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„Comparison of State Support of Research and Development in the Electronics Industries of Japan, South Korea and Taiwan“

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ABSTRACT

This Thesis explores the relationship between state involvement in R&D and various performance indicators of the electronics industries of Japan, South Korea and Taiwan between the years 2000-2019. In addition to potential similarities and differences between the country cases, the paper also compares the role of the state in innovation with that of the business and higher education spheres.

After a review of the existing literature on industrial policy and innovation systems theory, the research question is answered with the help of linear regression and correlation analysis using 12 variables in total.

ABSTRAKT

Diese Arbeit untersucht anhand von verschiedenen Leistungsindikatoren welche Auswirkungen staatliche Förderungsprogramme auf Elektronikindustrien haben können. Als Fallstudien werden für den Zeitraum 2000-2019 die Länder Japan, Südkorea und Taiwan untersucht. Weiterführend wird innerhalb der Studie diskutiert, welche Rolle der Staat in der Innovationsförderung einnimmt und wie diese sich von der Unternehmens- und Hochschullandschaft unterscheidet.

Nach einem Überblick über die vorhandene Literatur zur Industriepolitik und zur Theorie der Innovationssysteme wird die Forschungsfrage mit Hilfe einer linearen Regressions- und Korrelationsanalyse unter Verwendung von insgesamt 12 Variablen beantwortet.

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Part one: Introduction

(1) Section one: The Topic and Research Question

Do government policies really matter in economics? Or rather, in today's interconnected world, can the influence of one actor – any actor or event – be really isolated as the cause of something? Can such a thing even be proven?

Money being spent on research and development (R&D) is rising. In the OECD – the Organisation for Economic Co-operation and Development, an international organization with 38, predominantly developed countries (OECD n.d.) – total spending on R&D projects have almost doubled between the years 2000 and 2019. (OECD 2022)To take an Asian country and a slightly different metric for example, in South Korea, the country's R&D intensity (the share of gross domestic product or GDP being spent on research and development) has risen from 2,1% in the year 2000 to 4,5% by the most recent available data point of 2018. (World Bank 2021) In other words, the share of resources the country – all actors in it collectively – uses to try and innovate has more than doubled in the last two decades.

This means, that the weight and significance of this field is growing. The function that once was called industrial policy and characterized by Chalmers Johnson as a triangle of the government, bureaucracy and large corporations (C. Johnson 1985, 60), is today served by – according to others – technology and innovation policy. (Cherif & Hasanov 2019, 6-21) This means, that technological development and progress brings but also necessitates innovation. As a country makes its way from an agricultural society to light and then heavy industry, there is a need to increase the value-added at each step, because these do diminish eventually. The idea goes, that to get to the top – and stay there – constant innovation is needed. Research and development is a key part of that.

This paper analyzes works on industrial policy and state support of research and development (R&D) in Japan, South Korea, and Taiwan from the end of their high-growth years to today, with the area of analysis being the electronics industry. The period chosen for this is the last two decades, with the observed timeframe being the years between 2000 and 2019.

The specific question for this research is:

If compared, does the performance of the electronics industry of Japan, South Korea and Taiwan correlate with state support of research and development?

The research question seeks to analyze the relationship between various performance indicators and various inputs coming from state, business, and higher education sources. In addition to the comparison of the country cases, the goal is to see the strength of the relationship between each variable, and whether a difference in productivity between the three actors can be identified. The research question is going to be answered with the help of linear regression.

Throughout this inquest, there were some recurring themes. Some of the existing literature reviewed in this thesis – to be discussed in detail in following sections – suggests, that while Japan did very well in the past, lately it declined relative to South Korea and Taiwan. This decline can be characterized in an overall economic decline, as well as a decline of specific industries. To address the former, after experiencing a period of economic growth, in 1991 Japan entered a phase of economic stagnation with GDP growth hovering around 1% per year over a ten-year period, called the Lost Decade. (Horioka 2006, 378-379) During the stock market crash experienced in Tokyo in the period between 1989-1992, the Nikkei – the stock market's main index – lost 63,2% of its value. (Schiller 1996, 156) The timeframe of the analysis – between the years 2000 and 2019 – and why it was chosen is to be discussed more in detail in the analytical framework.

When analyzing the declining performance of a particular segment of the economy – in this case, a specific industry like electronics, or a specific area like innovation – different authors arrive at similar conclusions. (Arora et al. 2010) (Branstetter & Nakamura 2003) The works cited here all are centered around this issue of a perceived decline, with some of the specific points they raise to be examined in a more detailed manner later on.

Is this analysis going to fit into the same narrative of decline, or not? There are suggestions of the primacy of government with some even describing this supposedly East Asian model as the "developmental state". (Stubbs 2009, 2-9) Other research highlights the government, private enterprise, and higher education as the three main actors, with debate around which of the three is the most important. (Eriksson 2005, 9-14) This will also be probed in due course.

To determine if Japan declined compared to Taiwan and South Korea or not, various output performance indicators will be compared. The variables themselves are going to be selected following an analysis of the literature, with specific sections dedicated to the electronics industry, as well as the country cases. This is done to make sure, that the criteria used in the analysis are relevant for the topic.

Determining how (if) certain factors like government involvement in research correlate at all with such performance indicators, linear regression will be used. This method provides data on the relationship between multiple variables. Regression analysis reveals the strength of the connection (if any) as well as how sure we can be of the result, based on the sample size and the number of variables. Twelve variables will be covered in total, five output ones (goals in this sense) and seven input ones (predictors of these goals). The selection of these criteria seeks to be in line with the literature and thus not completely arbitrary, however due to the scope and complexity of the topic, there are many other criteria that could have also been examined. For this reason, recalibrating and modifying this specific framework for different research purposes is certainly encouraged. Also very important, is that the results are going to be a product of a fixed set of criteria in a mathematical model, but the actual economy it examines is much more complicated than that. Therefore, one should avoid too hastily jumping to big conclusions solely based on one single analysis, and should always seek to keep its additional conditions in mind.

The paper is broken down into six main parts, each then further divided into shorter sections. Part one is the introduction, where the concept of this thesis is outlined, and some brief background information on the topic, its relevance, and the limitations of the research project is provided.

Part two is the review of the literature on the subject. Its primary goal is to provide the background for the paper, as well as analytical criteria for the framework to be used. First, it will be defined what industrial policy is, and how experts are approaching the analysis of different policies. Second, it will be demonstrated how standard industrial policy theory progressed to the modern era, centered around innovation. Thus, sections one to three deal with the theoretical background of industrial policy at first, then zoom in on research and development as well as innovation support policies in order to extract potential analytical criteria for the framework. Sections four and five try to identify further criteria for through looking at the electronics industry and also the country cases specifically. Finally, sections six and seven will conclude the literature review with a discussion on how to measure the criteria identified earlier.

Part three contains the analytical framework. First, it discusses the method of analysis that was chosen and why. This is also supplemented by information on the potential problems and challenges that might arise when using such research methods. Second, come the criteria to be used are explained. The part is supplemented by definitions of each term as well as specific measurement that is used, alongside potential issues with the analytical method and criteria. The criteria are arranged into two blocs, first the dependent and then the independent variables are to be listed. Twelve variables were chosen in total.

Part four is the empirical part, where the data to be used for the analysis is presented. The section progresses in the same order as the analytical framework did, with each variable being illustrated with a graph depicting how data changed over time, as well as the relative positions of the three countries compared to each other. After this, the regression analysis was carried out and the results, or the items that are relevant for this analysis were arranged into tables, one for each dependent variable.

Part five contains the analysis of the results in relation of the research question. First, the results of the empirical part are summarized, followed by the actual regression results and the formal answering of the research question. This part also contains an assessment of the final results as well as their reliability, especially in light of certain properties of the methodology. The last paragraphs here are revisiting the work of some of the authors cited in the literature review, and comparing their ideas and explanations with the results of this analysis. Finally, part six reviews the main highlights and concludes the paper.

While some of the sources cited here only focus on one of these three countries, other studies included in this paper are comparative analyses themselves. It was a conscious decision, to see what kind of analytical structures and parameters are used in existing comparative research, as well as to have the most diverse pool of sources – geographically, culturally, and chronologically – as possible to minimize bias.

(1) Section two: Relevance

From this paper, the readers will be able to better understand how modern industrial policy and innovation and R&D are related, to what extent can state intervention play a role in the improvement of various metrics of performance in an industry, and what kind of attempts are being made in order to potentially measure a thing like this. The first sections of the literature review particularly benefits people seeking a starting point into industrial policy and systems of innovation theory with some prominent authors and ideas discussed.

The authors in that section arrived at the conclusion, that increasingly, R&D support became a core element of industrial policy. The section following that discussion is focused on identifying criteria for the analysis, where readers can gain knowledge on what the most widely used parameters, by which experts approach the topic in the context of the electronics industry, as well as Japan, South Korea, and Taiwan. Towards the end of the literature review, there is an explanation dedicated to correlation and regression, where one can gain some insight on the kind of conditions and assumptions, under which these methods can be used, and their results interpreted. In the next few paragraphs, the relevance of specific features of this study will be further discussed.

Why Japan, South Korea and Taiwan?

The three cases to be compared are relevant, because all three countries are members of the "East Asian Miracle", a period of rapid growth experienced in various nations in the region during the post-war era, with government intervention being one of their common elements. (Stiglitz 1996, 151)

On a personal note, seeing what these countries achieved from a perspective of a person from, in Hungary's case – a modestly sized resource-poor country (EEA 2015, 9) does make one envious, and examining different features of their development may just have some important lessons that other countries might be able to learn from. There might be a possibility to emulate some of these policies in other countries and be successful. Having ambitions in potentially entering or working with the public service in the future, having knowledge of previous good examples is a benefit.

Why their electronics industry?

The electronics industry was chosen, because according to the World Bank, integrated circuits are the top exports for South Korea (World Bank 2018 c) and Taiwan (World Bank 2018 a) and second in Japan (World Bank 2018 b), making it a significant force in their respective economies.

Why this method of comparison?

Finally, while correlation and regression is used extensively in economic analysis (Ramcharan 2006), a specific application of it on this specific topic did not come up at all during this inquest, giving this thesis a unique feature.

This paper does not claim to answer questions, like "Why X country is doing better, than Y?", as there are too many variables influencing economic policy to ever find a single reason for such a thing, the analysis will show if different things correlate or not. It can be helpful for policy makers – in government, bureaucracy but potentially also business – to see, if the indicators for the measurement of reaching our goal (to increase the number of patents filed by our nationals for example) and what we do to achieve it (government spending) at least point to the same direction or not. While the results on their own would not be enough to convince the budgetary commission or the company board to provide – or cut – funding for certain things, it could serve as a small fraction of the argument.

That is, if the result would seem to suggest a strong connection. However, results could also suggest, that private enterprise has a bigger influence. Or, that all of these relationships – at least according to the variables included in this research – are insignificant, which in itself would be its own result.

Why this specific question?

The goal of asking this question, is to contribute to the debate on whether states should engage in industrial policy, specifically in relation to innovation and R&D support. Should governments allocate money for this, or should research be instead done by private enterprise or academia? Which one is more productive? Does any of this correlate with increased performance, for example in exports or new patent filings? Theis paper aspires to contribute towards the discourse on these issues.

Fundamentally, is it worth spending all that taxpayer's money on specific industries and research, employ all those people to formulate big developmental plans? Politicians in general like to talk a lot about things such as "development", "innovation" or maybe "science" as well as the role they play in achieving success for their nations. (B. Johnson 2021) (Orbán 2016) (Xi 2020) Is it possible they make their role appear larger than it actually is?

Outright wasting money is one thing, however opportunity cost is also something that must be considered. If a project is pursued that proves to be unsuccessful, the money spent is the direct cost. However, this is not the full picture. Opportunity cost is the cost of the alternative option that was not chosen because the resources were spent elsewhere. (Parkin 2016, 12-15) If resources (capital as well as manpower or time) are tied up in unprofitable endeavors, they cannot be used for something else that might be better. Learning more about the relationship between performance and certain inputs that lead to it may have some merit also from this perspective.

Using the resources at your disposal productively is important not just a competitiveness or opportunity cost perspective, but also when considering the issue of sustainability. The debate around whether infinite growth is possible on a finite planet – logically, probably not – is more important than ever with issues such as pollution and climate change looming large over the future of mankind. (Dhara & Singh 2021) However, this is also important specifically from the perspective of research and development. If one takes a look at the latest sustainability report of the United Nations, the document stresses to further increase R&D expenditure to deal with unexpected crises such as COVID-19, but also for improving infrastructure and industrialization in a sustainable way. (United Nations 2021, 44-45) Thus, the proper allocation of research funding is a key component in not just economic development but also preserving the well-being of our planet.

At the end of the day, what is the objective of the growth of an industry, or the economy for that matter? The fundamental goal of economic development is, to increase the wealth of the community by raising incomes, providing better access to services, and combat unemployment. (Daniels 1991, 3) Meaning, to improve the lives of the citizens of said economy. Thus, more productive resource allocation – which this paper aims to contribute to – has the potential to play a significant role in improving the welfare of society as a whole.

(1) Section three: Limitations of the Research

The research has several important limitations. Industrial policy, even if this paper only deals with on aspect of it – innovation and R&D support – is a big topic that has been tackled by many experts over the years, and therefore, the works presented here only amount to a very small sample of them. This analysis is the product of the diversity of the debate and the many aspects of the topic, as well as the formal requirements and constraints and the question of the availability of data, however many other features that could not be included would certainly warrant their own, equally important paper.

The fact, that the concept of innovation and all the things that may or may not have an influence on it, is so complex, means that there is a plethora of different views and arguments to discuss and potential criteria to choose from. This means, that deciding upon inclusions and omissions is inherently challenging and is subject to debate.

On the other hand, there have been specific omissions that should be acknowledged, such as the general dispute whether state intervention – fundamentally – a good or a bad thing, in which this paper cannot possibly take sides as it is way beyond the scope of what can be covered here. Furthermore, the Global Financial Crisis – which, by virtue of being global, hand to have some kind of impact in all three countries and the data coming out of them – happened in 2007-2008 (Mrkaic & Nabar 2018) and thus fell into the observed period, but despite that will not be analyzed in detail.

In terms of sources, the only data that could be utilized was either publicly available, or accessible via the university credentials. While this did provide ample resources, a considerable number of materials that no doubt would have been useful were still behind the paywall, which was then unusable because of budgetary constraints or the lack of time to gain access through an individual request. The issues of time and money, along with the Coronavirus pandemic limiting movement around the world, also made conducting field work in any of the target countries impossible during the research process. Speaking of time as a factor, it has to be said, that the paper was written within a fixed timeframe, which constrained the number of revisions and changes that can be reasonably implemented.

As for languages, the sources and data used in this essay were written in English or Hungarian. While there was an intention to include as many "native" sources – written by Japanese, Korean or Taiwanese authors – as possible, for all of them the English version of their work was cited, meaning that it is entirely possible for some details to be lost in translation.

Regarding data sets, the only ones that are really comparable are data that came from the same source, to avoid discrepancy or bias. This is obvious, and all three countries being important players in the world of innovation, might not seem like a very difficult task at first. However, with the contentious legal status of Taiwan, it is not allowed to be a member of various international organizations. While some allow for various loopholes, competing under the name of "Chinese Taipei" in the Olympic Games just to name one, in some cases this meant a complete lack of comparable data.

It is also worth noting, that two of the three target countries are – as of writing this passage in 2022 – locked in frozen but tense military conflicts with North Korea and the People's Republic of China respectively, meaning that any data produced by South Korean and Taiwanese sources could also – in theory – also serve propagandistic purposes. While both nations are ranked very high in indexes such as Transparency International's Corruption Perception Index (28th place for Taiwan and 33rd for South Korea in the most recent editions) (Transparency International n.d.) or similarly admirable scores at the country reports of the Bertelsmann Stiftung's Transformation Index (Bertelsmann Stiftung n.d.) and therefore, such concerns are perhaps negligible, this might be something that should nevertheless be kept in mind.

The question of international politics aside, incomplete data sets did cause significant difficulties for different reasons too. Naturally, the only way in which data is comparable, if all data points are from the same source. Same data set, same methodology. If one were to compare the GDP of the United States, France, and Germany, the best course of action is to use data from an international organization that includes all three. If one gets the first one from the Fed and the latter two from the EU for example, there may be some differences in how it was gathered.

For these reasons, the research leans heavily on OECD data, but even there several criteria had not just one of the three countries missing, but years missing as well. Countries start recording certain things at different times. In some cases, they might not keep track of certain things at all. Databanks use different definitions for measuring similar things. The disparity starts with the names already, with the IT industry, Tech industry, Electronics industry, or ICT industry all existing with significant overlap. This is true for even different variables of the same source. The exact details will be discussed further in the analytical framework.

Furthermore, OECD works with either data provided by the countries themselves, or estimates they provide themselves. This also leads to potential issues around self-reporting (using different reporting standards as well as providing fraudulent data on purpose), as well as inaccuracies in the estimations where the numbers are missing. Again, while all three countries as well as other organizations where data was used from in this analysis are transparent and reputable, these conditions should be remembered when making conclusions.

Specific limitations of using regression and interpreting its results can be found in the theoretical discussion, as well as the methodology section. What is absolutely critical here, is that the result of this analysis is the product of a model with a fixed set of variables based on specific sources of data, when in fact the real economy is not. This means, that when interpreting the results, one should avoid rash judgements, and always keep the context in mind.

Part two: Review of the Literature

(2) Section one: Defining Industrial policy

The primary goal of this literature review is to extract analytical criteria, with which state support of research and development can be correlated with various performance indicators of the electronics industry of Japan, South Korea and Taiwan. To achieve this, various analytical frameworks are going to be presented, with a separate section dedicated to each major component of the topic. Thus, an initial discussion of industrial policy will be followed by R&D support policy – being its subset – and then separate sections analyzing the electronics industry, the country cases, and finally performance measurement.

The literature review is going to start with industrial policy theory. In order to build a framework for answering a question on the performance of the electronics industry and government policies related to it, a decision was made to start with exploring how authors approach talking about such policies. This is going to be followed by a discussion of what the performance might entail, and towards the end arrive at potential ways in which this can be measured and evaluated.

"There is probably not one concept in the economic policy field which raises today so much controversy, as industrial policy." (Soete 2007, 273)

Industrial policy as such has no single definition, as the way in which states supported private enterprise with taxpayer's money changed greatly over time. (Ambroziak 2016, 3) There is consensus however on three main avenues in which the state can nudge market forces to be more similar to their liking, which are: providing the legal and regulatory framework, a political climate of goal-setting and support, and finally financial assistance.

Chalmers Johnson, when talking about Japanese industrial policy, defined it as follows:

"Industrial policy means the initiation and coordination of governmental activities to leverage upward the productivity and competitiveness of a whole economy and of particular industries in it" (C. Johnson 1985, 65)

This is however just another characterization. According to others (Peres et al. 2009, 14), industrial policy can be divided into four things, with setting the rules being the first, the second and third being the direct participation of the state in the economy as a producer (state-owned enterprises) or a consumer through public procurement, and the fourth being financial management.

It can also be called a deliberate attempt by the government to make resource-allocation and investment decisions, influence the ones made by private entities, in order to achieve a societal goal that the market fails to do. (Dolfsma & Mamica 2020, 349)

From a theoretical standpoint there is debate on the extent to which states should intervene. According to the neoliberal view, it should not, because the market knows best. Contrary to that is the Schumpeterian, evolutionist and structuralist (Keynesian) view, there is room for public as well as private intervention. (Peres et al. 2009, 6) It can both be seen as restructuring that helps create growth, as well as intervention that distorts competition, depending on one's allegiance. (Ambroziak 2016, 3)

As for industrial development theory, the idea that economic development happens through qualitative change is mostly associated with Schumpeter and was, according to Peres (2009, 10) followed by three distinct phases. In phase one, which would be post-war growth era, the works and ideas of authors such as Hirschman or Prebisch are brought up, with an important caveat, that while they had very different ideas on how development should be achieved, but they did agree on the fact that developing economies are structurally, fundamentally different from developed ones, and how labor should be gradually shifted from low to high productivity industries. The second phase saw people gradually losing interest in the growth model, as it failed to account for innate technological differences between countries. The third phase then covers the 1980's with the peak of the Japanese miracle with authors like Chalmers Johnson, with innovation emerging again as a point of interest in relation to economic competition.

With many definitions come different scopes as well as different aims. (Ambroziak 2016, 6-12) According to Landesman, the goal in less advanced economies is to figure out the exact path towards development, and because these have already been explored by others, a vertical approach is what works best. In advanced economies however, this requires new solutions and a wider, horizontal buildup of various competencies. (Landesman 2015, 137)

Others claim that industrial policy is not even about industry, as a similar set of policies with the same goals could also be applied to improving agriculture or services. (Rodrik 2009, 3) Looking at the aims, some say it is not just economic growth through structural realignment, but also a change in social and civil development. The aim can be fixing market failures, or also national wealth creation through innovation. (Glykou et al 2011, 462) Sharp proposes that science and technology policy – broad as it is – is a subset of industrial policy pursuing the same goals, value creation internally and trade performance externally – essentially all being elements of the same broader plan working towards the same sort of goals. (Sharp 2001, 20-24)

While not all countries have an explicit industrial policy (that has a name, specific goals, people that are responsible for it, and resources directly allocated to facilitate its successful execution), actually all countries have a de facto industrial policy, that is a collection of various government actions, fitting neatly into a broader narrative of national development. (Peres et al. 2009, 14-24) In this study, the dichotomy of scope and aims is a bit different. Here, scope depends on two things: policy making capacity on the one hand, and the number of different instruments that one uses to achieve them. Based on this, industrial policy happens in three levels. The most basic one would be horizontal policies that supposedly only require basic capabilities, these would include general incentives for things like infrastructure or business development. The second, are sectoral policies that involve targeted, specific actions to support the competitiveness of, or draw foreign direct investment to a given industry. Direct action through state-owned enterprises for example would also come here. Last, are frontier policies, that represent the developmental vision of the nation, and thus requires the coordination of a very large number of actors over a long period of time.

When talking about the Asian miracles – Hong Kong, Singapore, South Korea and Taiwan – and what made them special, Cherif & Hasanov (2019, 24-26) identify three elements of their "true industrial policy". The first one is government intervention, specifically addressing market failures that make it difficult for domestic actors to engage in key industries. The second was export orientation – instead of import substitution – while the third one was the creation of a truly competitive environment through accountability. When talking about how to achieve them, a three-gear approach is presented, all representing different policy-mixes. The first level is called snail-crawl, intending to fix mostly government failures through investment in things like institutions, infrastructure or education. A gradual approach, not very radical, most policies fall under this category. The second gear is the leapfrog approach, which means an investment into specific industries the country perceives it might have a comparative advantage in. This can then be followed by further investment in related or similar industries, making gradual improvement. The final gear is the moonshot approach, which entails long-term vision, risk-taking, and investment in capabilities that help domestic firms grow way beyond what their existing advantages would normally allow them to.

So far, the theoretical discussion was centered around the depth and width of industrial policy. Depth, in terms of incremental corrections or fundamental changes, and width, in the scope or number of different sectors and industries targeted. But what are the actual policy areas, how have they been defined? Because of the variety of definitions of what industrial policy is, this also yielded some divergent results.

In Santiago's framework (2015, 45-49), five policy domains are identified through some examples from the aerospace and palm oil industries. The first of these is the product market, where specific policies include launching state-owned enterprises, tax incentives, public procurement or pegging prices to domestic input prices to keep the industry competitive. The second, is the labor market. Here, subsidized training schemes, labor mobility through either domestic incentives or targeted immigration, as well as striking a good balance between short and long-term needs through university or vocational school funding are mentioned. Next comes the third policy domain, which is the capital market. Credits and subsidies for foreign companies to invest, as well as import exemptions, direct funding for R&D are examples. Number four is the land market, which contains measures like infrastructure investment, or the development of specific areas into clusters or specialized business areas. Finally, the fifth domain is the technology market. This includes licensing agreements to bring in new technologies, as well as developing them locally through R&D, facilitating innovation through public research facilities as well as encouraging linkages between different actors.

