taking the logarithm of assets plus one since the logarithmic function is defined for $x > 0$ and observations might be reported zero in the panels. Second, a firm's financial performance is operationalized by return on assets (ROA) which is the ratio of net income to total assets and considered as one of the most relevant accounting performance metrics (Aliabadi, Dorestani, & Balsara, 2013). In this context, only observations of ROA within the range of values [-2;2] are subject to analysis in order to avoid biased estimates. Lastly, the proxy for capital structure has been chosen to be the debt-leverage-ratio measured as total debt divided by total equity. In agreement with Myers (1977), debt overhang is expected to cause underinvestment because of lower financial flexibility and partial benefits accruing to debtholders. Data on all of the three aforementioned micro-level control variables has been correspondingly retrieved from Compustat Global.

Table 1 summarizes the variables at hand and presents proxies, labels, expected signs and data sources, respectively. Corresponding descriptive statistics displaying means and standard deviations of the variables to be used in the econometric estimation as well as correlation statistics of the independent variables are compiled and can be found in Appendix B and Appendix C, respectively.

Table 1: Variables, Proxies, Labels, Expected Signs, and Data Sources

Variables	Proxy Description	Label	Expected Sign	Source
R&D Intensity	Business enterprise R&D expenditure in constant 2010 USD / Gross value added	RDI		OECD – ANBERD OECD – STAN
IP Protection	Property Rights Index	IPRP	+	The Heritage Foundation
Trade Openness	Sum of exports and imports as % of GDP	OPEN	+	World Bank
Human Capital	Total number of researchers (FTE)	HUMAN	+	OECD – MSTI
Government Funding	Government funding of business R&D in constant 2010 USD	GFRD	+	OECD – MSTI
Economic Prosperity	GDP per capita in constant 2010 USD	GDPCAP	+	World Bank
Inflation	Consumer Price Index (annual %)	INFLAT	-	OECD
Cost of Lending	Long-term interest rate (10-year government bond rate)	INTER	-	OECD
Unemployment	Annual unemployment rate (age 25-64)	UNEMPL	-	OECD
Firm Size	Total Assets	ASSETS	+	Compustat Global
Financial Performance	Return on Assets (net Income/Total Assets)	ROA	+	Compustat Global
Capital Structure	Debt-leverage-ratio (total debt/total equity)	DEBT	-	Compustat Global

3.3 Estimation Method

For the purpose of analysis, data has been structured in long format and has been processed by means of Stata 14 as the primary statistical software package. Taking into account the variety of alternative methods for the estimation of longitudinal data, model (1) and (2) and (3) are estimated through a fixed effects regression. The choice of the appropriate panel data model is based on a systematic execution of a set of preliminary tests. That is, following Breusch and Pagan (1980), the Lagrangian Multiplier (LM) Test has been conducted in a first step in order to test for random effects in the specifications. Here, the presence of random effects in the panel is deduced from the rejection of the null hypothesis claiming that the variance of all individual or time specific components is zero. Consequently, the outcome of the LM Test prefers a random effects estimation to a pooled Ordinary Least Squares (OLS) model. In a second step, the F-test has been conducted with the intention of investigating a fixed effects estimation. The test involves the underlying expectation that either the fixed effects estimation exhibits a significant gain in goodness-of-fit or that fixed effects are non-zero. Due to the refusal of its null hypothesis which states that every observed and unobserved effect is equal to zero, a fixed effects regression is favored over a pooled OLS model. However, it might be the case that individual effects, while being non-zero, are uncorrelated with the explanatory variables of the models under investigation. On that account, a comparison of fixed and random effects is drawn by dint of the Hausman Specification Test (Hausman, 1978) under the null hypothesis of no correlation between the independent variables and error terms. In consequence of a rejected null hypothesis, the Hausman test opts for a fixed effects estimation as the appropriate panel data model for the present specifications by indicating the difference in coefficients to be systematic (Wooldridge, 2002, p. 288). As such, the estimation method in this research presumes a correlation between the differences across individual specific effects and the explanatory variables. Corresponding p-values for the set of preliminary tests are displayed along with the results of the estimation method in Table 2.

Subsequently, the performance of the proposed estimates as well as non-biasing standard errors have to be assured. Therefore, following Wooldridge (2002, p. 274), a test with regard to autocorrelation in the idiosyncratic error terms is conducted under the null hypothesis of no first-order serial correlation. Corresponding outcomes provide evidence for the alternative hypothesis to be true with respect to the models in question. In addition, homoskedasticity in the residuals of the fixed effects estimation is tested with the help of a modified Wald statistic for groupwise heteroskedasticity discussed by Greene (2000, p.598). Being insensitive to the violation of the normality assumption, results give reason to refuse the null hypothesis of homoskedasticity. Lastly, cross-sectional independence is examined in accordance with Pesaran (2015). That is, given the large N panel, the null hypothesis of weak dependence of the error terms is preferred over the null hypothesis of independence of residuals and ultimately rejected. Against this background, the specification of how to estimate the variance-covariance matrix has been adjusted in order to control for the present heteroskedasticity and serial correlation of the error terms. Hence, in accordance with Wooldridge (2013, p. 483), cluster-robust variance estimates have been specified which allow for intragroup (firm-level) correlation and do not impact the estimated coefficients but standard errors.

4. Results

The subsequent section is a delineation of the empirical findings obtained by estimation of the models (1), (2), and (3). However, not only main empirical results of the fixed effects estimation using cluster-robust standard errors but also robustness checks exploring the stability of the models are subject to description.

4.1 Main Empirical Results

Initial empirical statistics of the fixed effects regression are illustrated in Table 2. The table delivers interesting insight into private R&D activity in the EEM sector given that the model estimation reports not only expected results consistent with the theoretical predictions but also surprising results.

In agreement with previous literature, strong significant results have been found when it comes to intellectual property protection (Varsakelis, 2001; Furman, Porter, & Stern, 2002; Kanwar & Evenson, 2003; Falk, 2006; Brown, Martinsson, & Petersen, 2017). The coefficient exhibits the expected positive sign and consistent significance at the one percent level among all specifications. However, the magnitude of the coefficient in model (2) and model (3) is considerably larger in comparison to model (1). More specifically, one unit increase in property rights is associated with a 2.3 and 2.1 percentage point increase in R&D intensity in model (2) and (3), respectively, whereas model (1) predicts the impact to be 0.4 percentage points.

Surprisingly, the coefficient of international trade openness exerts a negative and statistically significant influence on EEM sector-based private R&D expenditure in model (1), even though to a small extent. However, the finding reaches consensus with previous research from that of Bebczuk (2002). As soon as control variables enter into the specification, the coefficient switches sign and turns insignificant, thus, is inconsistent with regard to a priori expectations. As such, the lacking significance of the international trade openness estimator in determining business R&D investment has also been identified by Varsakelis (2001) as well as Falk (2006).