Another way to group policies in a study on China by Ling & Naughton (2016, 2142) quoting Xu et al. (2014) has five categories with a different approach. The first category is regulation and intellectual property rights, the second is financial support, the third is strategic objectives, while the last two are supply side policies and demand side policies. What is a bit confusing, is that it is not exactly clear, where financial support in a strategic industry would go as there seems to be some overlap.

Soete writes about the discussion around industrial policy chronologically and breaks it down in to three phases. (Soete 2007, 274-278) Phase number one was the post-war era, when reconstruction made the aggressive reallocation of resources necessary. In this period, the priority was given to scalable heavy industrial fields such as coal and steel, as well as agriculture. The second phase in the 1970's and 1980's saw de-industrialization in these traditional industries in the West, while Japan was rapidly catching up in areas such as cars or semiconductors. This period saw a general re-alignment towards the service industry in developed countries, while a shift in thinking was also happening, with policymakers adopting strategic thinking, debating on what strategic actually meant. The third phase from the 1990's – and this is the crucial part for the topic of this thesis – saw the thinking shift from sectoral policies to an overarching, systemic approach. Instead of for example creating demand for an industry deemed strategic, a new, holistic way of thinking emerged, that asserts, that for the growth and development of an industry or nation, an economy-wide, so called "knowledge and innovation system" is necessary.

Cherif & Hasanov (2019, 6-21) go as far as to say to name the aforementioned three (in their view) essential principles of true industrial policy: Technology and Innovation Policy. Basically, as later asserted, standard industrial policy only goes so far in development. After progressing from low-income to middle-income status through transitioning from agriculture to low-cost manufacturing and adopting foreign technology, the gains in added value through these diminish, and the country needs new sources of growth. To become a high-income country and then remain a high-income country, a shift must be made to innovation-driven strategy to increase productivity and produce new goods and technologies.

In other words, the complexity of the world economy changed, and the requirements to thrive in it changed too. What was known as industrial policy in the second half of the 20th century is referred to as innovation policy today. This study intends to follow this reasoning. Before progressing into what these innovation systems are in the following section, a definition of innovation – and a term closely connected to it: research and development – is needed, as well as a closer inspection of how industrial policy developed in that field. Following the thought processes of Soete (2007, 274-278) and Cherif & Safanov (2019, 6-21) cited earlier, the next sections will start to focus on science and technology policy, in order to establish the analytical framework for answering the research question of this paper. To determine whether there is correlation between state involvement and the performance of the electronics industry, various indicators are needed, and the next few sections will look to extract these criteria from the literature, each from the perspective of a different main facet of this topic, starting with innovation policy.

(2) Section two: Industrial policy turns towards innovation

In the previous section, it has been established how wide-ranging the topic of industrial policy is in general, how the theory around it developed, and in what way are different authors classifying and analyzing policies. Towards the end of this discussion, a new way of thinking was introduced, that identifies science and technology policy and the process of innovation – and its support – as the centerpiece of industrial policy today. While it is not being claimed, that all of industrial policy today would have this singular goal in mind and that science and technology policy and industrial policy would be one and the same. One is an important subset of the other, and as such, the goal of this section is to move one step closer to the research question and look at this subset of industrial policy that deals with innovation and R&D support.

While R&D and innovation do tend to go hand in hand, and while they are sometimes even used completely interchangeably, they are technically not the same thing. The Frascati manual of OECD – which provides guidelines for collecting and reporting data on research and experimental development – defines research and development as:

„Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge. „ (OECD 2015, 44)

For a definition of innovation, a different OECD document is called upon, this time the Oslo Manual, which, as a counterpart to the Frascati Manual, deals with collecting and interpreting innovation data.

„An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations." (OECD 2005)

Now, based on these definitions, R&D seems like the process itself, by which you increase your knowledge or come up with something new, while innovation is either the thing you came up with itself, or in this case the process, through which you implement your new, improved product or mechanism. This means, that for the most part one leads to the other. One conducts R&D, and through the research arrives at something new or improved, what is then put to good use through innovation. This distinction is important, as in order to understand these two things as a system, different variables are needed, mostly input in R&D and mostly output for innovation.

Dolfsma and Seo argue, that government policy to support innovation and technological development is different from policies seeking to aid a specific kind of firm or industry. (Dolfsma & Seo 2013, 173-174) The argument goes, that innovation is fundamentally more dynamic than other fields, and therefore, industrial policy targeting innovation has to be altered based on the life-cycle of the product or industry itself.

A paper on innovation policy evaluation by Edler et al. (2012, 170) uses the INNO-Appraisal database to distinguish 9 kinds of innovation policy measure types. It is a basic characterization from most frequently used – in the sample – to the least common, starting with direct financial support for innovation activities, followed by clusters, networking and technology transfer, the third being innovation management support and culture, science and industry cooperation, support for diffusion of innovation, mobility of personnel, creation of startups, development of intermediary bodies or agencies, and the last one was the category of indirect measures such as tax.

Others suggest a typology that classifies government policies based on the kind of technological innovations they try to stimulate. What is proposed is a 2x2 matrix (Dolfsma & Seo 2013, 173-176), where the two dimensions are: the nature of technology on the horizontal, and the network effect on the market on the vertical axis. When talking about the nature of the technology, the two categories are discrete, and cumulative technologies. In the first case, the innovation is the result of a breakthrough unrelated to previous knowledge, while in the cumulative case, progress is the result of taking the next step in an already existing research field. Looking at the network effect, the two categories are low and high. This parameter depends on whether a technology exists discretely, so more or less in isolation, or instead is a product driven by other technologies. The typology goes, that if a piece of technology develops discreetly with no network effect, the romantic view of the individual inventor is likely. In this case, government support policies include R&D funding and tax breaks, assisting universities and companies in their research and innovation and stimulation of entrepreneurship. The same thing in a network would suggest a larger organization aiding specialization and commercialization – named here Schumpeter Mark I, referring to the early work of the author – and in this case government can provide early access to intellectual property (IP) or promote compatibility between technologies. Cumulative innovation with no network effect is called “standing the shoulders of giants” by the authors, and here, the options of the government include procurement as well as promotion of forming regional clusters. Finally, the fourth category are cumulative innovations with strong network effects, where – labeled Schumpeter Mark II, referring to his later works – policy options cover the setting of standards, laws and regulations, market liberalization and antitrust legislation.

Mazzucato and Semieniuk discuss state involvement in innovation in terms of what kind of role they play in the process. (Mazzucato & Semieniuk 2017, 27-34) Specifically, three kinds of approaches are presented, according to which states might act and provide financial support for innovation. The first and oldest one, is the market failure approach. This one follows basic economic theory, in that state intervention is only justified, when they are targeting specific market failures. These market failures can be positive or negative externalities as well. An example of a positive externality would be a general contribution to public welfare by conducting basic research, while for negative externalities, one could think of environmental pollution for example. However, the literature suggests that on top of specific market failures, systemic failures also exist, and they require a different approach. The argument goes, that technological revolutions always required public financing in some form. In this sense, states became shapers and creators of markets themselves, not just through public procurement but also with launching decentralized, mission-oriented agencies such as NASA. This leads to the second approach, the emergence of innovation systems. This approach was so prevalent in the outstanding literature, that it will get its own entire section.

Finally, the third approach, which is named by the authors as the entrepreneurial state. Within this perspective, states actually challenge the assumption that risk-taking is only for private companies. Entrepreneurial states can and do take on risk, invest, create a vision and then execute it to realize economic growth.

Classifications of industrial policy, as well as specifically R&D support policy do seem to come in all shapes and sizes. Potential analytical criteria could be based on policy domain, as well as depth or scope. The topic could also be approached from the other side, discussing innovations, and then grouping policies based on the kind of innovations they are supposed to support. In the next section, a particular approach is going to be discussed in detail, which has surfaced repeatedly in multiple different sections: the innovation systems approach.

(2) Section three: National innovation systems

It was highlighted in the previous section that the systemic approach would come up multiple times in different chapters during the literature review process (Goto 2000, 104) (Arora et al. 2010, 23-26) (Sakai 2016, 540) and therefore this would warrant a separate section. To refer back to that part of the discussion, while the market failure approach argues, that economic intervention should only happen to correct specific market failure situations, this systemic approach counters that. The reasoning, is that in addition to market failures, there are also systemic failures, and systemic innovation and technology policy seeks to address those. (Crespri & Quatraro 2013, 1447) This discussion will contain five different kinds of innovation systems. As this section will discuss, there are many different levels and typologies in which innovation and R&D policy can be analyzed, however, eince the research question focuses on state support for research and development, the point of reference must be the national innovation system. The next few pages will present these some of the analytical approaches to this topic.

In her doctoral thesis, Zsófia Vas breaks innovation systems down into four types: national, regional, sectoral, and technological innovation systems. (Vas 2014) As this analysis of these Far Eastern countries entail both the national and also the industry level with some criteria addressing the former and others the latter, it is extremely important for us – not just methodologically but also simply to understand the topic better – to distinguish them and show how they relate to each other.

So, it is a system, meaning that, by definition, it is a combination of a variety of elements and actors working together. The two main category within these innovation systems are the organizations and the institutions. The former here are defined as formal structures created with a specific goal in mind, that become the players of the innovation system. Examples here are the corporations, research centers, universities, political or economic institutions, regulatory agencies, and various service industries around them. Institutions on the other hand are customs, rules, norms, procedures, and laws that govern the interactions between them – the rules of the game as they say. (Vas 2014, 16)

The starting point would be national innovation system, followed downwards by the lower layers with narrower scopes. Before that however, there is a notable interjection here, namely that in the age of globalization where everything, all economies, ideas, supply chains are interconnected, is it not possible that national systems as such are losing some of their relevance? After a discussion of the history of the theory, Vas arrives at two definitions of the national innovation system, a looser and a tighter one. (Vas 2014, 18-23) In the tighter one, the system is a combination of – separate – actors and institutions that influence a country's capabilities and performance in relation to science and technology. In addition to the private sector, the effect that the public sector and institutions that can have through policy is also highlighted.

According to the looser definition, the national innovation system would not just be an assortment of independent actors but also the environment they operate in, like macroeconomic conditions, infrastructure or market forces that are related to these. Here it is more about the interactions of the actors instead of just the actors themselves.

When it comes to regional innovation systems, while it is fair to say that they are a localized version of the national one, they do also possess some features that sets them apart in a different way. (Vas 2014, 23-33) After all, even Michael Porter said – as quoted by the author – that sustainable competitive advantage mostly comes from local factors, knowledge and connection. Vas goes into great detail based on the region's potential, level of integration and the mode of control, among other things, but without going way too deep for the scope of this section, what should be noted is the existence of clusters and their significance.

To briefly explain clusters, they are local productive systems or industrial districts, where companies in the same line of business concentrate geographically. (Möhring 2005, 21) This way, businesses are able to exploit economies of scale, work together in a more efficient way thus lowering transaction costs and facilitating various spillovers and synergies. Examples include the tech sector in Silicon Valley, or its Chinese counterpart in the Pearl River Delta centered around Shenzhen.

Back to systems of innovation, the next in line are sectoral innovation systems. These are of course not a subset of the ones before as they have nothing to do with geography. Vas summarizes the literature and all the different definitions and concludes, that sectoral innovation systems include all the actors – companies as well as public institutions – and their connections, may them be within or between companies, formal or informal. (Vas 2014, 33-36) A particularly interesting bit of this part for my thesis, is the assertion, that the main players in sectoral innovation are the companies themselves as they compete and cooperate with each other. The source also notes that this does not mean, that all other players here would be irrelevant, just that governments here rather take the back seat.
Finally, the fourth one, technological innovation systems. (Vas 2014, 37-39) The clarification, as to how and why is this different than the sectoral one, comes in the form of three uses for this conceptional framework. Firstly, it can be related to a single technology or knowledge field, that may be used in a bunch of completely unrelated products. Secondly, a single product, which may contain a variety of different technologies. Thirdly, competence blocks. These are groups of products that complement each other and are used in in the same setting.

A different perspective is offered by Etkowitz & Zhou (2018, 1-7). The triple helix theorem was developed from observing the innovation environments centered around Harvard and MIT in the Boston area, as well as the cooperation between Stanford University and Silicon Valley in the San Francisco Bay Area, all supported by government. According to the authors, while innovation systems theory puts firms in the center stage, supported by government, academia and various financial institutions with intermediaries where all of them operate following their own practicalities, the triple helix theorem puts the university as first among the equals of the three with government and business in one singular system.

Others describe triple helix as not so much a competing theory with innovation systems, but an evolution. (Kotsis & Nagy 2009, 123-125) The helix shape itself alludes to the fact, that – just like in a vortex – the three forces, or three actors in this case, strengthen each other and provide the dynamism for the whole system. If the government were to take full initiative that might stifle the potential of the others, however the complete absence would deprive the system from coordination and regulatory framework. Once again, the question of how much government intervention is good, remains the subject of debate. Reflecting on Etkowitz's own description, the participants according to this model can also engage in fields and functions traditionally belonging to the others, such as universities launching their own research projects instead of following the strategic agenda of the government.

(2) Section four: Industrial policy in the electronics industry

This section explores the previously discussed themes in the specific case of the electronics industry. The explicit goal of this section is to try and extract variables from the literature that are suited for the analysis of the performance of the industry. After focusing on the electronics industry here, the next section will look at Japan, South Korea and Taiwan with the same goal in mind. While these studies may use countries as case studies that are beyond the scope of this thesis, the focus of this section is to analyze the electronics industry, irrespective of its origin.

A United Nations document on the case of Thailand breaks down industrial policy in electronics into four categories. (UNCTAD 2005, 5-11) The first is the overarching national policy for economic development in general. These are aimed at creating proper macroeconomic conditions for progress to happen, as well as deciding on which industries to target specifically. Second, are investment promotion policies. These incentives were aimed at attracting FDI and could range from reductions of import duties and taxes, upgrading infrastructure, credit support and various other services. Third, are science and technology policies. In this case, this means the creation of state-run research centers and government agencies, the integration of these into the overarching plans mentioned in category one, improve linkages between different institutions and industry, as well as the development of specific capabilities. The fourth and last category are related to intellectual property. Patent laws and their enforcement are crucial to protect innovation.

For measuring the performance of the electronics industry (UNCTAD 2005, 13-18) the paper uses three outputs. The first one is foreign direct investments, namely net FDI flows as well as cumulative FDI stocks. These show the amount of foreign money arriving on a yearly basis, and also the total amount of funds that are invested in the industry. The second is export performance. An increase in the share of manufacturing in total exports suggests that a country moves away from primary goods towards higher value-added products. Then, the share of electronics in these manufacturing exports shows the influence and robustness of the industry in relation to others. The third output category consists of employment numbers and foreign ownership. The number of people employed in the electronics industry again signals the overall influence it wields within an economy, while the share of foreign ownership reflect the effects of the FDI the country attracts.

Using China as an example, Zhao (2007, 37-50) groups different policies into five categories. The first one was the strategy of forced technology transfer in exchange for market access. This was done through joint ventures between local and foreign companies, under constant review by the central government. These enterprises were mandated to have more than 50 percent local ownership. The second was the encouragement of innovation through public funding. While importing technology was necessary to get a good start and then expand quickly to maintain and improve competitiveness, some self-reliance is also needed. The state launched a development fund specifically targeting this industry, funding R&D and product development. Though much of the money was put forward by Beijing, financial institutions and local governments also contributed. Third was providing the regulatory environment, which mainly covers three areas: the establishment of technological standards, market access regulations, and targeted support for strategic fields through subsidized loans and tax breaks. The fourth category were FDI and trade barrier policies, with two kinds of FDI being identified: one aimed at import substitution, and another which was export oriented. Lastly, the framework finishes with special economic zones, locations where tenants from the high-tech industries would enjoy financial support from the government.

Tuan et al. (1995, 512-520) contrasts Hong Kong's industrial policy related to electronics with Taiwan's. As mentioned, Taiwan had a rather active industrial policy, the approach of the government in Hong Kong on the hand is described here as positive non-interventionism, basically a laissez-faire approach. While in Taiwan, the state facilitated R&D extensively though investment in research facilities and private companies in targeted industries, the policy in Hong Kong was limited to providing a dynamic business environment, in which an industry with short product life cycles such as electronics can thrive. While such a regulatory environment was beneficial, the lack of support and funding did result in a less innovative product mix that fell behind their Taiwanese counterparts on the long term.

Looking at industrial policy in the Malaysian electronics industry, Rasiah (2015, 8-17) describes succeeding master plans by the government, with the policies having two key goals: export-promotion and technological catch-up. This consisted of the launch of special economic zones with various financial incentives to attract FDI (tax holidays and tax credits for investment), as well as upgrading local infrastructure, providing R&D grants and importing personnel, as well as currency devaluation to boost exports.

As for how the performance of the electronics industry can be measured, the framework (Rasiah 2015, 5-8) consisted of: exports (both as a percentage of electronics in total and also in absolute value), changes in value-added activities, and technological capabilities. The technological aspect – being complicated and difficult to analyze – is then further broken down based on their HR activities, processes, and products on one hand, and the level of R&D on the other (from small improvements all the way to frontier technologies).

(2) Section five: Theory building in the context of the country cases

This section will expand on the theoretical foundations set out before, to see from what perspective do different authors approach these countries. In the previous section, the aim was to see what variables others use for analyzing the specific industry in the research question, that is electronics. Now, a similar approach is being taken in relation to Japan, South Korea and Taiwan. Looking at industrial development and policy, what criteria do various experts turn to in order to compare them?

While by some metrics, the innovation capacity of Japan even exceeded the United States by the mid 1980's, after the burst of the bubble economy in 1990, the decline was not only there in relation to the U.S. but also historical trends of Japan. (Branstetter & Nakamura 2003, 191-192) According to the Bloomberg Innovation Index for example, as of 2020, Korea just about lost its title after six years as world's most innovative country to Germany, while Japan is sitting on 12^{th} place. (Jamrisko & Lu 2020)

Without going into much detail on potential reasons behind this – because that only comes later – this section is aimed at expanding the pool of potential variables for the analytical framework. After discussing what R&D and innovation policy are in general, followed by what they are in the electronics industry, this bit will look at what they are in Japan, South Korea and Taiwan.

Branstetter & Nakamura analyzes Japanese R&D and innovation performance through a comparison with the United States and Germany. Their analysis is based on four variables. (Branstetter & Nakamura 2003, 195-205) The first point of comparison is an input variable: private sector R&D spending. This is then contrasted with patent data as output. Basically, how much money was spent (by companies) to invent new things, and by spending this amount of money, how many new things were invented. As for this patent data, three variables are presented in total. These three are the total number of new patents (registered in the United States), new patents registered specifically in the ICT (Information and Communication Technology) industry, and also patents by the nationality of the inventor. Out of these data then, an R&D productivity table is calculated using regression analysis.

Arora and colleagues also analyze Japan through a US comparison, and the usage of patent output as a variable is also similar, however their approach is a little bit different. (Arora et al. 2010, 5-35) Instead of using absolute values for new patents, they calculate patent productivity of certain companies. These companies are selected from historical S&P 500 indexes of US stock market data, filtered down so that the sample only includes electronics, semiconductors, and IT hardware or software firms. Other than this, other input data used in the analysis are: R&D investment (this is annual expenditure), R&D stocks (calculated from flows and then depreciated), and also firm market value, which here is the market value of its equity and debt added together. The study also presents some other perspectives, which highlight the potential effect of the number of ICT graduates as well as the degree of offshoring.

In Fukuda's framework – in a paper comparing Japan's readiness for the next industrial revolution with – again – the cases of Germany and the United States – there appear economy-wide as well as sector specific criteria. (Fukuda 2020, 3-8) While the first category contains parameters like GDP per capita, household spending or capital formation, it is the second one that is more relevant for this topic. These are: marginal productivity of technology, R&D investment, and shares of GDP produced by specific economic sectors, for example manufacturing. The study of Fukao and colleagues also uses a mostly macroeconomic perspective, with analyzing the performance of the Japanese economy, however ICT investment does come up as one of the factors. (Fukao et al. 2015)

Goto studies Japan's innovation system in a way that is in line with what was set out earlier, breaking the discussion up into three sections, one for each main actor: industry, government, and academia. (Goto 2000, 105-111) As for performance indicators, seven variables are presented. Three of them are related to R&D spending, such as R&D expenditure as a nominal value, as a share of GDP, and the share of government funds in all of this. Next, are the number of researchers, per 1000 inhabitants to adjust for population. The last two variables are related to scientific output, namely the share of scientific papers published, and the share of US patents. Sakai on the other hand uses firm data to measure performance, measuring value-added and labor productivity, finally comparing the rate of return on R&D capital and physical capital. (Sakai 2016, 534-540)

Sakakibara and Cho compare Korean and Japanese industrial policy, focusing on research & development. (Sakakibara & Cho 2002, 674-685) The basis of analysis may look familiar by now, as it starts off with R&D expenditure – both as a share of GDP and as a monetary value. This is followed by the number of patents granted in the United States. After that, comes an analysis of the budgets of research consortia with a sectoral breakdown. On the policy side, there is also a policy grouping, similar to the ones discussed in earlier sections. Industrial policy types are arranged into five groups. Group one includes R&D-specific policies like tax breaks and low-interest loans provided specifically for the purpose of R&D. Second, are import policies, such as forex allocation and import restrictions on certain products. The third category is FDI, again in the context of restriction and liberalization. This is followed by group for, industry structure, with support policies for specific industries. Finally group five contains the establishment of national research institutions.

Analyzing Taiwan and South Korea, Jenn-Hwan Wang utilizes the comparative institutional advantage approach to compare the South Korean IT industry with the Taiwanese one, analyzing the different patterns of innovation in the two countries. (Jenn-Hwan Wang 2007, 2-16) On top of structural differences and an analysis of major electronics companies, US patent numbers are once again used as a basis for analysis, alongside R&D investment. A concentration rate is then calculated, aimed at determining how big of a share the top companies each have from the total output. The patents versus R&D investment approach to measure performance is echoed by Choung (1998, 357-364), also analyzing the Taiwanese and South Korean cases. One caveat is that these are then arranged into different technological fields, so that in this second step of analysis, the most productive industries may be identified.

The triple helix theorem is used by Eriksson in his study on the national innovation systems of Taiwan and South Korea. Discussed earlier, this theorem understands innovation systems as an interaction of the state, business, and academia. Regarding performance, indicators in this study include the share of investment in GDP, the share of knowledge-based activities in GDP, as well as the information intensity of certain service industries. (Eriksson 2005, 15-37) Interestingly, Chalmers Johnson also originally described industrial policy in the Japanese case as a triangular relationship, however that time it was between the Diet (politics), the bureaucracy and then big business, basically two out of three representing the state. (C. Johnson 1985, 60)

Another triple helix paper, however this time on Japan, has a different approach. Yoda and Kuwashima (2020, 1131-1137) tip the three main actors against one another, measuring changes in their contributions, using patents and R&D funding as the basis of comparison. A breakdown then is added of the types of activities and their shares of the grand total, such as basic research, applied research and finally development.

(2) Section six: Measuring performance

After the discussion of what industrial policy is, how the theory of the topic developed over the years and how it applies to the electronics industry and the three countries specifically, this next section will look at how these policies can be evaluated. In other words, so far the topic was what the elements of industrial and innovation policy are and how they relate to the electronics industry and these three Far Eastern nations in particular. This section will go a step further and explore how and based on what the performance of all this can be measured. This is necessary, as “performance” as such can mean many things, and therefore distinguishing between good and bad performance also may not be straightforward. The first half of this section is going to look at the performance of industrial policy in general, while the second half will focus on innovation performance measurement.

What is industrial performance? In their paper titled “Assessing Industrial Performance”, the authors Vonortas & Auger (2002, 1-16) differentiate between three groups of performance indicators. Group number one is called first line indicators and they are called that because they are the broadest group, they can be applied to not just a specific sector, but widely across the board to different fields and countries. The text starts from a discussion of competitiveness – basically the extent to which a country or company can produce something that others would want to buy thus raising income – and gets to the two types of these first line indicators: productivity and market share.

Productivity is the number of inputs required to produce an output (with partial productivity looking at a single input like labor for example, while multifactor productivity creates an index out of multiple ones). These outputs can be gross values, as well as ones adjusted for other factors. Issues can arise from different methods of measurements in other countries and hard to define variables. For market shares, they can mean export markets, domestic ones as well as their ratios such as trade balance. Moving forward, the second line indicators are values that underline these ones, providing information on the socio-economic situation in which said data is to be interpreted.
Examples here include relative prices, costs of capital or labor, rates of investment or FDI. The third line is cluster analysis, focusing on the linkages between various actors in the value chain. The text lists a number of different methods for cluster analysis, quantitative and qualitative.

An UNIDO (United Nations Industrial Development Organization) document puts forward the so-called Competitive Industrial Performance Index (CIP) to measure industrial performance in a cross-country context. (Upadhyaya 2003, 3-7) This index is different from other indexes in that it is focused on a sector, namely its output. The competitiveness of an industry needs innovation, infrastructure, and effective policy in order to properly utilize existing comparative advantage. The CIP works with a grid of three dimensions and eight indicators in total that belong to them. The first dimension is the capacity of produce and export with the two indicators belonging to it being: manufacturing value added per capita, and manufacturing export per capita. The second dimension is defined as: Technological upgrading and deepening, and it contains four indicators. These are: the share of manufacturing in high-tech products, (MHT) activities in total manufacturing value-added (MVA), the share of MVA in GDP, share of MHT in manufacturing exports, and the share of manufacturing in total exports. Finally, the third dimension, which is the impact on world production and trade. It has two indicators, the share of the country in global MVA, and the share of the country in world manufacturing exports. This index is primarily used for four purposes. The first one is benchmarking, where countries can be identified and clustered based on different dimensions in their development, with the second one being the following step, that is ranking and grouping. The indicators are suitable for comparing the industrial performance of different nations. The third way of usage is industrial diagnostics, which means an identification of relative performances of certain fields and allows for policy correction in problem areas. Last but not least, the fourth purpose, which is its comparison with other composite measures and indexes and thus contributing to further policy debate and analysis in government and business circles.

Such indexes are however criticized by others (Bielinska-Dusza & Hamerska 2021, 2-3), highlighting issues such as them being way too complex, low readability, low reliability as the selection, number, precision and influence of the variables may be unclear, while also considering the fact that they are part of the same economic system, meaning that they might affect each other as well.

In previous sections, it was explained how industrial policy evolved to be centered today around innovation, and in a similar vein, this segment will now, after the topic of how to measure industrial performance, continue with a discussion on measuring innovation performance.

Bielinska-Dusza & Hamerska (2021, 4) assert:

"If the essence of innovation should be based on an interdisciplinary and multidimensional approach, taking into account the cause–effect relationships of the impacts of various phenomena and processes on the development of innovation, then the analysis of this problem should also be multidimensional."

In their discussion, they group and evaluate different ways to measure innovation. (Bielinska-Dusza & Hamerska 2021, 4-6) Two big groups are identified: methods applicable to a sector or company, and methods for the economy as a whole. In the first case, four categories are created, with one example of an index – the Community Innovation Survey (CIS) – towards the end. The first methods are called subject methods, and they analyze the number and nature already existing innovations, based on mostly materials provided by companies themselves, or the technical press. There are also object methods, using questionnaires aimed at companies producing innovation. The third, are statistical and mathematical methods that use descriptive statistics and inference tools. The fourth and last category are organizational tools. The second grouping that is for analyzing the economy has statistical and mathematic tools highlighted, after which the authors assess various indexes – such as the Global Innovation Index (GII) or the European Innovation Scoreboard (EIS) and their basic properties.

Taking a closer look at the measurement framework of the EIS, the indicators (25 in total) are broken down thematically into four groups. (Hollanders 2019, 3-4) The first category are framework conditions, containing variables such as the number of scientific publications, doctorate graduates or broadband penetration. The second category is titled: investments, and as the name suggests it is mostly concerned with financial matters. The R&D spending of governments, universities, firm investments in innovation as well as venture capital go here. The third one are innovation activities, which measure linkages (cooperation between actors such as government and business) and various firm-level statistics such as the share of companies implementing new processes or coming up with new products. The last category would be the impacts – of the above – analyzing the (hopefully) positive effects of innovation, such as increases in employment, sales or exports.

Edquist and colleagues target this EIS, or rather the ranking based on its data, namely the EU Summary Innovation Index (SII), offering some adjustments. (Edquist et al. 2018) The main assertion is, that the index does not focus enough on efficiency and productivity, and more attention should be paid to examining these issues. In other words, how do various inputs and outputs relate to each other.

From all the variables the EU index works with, twelve indicators are selected, eight on the output side and four on the input side. (Edquist et al. 2018, 4) Important to note, that the 13 variables dropped from the original are not deemed irrelevant by any means, the authors just feel that further research is needed to examine their applicability and potential effects. Starting with the output side, three indicators are tied to small and medium enterprise (SME) activities: percentages of such firms innovating in-house, introducing innovative products or processes, and using innovative marketing or organizational solutions. Two of them are GDP rations, namely community trademarks and community designs per billion USD. The last three are: contribution of exports of medium to high-tech products to the trade balance, share of knowledge-intensive services in all service exports and the finally the sales of innovations as a percentage of total turnover. Similarly to the list of output indicators, the four inputs also show a combination of firm-level and country-level variables. These four are: the R&D expenditures of the public as well as the business sector (both measured as a percentage of GDP), venture capital (again as a percentage of GDP) with the fourth and last addition to this framework being non-R&D innovation expenses as a percentage of turnover.

In any case, the evaluation of industrial policy faces many challenges and is underdeveloped compared to other fields. (Warwick & Nolan 2014, 7-9) The authors identify several of these, a lot of them have to do with the fact that this is a topic with a very high complexity and broad scope. It includes multiple policy areas and huge units of analysis which are difficult to compare as there are too many factors at play, for example macroeconomic conditions or different institutional contexts. Factors being interdependent, meaning that they affect each other, sometimes both ways. Policies may have different goals, the same thing in two countries may have been enacted with a completely different outcome in mind. Not just that, but a single policy may also have multiple goals, so based on what are they being evaluated is not always straightforward. On top of that, there is the time element. A lot of policies – such as the improvement of basic research – only have an effect long term and they may be modified or cancelled by other administrations before having their intended effect.

(2) Section seven: Correlation and regression

Finally, following the presentation of the theory behind the topic in general at first, then in the context of a specific industry and the specific countries second, as well as a few possible frameworks and approaches to performance measurement, the only thing left in the research question to address in the literature review, is correlation.

During correlation analysis, the strength of the relationship between two numerical variables is being examined. The correlation coefficient is the number responsible for this relationship, where it being negative or positive shows the direction of the movement of the two (in relation to one another) while the number itself measures how strong it is. This value can be between zero and one. A value of zero would mean, that the two values have no correlation at all. (Kulbert-Tarró 2020, 73) Actually, either of the two extremes are called perfect – negative or positive – correlation. Important with correlation, that the coefficient shows an average effect, not an absolute one. (Arkes 2019, 39) It should not be interpreted as something that is true for the entirety of the sample.

An example of correlation and regression being applied to a topic similar to the focus of this thesis could be the work of Onea (2020, 7-11), where a correlation analysis was utilized to analyze the relationship between innovation indicators: firm investment, employment impact, and their effect on the summary innovation index, for which data from the European Innovation Scoreboard was used.

Moving on, regression is *"the oldest, and probably, most widely used multivariate technique in social sciences"* (Bartholomew 2010, 16) Multivariate means, that it works with multiple variables. The goal of regression is, to obtain potential predictions or correlations of a variable, depending on the value of another. Linear regression analysis can be conducted with programs like Microsoft Excel or SPSS. It is different from correlation analysis, in that the association between the two variables is represented by an equation. Having this equation means, that regression can be used to map trends, and potentially predict future outcomes, as well as the degree to which variables may predict or depend on others. (Grech 2018, 60)

In order to visualize and thus maybe better grasp this, what is needed is a coordinate system. (Kerékgyártó et al. 2001, 371) The variable that is being predicted goes to the *y*-axis, while the predictor is being represented on the *x*-axis. Important to note, that this is simple linear regression, however there is also standard multiple regression that simultaneously looks at the effect of multiple variables on something. (Princeton University 2007) Because this study includes a system of multiple variables, this second one will be used here. It also must be said that the simple linear regression model assumes linear relationship between the two variables, but there are also other forms of regression models for curvilinear or exponential relationships. (Sullivan n.d.)

The former is called "dependent variable" – as it depends on other things, or at least it is suspected that it might – while the latter is going to be the "independent variable", these are the ones believed could have an effect on them. (Gallo 2015) Applying these principles to the topic, the output variables (results) fit neatly to become the dependent variables, as some kind of scientific or economic progress/change in performance is being measured. Similarly, the input variables, the resources that go into trying to achieve these results, are going to become the independent variables. The regression equation (Christensen 2016, 134) is:

$$yi = \beta 0 + \beta 1 xi + \varepsilon i,$$

To very briefly explain, y is the dependent variable, which equals a constant (the y-intercept, so how much the value of y would be if $x=0$), plus x times the second number (how much y changes per one x) plus an error value, that accounts for natural variance. To be exact, the error term is the difference between the actual outcome and the outcome predicted by the model. (Arkes 2019, 19) This formula belongs to simple linear regression – where two variables are examined – however multiple regression works exactly the same way, just with more variables added. More detail will be provided during the analysis itself, but the computer-generated result to this test will provide the actual predicting power of each variable, while also giving an estimate on how trustworthy the analysis really was through the evaluation of the model itself. This overall predicting power is represented by two things in the output. The first one is the R-Square, which is the proportion of variance in the value of y that is explained by x. (Arkes 2019, 26-28) That is, how much of the change is explainable by the combination of variables chosen for the analysis.

So, simple linear regression is almost like correlation, just represented through an equation. (Princeton University 2007) However, it must be stressed again, that correlation is not causation. When analyzing phenomena like complex economic developments that are influenced by market forces, private enterprise, government policy, decisions by individuals, as well as random chance, all in a complex interconnected system, even if two variables seem to move in the same way, we cannot say that one is the reason for the other. This is because the data set is not a closed system. If it were – if only the two variables in the analysis would exist – then, yes. However, this is not the case. The Harvard Business Review article quoted earlier brings up rain and umbrellas as an example. (Gallo 2015) To use the example from this specific study, say, there is a correlation between rain and umbrella sales, when people buy more in a rainy month and less in a dry one. Yet, it still cannot be said, that the rain caused the increase in sales, that is just an assumption, that would then require further investigation. The only way in which causality could be found is if the analysis would happen in a closed system, in a designed experiment for instance. If the world economy would only have these two variables with nothing else affecting the outcome, however this is not the case.

Regarding multiple regression, as mentioned before there is one major difference compared to the simple one presented above, that it has two or more explanatory variables. (Arkes 2019, 33-35) In addition to just using multiple variables at the same time, multiple regression can classify variables into two groups: key explanatory variables and control variables. This second classification is used for analysis that tries to isolate variables from a set, one by one, and measure their effect that way. It is also important, that even though running a multiple regression on the computer will provide coefficients for the variables – sounding similar to the correlation coefficient – it should not be interpreted like that. This is because it would not take the scale of the variable into consideration and is a common mistake.

Earlier it was said, that while R-Square is indicative of the "overall power" of the model, there is another indicator like that. It was also said, that in case of a multiple regression, the coefficient of the variables is not the correlation coefficient, but something else. (Arkes 2019, 82-107) Very briefly, the statistical significance (the *F statistic*) of the model – denoted also α – also appears in the output, along with a *P-value* for each variable. This significance shows the probability that the empirical relationship depicted by the model exists. The *P-value* does the same for each coefficient, and thus it will be this *P-value* that can distinguish – within the context of the model, not in absolute terms – which variables are useful for the analysis. The standard threshold is 5%, meaning that the model and the coefficients can be called significant, if the number is below 0.05, and insignificant if they are above that. In this case, there is a 95% chance, that the relationship is real. An insignificant result however – it has to be stressed – means only that based on these number, there is no (or not enough) proof of this phenomenon. Again, it does not mean that the thing does not exist, just that in this context it cannot be proven. Also very important, is that the goal is not to get a significant result, or to avoid an insignificant one. The real goal is to advance knowledge, therefore the result of insignificance is just as valid, as an outcome of statistical significance.

Regression analysis can have four main goals. (Arkes 2019, 15-16) Goal number one is to identify causal relationships between two factors. Second, is to forecast or predict some sort of an outcome based on patterns in already existing data. Third, is to determine predictors of some factor. The fourth and final possible objective of regression is to isolate factors and adjust for them. This means, that an analysis identifies a host of potential factors that could have an influence on the outcome, but would like to take one out of the equation, and see the relative performance of variables in relation to one another.

After the goals, one must also address some of the challenges as well. Regression operates under five key assumptions, commonly referred to as Gauss Markov assumptions. (Arkes 2019, 35-37) All five concern the aforementioned error term, so the difference between the real and estimated values. Firstly, the average of the error terms should be zero. This is done by the computer output automatically. Secondly, these terms should be independently and identically distributed. This means, that observations should not be correlated with each other. Thirdly, they should have a normal distribution. Fourth, the variance of the error term should be homoskedastic, which means that it is not correlated with any of the dependent variables, which is an assumption often being violated. Assumption five is that correlation should not be present not just between the variables and the variance of error term but also the error term itself, however in this study it is criticized as being unnecessary unless the model is used for forecasting or causal effects, which the one in this thesis is not.

To end this section, the question must also be asked: What are the shortcomings of this kind of analysis? To address some of the potential pitfalls of this method of analysis, Ramcharan (2006, 37) raises four key issues. Number one is what is missing. This has been mentioned before, but because of the complexity of the world economy, there are always going to be factors that are not taken into account, that in reality would be relevant. Also, in accordance with the acknowledged limitations of this thesis, the number of variables included would bound to be limited. However, in this case the argument can be made, that no or insignificant result is actually not a failure, as it tells the reader that one thing actually does not predict another very well. Issue number two is reverse causality, meaning that the independent variable may affect the dependent variable back, creating a loop. The example brought up is the question of whether education predicts higher pay, however if you have more money, you also may invest more into your education. This risk has to be taken into account while interpreting the results. Number three is if the data itself is incorrect. There is a risk of that, however it was minimized as much as it could have been through using reputable, well-known sources. Finally, problem number four is, that regression is only suited to measure small, incremental changes but is ineffective when it comes to huge, dramatic ones. This study however measures exactly small and incremental changes over two decades, with a limited number of variables included, meaning that based on this, it appears to be a suitable application.

Arkes labels the problems that might arise in relation to the interpretation of results as “big questions” and lists six of them. These issues can all lead to one of the assumptions to be void (Arkes 2019, 117-148) Essentially, the things that could go wrong and cause a misinterpretation of the results. Number one is reverse causality. This is when the dependent variable ends up affecting the independent variable. As the test is testing for *x* affecting *y* and not the other way around, this can be problematic. Number two is omitted-variable bias, which means that there are other factors that might correlate with *x* and influence *y*, however, are not included in the model. Number three is self-selection bias. Selection bias happens, if the subject – *y* in this case – has control over *x* and can determine its value. An example brought up here is years of schooling and future earnings, as the people who would think that they would earn more in the future from extra schooling are more likely to stay in school, than those for whom the benefits would be lower. Number four is if there was a measurement error, so the data itself ends up being inaccurate. Number five are mediating factors, and this issue is characterized as having a variable in the model, that is a direct product of an explanatory variable. To finish the list off, big question number six is using an outcome as a dependent variable. In the next part on the methodology, these issues and potential risks are going to be addressed.

Furthermore, a risk factor that should not be left out, is multicollinearity. One can talk about multicollinearity when explanatory variables are highly correlated with each other. At perfect multicollinearity, the R-Square would be 1, and the model would be unable to tell the effects of the variables apart. This can also be a problem because not being able to distinguish variables may inflate the value of standard error. (Arkes 2019, 149-152)

A final point here at the end of this section that must be mentioned, is the debate around the minimum number of observations for an analysis like this. (Arkes 2019, 36) Depending on the source, this minimum number that is necessary – to avoid too high of a variance – can range from 30-40 down to 15. This study works with 20 observations, so this criterion is met, although it must be acknowledged, that a higher number of observations – for instance if detailed economic data would be available from hundreds of years back – could provide a more precise outcome with less variance.

(2) Section eight: Summary of the literature review

The literature review starts with a definition of what industrial policy is with the first section discussing different definitions and approaches, laying the foundations for further analysis. It is expressed, how industrial policy itself is a much-debated field of economics, and therefore defining it is somewhat in the eye of the beholder. Then, following the natural evolution of the theory, the second and third sections move from the broader scope of industrial policy to a narrower subset of it, R&D and innovation support specifically, with innovation systems theory being discussed in more detail. Sections four and five explore applications of different approaches on first the electronics industry, followed by the three countries in scope, Japan, South Korea and Taiwan. Section six then looks at indicators with which to analyze and measure performance in policymaking. The seventh and – excluding the summary – last section discussed methods to quantitatively analyze interactions between these factors, with specific attention given to the methodological limitations and risks associated with using such methods of analysis.

The goal of the literature review was to map out the topic in a way in which an answer to the research question can be found. The goal of the first five sections was to build up a list of potential analytical criteria based on the different perspectives of various authors. What were the things they found important, when evaluating the success or failure? After this, the paper moves from *what* to measure to *how* to measure it, discussing correlation and regression, and some of the challenges and potential dangers of these methods.

As industrial policy itself leads to a country moving from agriculture to manufacturing and finally high value-added industries in a process of catch-up, the theory of industrial policy also progressed to focus on innovation and R&D to facilitate this. Government policies supporting research and development were grouped based on their depth and scope, as well as policy area. The topic boasts a diverse set of approaches and classification, but the discussion was consistent on the fact that the innovation ecosystem includes not just the state but also higher education institutions and private business, the importance of these interactions was prominent in both the first theoretical sections as well as the ones where authors applied them on the specific countries or the electronics industry.

Regression is a linear analytical tool with which one can study the relationship between certain variables. It is important to note however, that it is merely a model that attempts to describe real events, and therefore there are a number of conditions that one must adhere to when interpreting its results. There is a plethora of ways in which a regression analysis may be misused or simply just go wrong, therefore the assumptions under which this method must work, as well as the potential mistakes should always be clearly acknowledged. These include various ways in which there are hidden influences amongst variables where there should not be any, as well as errors in the data itself. In the next part, the ideas explored in this literature review are going to be used to construct the analytical framework of this thesis.

Part three: Analytical Framework

(3) Section one: Methodology

In this section, the analytical framework is going to be presented, alongside the thought process that went into it. The goal is to determine, whether government support for R&D correlates with various performance indicators of the electronics industries of Japan, South Korea and Taiwan. This is going to be determined by using regression analysis. In this part of the thesis, the analytical approach of the thesis is going to mapped out, including the variables to be used, the reasons for their selection, and after running the regression analysis itself, which parts of the output would lead to actually answering the research question.

Building on the previewed literature, and in particular industrial policy theory, innovation system theory, and ideas like the triple helix theorem, it became clear, that the analytical framework must contain criteria from the national level, as well as the industry level. These theories assert, that innovation policy is the natural progression and modern equivalent of the old industrial policy, and today's systemic approach analyzes the process as a joint effort by government, private enterprise, and academia.

So, with different weights, but all three main groups of actors in research and development are included: first and foremost, the government (as this is the main focus after all) but also the business sphere, and higher education. In addition, the analysis is broken down into input variables and output variables. The other two are also valuable points of reference, to determine if one may use their resources more productively than the others.

All variables needed to be quantitative because regression only works with numbers. In this case, what went in and what came out. The data also need to be comparable, so for each variable, only the same source could be used. As mentioned during the part on the limitations of this research, there are differences between the definition of "electronics industry" and within the framework, there are multiple overlapping terms popping up for this sector. This was the case even for variables from the same data source, namely OECD's Main Science and Technology Indicators, on which this thesis leans heavily for numbers. To avoid confusion or potential misrepresentation of the data, it will be stated in the description of each variable, which definition it uses and where data is coming from.

For consistency's sake, the definitions for the variables themselves also come from OECD. Not all of them were sufficiently explained in the data bank, so in these instances the standard OECD definition was used, in most cases from the Frascati Manual, which is the organization's research guidebook for data collection and analysis of R&D.

Developments in society can be analyzed in isolation, or together with other factors that might be related. In the former case the goal of the analysis is to find something out about something that already happened, while in the latter case, the main question is, why it happened and what were the factors that may or may not have influenced the outcome. (Kerékgyártó et al. 2001, 369) Since determining whether a specific government policy "caused" growth in the performance of an industry is next to impossible, this research can only compare the data from the three countries and see how they relate to each other. Correlations might be observed. However, and this cannot be stressed enough, there are other forces in play here, that are not part of this analysis because of either the lack of data, other limitations discussed earlier, or a conscious decision to omit them.

As for the time frame, the numerical analysis covers the last two decades, twenty data points or observations in total from the years 2000-2019. The decision to go with this period is the result of three factors. Firstly, it is so that the analysis is up to date. It must be said, that the idea here is not that historical analysis – for example if it would be between 1960 and 1980 – would be irrelevant, because it certainly is not, simply that the trends described in the literature are most representative in the period between 2000-2020. Secondly, the aim was to work with time series that are not too short but not too long either. Innovation and changing policies are long processes, so looking at data from only a few years would lead not just to more discrepancy, volatility and thus less consistent results, while two decades are long enough to potentially see a more compelling story. Related to this is, that with data either not being up to date now, or not being collected before the mid 1990's at all, compromises had to be made to settle for a time range where an adequate selection of materials were available. Finally, the third reason are the developments in East Asia at the time. Japan was still in the middle of the economic fallout after the burst of the bubble economy in 1991 (World Bank a n.d.), while South Korea was particularly hard hit by the Asian Financial Crisis of 1997. (World Bank b n.d.) Also in Taiwan, the democratization process reached its final stage, when in 2000, the Democratic Progressive Party (DPP) defeated the Kuomintang for the first time, ending 50 years of KMT rule and resulting in the first peaceful transition of power between parties. (Government of Taiwan n.d.)

(3) Section two: The analysis and its potential pitfalls

To answer the research question, whether there is correlation between state support of research and development and the performance of the electronics industries of Japan, South Korea and Taiwan, a three-step approach will be followed. In step one, the data representing the selected variables will be presented and visualized. During this, the observations of the three cases can be compared. Step two, multiple regression is going to be run with all the variables, using Microsoft Excel. On top of correlation, the output from the regression can show many kinds of data. Of these many kinds of data, three values are going to be highlighted in step three. Of these three, one represents correlation (and its potential significance) itself for each variable, while the two others measure the overall statistical power of the model. In step three, the results of the analysis will be evaluated.