In line with existing studies, strong and significantly positive effects at the one percent level have been found in terms of human capital on a consistent basis across all models under investigation (Furman, Porter, & Stern, 2002; Becker & Pain, 2008; Wang, 2010). As specified by the fixed effects estimations, human capital displays the comparatively highest coefficient

Table 2: Estimation R&D Intensity in EEM Sector

Independent Variable	Model (1)	Model (2)	Model (3)
IPRP	0.004***	0.023***	0.021***
	(0.001)	(0.004)	(0.005)
OPEN	-0.001***	0.001	-0.000
	(0.000)	(0.001)	(0.001)
logHUMAN	0.407***	0.402**	0.429**
	(0.030)	(0.187)	(0.210)
logGFRD	-0.081***	-0.175***	-0.182***
	(0.029)	(0.056)	(0.058)
logGDPCAP	-	0.130	0.295
		(0.439)	(0.499)
INFLAT	-	0.045***	0.049***
		(0.006)	(0.008)
INTER	-	-0.050***	-0.055***
		(0.014)	(0.020)
UNEMPL	-	-0.000	0.004
		(0.014)	(0.016)
logASSETS	-	-0.008	-0.008
		(0.009)	(0.009)
ROA	-	-0.007	-0.005
		(0.015)	(0.015)
DEBT	-	0.003***	0.002***
		(0.001)	(0.001)
dEU	-	-	0
			(omitted)
d2	-	-	-0.025
			(0.021)
dEU*d2	-	-	0.014
			(0.029)
Constant	-11.775***	-14.428***	-16.132***
	(0.226)	(2.787)	(3.788)
N: observations	3344	1682	1682
groups	426	374	374
R^2: within	0.164	0.448	0.449
between	0.310	0.060	0.118
overall	0.187	0.041	0.089
F- Test (p-value)	0.000	0.000	0.000
LM Test (p-value)	0.000	0.000	0.000
Hausman Test (p-value)	0.000	0.000	0.000

Fixed effects regressions of model (1), model (2), and model (3). An unbalanced panel of 12 countries and 4207 firm-year observations is used. Robust standard errors in parentheses. (Two-tailed) significance levels: *10%, **5%, ***1%

value causing this factor to be the most influential predictor of privately financed R&D activity in the electrical equipment division of the manufacturing sector. Showing consistency in the magnitude of the coefficients, models (1), (2), and (3) estimate one percentage point increase in the total number of researchers to provoke a 0.4 percentage point increase in the dependent variable. Still, the subsequently incorporated variables cause the significance of the coefficient to fall to the five-percent level in model (2) and (3).

Interestingly, government funding has been found to have a strongly significant impact on the response variable even though the sign, being negative, is inconsistent with a priori expectations. This outcome contradicts past research that has found the determinant to have a significantly positive association with private R&D investment behavior (Falk, 2006; Wu, Popp, & Bretschneider, 2007; Hussinger, 2008; Berubé & Mohnen. 2009). According to the estimation, the coefficient shows less than half the magnitude in model (1) compared to model (2) and (3). In particular, a sustained one percentage point increase in direct government funding is estimated to induce a 0.08 and 0.18 percentage point decrease in the responding variable, respectively. Obtained results provide evidence for a crowding-out effect of direct government subsidies as observed in the work of Görg and Strobl (2007).

With regard to macroeconomic control variables of specification (2) and (3), the coefficients of long-term interest rate are found to have the expected sign and strong significance at the one percent level which is in agreement with findings from that of Becker and Pain (2008). Surprisingly, contrary to findings from that of Wang (2010), inflation has turned out to consistently show significant results in both estimations while indicating a positive effect on R&D activity. Here, it has to be noted that the coefficients of interest rate and inflation, given their apposed magnitudes, seem to cancel each other out. No statistically significant association with the response variable has been recorded for the remaining two controls, even though both GDP per capita and unemployment show expected signs except for the unemployment coefficient in model (2). Among firm-level control variables, solely the coefficient of capital structure appears to be statistically significant, yet it displays an unexpected positive sign.

In the context of the difference-in-differences analysis, the inclusion of dummies and their respective interaction in model (3) has been found to show insignificant results when looking at the difference-in-differences estimator that carries a positive sign. This lacking statistical significance, however, substantiates earlier outcomes which have been discovered in terms of a negative association of direct government funding with the experimental variable. It has to be outlined that the coefficient of the treatment indicator *dEU* is omitted, and thus not reported in Table 2. This is rooted in the time-invariant nature of the dummy variable since EU membership does not vary with time in the panel (with the exception of Poland and Slovenia which both entered the EU in 2004).

Taken together, results suggest that there is a statistically significant association between all focus variables and the regressand with the exception of international trade openness across all models under investigation. What stands out in Table 2, however, is the reported strongly significant and negative association of government funding with business R&D activity that is inconsistent with a priori theoretical predictions. Reported values of the overall R-Squared vary considerably among specification (1), (2), and (3) and amount to 0.187 ($F = 142.63$, $p = 0.000$) 0.041 ($F = 1847.67$, $p = 0.000$), and 0.089 ($F = 1571.49$, $p = 0.000$), respectively. Nevertheless, as a consequence of the properties of the fixed effects estimation, the reported R-squared within is an ordinary R-squared and of primary interest in the estimation against the background of the research problem of this study. More specifically, the focal point of interest is not the cross-section (between variance) but the variance within each company over time. As such, R-squared within describes the explanatory power of the independent variables after partialling out the fixed effects. In this context, the value of R-squared within is subject to steady increase from specification (1) to (3), more precisely, amounts to 0.164, 0.448, 0.449, respectively. This, in turn, means that a higher proportion of the within variation in the dependent variable is explained by the within variation in the predictor variables in the course of the specification expansion. Moreover, the values of R-squared between are lower compared to values of R-squared within in model (2) and (3) signaling that the cross-sectional element of the data does not primarily account for the total fit of the corresponding specifications. Because of the findings mentioned above, model (3) is subsequently considered the baseline model in this research.

4.2 Robustness Checks

In a subsequent step, robustness checks have been conducted for the purpose of providing evidence for the structural validity of model (3). In line with Lu and White (2014), these sensitivity analyses have the potential to detect specification errors by checking the responsiveness of the coefficient estimates to specific modifications. For this reason, the following tests have been performed:

At first, the model is estimated by incorporating government funding, GDP per capita, and unemployment with one-year lag (t-1) to account for the effect of prior year information on the dependent variable. In conformity with Wu, Popp, and Bretschneider (2007), especially government funding is considered to potentially have deferred impact on business R&D investment as learning effects of direct government support might only prove beneficial for later R&D projects. Against this background, the time lag of government funding is further extended to two (t-2) and three years (t-3), respectively, in a subsequent step. Additionally, the lagging variable is potentially conducive to reduce the prevailing endogeneity problem of government funding associated with private funding.

Second, specification (3) is run using reduced sample size by discarding specific countries from the panel. More precisely, the sample is restricted by removing observations for Australia, Norway, and Turkey in order to countervail the imbalance between firms of EU- and non-EU countries.

Third, two additional robustness tests, each employing an alternative surrogate for trade openness, are conducted to provide better prediction accuracy. This is a consequence of the inconsistent results of the corresponding trade openness coefficients in the main analysis. Thus, the sum of imports and exports as percentage of GDP as the hitherto existing proxy of trade openness is disassembled into two separate proxies: the ratio of exports to GDP and the ratio of imports to GDP.

Fourth, the baseline specification is estimated with year fixed effects as well as a one-year lag (t-1) of each of the three firm-level controls. By doing so, year dummies are incorporated in the model that capture the influence of aggregate (time series) trends. Firm-level controls are lagged in order to control for the possibility that firms base their investment decisions on available information about prior-year firm performance. The model is specified as follows:

$$logRDI_{ijt} = \alpha + \beta_x X_{jt} + \mu_N N_{jt} + \gamma_M M_{ijt-1} + \lambda_0 dEU + \delta_0 d2 + \delta_1 EU \cdot d2 + \sum_{t=2000}^{2016} y_t + \varepsilon_{ijt} \quad (3.4)$$

Fifth, model (3) is estimated by employing an alternative measure for the dependent variable. That is, R&D intensity is defined on firm- rather than industry-level as the ratio of a company's R&D expenditures to its total assets. As such, this modification is likely to capture more of the cross-sectional variation since the dependent variable in model (3) is based upon averages. Since the new dependent variable already controls for a company's assets, the firm-control variable *logASSETS* is omitted in this diagnostic test. Table 3 and Table 4 accordingly display relevant outcomes. Year fixed-effects of model (3.4) are reported in Appendix E.