These three values in focus are the *P-values* of each variable, the value of *F*, and the value of R-Square. The model is going to use the standard significance of 5%. This means, that if the computer-generated value is lower than this 5% or 0.05, it would mean that the outcome is statistically significant, while if the value is higher than that, with means that it is insignificant. In the case of the *P-values*, this means the correlation between the dependent variables and the independent variable, with in the case of F, it is between all variables in combination, thus resulting in a value of overall significance. In addition, the R-Square statistic represents a different measure of statistical power, which show how much or the variance in the independent variable can be explained by the dependent variables.

Now, while in general, the limitations of this paper have already been discussed, some of the specific features and risks associated with regression – and interpretation of its results – must also be clearly expressed. In the literature review, Arkes (2019, 117-148) was quoted in listing six major ways in which regression can be misused or misinterpreted. Here, they are going to be revisited, in order to avoid misrepresentation of the overall result of this analysis.

Out of the six potential risk-factors, two have been clearly addressed, but four others remain and thus have to be accepted as additional conditions of this analysis. Risk factor number four and number six are measurement errors in the data and using outcomes as predictors. This paper only works with reputable sources, and while the OECD database works with self-reported data, all three countries are transparent, prosperous democracies, so the risk of mistakes or intentionally falsified data are low. (Bertelsmann Stiftung n.d.) Furthermore, output variables are clearly distinguished from the ones used for predicting them, so this potential pitfall is not really present here. However, the other four are, so when drawing conclusions from the outcome of the analysis, these risks must also be considered. Since the collaborative nature of industrial policy described in the literature review, there can be many influences at play, some of them informal or personal. Decisions to spend more or less money may be made based on research output, or the share price or a corporation may play a role in their budget for research and development. Thus, the chances of reverse causality, self-selection bias and mediating factors cannot be ruled out. The same thing is true for omitted-variable bias. There are so many factors that can influence economic outcomes, that it is impossible to account for all of them. This means, that relevant factors might be missing from the model.

In addition to these, there is also a chance of multicollinearity. Just to recap, this is when dependent variables are themselves correlated with each other, and not just the independent variable. There is a risk, because – for example – during an economic boom, there may just be more research funding available across the board, which would then cause government, business and higher education spending all increase at the same time, making them correlated. This is also a condition that should not be overlooked, and if that would be the case, a second round of analysis would be in order with a different set of criteria.

With these risks in mind, there is always the option to conduct further research, dive deeper into the issues causing this, and tweak the model or the data to minimize the danger, get an even clearer picture.

(3) Section three: Selection of the Criteria

For the purposes of this analysis, twelve variables were selected in total, with five of them being dependent variables (input) and seven of them being independent variables, representing output data. The dependent variables are discussed first, as technically they are what is being analyzed, followed by the independent variables, which are what are being used to analyze (predict) them with.

When selecting these criteria, the aim was to build the framework in a way which reflects the diversity of innovation policy as a topic. In other words, the literature was consistent on the fact, that to get the full picture, looking at just government actions or just business investment would not be enough. Thus, variables from all three main actors in R&D had to be included: government, private business, and academia. Since the actor mainly in focus is the government, and the sector is the electronics industry, the framework is skewed to include more of them specifically and not just overarching economic data in general.

In those cases, where the data did not make this possible – because of the unavailability of industry-specific numbers or reporting differences between Japan, South Korea and Taiwan – additional conditions must be applied. That is, the electronics industry being a formidable force in all three countries strongly suggests, that general R&D spending is going to be broadly applicable to the electronics industry as well. If all research spending is down, spending in the electronics industry is also – in all likelihood – going to be down. If patent output is up, very probably the output in our specific industry will also be on the rise. It must be stressed however, that in these instances the results must be interpreted only with this condition in mind.

To reiterate, the research question for this paper is the following:

If compared, does the performance of the electronics industry of Japan, South Korea and Taiwan correlate with state support of research and development?

Important, that even state support of research and development could mean multiple things. In the discussion in the literature review, many different kinds of support policies were highlighted, in the context of multiple frameworks and approaches. The decision was made for this framework to be heavily centered around R&D spending. There are three main reasons for this. Firstly, direct financial support is a very widely used policy instrument, even coming out as the single most common one in some studies. (Edler et al. 2012, 170) Secondly, since the analysis is quantitative and needs stable points of comparison, the more abstract kinds of policies, for instance cluster building, standard setting, but also major parts of traditional industrial policy like tax breaks or trade policies, would not yield results that were easily comparable with each other. Thirdly, to refer back to the section on the limitations of this paper, for a lot of these policy instruments, comparable data from all three countries was not even available, making the usage of them as criteria impossible.

So, taking a closer look at the composition of the twelve variables, there are two groups. In the first section in dependent variables, one of them is business-related (share prices of major electronics companies), one is mostly higher education (citable documents) and one is just innovation performance in general, namely patent output. Further two variables measure the export performance of the electronics industry. In the second section containing the independent variables, three of them looks at all R&D activity, two of them government, and finally there is one each for the business sector, and higher education. As mentioned, the attempt was to create a balanced framework that covers all big players, however it has to be said, that there is a plethora of other possible variables that ended up not being included, such as tax-breaks or trade-balance data for example. Again, what should not be overlooked, is that the definition of what the "electronics industry" changes based on the data bank itself. To avoid confusion, it will always be stated which definition the numbers represent.

(3) Section four: Dependent Variables - Output

This section contains the descriptions and definitions of the five dependent variables.

1: Shareholder Value

There are a number of variables regarding a company's performance that one can point at to illustrate its supposedly good performance. Depending on the publication, these can be the company's revenue, profits, share price or market capitalization. Talking about shareholder value, it is the latter two. For this variable, what the study would like to illustrate, is how well the three largest electronics companies from Japan, South Korea and Taiwan performed in relation to each other. Three firms were chosen because only looking at the largest one would be too volatile, but by analyzing three, a more balanced view of the performance of an industry can be obtained.

To decide on the three "largest" companies, the latest Forbes 2000 list was used, which contains the top 2000 enterprises on the planet, ranked by Forbes Magazine based on size. (Murphy et al. 2021) The list only contains publicly traded companies, and the methodology, based on which they decide the size of the business looks at four variables: sales, profits, assets, and finally market value. Then, a composite score is created from the four, and that decides the ranking. The analysis has a considerable timespan, so one might ask, why it is not the three largest companies at the first year. It is because by choosing the ones which are largest today and analyzing their performance is safer than if the analysis had companies that were big twenty years ago but may or may not be doing so well today.

Regarding the problem of what counts as "electronics industry", the tightest definition was used here, only choosing companies that have the manufacturing of electronic hardware as their main profile, so telecom providers and software firms – even though they are also ICT – did not make it in this time. Thus, the final list and their global ranking is:

Japan: Sony (no. 35), Hitachi (no. 133), Panasonic (no. 239);

South Korea: Samsung Electronics (no. 11), SK Hynix (no. 173), LG Electronics (no. 279);

Taiwan: TSMC (no. 66), Hon Hai Precision/Foxconn (no. 94), Mediatek (no. 543).

Now, after the three companies per country have been established, their historical share price movements were taken as the indicator of their performance in relation to each other. The data was obtained from the database of Yahoo Finance, with the calculation of the averages to be done by the author. (Yahoo Finance 2021) For the specific references for the individual companies, please find them in the Bibliography. Additionally, not all companies have their share prices listed in US Dollars, so that had to be addressed. Those that are not, have been converted by the author using the exchange rates valid on September 18th, 2021, extracted from the same source as the prices themselves. According to this, 1 USD was equal to 1182,02 South Korean Won (KRW) or 27,8 Taiwanese Dollars (TWD).

2: Export market share – Computer, electronic and optical industry:

Following the section of the literature review on performance indicators of the electronics industry, the share of exports was mentioned multiple times. OECD agrees, saying that:

"Indicators of trade performance in R&D intensive industries can be used as proxy measures of the industrial and economic impact of scientific and technological activity. The tables concerned give trade balances and export market shares for three selected groups of R&D intensive industries: "pharmaceuticals", "computer, electronic, and optical industry", and "aerospace"" (OECD 2021, 1)

Important to note, that this category does not only contain electronic manufacturing, but other information industries as well. Data is obtained from the "Main Science and Technology Indicators" dataset by OECD (2021). The unit of measurement is a percentage value.

3: Total exports – Computer, electronic and optical industry:

Next are the total exports with the same industry definition. Again, a variable quoted in the industry specific section of the literature review. In this case however it is not the share of such products from all sold, but a monetary value of everything exported. It is measured in current USD. (OECD 2021)

4: Output of citable scientific papers:

Based on the literature review, it is very clear, that educational institutions and their research and networking activities are pivotal in innovation. While this paper looks to analyze the (potential) effects of government activity first and foremost, and big business is influential as well, there was a need for some form of a measurement for the performance of this third sector too. When thinking about how to go about this, PISA test results and various global university rankings sprung to mind first. While the quality of high school education is indeed very important for a country's development and looking at the top lists every year there does seem to be a correlation between the PISA scores and welfare of a nation, for our purposes here, tertiary education and beyond should be in focus.

The number of institutions that appear in top university rankings in a given year is a similarly frequent feature of public debates when trying to decide whether the education system has improved or not. While research output is a part of the ranking – in the case of THE World University Ranking by Times Higher Education has a weight of 30% for research volume and another 30% for citations or research influence (Times Higher Education 2019) – there still may be a more accurate predictor of research output.

For this variable, the decision was made to use the number of cited documents published each year, based on the SCImago Journal & Country Rank, developed by the Scopus Preview, a publicly accessible wing of the publishing house Elsevier. (SCImago 2020) While the database offers data on non-citable documents and percentage of international collaborations as well amongst other things, for an output of research activity in general, seem like the number of citable documents would be the better than those two on the list. As per Publisher's Weekly, in 2020 Elsevier was the largest publishing house in the world (Milliot 2020), so their science database can be a decent indicator of the whole market.

5: Patents:

Patents are a prominent feature of the reviewed literature on innovation, and an important measurement of research output. This makes sense, after all, filing a patent is essentially a new item or technology (process), that the inventor wishes to register as his or her intellectual property. Not very far the definition of innovation presented in the earlier section of the paper.

The variable chosen for this was once again obtained from the databank „Main Science and Technology Indicators" by OECD. Regarding patent data in general, the database covers applications to the European Patent Office, the US Patent and Trademark Office, filed internationally under the Patent Co-operation Treaty (PCT) and also the Triadic Patent Families, which is a combination of the European, American and Japanese patent offices. (OECD 2021)

The criterion is the number of patents filed in the ICT sector under the PCT. Important to note, that the ICT sector here is defined differently, than the electronics industry was before. OECD defines the ICT industry as "a combination of manufacturing and services industries, that capture, transmit and display data and information electronically". (OECD 2002)
The document goes on to say, that in addition to manufacturing, this definition includes wholesaling and renting of such goods, telecommunications, as well as computer and related activities.

With its international scope, this variable can be a reasonably accurate depiction of global trends in science, and can give a decent picture of Japanese, Korean and Taiwanese innovation output in relation to each other.

(3) Section five: Independent Variables - Input

After listing the dependent variables, they are followed by their potential predictors in this analysis. In a similar fashion, the selection of the criteria seeks to represent the variety of all the different actors and inputs that result in advancing innovation.

1: Gross domestic spending on R&D (GERD):

To start with the definition, GERD is:

„Gross domestic spending on R&D is defined as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country. It includes R&D funded from abroad, but excludes domestic funds for R&D performed outside the domestic economy. This indicator is measured in USD constant prices using 2015 base year and Purchasing Power Parities (PPPs) and as percentage of GDP" (OECD n.d.)

For this definition, actually not the Frascati Manual itself was used, unlike for BERD and HERD below, but instead the standard OECD definition from the relevant website. It was done so, because compared to that one, this other definition of GERD was more detailed, clear, and thus provided a better foundation for this analysis. Essentially what this ends up being, is all research and development activity within the borders of a country. This was chosen to be the one to come first, because it is probably the most "general" and the one with the broadest scope.

What is important with this variable, is that, as the exert above says, also includes foreign companies that may conduct research in the country. This might skew data significantly, as these would become the innovations of somebody else. On the other hand, this number excludes research spending by native companies elsewhere. If Samsung Electronics funds research in Switzerland for example, that would not register here. If Tesla spends money in Japan, that does. While imperfect, GERD provides an overview of the "research market" and provides a comparable number for each country.

2: Gross domestic spending on R&D (GERD) per capita:

While measuring the absolute values of spending can already be telling, the per capita value might paint a different picture. This is because of the substantial size-difference between the three countries. The population of Japan is more than double than South Korea's and almost five times that of Taiwan. This means, that if all three are allocating the same amount of funds for innovation in a year, that is a significantly more substantial commitment in Taiwan, than in Japan. (OECD 2021)

3: Percentage of Government Performed GERD:

To zoom in a little bit on government activity, this next criterion measures the percentage of gross domestic spending on R&D performed by the government sector. First, how does the Frascati Manual define the "government sector"?

„The Government sector consists of the following groups of resident institutional units:

- *all units of central (federal), regional (state) or local (municipal) government, including social security funds, except those units that provide higher education services or fit the description of higher education institutions provided in the previous subsection*

- *all non-market npIs that are controlled by government units, which are not part of the higher education sector.*

The sector does not include public corporations, even when all the equity of such corporations is owned by government units. public enterprises are included in the Business enterprise sector; the defining difference is that public corporations are market producers, while units classified in the Government sector are not.„ (OECD 2015, 100)

From the perspective of this analysis the most important – or at least not self-explanatory – part of this definition is the last one. While the share and thus overall influence of state-owned enterprises may have shown some decline in the countries in scope for this paper – or at least they are not state-owned anymore – this is a significant distinction. The wave of privatization and restructuring in Japan started in the mid-1980's going on all the way into the 2000's – and thus encompassing also the years of the fallout after the burst of the bubble economy in the 1990's – included companies such as the Japan National Railways (today's JR), the Nippon Telegraph and Telephone Public Corporation (today's NTT) and also the Postal Service (today's Japan Post Holdings). (Saito 2017) Similar developments could be observed in South Korea under the leadership of Kim Dae-jung, when the 1998 Asian Financial Crisis spurred the government on with their privatization plans. (Kim & Chung 2008, 3-4) Companies such as Korea Telecom or the Korea Heavy Industries and Construction Corporation were fully privatized in this time.

To mention a somewhat confusing example, Tokyo Metro, the larger one of the two subway operators of the Japanese capital, is legally a private company. However, in the time of writing, all of its shares of Tokyo Metro Ltd. are owned by either the Government of Japan (53.4%) or the Tokyo Metropolitan Government (46.6%). (Tokyo Metro Co. n.d.) The R&D spending of these companies goes to the business sector. As this is a percentage, this variable helps us understand the share (influence) the government sector has in the actual R&D activities happening in their country.

4: Percentage of Government Financed GERD:

To pair up with the previous variable, this one measures not how much money was spend on R&D done by the government, but how much money the government provided for R&D. The purpose of this criterion being included here is similar to the previous one, but not exactly the same. While the one before looked at the role of government as the actual “researcher” while in this it is the facilitator. Private companies and non-profit institutions that receive government grants to innovate are recorded here.

It is going to be interesting to see how the two numbers – government conducted, and government financed R&D – relate to each other. Which of the two roles the state might embrace or expand, or which ones it abandons – or at least scales back their involvement in?

5: Business enterprise expenditure on R&D (BERD):

After the government, comes the business sphere. This is a subset of GERD (discussed above) and highlights the general weight the business sphere has within innovation spending. Just for reference – and to illustrate just how significant private enterprise is in this topic – while this paper mostly looks at government influence, the 2019 percentage of GERD in South Korea that was government financed was 20.68%, while the share of the business enterprise sector was 76.95%. Higher education and non-profit financed ones come in third with less than a single percentage with foreign sources accounting for the remaining fraction. (OECD 2021) This is a substantial difference. It might suggest, that while there may or may not be a correlation between government activity and success in innovation, there might just be one (or a stronger one) between the same desired output increase, and that of the business sphere.

The variable of BERD is defined as:

„the component of GERD incurred by units belonging to the Business enterprise sector. It is the measure of intramural R&D expenditures within the Business enterprise sector during a specific reference period” (OECD 2015, 365)

On the next page, the Frascati Manual discusses, what counts as the “business enterprise sector”.

„- all resident corporations, including not only legally incorporated enterprises, regardless of the residence of their shareholders. this group includes all other types of quasi-corporations, i.e. units capable of generating a profit or other financial gain for their owners, recognised by law as separate legal entities from their owners, and set up for purposes of engaging in market production at prices that are economically significant.

- *the unincorporated branches of non-resident enterprises are deemed to be resident because they are engaged in production on the economic territory on a long-term basis.*

- *all resident non-profit institutions (NPIs) that are market producers of goods or services or serve business.„* (OECD 2015, 366)

The section finishes by stating, that the sector contains both private and publicly traded companies. The function of this criterion is to provide some contrast to the government numbers when it is analyzed how (if) government influences change in research performance or value creation in a certain industry.

6: Higher education expenditure on R&D (HERD):

Number six is a variable representing the third main player in innovation, the higher education sector must be included. After all, one of the dependent variables is the number of citable documents produced by Japan, South Korea, and Taiwan, and the output of (public) research papers is mostly done by universities and research institutions. The criterion itself follows the pattern of BERD as:

„Higher education expenditure on R&D (HERD) represents the component of GERD incurred by units belonging to the higher education sector. It is the measure of intramural R&D expenditures within the higher education sector during a specific period. see also Gross domestic expenditure are R&D (GERD) and intramural R&D expenditures." (OECD 2015, 372)

The „higher education sector" here is defined as:

„all universities, colleges of technology and other institutions providing formal tertiary education programmes, whatever their source of finance or legal status, and all research institutes, centres, experimental stations and clinics that have their R&D activities under the direct control of, or are administered by, tertiary education institutions." (OECD 2015, 372)

7: Number of R&D personnel per thousand employed

The final input variable is going to be the share of research and development personnel in total employment. Proportionally, how many people are working towards creating innovation in these countries. But what does it exactly mean to work in this field, if it is so complex? The definition of who R&D personnel are:

„all persons engaged directly in R&D, whether employed by the statistical unit or external contributors fully integrated into the statistical unit's R&D activities, as well as those providing direct services for the R&D activities (such as R&D managers, administrators, technicians and clerical staff)." (OECD 2015, 31)

This is different from the workforce, because employment does not include inactive people, only those that are actively working. Choosing the number of R&D personnel instead of the number of researchers is also not a coincidence. All this support staff is tied to R&D and is thus – according to the ideas expressed in the literature review – a better representation of the interconnected nature of innovation, as well as the true economic effect of research activity.

(3) Section six: Summary of the Analytical Framework

In this part, the analytical approach of the thesis was presented. First the basic thought process behind the framework was explained, how it was developed from the literature review, and what some of its basic properties and potential weaknesses are. The research question is to be answered with regression analysis, in three steps. In the first step, the data corresponding to all the analytical criteria is to be presented and visualized. The second step is the regression analysis itself, and the highlighting of the relevant pieces of data from its output. Finally, step three is going to be the evaluation of the results and answering the research question itself.

Twelve variables are included in the framework, analyzed over the course of the two decades from the turn of the millennium to the present day. The data will cover the years between 2000-2019, amounting to twenty observations in total. The method of the analysis is going to be linear regression, which is a formula that provides data on the relationship between two or more variables over time. With this, potential correlations between variables – such as scientific output and government spending – can potentially be discovered. Of the twelve variables, five are dependent variables that represent input data, while seven are independent variables, representing output data. Once the regression analysis is completed, three relevant pieces of statistical data will be highlighted: the *P-values* of each variable, the R-Square, and the *significance F*. The first one examines the linear relationship between individual variables, while the other two are measurements of the statistical power of the combination of all the variables, or in other words the model as a whole.

As the world economy is not a closed system of any two given variables, it must be stressed, that correlation is not causation. Even if a relationship is found between two things, we cannot say that one led to the other. Because of the method of the analysis, all criteria had to be quantitative. Therefore, the basis of comparison between the cases of Japan, South Korea and Taiwan is going to be financial data – to really be comparable – and government involvement will be represented by spending and percentage of research paid for or done by them. That will be measured against various performance indicators of the electronics industry.

Thus, the variables were assembled to reflect the many descriptions of systems of innovation, with all three major players – government, business, academia – included. For output, the choice was made to include the number of patents produced in the ICT industry, total exports and export share of the “computer, electronics and optical industry” as well as the share prices of the three largest electronics companies for all three countries and finally the number of citable scientific papers. Input variables would be the amount of research spending by the government or business, the share of government in R&D activities, or the number of personnel working in these fields.

This framework has no intention to be a “definitive” way to look at this subject, it must be recognized that all sorts of other combinations of criteria could have also been used. However, based on the literature presented in this analysis, following the theoretical framework of the topic, and constrained by all the limitations discussed, this was found to be the most suitable for this analysis.

Crucially, this is just a linear model, that tells the person running it information on the relationship between variables. However, the real economy is vastly more complicated than that. Throughout the discussion on the pitfalls of regression, there were several assumptions that must hold, and common mistakes in the interpretation of its results. One must not forget about the limitations of a method like this. This paper works with a finite set of criteria based on one set of data. However, the actual world economy has an infinite number of potential influences and actors that exert them. For this reason, the results of this analysis should only be interpreted within this context.

Table 1: Analytical Framework

	Criterion	**Unit of Measurement**	**Source**
	Dependent Variables - Output		
1.	Shareholder value	Current USD	Yahoo Financial Data
2.	Export market share – Computer, electronic and optical industry	Percentage	OECD
3.	Total exports – Computer, electronic and optical industry	Current USD	OECD
4.	Output of citable scientific papers	Number	Scimago
5.	Patents	Number	OECD
	Independent Variables - Input		
1.	Gross domestic spending on R&D (GERD)	Current USD	OECD
2.	GERD per capita	Current USD	OECD
3.	Percentage of government performed GERD	Percentage	OECD
4.	Percentage of government financed GERD	Percentage	OECD
5.	Business enterprise expenditure on R&D (BERD)	Current USD	OECD
6.	Higher education expenditure on R&D (HERD)	Current USD	OECD
7.	Number of R&D personnel per thousand employed	Per thousand	OECD

Part four: Empirical Inquiry

(4) Section one: Displaying the Data

In this part of the thesis, the data corresponding to each variable included in the analytical framework is going to be presented. The variables will appear in the same order, as they did during the discussion of the analytical framework in the previous part. This means, that the five dependent variables are going to come first, followed by the seven independent variables. For each criterion, this presentation of data will have four elements. Firstly, the data is going to be displayed in a chart, so that the three country cases are easily comparable, and the changes in the data over time observable. Secondly, this chart is to be supplemented with a description of the chart, the discussion of the data, and how the three cases relate to each other. Thirdly, this is going to be followed by the previously highlighted data from the regression output for the analysis, the R-Square, *Significance F*, and *P-value* for each variable. The fourth and last element is going to contain the numbers these analyses are based upon, however these are to be moved into the appendix. These consist of the tables for each variable, as well as the complete, original version of every regression output, as they were performed. This has been done because a full regression output is full of numbers and data that are not part of this analysis, and therefore including everything in the text could be confusing for the readers. However, full disclosure of all the data is nevertheless necessary, therefore everything else – that may be out of scope now but could otherwise be interesting – can be found towards the end of the paper.

All graphs are going to use a uniform style with the three countries assigned the same colors: red for Japan, blue for South Korea and green for Taiwan. The red and blue refer to the colors of the Japanese and South Korean flags, while the green for Taiwan is in reference to the ruling party mentioned earlier, the Democratic Progressive Party (DPP). The format of the graphs will also be the same, as everything to be presented here are time-series data. For these purposes, the line chart was chosen, with the year of the observation being located down at the *x*-axis, and the variables to be looked at being shown at the *y*-axis on the side.