Table 3: Robustness Checks Model (3) 1/2

Independent Variable	Model (3.1.1) Lagged t-1	Model (3.1.2) Lagged t-2	Model (3.1.3) Lagged t-3	Model (3.2) Reduced Sample
IPRP	0.020***	0.016**	0.020***	0.021***
	(0.005)	(0.006)	(0.004)	(0.005)
OPEN	-0.001	-0.002	-0.001	-0.001
	(0.002)	(0.002)	(0.001)	(0.001)
logHUMAN	0.280*	0.265**	0.267**	0.484**
	(0.145)	(0.134)	(0.123)	(0.218)
logGFRD	-0.079***	-0.035**	0.011	-0.195***
	(0.028)	(0.017)	(0.009)	(0.060)
logGDPCAP	0.053	0.024	0.053	0.372
	(0.051)	(0.028)	(0.034)	(0.511)
INFLAT	0.050***	0.058***	0.060***	0.050***
	(0.010)	(0.011)	(0.010)	(0.009)
INTER	-0.074***	-0.082***	-0.069***	-0.050**
	(0.015)	(0.018)	(0.013)	(0.021)
UNEMPL	-0.022***	-0.021***	-0.016***	0.005
	(0.007)	(0.006)	(0.005)	(0.016)
logASSETS	-0.010	-0.009	-0.012	-0.007
	(0.009)	(0.009)	(0.009)	(0.010)
ROA	-0.013	-0.004	-0.003	-0.006
	(0.017)	(0.017)	(0.016)	(0.016)
DEBT	0.002**	0.002**	0.002**	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
dEU	0	0	0	0
	(omitted)	(omitted)	(omitted)	(omitted)
d2	-0.011	-0.010	-0.012	-0.042**
	(0.022)	(0.023)	(0.020)	(0.021)
dEU*d2	-0.009	-0.008	0.008	0.036
	(0.033)	(0.030)	(0.028)	(0.029)
Constant	-12.287***	-11.750***	-12.795***	-17.591***
	(1.539)	(1.454)	(1.263)	(3.797)
N: observations	1660	1655	1647	1630
groups	369	372	371	346
R^2: within	0.458	0.442	0.468	0.447
between	0.006	0.002	0.000	0.049
overall	0.004	0.001	0.000	0.067
F- Test (p-value)	0.000	0.000	0.000	0.000
LM Test (p-value)	0.000	0.000	0.000	0.000
Hausman Test (p-value)	0.000	0.000	0.000	0.000

Fixed effects regressions of model (cluster robust variance estimates) with modification. Robust standard errors in parentheses. (Two-tailed) significance levels: *10%, **5%, ***1%

Table 4: Robustness Checks Model (3) 2/2

Independent Variable	Model (3.3.1) Exports	Model (3.3.2) Imports	Model (3.4) Year-effects	Model (3.5) Firm-level DV
IPRP	0.025***	0.018***	0.012*	0.001**
	(0.005)	(0.005)	(0.006)	(0.000)
OPEN	0.004*	-0.003	-0.001	0.000
	(0.002)	(0.002)	(0.001)	(0.000)
logHUMAN	0.344	0.475**	0.653**	0.105**
	(0.211)	(0.206)	(0.264)	(0.046)
logGFRD	-0.198***	-0.165***	-0.434***	-0.047**
	(0.053)	(0.062)	(0.076)	(0.022)
logGDPCAP	0.287	0.202	0.521	-0.026
	(0.484)	(0.512)	(0.439)	(0.101)
INFLAT	0.041***	0.057***	0.030**	-0.002
	(0.007)	(0.009)	(0.013)	(0.002)
INTER	-0.048**	-0.062***	0.064**	0.002
	(0.019)	(0.020)	(0.025)	(0.003)
UNEMPL	0.004	0.001	0.033***	-0.003
	(0.015)	(0.016)	(0.010)	(0.003)
logASSETS	-0.008	-0.008	-0.002	-
	(0.009)	(0.009)	(0.002)	-
ROA	-0.008	-0.002	-0.003	0.022
	(0.015)	(0.015)	(0.017)	(0.027)
DEBT	0.003***	0.002**	0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
dEU	0	0	0	0
	(omitted)	(omitted)	(omitted)	(omitted)
d2	0.001	-0.037*	0.164	-0.005
	(0.022)	(0.019)	(0.181)	(0.004)
dEU*d2	-0.013	0.026	0.093***	-0.011
	(0.022)	(0.027)	(0.028)	(0.010)
Constant	-15.404***	-15.529***	-19.229***	-0.731
	(3.759)	(3.888)	(4.223)	0.761
N: observations	1682	1682	1635	1522
groups	374	374	371	354
R^2: within	0.451	0.451	0.634	0.081
between	0.185	0.037	0.353	0.033
overall	0.148	0.025	0.365	0.035
F- Test (p-value)	0.000	0.000	0.000	0.000
LM Test (p-value)	0.000	0.000	0.000	0.000
Hausman Test (p-value)	0.000	0.000	0.000	0.000

Fixed effects regressions of model (cluster robust variance estimates) with modification. Robust standard errors in parentheses. (Two-tailed) significance levels: *10%, **5%, ***1%. Year- effects of model (3.4) reported in Appendix E.

Overall, model (3) has been found to show robustness against changes in time shifts, sample size, and proxy specification as results of the sensitivity analysis preponderantly verify its main estimation outcomes. In particular, coefficients of the focus variables property protection, human capital, government funding as well as the control variables have been observed not to switch sign nor considerably change significance or estimation weight with the choice of specification.

Still, closer inspection of the table indicates some notable deviations from the baseline findings, thus, are subject to description. That is, the significance of human capital has been found to fall to the ten percent level in model (3.1.1) and even above in model (3.3.1). Even though the coefficient of human capital appears to lose its significance when incorporating the ratio of exports to GDP as the proxy for trade openness, it has to be mentioned that it closely exceeds the ten percent hurdle ($p = 0.105$). Also, it is apparent from Table 3 that all robustness checks confirm the insignificant relation of trade openness to the response variable with the exception of model (3.3). As a striking result to emerge from the data in this context, a positive effect has been estimated to be statistically significant at the ten percent level when it comes to exports as percentage of GDP as the swapped surrogate for trade openness. Surprisingly, the coefficient of government funding loses statistical significance in model 3.1.3 when employing a three-year lag (t-3).

In terms of control variables, what stands out is the coefficient of unemployment in all sub-models (3.1) as well as model (3.4). Specifically, while appearing robust to changes in proxies and sample size, the estimate has been found to show the expected negative sign as well as strong significance at the one percent level as soon as the variable is lagged (models 3.1) as well as year-fixed effects and lagged firm-controls incorporated (model 3.4). Surprisingly, the counterintuitive positive and significant association of inflation and capital structure have been consistently identified to remain significantly positive among all modifications except model

(3.4) and model (3.5). As opposed to the baseline findings and all diagnostic tests, model (3.4) shows a positive and statistically significant difference-in-differences estimator at the one-percent level. Also, it is apparent from Table 4 that all control variables, as well as the constant, are insignificant in model (3.5).