The OECD databank that many of the criteria refer to adds disclaimers to its numbers, as some of them are only estimates, and some of them have been recorded differently. Because of this, the appendix will contain a disclaimer for every table, noting all of these differences and any additional condition they may have. In general, all variables are to be observed from the years 2000-2019 stated earlier, however there ended up being two exceptions. The first one is the share price, because due to two of the constituting companies going public later than that: LG Electronics in 2002 (Yahoo Finance 2021) and Mediatek in 2001 (Yahoo Finance 2021). This means that they did not have a share price, so that would have skewed the averages. The second one is patent output, where the most recent data from the dataset was from 2018, thus ending the analysis one year early.

To mention it again, from the regression, three statistics are going to be in scope now: the *significance F*, the R-square, and the *P-values*. The analysis will use a confidence α of 0,05 or 5%, meaning that if the *significance F* for the model, and the *P-values* for the variables are below that, there is a 95% chance that the linear relationship exists. In case of the model, it means that these independent variables together can predict the value of the dependent variable in a statistically significant way – again, in the context of the model only – while in case of the individual variables, the *P-values* show how relevant of a predictor the specific variable is, in much the same way.

The R-square on the other hand shows how much of the variance in the dependent variable can be explained by the independent variables, thus measuring the "statistical power" of the model in a way. For example, an R-square of 0,9 would mean, that 90% of the change in the dependent variable can be explained by this specific set of independent variables.

Important to stress once again, that the results of this analysis are only to be interpreted in this closed system, and any kind of conclusion regarding the real economy it models should only be applied with utmost caution.

(4) Section two: Presentation of the dependent variables

1: Shareholder value

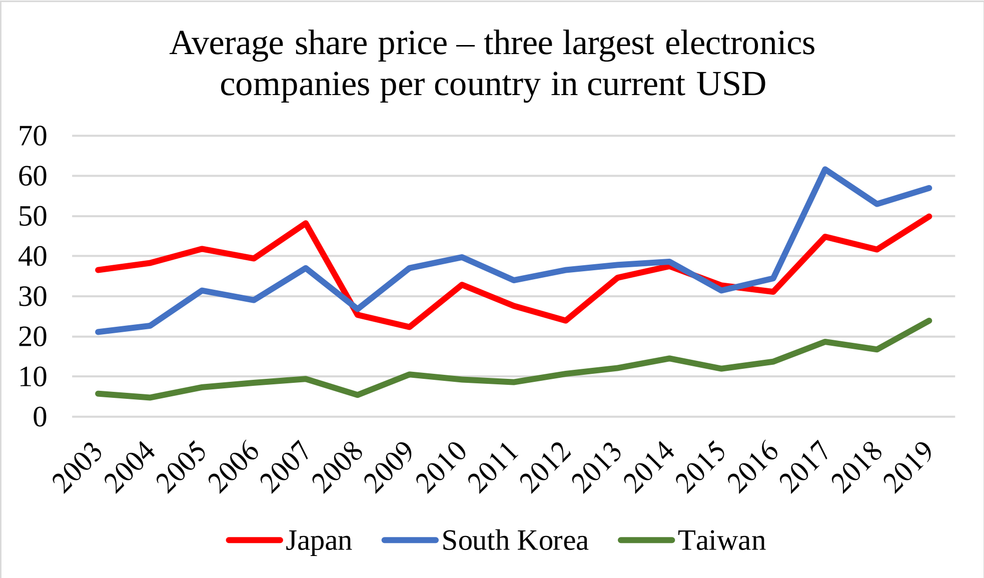

Figure 1: Shareholder value (Yahoo Finance 2021) – references to individual share prices to be found in the Bibliography, calculation of exchange rates, averages, and chart performed by the author

Because of the unavailability of earlier data, this variable can only be analyzed between the years 2003-2019, making the number of observations 17 instead of the 20 that is used as a general framework for this paper. As a reminder from the previous section on specific variables, the components for this index are Sony, Hitachi and Panasonic for Japan, Samsung Electronics, LG Electronics and SK Hynix for South Korea, and TSMC, Foxconn and Mediatek for Taiwan. In 2003, the Japanese index was close to 36 dollars, followed by South Korea with 21, and Taiwan with over 5 dollars.

All three numbers have been following a similar trend with initial growth, then a substantial drop in 2007, leading to a fluctuating but overall increasing trend until 2019. By that time, the South Korean companies – starting from only two-thirds of the Japanese index – gained the most in value, overtaking their Japanese rivals by over 10%, ending the observed period at close to 57 dollars to Japan's 50. At the same time, the Taiwanese index roughly quadrupled its value to reach an average price of close to 24 dollars in 2019. While all three indexes grew, the proportions were different with the South Korean one more than doubling in value, and the Japanese one experiencing an increase of around 50%.

2: Export market share – Computer, electronic and optical industry:

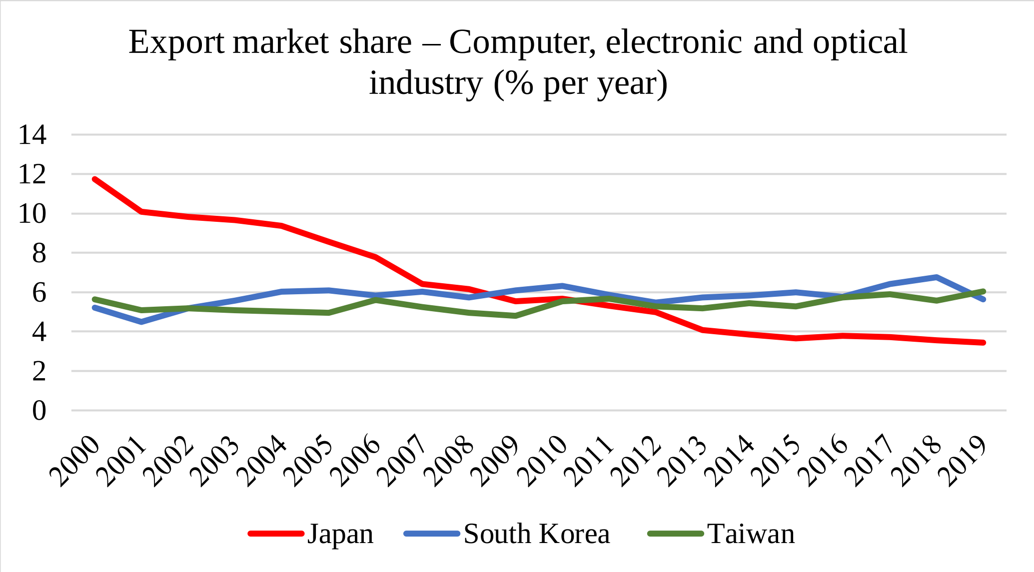

Figure 2: Export market share (OECD 2021) – chart created by the author

While the title may be confusing, this export market share means the role of this industry plays domestically, so how much of a country's exports is it amounting to, not the share of these countries in the global market. Looking at the percentages of the export market share of the industry, the numbers from Japan show a steady downward trend, with electronics moving from having the highest percentage of its export market with 12% all the way down to below 4%, a decrease of three-quarters in 20 years. In the same period, South Korea and Taiwan both show a stable, stagnant share, oscillating between 5% and 6%. With this, the relative performance of their electronics industries converged with Japan's around the years 2007-2011, taking the lead thereafter. In the observed period, the South Korean and Taiwanese export market share moved from amounting to half of the Japanese one to being almost 1.5 times as high in the year 2019.

3: Total exports – Computer, electronic and optical industry:

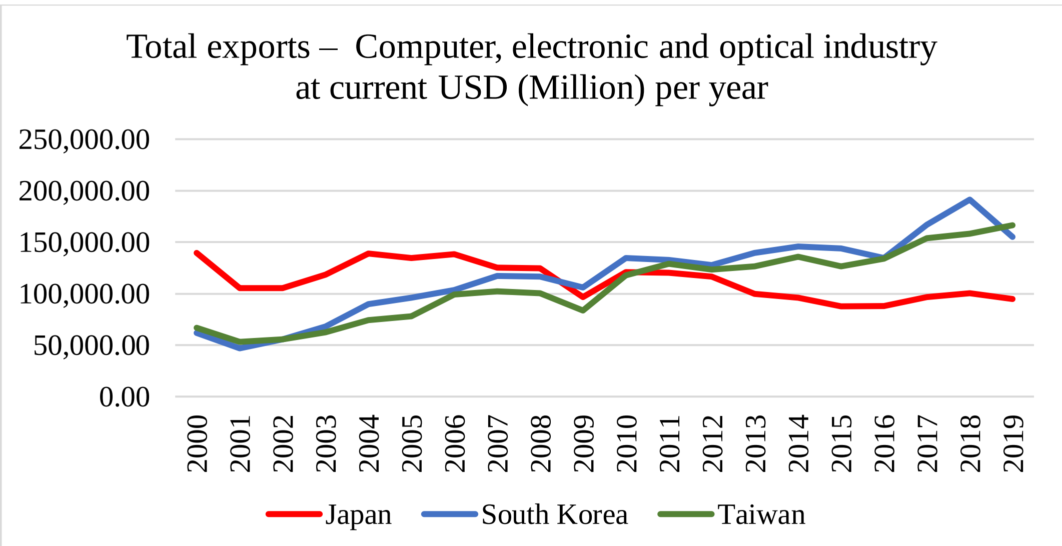

Figure 3: Total exports (OECD 2021) – chart created by the author

This chart shows how the total exports of the focus industry of this thesis changed over time. In the beginning of the observed period, Japanese exports of electronics were valued at 140000 million USD, more than double that of their counterparts from South Korea and Taiwan, at 67000 and 61000 in the year 2000. After all three moving in sync with each other, decreasing in 2001, then increasing and decreasing again in 2007-2008 and again in 2011, Japan diverges from the other two in a downward trend. In 2019, Japan's electronics exports amounted to 94000 million dollars, a drop of around 40%. Meanwhile, South Korea and Taiwan continued their upward trend with 155000 and 166000 respectively, growing to more than twice the values from 20 years ago. Relative to each other, the firms of the two Asian Tigers came from exporting half as much as Japanese companies to doing so 1.5 times more in 2019.

4: Output of citable scientific papers:

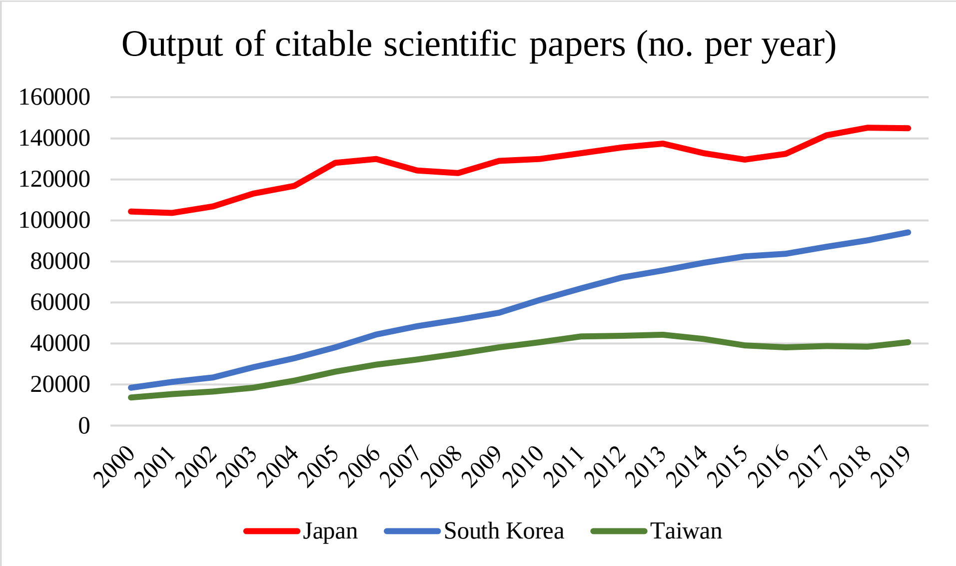

Figure 4: Output of citable scientific papers (SCImago 2020) – chart created by the author

This chart illustrates how many citable scientific documents were produced in Japan, South Korea and Taiwan. Japan begins the new millennium with over a hundred thousand papers a year, with South Korea and Taiwan grouped close together with 18000 and 13000 respectively. Japanese output increased by over 40% with 144000 publications in 2019. South Korea increased its output over five-fold, swelling up to 94000, while the Taiwanese production also rose to over 40000, more than tripling its output over the 20-year period.

While, looking at their publishing output, the order of the three countries did not change in the observed period, their proportions very much did. In the year 2000, Japan produced more than five times as many papers as South Korea and almost seven times as many as Taiwan. However, this has changed drastically over the course of these two decades, with South Korea now publishing more than 60% as many scientific documents as Japan, and Taiwanese output also increasing to being more than a third of the Japanese value.

5: Patents

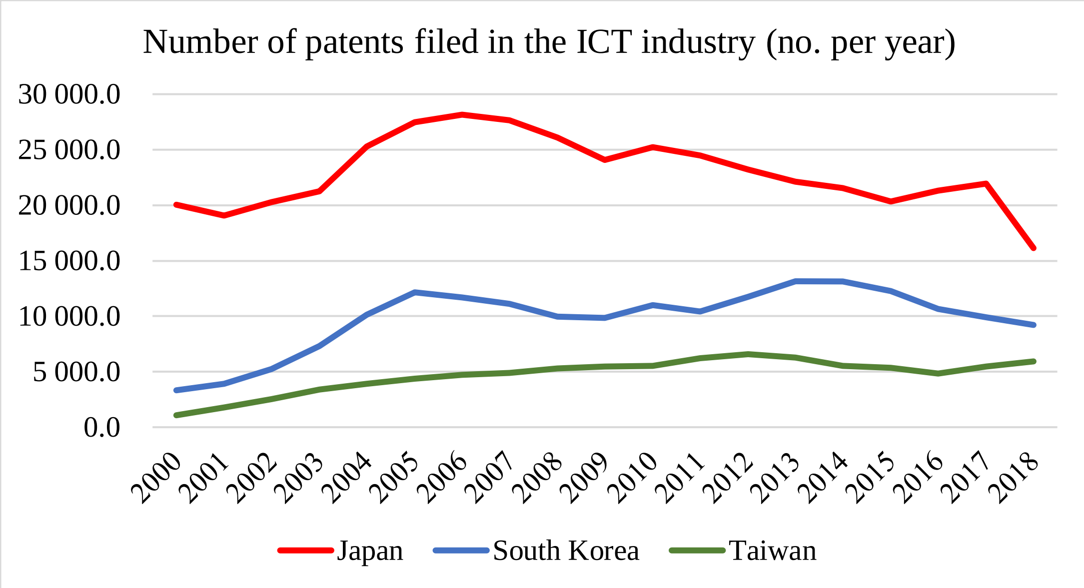

Figure 5: Patents (OECD 2021) – chart created by the author

Unfortunately, this dataset does not yet have the 2019 data points, so this analysis stops a year early. In 2000, Japanese residents filed around 20000 patents, reaching a high point of over 28000 in the year 2006, before decreasing all the way down to 16000, a 20% decrease compared to the beginning of the period. South Korean inventors started from an output of over 3000, reaching two highpoints in 2005 and 2013 with 12-13000 respectively, before also dropping slightly to below the 10000 mark in 2018, seeing patent filings triple in the country. In the same period, Taiwan saw almost a 6-time increase to just below 6000 in the last observed year. Notable, that two of the three countries saw their patent filings drop towards the end, with the three values starting a converging trend.

(4) Section three: Presentation of the independent variables

1: Gross domestic spending on R&D (GERD):

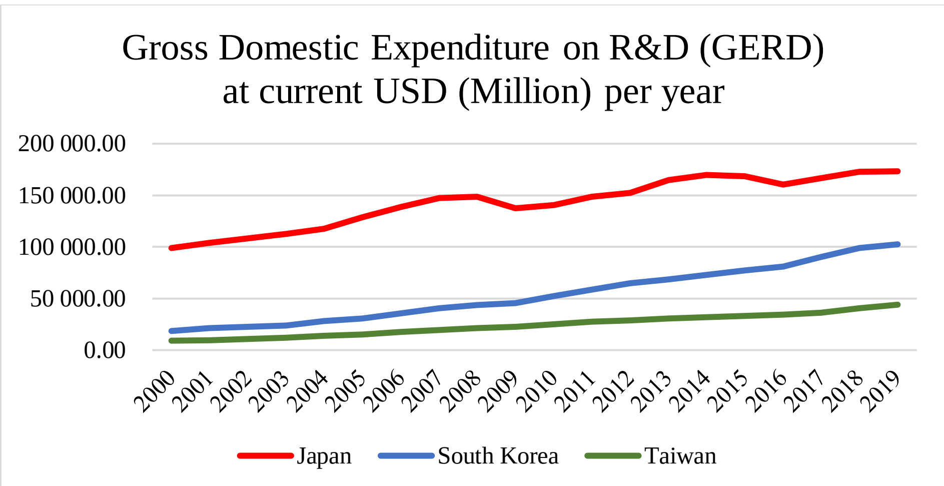

Figure 6: GERD (OECD 2021) – chart created by the author

For the first independent variable in this study, the chart shows gross domestic spending on R&D (GERD) in current million USD. The Japanese value starts at just under the 100.000 million USD mark, reaching over 173.000 by the end of the observed period, and increase of almost three-quarters. South Korea starts from a spending of 18.000, reaching over a 100.000, increasing more than five-fold in twenty years. Taiwan began the period with a value just over 9000, growing to over 44.000, just a little under the five-fold increase of South Korea.

While the values for all the countries showing an increasing trend, with the Japanese values fluctuating slightly, decreasing and then recovering twice in this period. The ranking of which country spends the most or least on research and development did not change over the course of the period either, their relative sizes did. In the first year of 2000, the Japanese spending was five times larger than the South Korean one, and more than ten times that of Taiwan. By 2019, the gap was closed significantly, with Korea reaching more than half of the Japanese spending, and Taiwan achieving one quarter of it.

2: Gross domestic spending on R&D (GERD) per capita:

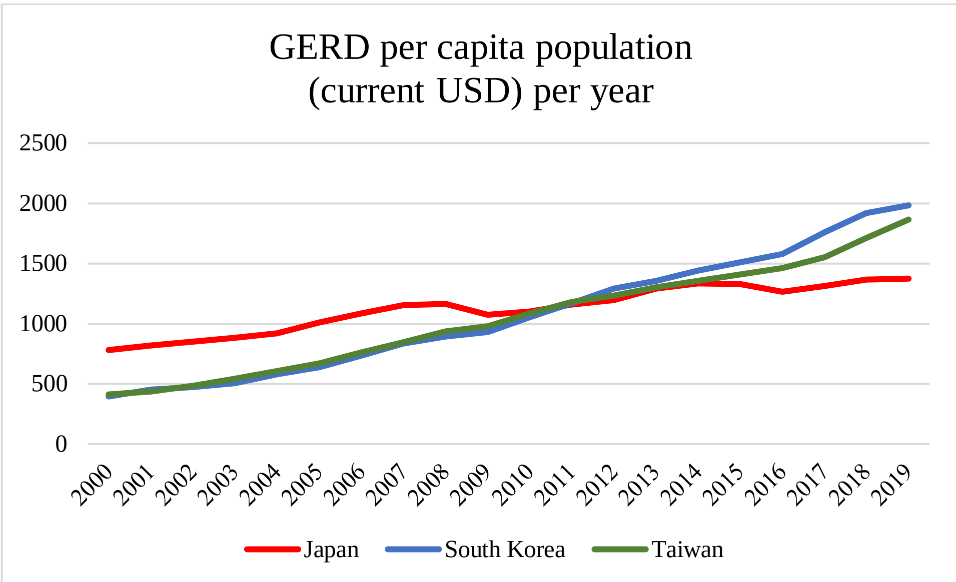

Figure 7: GERD per capita (OECD 2021) – chart created by the author

The difference in population between the three countries makes one wonder, how these data would look like, if accounted for such disparities. Remember, Japan has a population of 125 million, South Korea has 51 million (OECD 2020), and Taiwan just 23 million. (National Statistics - ROC (Taiwan) 2019) If the previously seen data is adjusted, the picture indeed looks different. The Japanese value starts from slightly under 800 and ending over 1300, growing around 60% during the twenty years observed. South Korean spending begins just under 400 in the year 2000, reaching almost 2000, once again a five-fold increase. The Taiwanese numbers begin slightly higher than the South Korean one with being over the 400-mark, growing to over 1800, increasing over four-fold. The fluctuation in the Japanese numbers also match the previous chart.

Albeit with some differences, the per capita changes in the three cases mirror the absolute values, however their relationship to each other is drastically different. Adjusted for population, Japan's lead was already much smaller than in absolute value. Previously, it was five and ten times larger, however now it is down to less than double. Over time, the picture changes even more, as previously only the proportion of the difference was changing with South Korea and Taiwan catching up, in this case, both of them ended up even pulling ahead, quite significantly. The point of this divergence were between the years 2010 and 2011, with the trend continuing then steadily until the present day.

3: Percentage of government performed GERD:

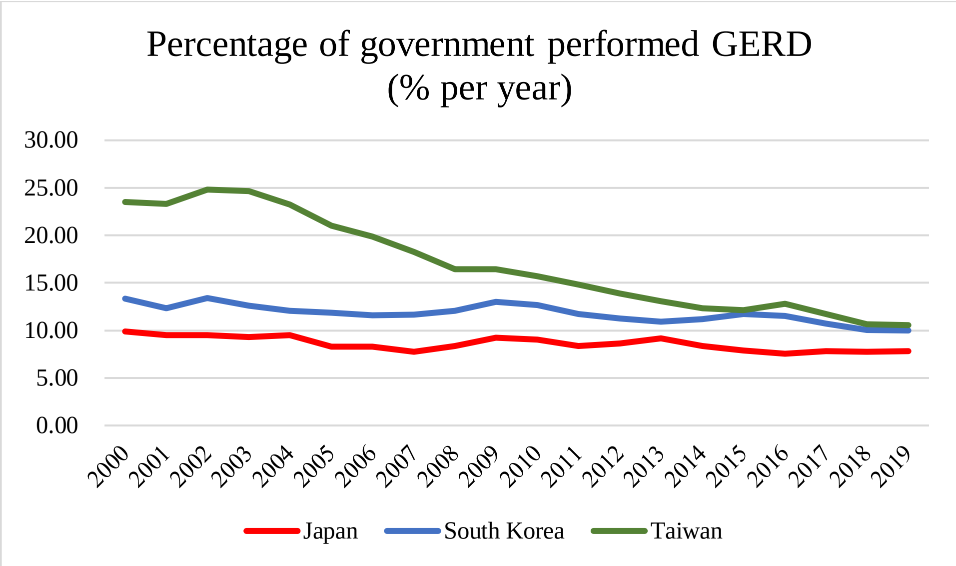

Figure 8: Percentage of government performed GERD (OECD 2021) – chart created by the author

This data belongs to the first of two variables on government involvement in research and development: the percentage of government conducted GERD. The chart has a shape very different from the previous ones, with the percentage of government performed R&D being the lowest in Japan – less than 10 percent – followed by South Korea – over 12 percent – not far from each other, and the Taiwanese value being much higher, almost 25 percent at the beginning of the analyzed period. From a peak in 2002-2003 however, the Taiwanese value also starts to drop, and with the ratio stagnating and then slightly decreasing in the other two countries, the three cases converge around 2015. In 2019, the percentage of Taiwan still edges out South Korea by less than a single percentage point at around 10% with Japan ending the period at 7,8%.

4: Percentage of government financed GERD:

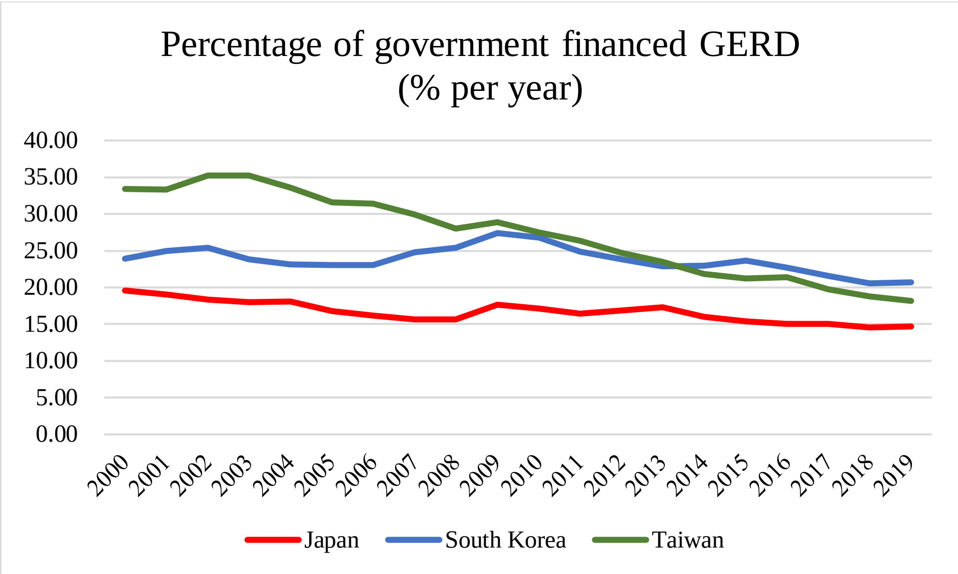

Figure 9: Percentage of government financed GERD (OECD 2021) – chart created by the author

As a follow-up to the previous criterion on the percentage of government conducted R&D, here is the chart on the percentage of government financed R&D. Similarly to the previous chart, Taiwan starts the year 2000 with the highest percentage of government involvement, with the share of government financed R&D being almost 35%. South Korea and Japan both have lower values, with 24% and just under 20% respectively. In this case as well, the three countries converge as time goes on, however to a lesser extent than with government conducted R&D. In 2019, Japan still has the lowest proportion out of the three with Taiwan second and South Korea first, all three in the 15-20% range.

5: Business Enterprise Expenditure on R&D (BERD):

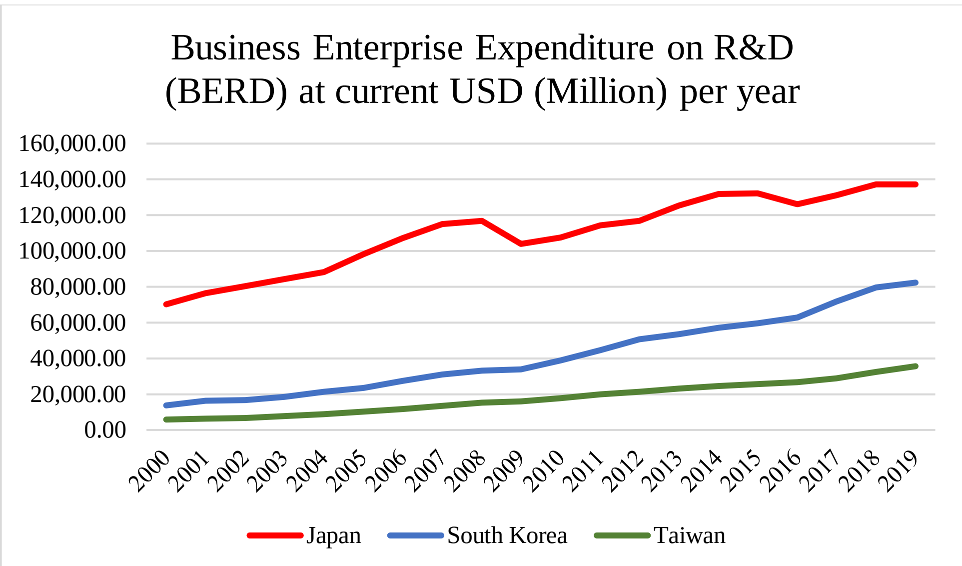

Figure 10: BERD (OECD 2021) – chart created by the author

Supplementing the variables on government involvement, comes the R&D spending of the business sphere. Out of the three countries, Japanese companies spent the most on research and development with over 70000 million dollars at the beginning of the observed period, with the corresponding data from South Korea being around 16000, and over 6000 for Taiwan. In the 20-year period, Japanese business spending almost doubled, reaching 137000 million USD in 2019. By the end of the period, South Korean and Taiwanese business spending grew to more than 82000 million USD and 35000 million USD each.

In a similar vein to the graph on total spending, this one also shows a trend of South Korea and Taiwan closing the gap on Japanese expenditure. While in 2000, South Korean company expenditure on research and development was just a little over one fifth of the Japanese one, however grew to more than half by 2019, with Taiwan moving from less than a tenth to over a quarter in the same period.

6: Higher Education Expenditure on R&D (HERD):

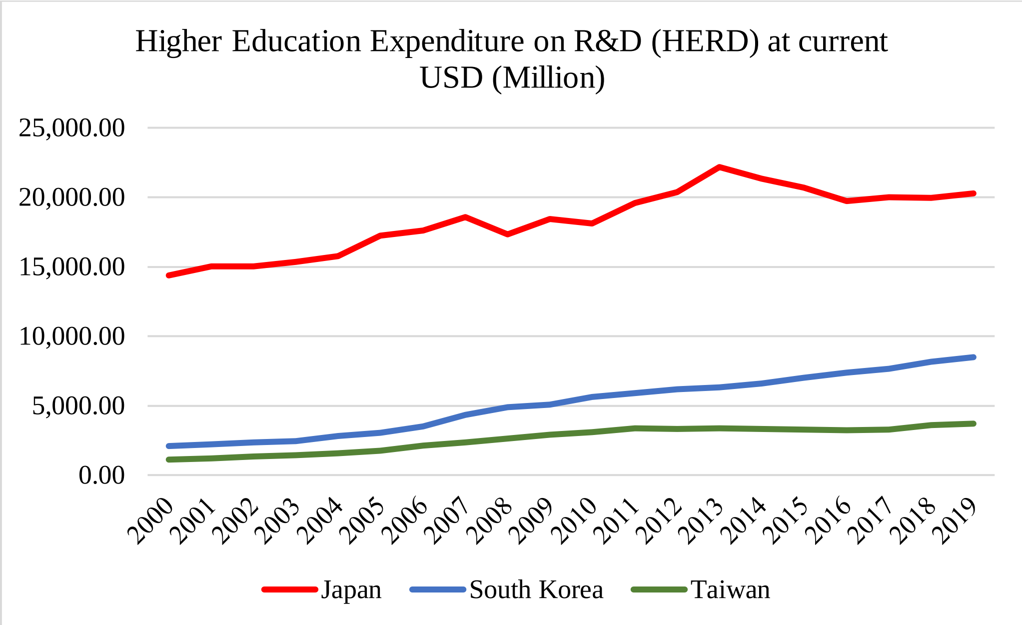

Figure 11: HERD (OECD 2021) – chart created by the author

To present the last of the three main actors in R&D, this chart illustrates higher education spending on research and development in Japan, South Korea and Taiwan. Looking at the Japanese data, it begins slightly below 15000 million USD in the beginning of the observed period, finishing at over 20000 million for a 25% increase in 20 years. In South Korea, the time series begin at over 2000, reaching over 8000 by 2019 for a more than four-fold increase. Taiwanese higher education institutions also more than tripled their research spending in the observed period, starting from a bit over 1000 million USD, growing to be over 3000 by the year 2019. The previously seen trend continues here, where the universities of the two Asian Tigers move from one-seventh (South Korea) and thirteenth (Taiwan) of the expenditures of their Japanese peers to a little less than half and one-sixth respectively by the last observed year of 2019.

7: Number of R&D Personnel per thousand employed:

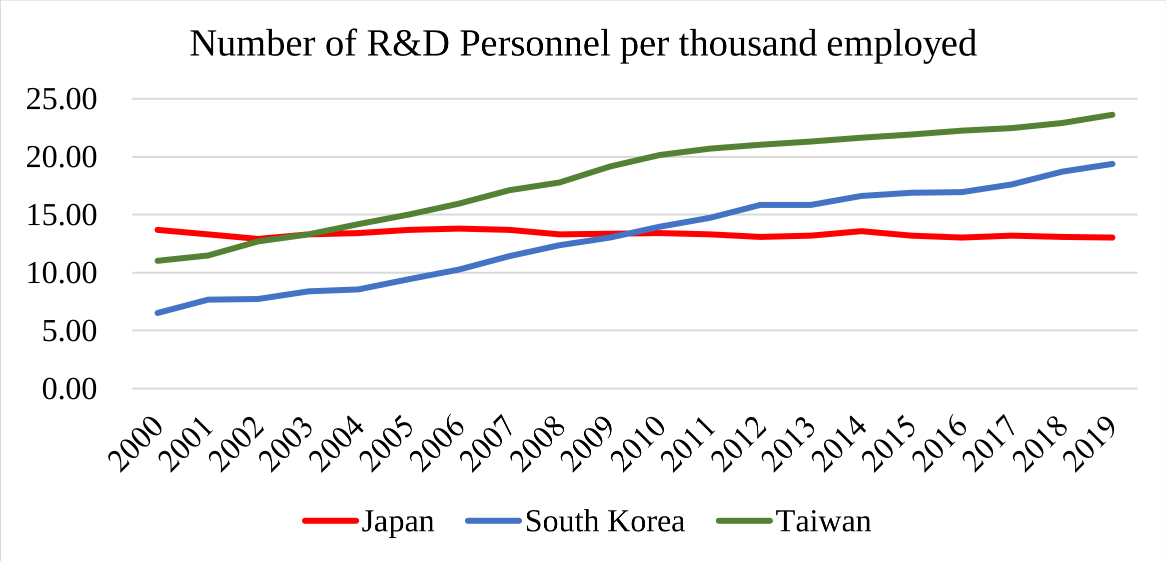

Figure 12: R&D Personnel (OECD 2021) – chart created by the author

Observing the number of research personnel in employment, Japan and Taiwan starts the period towards the top, grouped relatively close together with numbers above 13 and 11, with South Korea a bit behind at over 6. As time went on, the number for Japan stagnated and finally decreased by half a percentage point by the end of the period. In 2019, the Taiwanese value was over 23 people per one thousand working in R&D, more than double that of 20 years earlier. The number for South Korea has close to tripled in during the same period, reaching almost 20. The shift when Taiwan and South Korea passed Japan based on this metric happened in 2003 and 2010, with the increasing trend in their numbers continuing steadily at a similar pace.

(4) Section four: Regression output

Now that all variables have been presented and visualized, this section will show the results of the linear regression analysis. As before, the order in which the results will appear will follow the previous numbering. This section is only for the specific elements of the output that this paper focuses on, however the complete results can also be found in the appendix. This means, that three statistical items are going to be presented for each of the three countries: the R-Square, *Significance F*, and finally the *P-values* for each variable in the regression. All of these have already been discussed in the literature review as well as the analytical framework, however, a short reminder has also been included here to avoid confusion.

The R-Square measures how much of the variance of the dependent variable can be explained with the seven independent variables (a number between 0 and 1, usually discussed as a percentage). The *Significance F*, which measures whether one can confidently say if a linear relationship – correlation – exist between the dependent variable and the seven independent variables or not. The threshold here is 0,05 or 5%, if the corresponding number is smaller, then one can say there is a relationship, thus making the test statistically significant.

On the other hand, if the number exceeds 0,05, one cannot say that – this does not mean that there is no relationship, merely that it cannot be judged based on the result – thus rendering the result statistically insignificant. Finally the *P-values* do something very similar, except for the variable itself, meaning that a *P-value* of 0,05 or lower means that it is a – statistically – significant predictor, while a value more than that says the opposite.

The format will also follow the sections from before, where first the numbers are presented, followed by a description and commentary on the results. The first table will always contain the R-Square and the *Significance F*, while the *P-values* can be found in a second table. Before looking at the results, once again it has to be said that all of this analysis should be understood only within the context of the model. All and any inferences on issues outside of the model should only be made with the necessary conditions in mind – discussed earlier – and with utmost caution.

1: Shareholder value

Regression Summary Output for Shareholder value			
	Japan	South Korea	Taiwan
R-Square	0,781904537	0,903369574	0,914913589
Significance F	0,032982216	0,001673732	0,001031399

P-value Output for Shareholder value			
	Japan	South Korea	Taiwan
GERD	0,864019543	0,088874285	0,502321579
GERD per capita	0,009266946	0,046649318	0,544566129
GOV Performed GERD	0,749654298	0,348918954	0,293434731
GOV Financed GERD	0,8831287	0,5765976	0,150931726
BERD	0,493307745	0,299628679	0,484919239
HERD	0,621856363	0,592589459	0,137795216
RD Personnel	0,127825127	0,025420128	0,251222197

Table 2: R-Square, Significance F and P-value regression output for Shareholder value– performed by the author

Starting with the summary output, all the R-Square values are above 0,7 with South Korea and Taiwan even crossing the 0,9 mark, meaning that 78% and over 90% of the variance in shareholder value can be explained by the changes in the seven independent variables. As for the *Significance F*, comparing the three values to the 0,05 baseline, it turns out that all three are below that, making these results statistically significant, meaning that there appears to be a linear relationship between the independent variables, and the company share prices in all three country cases.

Analyzing the *P-values* of the variables, the picture looks very different. In the Japanese case, only one predictor ends up being statistically significant – that is GERD per capita with 0,009 – with South Korea having three significant – GERD, GERD per capita again and the number of R&D personnel – against four insignificant, and Taiwan having zero out of seven being individually significant predictors.

2: Export market share – Computer, electronic and optical industry:

Regression Summary Output for Export market share of electronics			
	Japan	South Korea	Taiwan
R-Square	0,977954288	0,596947371	0,549589526
Significance F	5,45686E-09	0,07489746	0,124864711

P-value Output for Export market share of electronics			
	Japan	South Korea	Taiwan
GERD	0,588211352	0,137290274	0,602020358
GERD per capita	0,092340784	0,025482684	0,849023225
GOV Performed GERD	0,36248258	0,493688162	0,416608327
GOV Financed GERD	0,171420541	0,738638516	0,286452501
BERD	0,341791563	0,458257552	0,237470294
HERD	0,945733924	0,412261941	0,565155225
RD Personnel	0,055197856	0,056255028	0,174477692

Table 3: R-Square, Significance F and P-value regression output for Export market share– performed by the author

Observing the results of the summary output first, the Japanese values do end up being different than the other two. For the R-Square, the value for Japan is 0,97, meaning that the model claims to explain 97% of the variance is the share of electronics exports, based on these seven inputs, against 59 and 54% in the cases of South Korea and Taiwan.

Of the individual variables in the second table, it becomes apparent that none of the seven *P-values* end up being smaller than the 0,05 benchmark for Japan or Taiwan, meaning that none of these variables are deemed by the model as strong predictors. South Korea on the other hand has one single variable where a linear relationship does exist, which is GERD per capita.

3: Total exports – Computer, electronic and optical industry:

Regression Summary Output for Total exports of electronics			
	Japan	South Korea	Taiwan
R-Square	0,789085224	0,959357417	0,969865778
Significance F	0,002670996	2,05644E-07	3,49674E-08

P-value Output for Total exports of electronics			
	Japan	South Korea	Taiwan
GERD	0,126641911	0,032243647	0,352514037
GERD per capita	0,459326853	0,006860696	0,121765269
GOV Performed GERD	0,180144777	0,555703153	0,192561748
GOV Financed GERD	0,031470407	0,550386687	0,063653108
BERD	0,059242092	0,711831232	0,265078142
HERD	0,967520999	0,718490848	0,886999086
RD Personnel	0,11977428	0,047268143	0,345163874

Table 4: R-Square, Significance F and P-value regression output for Total exports– performed by the author

According to the summary output of this regression, once again a very high R-Square is noticeable, above 0,95 for South Korea and Taiwan, and not much below 0,8 in the case of Japan. This means, that based on these variables, the model can explain 78% and over 95% of changes in total exports with the help of the seven independent variables. In terms of the significance, the same pattern emerges. South Korea and Taiwan have values four and six times the 0,05 or 5% threshold, meaning that the result does not reach statistical significance. The Japanese value on the other hand is way below, falling withing the confidence interval at 0,002, thus resulting in a statistically significant linear relationship.

Analyzing the *P-value* table, the distribution of predictors is uneven with none of the values being significant in two countries. For Japan, the only statistically significant predictor ends up being the share of government financed GERD, while South Korea having GERD, GERD per capita and the number of research personnel as predictors of total export performance. For Taiwan, none of the individual variables reached the 5% benchmark.

4: Output of citable scientific papers:

Regression Summary Output for number of citable scientific papers			
	Japan	South Korea	Taiwan
R-Square	0,913445285	0,998395096	0,995179239
Significance F	1,72927E-05	1,79151E-14	6,19302E-13

P-value Output for number of citable scientific papers			
	Japan	South Korea	Taiwan
GERD	0,534901169	0,041801578	0,085147887
GERD per capita	0,151106776	0,998495671	0,025172351
GOV Performed GERD	0,024806648	0,334721479	0,230528939
GOV Financed GERD	0,01468654	0,0200375	0,056939919
BERD	0,562006363	0,017177037	0,396905549
HERD	0,050117862	0,729538584	0,010677447
RD Personnel	0,299876591	0,000795623	0,38998605

Table 5: R-Square, Significance F and P-value regression output for Output of citable scientific papers – performed by the author

Looking at the summary output first, a very strong R-Square above 90% is observable in all three cases, with the Japanese one being the lowest at 0,91. Both the South Korean and the Taiwanese values exceed 0,99, meaning that in this model, over 99% of the variance in the number of citable documents produced can be explained by these seven inputs. On the other hand, the significance of the model in all three cases is above the threshold of 0,05, more than triple in the first two cases, and over ten times in Taiwan, making all three of them statistically insignificant.

Following that up with the *P-value* table, Japan has two out of seven variables being significant with two additional ones being very close, while South Korea have four, and Taiwan have two with an additional one being just above 0,05. The only variable being consistently significant for all three is the share of government financed GERD.

5: Patents

Regression Summary Output for Patents filed in the ICT Industry			
	Japan	South Korea	Taiwan
R-Square	0,900699437	0,926539873	0,956780577
Significance F	0,000103	2,08171E-05	2,08171E-05

P-value Output for Patents filed in the ICT Industry			
	Japan	South Korea	Taiwan
GERD	0,009116455	0,36818596	0,103141618
GERD per capita	0,000493959	0,007861867	0,043805732
GOV Performed GERD	0,244850439	0,726957428	0,580110479
GOV Financed GERD	0,048595573	0,029938915	0,845101588
BERD	0,328572554	0,008657529	0,859753736
HERD	0,240556087	0,016316317	0,800596021
RD Personnel	0,055020187	0,403704674	0,632585012

Table 6: R-Square, Significance F and P-value regression output for Patents– performed by the author

For the patent output, the R-Square was over 0,9 or 90% in all three country cases, meaning that a very high proportion of patent output can be explained by a combination of these seven variables. On the other hand, out of the three, only the Japanese *Significance F* reaches the threshold of statistical significance, falling below the 0,05 benchmark. The South Korean and Taiwanese values exceed that comfortably with values around 2, making the result of the test in their cases insignificant.

In terms of the individual variables Japan has three out of seven variables being statistically significant predictors, with South Korea having four of these, and the Taiwanese case having just one. That one is consistent in all the of these cases: GERD per capita. Japan and South Korea also have the share of government financed GERD as a common, statistically significant variable.

(4) Section five: Summary of the Empirical Inquiry

This part of the paper was focusing on the presentation and visualization of the data behind the analytical framework. It is meant to serve as a bridge between the framework itself and its results, discussing the observations one can make based on the data only. After an introductory section, there is a passage for each of the 12 variables, going from dependent to independent, in the same sequence as before. In these passages, there is a chart with the time-series data for the variable, showing how the values changed in the observed period between the years 2000 and 2019.

The charts are then supplemented with a few paragraphs of description, discussing the numbers in relation to the three country cases, and how they changed relatively over time. This is then followed by the corresponding regression output. For each of the five dependent variables, the results of the regression were compiled into two tables – one for the R-Square and *Significance F*, and a second one for the *P-values* – containing all three countries. All additional data that the charts were based on, as well as the full regression output as it was performed, can be found in the appendix.

While the following part is going to discuss the results and what they might possibly mean in more detail, one could make a quick preliminary assessment and say that the analysis came back with mixed results. Regarding the data behind the 12 variables, the picture does seem to be in line with previous analysis, as far as the relative performance of the three country cases are concerned. While the results should obviously first and foremost interpreted on a case-by-case basis, looking at all the variables there does seem to be general theme emerging, albeit, what this trend means or represents is a very different question altogether. Regarding the regression, the results are much less consistent, with a diverse set of significant and insignificant outcomes for both entire sets of variables and also individual ones.

Part five: Final Analysis

(5) Section one: Summary of the findings

As the title suggests, this part of the thesis will be centered around the actual results of the analysis. Firstly, the actual outcome of the empirical part is going to be compiled and assessed. Secondly, the research question for this thesis is going to be revisited and answered. Thirdly, the particularities of the results – the data itself, the regression analysis, its outcome, and also how it relates to the research question – are going to be discussed, with some of their potential causes, or what they could potentially mean in a bigger context. This section is also going to address the reliability of the result. Section number four will refer back to the literature review, specifically the section on the country cases. After all, a number of authors were referenced, whose work is relevant to this study. While the literature review had the main function of laying the theoretical foundations for this paper and provide the analytical framework, the studies used there had their own conclusions, and the experts writing them had their own opinions. This section intends to discuss these, as well as how it might support or challenge the takeaways from this analysis. Finally, section five is to contain a short summary of all of the above.

The summary of the results is going to follow the same arrangement, as the analytical framework, and subsequently the empirical part did. First, the data behind the analysis and the graphs that were born out of them are to be looked at (dependent variables first, independent variables second), however not individually as before, but the twelve analytical criteria as a whole. After that, the regression analysis and its results are to be evaluated in the same way.

Number of top spots - All 12 variables		
Year	2000	2019
1st	Japan - 10	Japan - 5
2nd	Taiwan - 2	South Korea - 4
3rd	South Korea - 0	Taiwan - 3

Table 7: Number of top spots - All 12 variables – created by the author

This first table depicts the aggregate ranking of each country relative to one another at the beginning of the period of observation – the year 2000 – and again at the end of it in 2019. Looking at the time series charts, in many cases there have been a trend, whereby the lead Japan had at the beginning either got reduced substantially, or their numbers got overtaken completely altogether by their two neighbors. This table containing all the data used for this analysis does confirm that. In the beginning, Japan had the largest value for 10 out of 12 variables, while Taiwan had two, and South Korea zero. After 20 years, the picture looks very different. While Japan still retains the top spot in five analytical criteria, South Korea and Taiwan also have four and three each now, making the race very close.