In conclusion, the sensitivity analysis provides evidence for the robustness of model (3) under the influence of different modifications given the general qualitative consistency in the outcomes across all robustness checks. Put differently, no considerable fragility among the different test specifications have been observed that, in turn, gives reason to generally infer the structural validity of the specification. Nonetheless, the structurally informative nature of specific control variables has to be challenged against the background of counterintuitive but significant findings.

5. Discussion

5.1 General Discussion

Bearing in mind the economic importance of R&D investment activity as well as its strategic relevance in the context of sustainability, policy actors attempt to effectively stimulate private R&D behavior on a national as well as supranational level. However, the present state of knowledge in this field of research causes a lacking systematic understanding that impedes politics in its endeavor. More precisely, to date, one of the main empirical concerns in this context is not only a lacking consensus in the determinants of privately-financed R&D investment but also the scarcity of investigation at the industry level. Hence, this research was conducted to comprehensively shed light on the driving forces of business R&D activity in the electrical equipment manufacturing sector which is considered a contributor to technical change holding high potential for making a decisive impact on sustainable advancement. Against this background, the current study delivers interesting insights into the research problem, and thus allows to draw multiple conclusions. That is, when collectively contextualizing the main outcomes, there is evidence for the nature of the EEM industry's R&D investment behavior to feature a general industry-dependent sensitivity to the investigated political and institutional factors with the exception of the outward orientation of a given country's economy. An overview of findings with regard to all hypotheses under examination is provided in Appendix D. Subsequently, these findings are discussed on an individual basis.

First, referring back to Hypothesis 1, it was hypothesized that the stronger the patent rights protection framework in a country is the higher its R&D investment intensity. Providing evidence in favor for this postulation, the current study found that an increase in the strength of a country's intellectual property rights protection regime is strongly associated with an increase in privately financed EEM sector-based R&D expenditures. Put differently, property rights appear to be of relevance for companies in their R&D investment decision. These results corroborate the findings of a great deal of previous work in this context which predominantly employs the Ginarte-Park Index as the proxy for IP protection (Varsakelis, 2001; Furman, Porter, & Stern, 2002; Kanwar & Evenson, 2003; Falk, 2006; Brown, Martinsson, & Petersen, 2017). In light of the existing disagreement related to the causality direction between both variables, the uncovered relationship thus provides evidence for the causation to go from IP protection to R&D. Moreover, findings substantiate the underlying theoretical framework of this research in terms of innovation systems and endogenous growth literature. To be more specific, they verify the view that IP protection increases confidence with regard to appropriation possibilities and simultaneously gives impetus to R&D by enabling the capture of temporary technological rents (Edquist, 1997, p.52-53). According to the observations of this study, it could be argued that it is the possibility to establish a monopolistic advantage that is pivotal for the innovator's decision to invest in R&D because of the potential to eliminate the appearance of imitators and to magnify its market share. In general, it can be concluded that current findings suggest IP protection to be a robust institutional factor spurring R&D activity.

Second, with regard to Hypothesis 2, it was postulated that the higher the degree of an economy's international trade the higher its R&D investment intensity. It is interesting to note that the results of this study do not support this statement as no statistical evidence for trade openness to determine business R&D investment in the EEM sector has been found. The lacking significance not only accords with prior work from that of Falk (2006) by employing the same surrogate for trade openness but also from that of Varsakelis (2001) by making use of black-market exchange rate premia for proximation purposes. Nevertheless, results are contrary to that of Furman, Porter, and Stern (2002) as well as Wu, Popp, and Bretschneider (2007) which indicate the degree of international trade to be robust determinants of R&D investment behavior. The results of the current study, therefore, need to be interpreted with caution. When looking at previous research investigating only one side of an economy's international trade activity, it seems possible that these inconsistent findings are due to the lacking capability of the chosen surrogate to disentangle individual effects of exports and imports. To be more precise, Wang (2010) found evidence for import enlargement to spur R&D activity and rationalizes a challenge-response mechanism to be the reason for this effect. On the other side, Lee (2008), as well as Yang and Chen (2012), have demonstrated exports intensity to have a statistically significant association with business R&D investments. As a consequence, two individual robustness checks separately estimating the effect of import and export activity have been conducted. Whereas no evidence has been found for a relationship of import intensity, the degree of export has been identified to have a modestly significant and positive effect on EEM-sector dependent R&D activity. These findings do not provide support for the importance of international trade as a channel for knowledge spillovers in an EEM-sector company's decision for R&D expenditures. However, observations, while preliminary, may support the argumentation that international trade openness is predominantly of relevance for a company's investment decision in terms of its potential to open up new markets and thus to enhance appropriability of innovation outputs. As such, this interpretation of an underlying foreign-market-seeking intention finds support in the previously outlined rationale in the context of property rights protection. A note of caution is due here since the estimation in model (3.3) only shows modest evidence at the ten percent significance level. The reason for the baseline finding is not apparent, and there may be other possible explanations for insignificance.

Third, Hypothesis 3 states that the stronger the human capital formation in a country is the higher its R&D investment intensity. In line with expectations and previous literature, the current study provides strong evidence for this proposition, and thus human capital to be a robust determinant of R&D activity in the EEM sector (Furman, Porter, & Stern, 2002; Becker & Pain, 2008; Wang, 2010). More precisely, the elasticity of human capital has been consistently found to be positive and significant in the majority of estimation models. In this context, it could be assumed that human capital is considered as critical input and a central prerequisite for innovation activity. While skilled and talented workers are predicted to enhance innovation capabilities, in general, it is possible that increases in human capital positively impact the inclination to invest in R&D. As such, the variation in R&D spending seems to be partly explained by differences in human capital endowments. This argument conforms both endogenous growth as well as national innovation system literature which stress the importance of human capital in the context of R&D activity and economic growth (Romer, 1990; Nelson, 1993; Edquist, 1997).

Lastly, the fourth hypothesis in this research posited direct government funding of business R&D in a country to be a complement for private R&D intensity. An unexpected and significantly negative effect of government funding on EEM sector-based R&D intensity has been found across all estimations except for one. As such, results of the current study provide no support for Hypothesis 4. This finding is contrary to previous studies who suggest an additionality effect by decreasing private R&D costs and increasing returns of R&D investments (Falk, 2006; Wu, Popp, & Bretschneider, 2007; Hussinger, 2008; Berubé & Mohnen. 2009). More specifically, prior studies suggested that government funding functions as a means to shift private R&D activity closer to the social optimum by, for example, turning initially negative NPV projects into profitable ones. In fact, having obtained significantly negative elasticity estimations gives reason to assume that public subsidies do not act as a stimulus to business R&D activity but rather invoke crowding out effects. That is, it seems possible that business R&D projects, subject to public funding, would have been undertaken even without governmental support and thus eliminate the initially intended privately financed portion. However, a note of caution is due here since additionality or crowding-in effects may indeed exist but could be solely outweighed by crowding-out effects. Overall, results provide evidence for public subsidies to have substitutional rather than complementary effects, and thus to not be a robust institutional factor spurring R&D activity in the EEM sector.

The second intention of this study was to examine the effectiveness of specific policies targeted at the EEM industry. In this context, a broad set of funding initiatives under the European Union's research program Horizon 2020 have been investigated by employing a difference-in-differences approach. In accordance with prior findings in regard to direct government subsidies, the results of this research provide no evidence in favor of a significant effect of these initiatives on EEM-sector private R&D intensity. Nevertheless, when capturing year-fixed effects as well as controlling for lagged firm controls in the context of the sensitivity analysis, the difference-in-differences estimator shows statistically significant association at the one percent level between these policy initiatives and R&D investment. It is important to bear in mind that these results have to be interpreted with caution.