Number of top spots - Only output variables		
Year	2000	2019
1st	Japan - 5	Japan - 2
2nd	South Korea - 0	Taiwan - 2
3rd	Taiwan - 0	South Korea - 1

Table 8: Number of top spots - Only output variables – created by the author

Now, if one were to only look at the dependent variables – the ones that actually represent the output or performance of the electronics industry of these countries – this is what it would look like. In the year 2000, all five of the dependent variables – the targets of the regression – were led by Japan, suggesting that there was not much of a competition in this field at the time. On the other hand, revisiting the numbers from 2019, Taiwan now shares the top spot with Japan with the two having two each, and South Korea also adding one. Looking at the distribution, South Korea topped the charts in the share prices of their companies with especially the stellar performance of Samsung Electronics – their share price growing over 20-fold in this period – going a long way in facilitating that. (Yahoo Finance 2021) Taiwan leads the pack in the export market share and also total exports of electronics, most likely not unrelated to the global semiconductor boom and Taiwan’s position at the forefront of it. (Chen et al. 2019, 2377-2378)

Number of top spots - Only input variables		
Year	2000	2019
1st	Japan - 5	Japan - 3
2nd	Taiwan - 2	South Korea - 2
3rd	South Korea - 0	Taiwan - 2

Table 9: Number of top spots - Only input variables – created by the author

After the output, come the input variables, so how much resource and effort the countries dedicate to reaching or improving upon the aforementioned goals. The changes in the numbers follow the same pattern as earlier. In 2000, Japan tops the chart with five, Taiwan comes second with two, and South Korea third with zero. In 2019, South Korea and Taiwan both have two with Japan retaining three. The gap has indeed been reduced. Taking a closer look at the specific variables, Taiwan led in both the share of government financed and government performed R&D, suggesting a higher engagement of the Taiwanese state in general, compared to the other two. Going back to the charts, both values did converge by 2019, so much so that now the South Korean state finances a higher percentage of R&D projects than the Taiwanese one. South Korea also has the highest GERD per capita, meaning that proportionally that country spends the most on research and development. Taiwan still has the highest percentage of government performed R&D as well as the highest share of research staff, while in 2019 Japan still spends in the most in absolute terms, as well as business terms, and in higher education.

(5) Section two: Regression results and answering the Research Question

Now, this the section to finally, formally, actually answer the research question that all of these pages were leading up to. The goal of this analysis was, to answer the question:

If compared, does the performance of the electronics industry of Japan, South Korea and Taiwan correlate with state support of research and development?

To answer this question, the related literature was reviewed, which concluded that even if the focus is state involvement, the business sphere and higher education also must be included somehow, because R&D is one integrated system of these three actors. Their inclusion is also beneficial for the purposes of comparison. In the end, 12 variables were chosen, and the question was to be answered with the aid of linear regression. The five dependent variables – various outputs measuring the performance of the electronics industry as well as R&D in general – were tested with models of seven independent variables each, which represented various inputs, such as resources used or share of government financing in R&D projects.

The specific values from the regression output that were chosen looked at the overall statistical power of the models through the R-Square, *Significance F*, and also the relevance of individual factors through the *P-values*. Basically, how much of the change in the dependent variable can be explained by changes in the seven criteria? Can one confidently say that there is a linear relationship between them, and finally, can such a connection be found for any individual criteria?

This last one, specifically for the two government-related variables will provide the explicit answer to the research question.

So, what were the results of the regression?

Model Significance				
	Japan	South Korea	Taiwan	Total
Significant	3	1	1	5
Insignificant	2	4	4	10

Table 10: Model Significance – created by the author

There were five dependent variables and three countries, making the total number of regressions 15. Out of these 15 models, 5 were statistically significant, while 10 were insignificant. This means, that in five cases out of 15 can be said with 95% confidence, that a linear relationship exists between the variables. In 10 cases – two-thirds of the total – this cannot be said. The only case where the significant results outnumber the insignificant ones is Japan, but even there the ratio is only 3:2, with the other two cases being 1:4.

Variables Significance				
	Japan	South Korea	Taiwan	Total
Significant	7	15	3	25
Insignificant	28	20	32	80

Table 11: Variables Significance – created by the author

Looking at the variables individually, there were 7 independent variables and five regressions for each country, making it 35 each. In total that ends up being 105, with 25 being statistically significant and 80 being insignificant. This means, that only in less than a quarter of the cases can it be confidently said, that a variable has some influence on the outcome. The South Korean case has the highest success rate here with 15 against 20, followed by Japan at 7 against 28, and finally in Taiwan only 3 times, merely 3 combinations out of the 35 were it marked by the analysis as an influencing factor.

Government-related Subset Significance				
	Japan	South Korea	Taiwan	Total
Significant	4	2	0	6
Insignificant	6	8	10	24

Table 12: Government-related Subset Significance– created by the author

And now the last table, providing the actual answer to the research question. There were two variables for state support: the share of government performed, and government financed R&D. Two in each of the five regressions for the three country cases, making it 30 observations. Out of the 30, only 6 were statistically significant and 24 insignificant. The insignificant results outnumber the significant ones in all three country cases, with especially the Taiwanese result of a zero out of ten being rather striking. Therefore:

Can it be confidently said, that in the electronics industry of Japan, South Korea and Taiwan, based on these set of criteria, state support of research and development influences the performance of the industry?

No, it cannot be confidently said.

However, this does not mean, that there is no influence either, only that one cannot be sure if there is or not. It may just be – on average – too weak, or the model may be malfunctioning somehow. Modifying the data or the selection of the criteria could potentially change the result and thus the answer entirely.

In the introductory section of the whole paper the debate around national innovation systems was referenced, specifically that to what extent should the government, business sphere, and higher education engage in research and development, and how their cooperation should look like. (Eriksson 2005, 9-14) This was one of the reasons behind their inclusion, to compare them.

Business and Higher Education Subset Significance				
	Japan	South Korea	Taiwan	Total
Significant	0	3	1	4
Insignificant	10	7	9	26

Table 13: Business and Higher Education Subset Significance – created by the author

Just like in the previous table that answered the research question, here there are also two variables – BERD and HERD – so the total number of items in the table is also 30 and thus very easily comparable. Through this comparison, it turns out that the ratio of significant to insignificant is even worse here than in the case of government involvement. In the previous case it was 6/24 while for business and higher education it is 4/26, meaning that based on this model only, government involvement does have a larger effect on the electronics industries of Japan, South Korea and Taiwan, however only by a very small margin.

(5) Section three: Reliability of the result

Of the three statistical terms chosen for this analysis, the final conclusions were drawn based on only two: the *Significance F* and the individual *P-values* of the analytical criteria. Since its values were introduced during the discussion on the regression output in the empirical part, not much was said about the R-Square at all.

If one were to think back to the output of the R-Square, they have been very high in almost all cases. A high R-Square – normally – would mean, that the model was assembled well, and the predictors (independent variables) can explain the movement of the dependent variables to a large extent. During the analysis, the absolute lowest R-Square was produced by South Korea and Taiwan in the regression on the export market share of their electronics industry but even those were 0,59 and 0,54 respectively. All the other values were much higher than that, with the most common result being over 0,9 or 90%. However, it seems a little counterintuitive, that a model with such a high “statistical power” would end up being insignificant. However, both the models and the individual variables were, more often than not, statistically insignificant. How can this be?

For a potential solution of this problem, the concept of multicollinearity could be useful to recall. Discussed in the literature review as one of the risks regression models face, it is the condition where the independent variables end up being not very independent at all, but instead correlated with each other. (Arkes 2019, 149-152) The corresponding chapter also mentions that under perfect multicollinearity, the value of the R-Square would be 1,0, to which the values around 0,9 are suspiciously close to. To test, whether the models could have been affected by multicollinearity, a simple correlation analysis was carried out.

Unlike multiple regression, where there is a set of variables measured against something all at once and then it provides information on the linear relationship between them – within the framework of that model – simple correlation merely looks at the movements of a set of variables individually. Are they moving in the same direction, or the opposite way to one another, and to what extent? (Arkes 2019, 321)

With this method, a potential correlation between the – supposedly – independent variables can be measured. Almost as a by-product of this, another answer can also be given to the research question. After all, the research question aimed to find out whether state involvement in research and development correlates with the performance of the electronics industries in these three East Asian countries or not. One wonders if the results of this would contradict the results of the multiple regression or arrive at the same conclusion.

For the purposes of this test, the correlation function of Microsoft Excel was used, just like in the case of all the previous analysis. Also in a similar vein, all the original output from the program can be found in the appendix. However, to not leave this section without illustration, the results of the simple correlation analysis for the first variable – Shareholder Value – are to be displayed here with some of its most relevant features highlighted. These are going to be two items in particular. Number one is whether the independent variables do indeed correlate heavily with each other (a cutoff to be used here is 0,9) in which case their values are going to be circled with red. Number two is, whether individually, the dependent variable correlate with government involvement (marked with yellow) or not. Does this analysis suggest the same as the previous one?

CORRELATION OUTPUT for Shareholder Value (Japan)								
	Share Price Average	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Share Price Average	1							
GERD	0,166194503	1						
GERD per capita	0,181050347	0,999605868	1					
GOV Performed GERD	-0,403730782	-0,670426367	-0,673503014	1				
GOV Financed GERD	-0,39623421	-0,786730465	-0,791482969	0,95177952	1			
BERD	0,196938224	0,996781623	0,997246852	-0,716920138	-0,831797892	1		
HERD	-0,000716331	0,900308808	0,895656133	-0,423523532	-0,488718115	0,86523932	1	
RD Personnel	0,233571345	-0,474112114	-0,485027511	0,149173109	0,301535736	-0,4726496	-0,414593186	1

Table 14: Correlation output for Shareholder value in Japan – created by the author

In the case of the share prices of the top electronics companies in Japan, there appear to be five cases, where independent variables have a 90% correlation with each other. Three of these are in the column of GERD, with GERD per capita, BERD and HERD all being above 0,9. Looking at the correlations for the share of government financed and performed research and development, based on the numbers there is a negative correlation of close to 0,4 in both cases. This would mean, that the more the state does, the worse it has been for the share prices of Sony, Panasonic and Hitachi.

CORRELATION OUTPUT for Shareholder Value (Soth Korea)								
	Share Price Average	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Share Price Average	1							
GERD	0,821724741	1						
GERD per capita	0,822283735	0,999889203	1					
GOV Performed GERD	-0,713643333	-0,784955954	-0,783032072	1				
GOV Financed GERD	-0,48382414	-0,584274777	-0,57615651	0,871688309	1			
BERD	0,826744587	0,999250282	0,998779335	-0,804805646	-0,612464763	1		
HERD	0,792612119	0,981731405	0,983887821	-0,689930546	-0,429060783	0,97414612	1	
RD Personnel	0,776853842	0,978099784	0,980616152	-0,697196989	-0,431757534	0,9707791	0,9950646	1

Table 15: Correlation output for Shareholder value in South Korea – created by the author

In South Korea, there are ten cases of multicollinearity of 0,9 or above, with GERD being particularly heavily positively correlated with everything other that the two government-related variables. For those ones, just like in the Japanese case, there are once again negative correlations of 0,71 and 0,48. This suggests, that the higher share of research projects the South Korean state carries out and pays for, the worse Samsung and co. performs at the stock exchange.

CORRELATION OUTPUT for Shareholder Value (Taiwan)								
	Share Price Average	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Share Price Average	1							
GERD	0,909058453	1						
GERD per capita	0,908055054	0,999972328	1					
GOV Performed GERD	-0,805402933	-0,956487552	-0,957745948	1				
GOV Financed GERD	-0,875565761	-0,986956842	-0,986734528	0,973191236	1			
BERD	0,917298405	0,999010377	0,998724343	-0,946038113	-0,985862654	1		
HERD	0,744179668	0,918645518	0,920986536	-0,973026701	-0,913953983	0,90089845	1	
RD Personnel	0,81684856	0,963550522	0,964690813	-0,988238276	-0,965250076	0,95164257	0,982527991	1

Table 16: Correlation output for Shareholder value in Taiwan – created by the author

Probably the most extreme result out of this three is the Taiwanese one, where every single one of the seven independent variables have an almost perfect (positive or negative) correlation with one another. There are no exceptions here. The pattern with government involvement being negatively correlated with the share prices of major electronics companies continue here, with both values being around negative 0,8 for the Taiwanese state and the likes of TSMC or Foxconn.

One must remember again that correlation is not causation. It would be tempting – however illogical – to think that the Japanese, South Korean and Taiwanese governments are so incompetent, that the more they do the worse it gets, but there is another explanation. If one thinks back to the charts on the data behind the variables, both the share of government financed and government performed R&D projects saw a decreasing trend over the observed period. On the other hand, the share prices of the nine electronics companies used here went up. Thus, these two developments registered as negative correlation, even though it cannot be said that one created the other. Looking at the other cases, every single dependent variable is negatively correlated with government involvement, with the exception of the export market share and total exports for Japan. While all other variables have been on the increase – leading to a negative correlation with government involvement that was on the retreat – in these two cases the numbers have actually decreased, meaning that the correlation itself ended up being positive.

Regarding the other variables, multicollinearity remains an issue. Using 0,9 as a cutoff, there are correlated independent variables in every model for all three country cases. This means that there is good reason to doubt the results of the regression, and that further research could be carried out to recalibrate the model – remove some of the independent variables that do not work together and add new ones – and re-run the analysis, comparing the results to this one in the end.

On top of potential multicollinearity and the multiple regression analysis and simple correlation analysis giving inconsistent results, this would also be the place to return to the end of the literature review and once again mention some of the other conditions and potential risks associated with using these analytical tools.

When interpreting results, the cited literature referenced six things in particular to watch out for. (Arkes 2019, 117-148) Number one was reverse causality, where the dependent variable would not just be a product of the independent variables, but actually influence them back. Theoretically, this is possible. For example, the share prices of the largest electronics companies were taken as a dependent variable, and business enterprise spending on R&D as an independent variable. Now, better performance on the stock exchange and a higher share price may spur the company on to spend even more on research and development next year, thus contributing to the overall business R&D spending. Number two is omitted-variable bias, where there are other factors that influence the result, however they are not included in the model. This condition is certainly true, however with this one has to face the problem of using mathematical models – with finite variables – to model the real economy. As discussed before, the real economy is controlled by real people, and element of random change, and an infinite number of variables. Any kind of statistical model can just approximate real events, with varying success. Number three is selection bias, where *y* has control over *x* and is able to modify its value. Number four is measurement error, the effect or chance of which can be minimized by using reputable sources and due diligence, however it is never zero. Number five are mediating factors, which means that one of the dependent variables is a product of an independent variable, while risk number six is if one uses an outcome as a predictor in the model.

Similarly to the section on this very issue in the methodology, there is a potential for four of the six risk factors to be at play here. Number four and number six are not really an issue, as none of the sources are particularly dubious and the input and output variables are clearly distinguished from each other, and none of the dependent variables were included in any of the tests as an independent variable. On the other hand, there is a risk of the other four, particularly omitted-variable bias, as there is always a factor that might have an influence on the result yet is not accounted for in the test.

Overall, based on the literature there are certainly reasons to be skeptical of this result. For this reason, the notion that one should always treat the results of statistical analysis like this with a great deal of caution does apply here as well. Attempts at analyzing the actual world with a finite set of variables is always going to have limitations. Statistical model diagnostics in is an extensive field in and of itself that is beyond the scope of this paper. However, these findings could be the starting point of further studies digging deeper into this subject, where one adjusts the model based on the results of this paper, and runs the analysis again according to that, or tackles this problem using a different method altogether.

(5) Section four: Trends in the data, alternative explanations

The previous two sections focused on the results of the regression, answering the research question and adding some context to the outcome with checking for a possible alternative conclusion and general reliability. This section intends to follow up on section one, dive a bit deeper into the data behind the variables and address another point floated in the beginning of the thesis. Throughout examining the literature looking for the most fitting analytical criteria for the electronics industry, many authors referenced in the introduction and the literature review (Arora et al. 2010) (Branstetter & Nakamura 2003) (Fukao et al. 2015) (Fukuda 2020) painted a picture of Japan's decline in this field relative to its Asian rivals (South Korea and Taiwan) as well as some Western countries such as the United States or Germany. While simply just observing and assessing the data as it appeared already gave away some information on this issue, this section will look at what the data suggests is the case, and how these authors referenced earlier saw the situation with some potential explanations for these developments.

In the work of Arora and colleagues (2010), the lack of software-related innovation and human capital was pinpointed as the main reason behind Japan losing some of its competitive edge. Following up on the empirical results based on patenting performance, four alternative hypotheses are presented, which may also in combination with each other also contribute to the change in the relative performance of Japanese innovation at large. First is the most obvious, the burst of the bubble economy, however it is stressed, that in case of cuts to extra spending – say, in research and development – would not lead to decreased productivity and would definitely not lead to a disproportionate decrease of productivity in software-intensive industries. Second is the role of venture capital in U.S. innovation, and the relative disadvantage Japanese science-based industries suffer because of the relative weakness of it at home. Third are the university-industry linkages that facilitate technology transfer, where, again, Japanese universities and such formal linkages are behind the ones to be found in America. Finally, the U.S. owns all major technological standards in the industry, and as such, all externalities coming from it reinforce its position. (Arora et al. 2010, 23-26)

Based on this analysis, the authors provide two explanations for Japan lagging behind. Explanation number one is the labor constraint of the Japanese ICT sector in terms of software engineers. This is both true for the number of people with adequate skills they train domestically, the number they can use as auxiliary employees through outsourcing, and also the talent they can attract to live and work in Japan. There can be many possible reasons for this, including the massive language barrier in Japan, and also the country's notoriously restrictive immigration policies. Explanation number two that is put forward is that the decrease in relative innovation productivity is due to the lower absorption capacity of Japanese companies. Entrenched managerial mindsets make strategic decisions and realignments difficult, particularly in the Japanese case, where managers work – in comparison with the U.S. – in a very homogenous setting where promotion from within and lifetime employment are prevalent features. (Arora et al. 2010, 30-37)

According to Branstetter & Nakamura (2003, 192-193), basing their findings on basic macro data on R&D spending as well as interviews, the primary reasons behind Japan's economic woes were macroeconomic – collapsed asset prices, banking crisis and bad government response to all of it – a decline in innovative capacity can still have significant ramification for Japanese growth prospects. As is the case with complex issues – like the perceived decline of the innovation performance of an entire nation – there are a few possible explanations, however the authors again echo other researchers already cited in this review. Firstly, Japanese R&D was focused on utilizing and perfecting already existing technology and not coming up with fundamentally different new solutions. Secondly, there is a lack of PhD level talent and a relative weakness of academic science in Japan. Thirdly, the large corporate R&D centers that worked so well during catch-up are not fit for such a dynamic new economic landscape. Finally, the environment to support startups that developed in America – institutions but also venture capital – did not develop to the same extent in Japan.

Very much the same issues are echoed in a different study looking at the structural problems of the Japanese economy. Starting off with the demand side, highlighting the lack of consumer demand and the excess savings – instead of investment – and the deflation problem as key issues. (Fukao et al. 2015, 2-14) Then, from the supply side, the shrinking working population and thus deployable manhours, also the quality of workforce available (increasing share of lower-skilled, temporary workers) and the – compared to the U.S. – sluggish total factor productivity (TFP) growth.

What is most relevant here, is that one of the main reasons for this, is the ICT revolution in the United States, and low investment in them in Japan. This is significant, as ICT influences not just the industry that is producing such equipment, but also all other industries that use them. (Fukao et al. 2015, 14-29) In short, IT makes everything more efficient, and thus has a compounding effect on the economy.

Specific to the ICT industry, this study by Fukao offers six reasons, as to why investment ended up being low, leading to the impediment of progress. (Fukao et al. 2015, 29-31) Firstly, due to very high job security in Japan, introducing ICT to trim the company and make it more efficient is very difficult. Secondly, the benefits of ICT investment are inherently linked to corporate management and thus, shortcomings like bad incentive regimes or only implementing such reforms on certain departments make such benefits diminish. Thirdly, young and more agile firms tend to be more successful at implementing new ICT, but because of the low entry and exit ratios of Japan, there are comparably not that many of those. Fourth, the retail market in Japan is much more fragmented unlike the oligopolistic U.S. market, and small shops found it difficult to implement such new technologies. Fifth, there is a chronic shortage of software engineers in Japan. Lastly, because of so many small firms, they cannot all develop their own systems, they need firms that they can buy the service from, however the market for such in Japan for business process outsourcing (BPO) is not very well developed.

Furthermore, looking into the future, Fukuda (2020, 9-12) , presents three major socio-economic threats to the success of Japan's STI (Science, Technology, Innovation) prospects. The first one is labor risk, caused by Japan's shrinking population, requiring increased immigration, increased participation of women in the workforce, or increased productivity, with the latter being the one the government is mostly focusing on.

The second is capital risk, as the available venture capital in Japan is much lower than in Germany or the United States. Even though Japanese companies end up saving a significantly larger chunk of their income, a generally risk-averse attitude means, that the money does not find its way to potential innovators, while domestic consumer demand is also low. Third, is spatial risk, with the shrinking population hitting specific regions particularly hard, especially the northern regions of Tohoku and Hokkaido. Adopting next generation technologies and reforming Japanese corporate governance practices in particular are seen as areas, where there is definitely room for improvement.

So, the authors whose work the analytical framework and its criteria was extracted from seem to be in a consensus, that Japan's performance has regressed in recent times. While they mostly use Silicon Valley as their comparison, the comparison of Japan with South Korea and Taiwan in the earlier sections in this thesis also seem to suggest, that the gap between them and the two Asian Tigers has been reduced or disappeared completely. However, this does not necessarily mean something to be concerned about or that certain mistakes were made in Japan that were avoided in Taiwan for example.

An alternative explanation lies in the nature of economic growth cycles. Of the three countries in focus, Japan was the first one to start their economic development. According to World Bank data, Japan's post-war economic miracle ended exactly around the same time as the period of hyper-growth started in South Korea. The last year of annual GDP growth reaching 10% or more in Japan was the year 1969 (World Bank a n.d.) while in South Korea, the first such year was 1966 with the last one – so far – being 1999. (World Bank b n.d.) The roughly one generation lag between them is also highlighted by the time of them hosting the Olympic Games: Tokyo 1964 was followed 24 years later by Seoul 1988 and finally Beijing 2008 two decades later. (Library of Congress 2018) Thus, these trends many not be indicative of some country-wide mismanagement of the electronics industry of Japan, but instead just be products of the fact that the Japanese economy was the first to mature and thus slow down. As all three countries reach the same level of development, South Korea and Taiwan also may encounter similar challenges as Japan before them, and thus it is entirely possible, that their relative position would not be markedly different, even if the same analysis would be carried out decades into the future.

A good example of this might be the issue around the aging population, highlighted also by Fukuda (2020, 9-12) as one of the three key risk factors facing Japanese industry. This condition of Japanese society is rather well-documented and – not coincidentally – is extensively studied by others. A European Parliament briefing also notes the fact that Japan's society is the oldest in the world, discussing some of the causes of the problem, as well as the response of the Japanese government. (European Parliament 2020, 1) However, what is perhaps lesser known, is that its neighbors are aging too. According to a United Nations projection, the current ratio of citizens over the age of 60 – which is 33,4% in Japan, and 20,1% and 20,2% for South Korea and Taiwan respectively – is going to even out by 2050, resulting in 42,4% for Japan, 41,6% for South Korea and 41,3% for Taiwan. (United Nations 2017, 28) Similar to population ageing, other challenges exhibited by a post-maturity Japan may not be that unique in a couple of decades and may also develop in the other two countries as well.

(5) Section five: Summary of the final analysis

This section is going to summarize part five of the thesis, discussing the main findings. The structure that was followed was identical to the structure of the paper itself. First, the results of the empirical part – the data behind the analytical framework – was compiled. Then, it was followed by the results of the regression, and a formal answering of the research question. In the third section, these findings were further checked against some of the fundamental limitations of the research method, discussing potential reasons to doubt the results. Finally, section four revisited some of the authors referenced earlier in the thesis, but this time their work was not used to look of analytical criteria, but instead their ideas were presented to see their explanations and how it relates to the results of this paper.

The summary of the preliminary empirical results aggregated first all the variables for the three country cases, followed by a separate table for the independent and dependent variables. The goal of this was to see how the various inputs from government, business and higher education spheres changed relative to one another, and how the previously set out performance indicators of the electronics industry improved or regressed over the course of the 20-year analysis. The results indeed show a trend of South Korea and Taiwan catching up to Japan. While the island nation dominated in most of the variables in the beginning, the playing field seems to be much more even in recent times.