5.2 Policy Implications

Next to the innate theoretical and academic relevance, this research was undertaken to facilitate the understanding, coherence, and adjustment of an economy's institutional framework in its endeavor to promote private R&D activity from a political standpoint. Resulting as a consequence of previously outlined empirical results, profound practical policy implications can be deduced containing important courses of action for governments. Nevertheless, sound policy recommendation should rest upon an accumulation of several empirical examinations taking into account diverse samples.

Research findings give reason to assume that policies directly dealing with appropriability problems are effective in spurring EEM sector-based business R&D investments. When it comes to a country's intellectual property rights regime, policy makers are advised to improve the effectiveness of and trust in the system itself due to the fact that a lack of confidence in basic property recognition is still existent in a number of economies (OECD, 2001). With regard to the index used in order to proxy the strength of a nation's property rights protection, governments should strive for clear legislation as well as its total enforcement in order to establish a certain and trustworthy legal protection of intellectual property. The primary importance of IP protection often revolves around contract enforcement and IP protection processes (Lanjouw & Lerner, 2000) so that improvements can be achieved through adequate investments in IP registration institutions as well as basic legal institutions. This investment is considered an appropriate mechanism in order to ensure better efficiency of, and ultimately confidence in a nation's intellectual property regime. Given the variety of instruments in the IP protection system, patent law should be brought into focus when improving the regime as it is deemed the most powerful tool, especially in the electrical equipment manufacturing industry (Maskus, 2000, p.16). Nevertheless, the desirability of simply 'stronger' IP rights is not seen as a ubiquitous solution in the context of IP protection system modification causing difficulties in formulating general policy guidelines. Since IP protection systems are the product of decades of continuous economic, political and legal change, each regime has its individual history and nature, thus differs in specifics (Maskus, 2000, p.3). In accordance with Maskus (2000, p.8), setting optimal policies for encouraging innovation necessitates accounting for several market characteristics that are largely uncertain, and thus, is problematic. As there is no universally optimal system with a general set of features, governmental points of action are considered to be related to mechanisms ensuring a continuous relevance of the institution to country-specific needs in their attempt to strengthen the system. According to Boudreaux (2005), it is recommended to look beyond written legal codes and enable creative development of individual property rights. Here, the system of IP protection should be seen as an evolutionary process in which legislative changes require an understanding of the process involved in establishing property rights as well as of a nation's changing conditions. Consequently, this includes not only capturing property rights by means of legal codes, but also by allowance for customary rules and norms that give space to respond to emerging local needs and conditions.

Additional implications arise as a consequence of significant empirical findings in terms of human capital endowment. In an endeavor to promote EEM-sector private R&D investment, policy-makers are advised to stimulate a nation's human capital formation. In line with OECD (2005), this is done by concentrating on specific elements of human capital development policies: educational attainment as well as workforce skills. Rooted in the high level of development of the investigated countries as well as the R&D-related nature of the EEM-sector, the primary focus in the context of educational attainment is higher formal education. Here, targeted investment in the form of government expenditure to higher-level education is recommended as a means to support the formation of adequate human capital. Nonetheless, this approach requires effective allocation strategies in terms of appropriate funding streams as resource distribution problems are likely to arise. In particular, state financial aid programs and education credit opportunities should be expanded that improve the affordability of higher education. In this context, not only Dynarski (2003) found evidence for student aid to have a spurring association with college attendance and educational attainment but also a few years later Deming and Dynarksi (2010) showed that reducing university costs increases enrollment rates. Also, the direct subsidization of public universities is conducive as it causes universities to charge lower tuition prices. Additionally, another control lever that can be shifted is to strengthen the linkages between universities and businesses through specific government initiatives. By doing so, likely future business demands for specific skills can be identified and, as a consequence, curricula adjusted that facilitate the fulfillment of those needs. Also, according to OECD (2005), the quality of tertiary education can be improved and ensured through quality assurance mechanisms and minimum quality standards like accreditation schemes or certification. When it comes to workforce skills, it has to be noted that deficiencies exist in terms of firm-specific knowledge of new employees entering the business world (OECD, 2005). However, companies are in need of such skills in order to be able to tap the full potential of these workers and associated investments. Being considered as a means to transmit this type of knowledge and ultimately to facilitate the formation of an adaptable and skilled workforce, on-the-job employer-provided training can be promoted through policy tools such as co-financing arrangements.

However, it has to be noted that the investigation does not enable to draw policy conclusions on what factors or composition of factors may be relatively preferable in the attempt to spur R&D intensity in the EEM-sector. According to Kanwar and Evenson (2003), human capital formation may be an important enabling determinant but may by itself not sufficient in spurring R&D expenditures. Such stimuli may rather emanate from better appropriation possibilities enabled through adequate IP protection rights. In this context, further speculations could also be made with regard to the relative ease of influencing the determinants human capital formation and intellectual property systems.

5.3 Limitations and Future Research

It is necessary to concede some methodological limitations of this study and to describe their potential impact on obtained empirical findings. In a second step, communicating this understanding of drawbacks lays the foundation for future research suggestions.

First, the choice of the dependent variable in the model specification comes along with an inherent drawback. That is, the definition of R&D intensity on industry level as the ratio of EEM-sector business enterprise R&D expenditures to EEM-sector value added is based on averages making the chosen variable likely to distort adequate inference of cross-sectional variations. As a consequence, one diagnostic test has been conducted that employs R&D intensity on the firm-level in order to address this drawback, in part, by evaluating the sensitivity of baseline findings in this respect. However, a greater focus on firm-level R&D intensity in future research has the potential to produce valuable findings that account more for cross-section variations, and hence, to improve prediction accuracy. In the interest of cross-section variation, it has to be mentioned that the fixed-effects regression applied in this research does not model the between variation but rather takes it as given. Hence, the question of why there are differences in the units between firms is not considered.

Second, a shortcoming is the fact of basing findings of this research on the sample of solely twelve OECD countries and 17 years. The number of countries, as well as the time period subject to analysis, is predominantly restricted by the short series of EEM-sector business enterprise R&D investment of the OECD’s Analytical Business Enterprise Research and Development (ANBERD) database as well as observed firm-level data within the Compustat body of information. In the interest of more accurate results, future research should repeat the study using a larger sample size by implementing a sophisticated primary data collection method. Especially, firm-level observations from the United States, retrievable from the Compustat North America Daily database, could be incorporated in future investigations in a first step. Also, the constructed panel of this study predominantly contains observations about advanced economies and, consequently, impedes proper inferences with regard to developing countries. Similarly, firm-level observations are primarily retrieved from public enterprises, and thus, hinder the validity of application to non-public companies. Therefore, attempts to source additional data from these two perspectives should be made by future research in order to provide more definitive evidence.

Third, the evaluation of the effectiveness of the consolidated set of funding initiatives in the context of the European Union’s research program Horizon 2020 is subject to some weaknesses that, in turn, impede the generalizability of findings. That is, even though the difference-in-differences approach accounts for the eligibility for Horizon 2020 funding through the dichotomy EU-member and non-EU member state, no information is provided about specific amounts of the funding budget received by the beneficiaries in a subsequent step. Further research incorporating this information in the empirical investigation could shed more light on the effectiveness of the research program in question.

Fourth, as a consequence of using an aggregated index when operationalizing the strength of a nation’s intellectual property rights system, statistical data interpretation is considered problematic. More specifically, the index is a composite of several sub-metrics causing difficulties in the disentanglement of individual sub-effects. A greater focus on the investigation of more disaggregated data in future research could produce more comprehensive estimates of the effects that an intellectual property regime has on EEM-sector business enterprise R&D expenditures.

Fifth, it has to be noted that the correlation tables in Appendix C indicate the existence of correlations between the predictor variables *logGFRD* and l*ogHUMAN*. For this reason, a further detection approach is applied in the form of variance inflation factors (VIF) in order to investigate how much the variance of a regression coefficient is inflated because of multicollinearity in the specification. As reported in Appendix F, numeric values within the VIF analysis range from 1.06 to 19.42 with a mean of 6.26. Applying a numeric threshold of 10 in accordance with Burns and Burns (2008, p.389), the VIF values of *logHUMAN* (18.72) and l*ogGFRD* (19.42) might be a cause of concern that needs to be addressed by future research in order to increase reliability of the statistical inferences made with regard to the individual effect of the explanatory variables.

Sixth, if the debate about EEM-sector R&D activity is to be moved forward, a better understanding of the industry's sub-sectors needs to be developed as a result of the heterogeneous nature of the electrical equipment manufacturing sector. Doing so could provide additional and valuable insights into R&D investment behavior. In this context, investigation and experimentation into highly relevant sub-industries in terms of sustainability is strongly recommended.

6. Conclusion

The soaring competitive pressure on the rate and scope of innovation as well as its associated importance for sustainable growth causes business R&D activity to become a highly relevant area of research in recent times. In this regard, a central discussion in the literature revolves around country-level variation in R&D intensity. Up until now, however, a deficient consensus on the determinants of business enterprise R&D investment behavior remains a major empirical concern in recent literature. This lacking systematic understanding, in turn, hinders politics in its endeavor to effectively spur private-sector R&D activity, especially, when it comes to highly sustainability-relevant industries in light of current systematic and structural weaknesses emerging as universal environmental sustainability challenges. For this reason, the study set out to empirically investigate the research question: what are the institutional and political drivers of a country's business R&D expenditure in the electrical equipment division of the manufacturing sector? Additionally, a difference-in-differences approach has been employed in order to evaluate the effectiveness of a specific set of funding initiatives targeted at the manufacturing sector of electrical equipment. In view of this, an econometric model, consisting of four focus variables inferred from the underlying theory, has been determined and ultimately estimated by making use of a fixed effects regression incorporating cluster-robust variance estimates. A panel comprising macroeconomic data as well as firm-level observations on twelve OECD countries spanning the years between 2000 and 2016 has been constructed for this purpose.

The investigation and its resulting findings have shed light on the driving factors of EEM-sector dependent R&D investment behavior and generally suggest that institutions do matter to a certain extent. In particular, results advocate the conventional view that intellectual property rights, as well as human capital formation, are essential to spur business enterprise R&D investment activity regardless of the type of specification causing these factors to be considered as robust determinants. Another important contribution of this investigation is the consideration of an association of direct government funding with R&D expenditures in the EEM-sector. Interestingly, a negative impact of government funding on business enterprise R&D intensity is obvious and consistent, suggesting an inducement of crowding-out rather than additionality effects. Adding to this, the difference-in-differences approach has not been found to provide evidence in favor of a significant effect of the research initiatives on EEM-sector private R&D intensity. Surprisingly, the paper was incapable of drawing a definite conclusion on the relationship of international trade openness to R&D investments, and thus, to find evidence for this factor to be a robust determinant in this respect.

Present research findings not only contribute to the deficient understanding of industry-specific factors influencing the amount of R&D expenses generated by private markets in the electrical equipment division of the manufacturing sector. Also, these results are supportive and of high value from a political perspective since assistance is provided to policymakers when it comes to the understanding, reconsideration, and reformation of essential parts of a nation's institutional and political framework in an endeavor to promote private R&D activity in the sector under investigation.

References

Acemoglu, D. (2008). *Introduction to modern economic growth*. Princeton University Press.

Acs, Z. J. & Audretsch, D. B. (1988). Innovation in Large and Small Firms: An Empirical Analysis. *The American Economic Review, 78*(1), 678–690.

Aghion, P. & Howitt, P. (1992). A Model of Growth Through Creative Destruction. *Econometrica*, 60(2), 323-351.

Aliabadi, S., Dorestani, A., & Balsara, N. (2013). The most value relevant accounting performance measure by industry. *Journal of Accounting and Finance, 13*(1), 22-34.

Badinger, H., & Tondl, G. (2002). Trade, Human Capital and Innovation. The Engines of European Regional Growth in the 1990s. Institute for European Affairs, Working Paper Nr. 42.

Becker, B. (2015). Public R&D policies and private R&D investment: A survey of the empirical evidence. *Journal of Economic Surveys*, *29*(5), 917-942.

Becker, B., & Pain, N. (2008). What determines industrial R&D expenditure in the UK?. *The Manchester School*, *76*(1), 66-87.

Belitz, H. (2016). Support for private research and development in OECD countries on the rise but increasingly inefficient. *DIW Economic Bulletin*, *6*(8), 106-114.

Bloom, N. (2007). Uncertainty and the Dynamics of R&D. *The American Economic Review, 97*(2), 250-255.

Bloom, N., Griffith, R., & Van Reenen, J. (2002). Do R&D tax credits work? Evidence from a panel of countries 1979–1997. *Journal of Public Economics, 85*(1), 1-31.

Boudreaux, K. (2005). The role of property rights as an institution: Implications for development policy. Mercatus Policy Series Policy Primer No.2. Arlington, VA. Mercatus Center at Georgia Mason University.

Bottazzi, L., and Peri, G. (1999), Innovation, demand and knowledge spillovers: Theory and evidence from European regions. CEPR discussion paper, no. 2279, London: Centre for Economic Policy Research.

Bravo-Ortega, C. & Marin, A.G. (2011). R&D and productivity: A two-way avenue? *World Development, 39*(7), 1090-1107.

Breusch, T. S., & Pagan, A. R. (1980.) The Lagrange Multiplier Test and its Application to Model Specification in Econometrics. *Review of Economic Studies, 47*(1), 239-253.

Brown, J. R., Martinsson, G., & Petersen, B. C. (2017). What promotes R&D? Comparative evidence from around the world. *Research Policy*, *46*(2), 447-462.

Burns, R., & Burns, R. (2008). Business research methods and statistics using spss. Los Angeles: SAGE.

Callejón, M., & García-Quevedo, J. (2005). Public subsidies to business R&D: do they stimulate private expenditures?. *Environment and Planning C: Government and Policy*, *23*(2), 279-293.

Coe, D.T. & Helpman, E. (1995). International R&D spillovers. *European Economic Review, 39*(5), 859-887.

Coe, D.T., Helpman, E. & Hoffmaister, A.W. (2009). International R&D spillovers and institutions. European Economic Review, 53(7), 723-741.

Costamagna, R. (2015). Inflation and R&D Investment. *Journal of Innovation Economics and Management, 17*(2), 143-163.

Dang, C., Li, Z. F., & Yang, C. (2018). Measuring firm size in empirical corporate finance. *Journal of Banking & Finance, 86*, 159-176

David, P. A., Hall, B. H. & Toole, A. A. (2000). Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence. *Research Policy, 29,* (4–5), 497–529.

Deming, D. & Dynarski, S. (2010). College aid. In *Targeting investments in children: Fighting poverty when resources are limited* (pp. 283-302). University of Chicago Press.

Dynarski, S. M. (2003). Does aid matter? Measuring the effect of student aid on college attendance and completion. *American Economic Review, 93*(1), 279-288.

Edquist, C., (1997). Systems of Innovation. Technologies, Institutions and Organizations. Pinter, London.

Edquist, C., (2005). Systems of Innovation: Perspectives and Challenges. Oxford Handbook of Innovation. Oxford, UK: Oxford University Press.

European Commission (2003). Investing in Research: an Action Plan for Europe. Communication from the Commission COM 2003, 226 final.

European Commission (2004). Facing the Challenge: The Lisbon Strategy for Growth and Employment. Report from the High Level group chaired by Wim Kok.

European Commission (2010). A Strategy for Smart, Sustainable and Inclusive Growth. Communication from the Commission .

European Commission (2018). Waste Electrical & Electronic Equipment (WEEE). Retrieved June 29th from http://ec.europa.eu/environment/waste/weee/index_en.htm

European Competitiveness and Sustainable Industrial Policy Consortium (2013). Study on the Competitiveness of the Electrical and Electronic Engineering Industry. Final Report.

Falk, M. (2006). What drives business Research and Development (R&D) intensity across Organisation for Economic Co-operation and Development (OECD) countries?. *Applied Economics, 38*(5), 533-547.

Freeman, C. (1995). The national systems of innovation in historical perspective. *Cambridge Journal of Economics*, 19(1), 5-24.

Funk, P., Kromen, B. (2010). Inflation and Innovation-driven Growth. *The B.E. Journal of Macroeconomics, 10*(1), 1-52.

Furman, J. L., Porter, M. E., & Stern, S. (2002). The determinants of national innovative capacity. *Research policy*, *31*(6), 899-933.

Galindo-Rueda, F. & Verger, F. (2016). OECD Taxonomy of Economic Activities Based on R&D Intensity. *OECD Science, Technology, and Industry Working Paper.* OECD Publishing, Paris.

Garcia, A., & Mohnen, P. (2010). Impact of government support on R&D and innovation. Retrieved June 24th from https://cris.maastrichtuniversity.nl/portal/files/1017547/guid-843c9cd3-3abc-4d73-967e-85e54d16249c-ASSET1.0

Girma, S., Görg, H., & Hanley, A. (2008). R&D and exporting: A comparison of British and Irish firms. *Review of World Economics*, *144*(4), 750-773.

Girma, S., Gong, Y. D., Görg, H. & Yu, Z. (2009). Can production subsidies explain China's export performance? Evidence from firm-level data. *Scandinavian Journal of Economics, 111*(4)*,* 863–891.

Görg, H. & Strobl, E. (2007). The Effect of R&D Subsidies in Private R&D. *Economica, 74*(294), 215-234.

Greene, W. (2000). *Econometric Analysis*. New York: Prentice-Hall.

Griffith, R., Harrison, R., & Simpson, H. (2010). Product market reform and innovation in the EU. *Scandinavian Journal of economics*, *112*(2), 389-415.

Grossman G. & Helpman, E. (1991). Innovation and Growth in the Global Economy, MIT Press, Cambridge.

Guellec, D. and Van Pottelsberghe De la Potterie, B. (2004). From R&D to Productivity Growth: Do the Sources of Funds and Institutional Settings Matter? *Oxford Bulletin of Economics and Statistics, 66*(3), 353–376.

Hall, B. H., Mairesse, J. & Mohnen, P. (2009). Measuring the Returns to R&D. In *Handbook of the Economics of Innovation*. Elsevier-North Holland.

Hall, B.H. and Reenen, J., van, (2000). How effective are fiscal incentives for R&D? A review of the evidence. *Research Policy 29*, 449-469.

Hausmann, J. A. (1978). Specification Tests Econometrics. *Econometrica, 46*(6), 1251-1271.

Hussinger, K. (2008). R&D and Subsidies at the Firm-Level: An Application of Parametric and Semiparametric Two-Step Selection Models. *Journal of Applied Econometrics 23*, 729-747.

Kahn, J. (2015). The Role of Research and Development in Economic Growth: A Review. *Journal Of Economics Bibliography, 2*(3), 128-133. doi:10.1453/jeb.v2i3.480

Kanwar, S. and Evenson, R. (2003). Does intellectual property protection spur technological change?. *Oxford Economic Papers, 55*(2), 235-264.

Keller, W. (2004) International Technology Diffusion. *Journal of Economic Literature*, **42**(3), 752–782.

Kumar, N. (2001). Determinants of location of overseas R&D activity of multinational enterprises: the case of US and Japanese corporations. *Research Policy, 30*(1), 159-174.

Lanjouw, J. O., & Lerner, J. (2000). The enforcement of intellectual property rights: a survey of the empirical literature. *Annals of Economics and Statistics, (49-50)*, 223-246.

Lee, C. (2008). Innovation, productivity and exports: Firm-level evidence from Malaysia. *Nottingham University Business School University of Nottingham-Malaysia Campus, Working Paper Series*, *6*.

Leyden, D. P. & Link, A. N. (1992). *Government' s Role in Innovation*. Dordrecht/Boston /London: Kluwer Academic Publishers.

Lokshin, B., & Mohnen, P. (2012). How effective are level-based R&D tax credits? Evidence from the Netherlands. *Applied Economics*, *44*(12), 1527-1538.

Lu, X., & White, H. (2014). Robustness checks and robustness tests in applied economics. *Journal of Econometrics, 178*, 194-206.

Lundvall, B.-Å. (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publishers.

Lundvall, B. Å. (2007). National innovation systems—analytical concept and development tool. *Industry and Innovation, 14*(1), 95-119.

Maskus, K. E. (2000). *Intellectual property rights in the global economy*. Washington, DC: Institute for International Economics.

Mazzucato, M. (2011). The entrepreneurial state: overlooking the key role of the state in promoting innovation is one of the biggest mistakes of market fundamentalism. *Soundings*, (49), 131-143.

Mulkay, B. & Mairesse, J. (2013). The R&D tax credit in France: Assessment and ex-ante evaluation of the 2008 reform. *Oxford Economic Papers, 65*(3), 746-766.

Myers, S.C. (1977). Determinants of corporate borrowing. *Journal of Financial Economics, 5*(2), 147– 175.

Nelson, R. (1993). *National Innovation Systems: A Comparative Analysis*, New York: Oxford University Press.

O'Mahony, M. & Vecchi, M. (2009). R&D, knowledge spillovers and company productivity performance. *Research Policy, 38*(1), 35-44.

Organisation for Economic Co-operation and Development (OECD). (2001). *Regulatory Investment Incentives, November 2001.* Paris: OECD. Retrieved from https://www.oecd.org/daf/inv/investmentstatisticsandanalysis/2510459.pdf

Organisation for Economic Co-operation and Development (2002). STI Report: tax incentives for research and development - trends and issues, Paris. (VON BERUBE AND MOHNEN)

Organisation for Economic Co-operation and Development (2005). A Policy Framework For Investment: Human Resource Development Policy. OECD Conference

Organisation for Economic Co-operation and Development (2011). Technology and Industry Scoreboard. *OECD Publishing*

Organisation for Economic Co-operation and Development (2012). *OECD Factbook 2013:* Science and Technology. Expenditure on R&D. *OECD Publishing.*

Organisation for Economic Co-operation and Development (2015). Frascati Manual 2015: Guidelines for collecting and reporting data on research and experimental development. OECD Publishing 2015.

Pesaran, M. H. (2015). Testing Weak Cross-Sectional Dependence in Large Panels. *Econometric Reviews, 34*(6-10), 1089-1117.

Romer, P. (1986). Increasing Returns and Long-Run Growth, *The Journal of Political Economy*, 94 (5), 1002-1037.

Romer, P. (1990). Endogenous Technological Change, *Journal of Political Economy*, 98, 71-102.

Sachs, J.D. & Warner, A. (1995). Economic reform and the process of global integration. *Brookings Papers on Economic Activity*, *26*(1), 1–118.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics, 70*(1), 65–94.

Swan, T. W. (1956). Economic Growth and Capital Accumulation. *Economic Record* 32(2), 334–361.

Wang, E. C. (2010). Determinants of R&D investment: The Extreme-Bounds-Analysis approach applied to 26 OECD countries. *Research Policy*, *39*(1), 103-116.

Wooldridge, J.M. (2002). *Econometric Analysis of Cross-section and Panel-data*. Cambridge, MA: MIT Press.

Wooldridge, J. (2013). *Introductory econometrics: A modern approach* (5th ed.). Australia, etc.: South-Western/Cengage Learning.

Yang, C. H., & Chen, Y. H. (2012). R&D, productivity, and exports: Plant-level evidence from Indonesia. *Economic Modelling*, *29*(2), 208-216.

Appendix A

Country Register

Number	Country Name	ISO Country Code	EU-Membership	Observations
1	Australia	AUS	No	374
2	Austria	AUT	Yes	58
3	Belgium	BEL	Yes	102
4	Finland	FIN	Yes	118
5	Germany	DEU	Yes	541
6	Italy	ITA	Yes	214
7	Korea Republic	KOR	No	2271
8	Norway	NOR	No	70
9	Poland	POL	Yes (2004)	233
10	Slovenia	SVN	Yes (2004)	17
11	Spain	ESP	Yes	17
12	Turkey	TUR	No	192

All listed countries are members of the OECD

Appendix B

Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max	Observations
logRDI	-7.007489	3.358651	-10.15576	-1.234192	3500
IPRP	74.27739	12.50776	40	95	4207
OPEN	80.63856	23.25363	37.15629	164.71	4207
logHUMAN	12.11319	0.790811	8.236156	12.90127	3888
logGFRD	7.176522	1.028799	2.944083	8.129096	3996
logGDPCAP	10.19458	0.456108	8.94006	11.42537	4207
INFLAT	2.5124	3.254222	-0.8741259	54.91538	4207
INTER	3.81392	1.465819	0.09	10.68167	3985
UNEMPL	4.795927	2.606552	1.764063	23.86754	4207
logASSETS	8.571629	4.189044	0.0256677	21.77584	4189
ROA	-0.0217736	0.2199351	-1.972461	1.177891	3792
DEBT	1.249435	7.45257	-223.1053	129.1538	2483

Unbalanced panel in a period from 2000 to 2016

Appendix C

Correlation Table 1/2

	logRDI	IPRP	OPEN	logHUMAN	logGFRD	logGDPCAP	INFLAT
logRDI	1.000						
IPRP	0.3567	1.0000					
OPEN	-0.4008	-0.0754	1.0000				
logHUMAN	-0.6178	-0.0167	0.1388	1.0000			
logGFRD	-0.6852	-0.0681	0.2896	0.9442	1.0000		
logGDPCAP	0.6557	0.6978	-0.3759	-0.3248	-0.3379	1.0000	
INFLAT	-0.1675	-0.1159	0.3216	-0.0667	-0.0016	-0.1504	1.0000
INTER	-0.2928	-0.5844	0.1256	-0.1472	-0.0886	-0.4774	0.7050
UNEMPL	0.7543	-0.1534	-0.3976	-0.5514	-0.5846	0.2163	-0.1516
logASSETS	-0.9073	-0.3352	0.4022	-0.5386	0.6300	-0.5889	0.1483
ROA	-0.0392	-0.0687	0.0752	0.0353	0.0586	-0.1128	0.0439
DEBT	0.1260	-0.0770	-0.0806	-0.0939	-0.0783	0.0720	-0.0085
d2	-0.0409	0.0513	-0.2797	0.1350	0.0637	0.0197	-0.6667
dEU	-0.9468	0.2147	-0.3026	-0.4948	-0.5528	0.4520	-0.1923
dEU*d2	-0.5000	0.0920	-0.1845	-0.2330	-0.2973	0.2266	-0.4302

Unbalanced panel in a period from 2000 to 2016

Correlation Table 2/2

	INTER	UNEMPL	logASSE	ROA	DEBT	d2	dEU	dEU*d2
INTER	1.0000							
UNEMPL	-0.0023	1.0000						
logASSETS	0.2415	-0.6686	1.0000					
ROA	0.0317	0.0074	0.1407	1.0000				
DEBT	0.0321	0.1723	-0.0970	-0.0861	1.0000			
d2	-0.5528	0.0017	0.0454	-0.0252	-0.0249	1.0000		
dEU	-0.2899	0.7997	-0.8463	0.0169	0.1296	-0.0294	1.0000	
dEU*d2	-0.4721	0.4252	-0.4533	-0.0170	0.0542	0.4154	0.5296	1.0000

Unbalanced panel in a period from 2000 to 2016

Appendix D

Summary of Hypotheses

Label	Hypothesis	Considered Variable	Supported
H1	The stronger the patent rights protection framework in a country is the higher its R&D investment intensity.	*IPRP*	Yes
H2	The more open the economy of a country is to international trade the higher its R&D investment intensity.	OPEN	No
H3	The stronger the human capital formation in a country is the higher its R&D investment intensity.	logHUMAN	Yes
H4	Direct government funding of business R&D in a country is a complement for private R&D intensity.	logGFRD	No

Appendix E

Year-fixed Effects Estimation Results Model (3.4)

Year	Model (3.4) Year-effects
2001	-0.021
	(0.160)
2002	-0.246*
	(0.127)
2003	-0.089
	(0.060)
2004	-0.162**
	(0.064)
2005	-0.120
	(0.076)
2006	-0.006
	(0.075)
2007	0.138*
	(0.072)
2008	0.068
	(0.081)
2009	0.104
	(0.065)
2010	-0.038
	(0.101)
2011	0.002
	(0.121)
2012	0.180
	(0.131)
2013	0.089
	(0.139)
2014	-0.112***
	(0.020)
2015	0
	(omitted)

Fixed effects regressions of model (cluster robust variance estimates) with modification. Robust standard errors in parentheses.
(Two-tailed) significance levels: *10%, **5%, ***1%

Appendix F

Variance Inflation Factors Model (3)

	VIF	1/VIF
logGFRD	19.42	0.051494
lohHUMAN	18.72	0.053423
dEU	8.11	0.123312
INTER	7.35	0.136031
logASSETS	5.99	0.166807
logGDPCAP	5.06	0.197665
UNEMPL	5.03	0.198783
IPRP	4.60	0.217271
INFLAT	3.68	0.271969
OPEN	2.72	0.367074
d2	2.61	0.382916
dEU*d2	2.14	0.467760
ROA	1.11	0.899604
DEBT	1.06	0.941847
Mean VIF	6.26	

Declaration of Originality

I hereby certify that I am the sole author of this Master thesis for the M.Sc. International Business track Strategy and Innovation. The views and arguments provided in this thesis reflect my opinion, and not necessarily that of Statistics Netherlands.

I certify that, to the best of my knowledge, my thesis does not infringe upon anyone's copyright nor violate any proprietary rights. Any ideas, techniques, quotations, or any other material from the work of other people included in my thesis, published or otherwise, are fully acknowledged in accordance with the standard referencing practices.

Maastricht, 16th of December 2018