Next, the results of the multiple regression were presented, and the research question answered. The question the thesis was sought to answer, is whether the performance of the electronics industry in Japan, South Korea and Taiwan correlate with state involvement or not. The multiple regression model yielded substantially more insignificant than significant tests, meaning that based on these variables, the answer to the research question is no, there does not seem to be a notable relationship between the two. Not just that, but the same assertion was true for the models themselves – the set of variables – as well as all the individual variables. Furthermore, for comparison the potential influence of the business and higher education-related variables were also examined, and the ratio of statistical significance there was even worse than in the case of the government. This means, that based on this analysis, all actors in the research and development ecosystem only have a limited impact on the output of an industry.

An insignificant result does not mean that there is no influence between the variables, merely that it cannot be proven at this stage. However, thinking back to all the potential pitfalls of regression, it is essential not to overlook some of the risks involved, as one has to avoid accidentally misrepresenting the results. Of these, the possibility of multicollinearity – correlation between independent variables in the model – stood out, and once tested using simple correlation analysis, there does seem to be a substantial chance of this being the case. Further research building on this paper may modify the model to combat challenges such as these, and therefore could potentially have a different outcome.

It is very important to always contextualize developments first before rushing to draw conclusions. Earlier, the data suggested that there was a negative correlation between state involvement and the performance of the electronics industry, which could lead some to think that the state might be doing a bad job and perhaps it could be better to outsource as many research projects to the private sphere or higher education as possible. However, there was a general trend of the state retreating and scaling down its efforts in this field, which then, when measured against an increasing output, registered as negative correlation, even though they may have been completely unrelated.

The results of the regression analysis as well as the correlation later did not provide definitive answers, with a very high R-Square values on the one hand – suggesting that the model predicts the dependent variable to a high degree – and lots of statistically insignificant tests and variables – suggesting the opposite – on the other. At the same time, one must not forget the necessary limitations and conditions of regression that were set out in the literature review. These linear methods aim to describe real events caused by an infinite number of variables with a finite set of tools, so consequently all outcomes should be treated with caution.

Not just that, but the view that the Japanese electronics industry has declined compared to their rivals, while does have its backers from Arora and colleagues (2010) to Branstetter & Nakamura (2003), and it must be said that the data presented in this thesis also points to to the same direction, it is important to acknowledge the fact, that the Japanese economy started to develop and thus reached maturity earlier than the other two, and some of the issues it faces today have a good chance of developing also in South Korea and Taiwan.

Part six: Conclusion

(6) Section one: Review of the Thesis

Part six is the last and closing part of this paper. In section one, the contents of the thesis are going to be summarized. Section two focuses on the main takeaways from the research itself and its results. The main goal is to highlight the overarching themes of this projects, go through the major points, what was uncovered and how it relates to the research theme and goals set out in the beginning.

The thesis set out to answer the question, whether there is a correlation between state support for research and development and the performance of a selected industry: electronics. The paper was going to compare the cases of Japan, South Korea and Taiwan in this field, between the years 2000 and 2019. The method to be used for this purpose was multiple regression, an analytical tool that tells the user information about the relationship between the movement of a combination of inputs on one side, and an output variable on the other. Additional themes were Japan’s perceived decline compared to the other two countries, and whether the linear relationship with the business or higher education sphere – the other two main players in research and development – might be stronger. This could provide an argument for either of these actors to perhaps have their influence expanded for better performance.

The relevance of the research is derived from the economic success of these East Asian countries (Stiglitz 1996, 151) with electronics being a prominent industry in all three cases. (World Bank 2018 a) (World Bank 2018 b) (World Bank 2018 c) The development of these countries does warrant attention from any country that may attempt something similar, and analyzing whether the public or the private sphere is more productive, or they have no measurable effect either way can also provide valuable insight to the reader. Do government science policies have an impact that is even measurable this way?

The paper is inherently limited by time, formal requirements, access to data (specifically have to do with the special status of Taiwan internationally as well as sources being behind paywall), self-reporting by governments that may or may not have an agenda, the language barrier, and finally the innate limitations of regression as a method of analysis.

The introduction was followed by the literature review, which serves one single purpose, and that is to find potential analytical criteria for the regression analysis, suitable for the electronics industry. The literature review started out highlighting the debate and general lack of consensus on the topic of industrial policy. (Ambroziak 2016, 3) After trying to define what industrial policy really is, the discourse around it turns towards innovation and R&D support as they become today's main area of focus. A distinction between innovation and R&D was made here, and with the definitions to be used all set, the literature moves towards innovation systems theory (Vas 2014), explaining how R&D today a collaborative effort between government, the business sphere and higher education. This meant, that for any analysis it would be advisable to include all three of these actors in some form.

After examining various different frameworks, based on which such policies are being described – for instance its depth so vertically on what level they are being formed, or the horizontal width so how many policy areas they might have an effect on – the quest to find suitable analytical criteria moved towards the specific research topic, namely the three country cases, and the electronics industry, highlighting what kind of analytical frameworks are used in research when looking at either policies and their categorization or their possible goals.

In the closing sections of the literature review, the focus was on how performance as such can be measured and the description or correlation and regression. Defining what performance actually is – and what it would be in an industrial policy setting – is not as straightforward as one might think and furthermore it is crucial in pinpointing what constitutes as "better" or "worse" performance. As for correlation and regression, these paragraphs build heavily on the work of Arkes (2019), providing the definitions for not just what these modes of analysis really analyze and give definitions for the individual statistical items that are to be used here to compare things, but also what might go wrong when using regression and what its constraints are when trying to formulate an opinion regarding the results and what they might mean.

In order to measure the statistical power and significance of the models used in the multiple regression, their R-Squared, *Significance F*, and for each individual variable their *P-value* are going to be the ones taken into consideration. The first one tells the user to what extent the combination of independent variables explain the movements of the dependent variable, while the latter two signals – with 95% certainty – whether a linear relationship exist within the context of the model (*F*) or the variables (*P*). It is also here that some of the potential problems of regression are mentioned.

Absolutely crucial to understand that at the end of the day, this is a method of modeling a system of infinite variables (the real economy) with a finite set of criteria. There might be issues with the data, the selection and assortment of variables and various other conditions that must be taken into consideration before trying to understand and drawing conclusions from the outcome.

In the end, twelve variables were chosen, the process and outcome of which is presented in part three, the analytical framework. The selection had to factor in the multi-faceted nature of R&D as a topic, both on the input and on the output side. This means, that to have something to compare potential government influence to, private business and higher education should also be included, and the performance side should also include variables for research performance as well as the production of the electronics industry. Of the twelve variables, five were dependent variables that measure these outputs, these being the average share prices of the three largest electronics companies, the export market share and total exports of electronics, the number of patents filed, and the number of citable research papers produced. These are going to be the targets of the regression. To find out what might influence these, the seven independent variables were: the total spending on R&D in the country – both as a total value and also per capita – the percentage of government financed and government conducted R&D projects, the total spending of the business sphere on R&D, the total spending of the higher education sphere on R&D, and finally the number of research personnel per 1000 persons in employment. As mentioned, one regression was targeting each of the five dependent variables for all three countries, making in 15 tests in total.

Once the analytical framework was ready, came the presentation of the data in the empirical part. This is part four of the thesis, where the data behind the twelve variables chosen is visualized in a format which makes the data from the three countries easily comparable. The sequence of the variables follows the same numbering as in the analytical framework, and for each of them, the data is shown as a time series on a graph, making the changes that happened between 2000 and 2019 as well as the differences between the relative positions of Japan, South Korea and Taiwan visible. Observing the data, the general trend has seen a substantial shift in the power balance between the three countries. In the beginning, the data showed a Japan that is quite overbearing, massively outspending and outperforming the other two in most metrics.
However, by the year 2019 the outlook has changed, and even though there are metrics where they still retain the top spot, their lead has noticeably shrunk, or disappeared completely as South Korea and Taiwan managed to outperform them in certain variables. Altogether, recent data from the data sets used for this analysis shows the three countries as more of less evenly matched.

Following the showcasing of the data, it was time to run the regression analysis and see how these variables would interact with each other. In the same sequence as before, the results of the relevant data from the regression output were compiled in a separate table for each dependent variable, making it five in total. The values of the R-Square can vary between 0-1, with the higher it is, the more statistical power the model has. For the *Significance F* and the *P-values*, as mentioned the threshold chosen for the degree of confidence was 95%, meaning that the test would be significant if these values fall below 0,05 or 5%, being insignificant otherwise.

The data was then assessed in part five with the results of the final analysis again arranged into tables. When looking at the empirical data that was used for the criteria, the position of the three countries changed quite dramatically in 20 years. Initially in the year 2000, out of the 12 variables – input and output together – Japan has been number one in 10 of them with Taiwan being on top in the remaining two. However, by 2019 Japan only retained its lead in five of them, closely followed by South Korea with four and Taiwan with three. Looking at the output, in other words the dependent variables only, Japan in the beginning had the largest values in all five of them, but by 2019 the situation evened out here too with Japan preserving its lead in two, Taiwan with two and South Korea also being the best in one. With the input variables, the story is very much the same with Japan's lead shrinking from five out of seven variables against Taiwan's two in 2000, with only retaining three in the year 2019 against two each for South Korea and Taiwan. Thus, the data does show a trend of the two Asian Tigers indeed closing the gap they had in many ways in relation to Japan.

To answer the research question, the same approach was taken as before. Organize the results of the multiple regression analysis in easily readable tables and formulate an answer from that. The models returned very high R-Square values, oftentimes higher than 0,9, suggesting that the independent variables in the models can explain over 90% of the variance in the dependent variable. The research question itself was, whether state involvement correlate with the aforementioned performance indicators of the electronics industry. Out of the 15 models in total, only five came back statistically significant. Looking at all of the variables, 25 predictors were significant against 80 insignificant. In the government-related subset of variables – formally answering the research question – the ratio of significant tests versus insignificant ones was 6/24, meaning that based on this it cannot be confidently said, that a linear relationship exists between what the state does in research and development and how the electronics industry performs after that. Comparing it with the business and higher education spheres, the ratio here ends up even lower, with just four statistically significant ones against 26 being insignificant.

What is very important, is that a statistically insignificant test does not mean that there is no relationship, merely that it cannot be proven with reasonable confidence. Furthermore, a significant test also does not mean that one thing was caused by the other, merely that the values are moving in a similar way. Not just that, but these results do contain a risk of multicollinearity.
The high R-Square suggested that the independent variables may in fact correlate with not just the dependent variable but also each other, and that might influence the result. Performing a simple correlation analysis on the independent variables, this phenomenon does appear in some cases. If there was further research building on these results, it would be advisable to modify the model with removing certain variables and adding new ones, which could potentially lead to different results altogether.

In the last section of this part, the work of some scholars cited in the literature review was revisited. There, the goal was to extract potential analytical criteria from their writings for the analysis, however the likes of Fukao (2015) or Fukuda (2020) also offered explanations for trends such as Japan's perceived decline. Important to contextualize these however. The economic miracle of Japan was the first one in the region, followed only by South Korea and Taiwan a few decades later. This means, that the Japanese economy has also reached maturity earlier and thus its potential issues are not necessarily the results of mistakes, but instead the natural course of events that may just reach its rivals. Taking the aging population as an example, while Japan is being particularly hard hit by this problem now, this too is projected to balance out between the three country cases in the future. (United Nations 2017, 28)

(6) Section two: Relevance of the results – final thoughts

While it may not be most hard-hitting or headline-grabbing conclusion there is, in the end perhaps the most significant takeaways here are: caution and context. Specifically, the importance of these two things in not just economic but any kind of research.

Thinking back to section seven of the literature review on correlation and regression, as well as section two of the analytical framework discussing the risks of actually carrying out such an analysis, the inherent limitations of methods like these become rather clear. The world is infinite, the number of variables in a statistical analysis on the other hand are not. In the real economy, there is such a vast number of actors, real people and organizations with real agency, that any model drawn up to learn more about them will – basically by definition – be a simplification.

This of course does not mean that they would be useless, far from it. However, no matter how tempting it may be, one should always keep the necessary conditions in mind. As presented in section seven of the literature review and followed up by the analytical framework itself, regression in itself is not very well suited to give definitive answers, because of all the conditions that must be met in order for a rock-solid conclusion to be formed, some of which are very difficult to achieve in the real world. This is why ample caution is necessary, when basing one's conclusions on such results.

Going back to the rhetorical questions asked in the very beginning, the analysis suggested that government policy – in itself – does not really correlate with the performance of the electronics industry in these three countries, and the same was true for the business and higher education spheres too – completing all three main actors in research and development. It is tempting to read something profound into all of this, such as none of these actors matter and anyone can just do whatever they want. However, this is not what the analysis says. It only says, that – based on only this – no definitive conclusion can be derived and the additional research into the subject is required.

This study also provides much needed context to Japan's "Lost Decades" and the general perception of decline as presented at various points throughout the paper. It is not so much that these opinions were refuted by these findings, but rather they were provided with some additional nuance. Based on the variables chosen for the analytical framework, it is certainly true that the Japanese electronics industry no longer enjoys the degree of dominance compared to the South Korean and Taiwanese one in 2019, as it did back in the year 2000, and it is entirely possible that bad policies and planning on behalf of various actors have contributed to that. However, there are a few notable points not to be overlooked here. The first one is, that Japan actually still leads in quite a few of these criteria, it is merely the case, that the competition became fiercer, with the playing field becoming more even. As one looks at the graphs of sections two and three in the empirical part, in most cases the Japanese numbers did grow, it just happened to be the case, that South Korea and Taiwan grew much more. And this is the second point, which is when these countries started to develop. Japan very much started it all in the region (World Bank a n.d.), and thus its economy reached maturity roughly a generation ahead of the other two, but some of the challenges it faces today, illustrated through the case of ageing population, may just catch up with its neighbors as well. (United Nations 2017, 28)

With that being said, this research should provide a solid potential starting point into the research of industrial policy, and the development of innovation systems theory. The first half of the literature review in particular contains a compilation of the state of the art today, compressing a gargantuan topic into a manageable size. A host of different authors and ideas are discussed, frameworks listed, therefore it could be of value to anyone wishing to pursue a research project in this field. The same assertion also applies to the following section on assessing performance with a number of indexes and their components being highlighted.

Regarding the result itself, it does warrant further attention. Using the outcome of this thesis as a platform, a modified, adjusted version of the framework – or an entirely different one that simply just builds on the same literature – could bring the researcher, and eventually maybe even policymakers, closer to a more productive allocation of their resources. While it has been stressed many times that correlation is certainly not the same as causation, the linear relationship that is correlation can further one's knowledge on the properties of the variables one wishes to study. And after all, is furthering knowledge not the fundamental goal of academic research?

The idea of finite and infinite things and how they might relate to each other is not only important when one contextualizes statistical models and their results, but also – as mentioned in the introductory part of the whole thesis – when one thinks of the possibility of infinite growth in a finite world, and the crucial role sustainability plays in the future of society. In order to develop the ability to successfully tackle the challenges of the 21st century, improving the productivity and efficiency of research and development is fundamental. Hopefully, this thesis managed to make some – however small – contribution towards that goal.

Appendix

Section one: Tables for empirical data

Average Share Price of the three largest Electronics Companies in current USD			
	Japan	South Korea	Taiwan
2003	36,5066677	21,11381518	5,665818554
2004	38,336667	22,73915231	4,763313086
2005	41,8433347	31,47934565	7,318713388
2006	39,4933333	29,1016319	8,380562645
2007	48,1866673	36,95464121	9,476969165
2008	25,45	26,77042443	5,447097717
2009	22,346667	37,09996094	10,49623675
2010	32,8033327	39,78828351	9,296416643
2011	27,6133337	33,99547667	8,609254388
2012	23,953333	36,54760495	10,74840305
2013	34,7100013	37,83071916	12,04947391
2014	37,5166673	38,69928879	14,46093862
2015	32,6433333	31,50820911	11,90235664
2016	31,1933333	34,54538276	13,74670264
2017	44,9	61,64588304	18,73033606
2018	41,593334	52,94608664	16,73016784
2019	49,896667	56,90823054	23,93033537

Table 17: Empirical data for Shareholder value (Yahoo Finance 2021)
– created by the author

Disclaimer: Because of going public at later than the year 2000 and at different times, two constituent companies have their first few years of data mission, thus skewing the averages. For the Taiwanese index, the number for Mediatek in 2000 is missing, while for South Korea, the same is true for LG Electronics between 2000-2002. Since these facts would have made the first three observations drastically different, the decision was made not to put them on the chart, nevertheless they are included here in the appendix.

Export market share – Computer, electronic and optical industry (% per year)			
	Japan	South Korea	Taiwan
2000	11,74	5,21	5,65
2001	10,10	4,49	5,09
2002	9,83	5,17	5,19
2003	9,67	5,56	5,10
2004	9,36	6,03	5,01
2005	8,55	6,09	4,94
2006	7,79	5,83	5,60
2007	6,42	6,02	5,24
2008	6,14	5,75	4,96
2009	5,55	6,09	4,80
2010	5,68	6,33	5,55
2011	5,31	5,86	5,68
2012	4,99	5,46	5,27
2013	4,08	5,72	5,19
2014	3,84	5,82	5,43
2015	3,65	5,99	5,27
2016	3,77	5,76	5,73
2017	3,71	6,41	5,91
2018	3,55	6,76	5,58
2019	3,44	5,63	6,04

Table 18: Empirical data for Export market share (OECD 2021) – created by the author

Total exports – Computer, electronic and optical industry at current USD (Million) per year			
	Japan	South Korea	Taiwan
2000	139 544,00	61 899,73	67 093,74
2001	105 532,59	46 875,05	53 154,74
2002	105 457,23	55 449,48	55 713,08
2003	118 166,84	67 969,86	62 311,87
2004	138 900,31	89 534,12	74 385,42
2005	134 809,70	95 945,97	77 859,37
2006	138 043,27	103 288,18	99 263,90
2007	125 186,94	117 348,47	102 171,08
2008	124 516,60	116 584,69	100 521,18
2009	96 464,90	105 990,93	83 435,51
2010	120 620,21	134 321,36	117 899,96
2011	120 370,03	132 836,87	128 689,27
2012	116 486,36	127 595,40	123 194,71

2013	99 529,56	139 467,95	126 527,64
2014	96 206,75	145 827,40	135 894,35
2015	87 648,38	143 693,88	126 296,79
2016	88 201,43	134 655,11	134 133,05
2017	96 580,95	166 756,93	153 726,93
2018	100 456,25	191 294,86	157 973,95
2019	94 818,41	155 163,22	166 391,33

Table 19: Empirical data for Total exports (OECD 2021)
– created by the author

Output of citable scientific papers (no. per year)			
	Japan	South Korea	Taiwan
2000	104444	18439	13683
2001	103609	21234	15385
2002	106877	23358	16457
2003	112910	28348	18584
2004	116767	32735	21797
2005	127962	38201	26105
2006	129974	44290	29776
2007	124403	48532	32168
2008	123096	51425	34946
2009	129041	54977	38265
2010	129921	61338	40758
2011	132608	66869	43482
2012	135403	72107	43744
2013	137265	75510	44252
2014	132565	79222	42241
2015	129630	82495	39025
2016	132501	83641	38237
2017	141532	87172	38826
2018	145124	90291	38558
2019	144883	94142	40516

Table 20: Empirical data for Output of citable scientific papers
(SCImago 2020) – created by the author

Number of Patents filed in the ICT Industry (no. per year)			
	Japan	South Korea	Taiwan
2000	20 064,2	3 322,5	1 073,2
2001	19 050,9	3 919,7	1 755,1
2002	20 288,1	5 206,2	2 546,3
2003	21 241,5	7 333,7	3 395,5
2004	25 257,3	10 131,7	3 922,9
2005	27 464,8	12 134,9	4 360,0
2006	28 153,6	11 697,4	4 726,0
2007	27 663,9	11 117,7	4 868,7
2008	26 097,1	9 982,1	5 313,8
2009	24 078,8	9 844,7	5 469,8
2010	25 221,9	10 980,9	5 542,9
2011	24 455,3	10 420,9	6 213,8
2012	23 222,3	11 722,0	6 575,4
2013	22 101,3	13 143,6	6 259,6
2014	21 554,9	13 118,6	5 497,2
2015	20 354,7	12 267,6	5 371,6
2016	21 298,7	10 665,6	4 847,6
2017	21 969,9	9 908,0	5 476,4
2018	16 132,8	9 196,4	5 935,2

Table 21: Empirical data for Patents – created by the author

Disclaimer: As mentioned in the description in the empirical section, this dataset does not include the latest values from 2019, therefore in this case the number of observations is only 19. (OECD 2021)

Gross Domestic Expenditure on R&D (GERD) at current USD (Million) per year			
	Japan	South Korea	Taiwan
2000	98 918,28	18 521,10	9 158,05
2001	103 809,22	21 278,76	9 768,58
2002	108 166,23	22 506,78	10 908,88
2003	112 412,86	24 085,84	12 200,16
2004	117 463,40	27 904,15	13 678,54
2005	128 694,56	30 618,33	15 283,97
2006	138 701,55	35 399,87	17 423,52
2007	147 484,16	40 626,29	19 436,58
2008	148 719,23	43 906,41	21 496,32
2009	137 366,21	45 817,46	22 657,59
2010	140 565,58	52 165,72	25 042,98
2011	148 389,23	58 379,65	27 414,47

2012	152 325,57	64 862,49	28 777,73
2013	164 655,76	68 234,05	30 476,88
2014	169 554,15	73 099,81	31 773,19
2015	168 514,03	76 922,04	33 058,82
2016	160 269,31	80 815,96	34 340,58
2017	166 621,73	90 289,88	36 522,67
2018	172 785,86	99 025,73	40 336,97
2019	173 267,15	102 521,44	44 014,27

Table 22: Empirical data for GERD (OECD 2021)
– created by the author

Gross domestic spending on R&D (GERD) per capita at current USD			
	Japan	South Korea	Taiwan
2000	779,92	394,00	411,10
2001	816,55	449,20	435,98
2002	849,03	472,38	484,39
2003	880,74	502,92	539,71
2004	919,59	580,33	602,87
2005	1 007,35	635,43	671,23
2006	1 084,98	730,83	761,62
2007	1 152,40	834,49	846,61
2008	1 161,46	895,04	933,12
2009	1 072,89	929,21	980,00
2010	1 097,80	1 052,70	1 081,21
2011	1 160,82	1 169,07	1 180,39
2012	1 194,22	1 292,08	1 234,25
2013	1 293,11	1 353,07	1 303,88
2014	1 332,32	1 440,48	1 355,86
2015	1 325,73	1 507,83	1 407,24
2016	1 262,63	1 577,88	1 458,82
2017	1 315,03	1 757,91	1 549,47
2018	1 366,51	1 918,84	1 709,99
2019	1 373,61	1 982,66	1 864,77

Table 23: Empirical data for GERD per capita (OECD 2021)
– created by the author

Percentage of Government Performed GERD (% per year)			
	Japan	South Korea	Taiwan
2000	9,89	13,31	23,53
2001	9,54	12,36	23,29
2002	9,54	13,41	24,82
2003	9,31	12,59	24,67
2004	9,49	12,06	23,22
2005	8,29	11,86	21,05
2006	8,28	11,56	19,86
2007	7,77	11,66	18,28
2008	8,33	12,06	16,44
2009	9,21	13,02	16,47
2010	9,02	12,67	15,73
2011	8,38	11,73	14,85
2012	8,62	11,25	13,87
2013	9,17	10,91	13,06
2014	8,33	11,21	12,30
2015	7,90	11,74	12,14
2016	7,55	11,54	12,78
2017	7,81	10,70	11,74
2018	7,75	10,07	10,67
2019	7,81	9,99	10,56

Table 24: Empirical data for Government performed GERD (OECD 2021) – created by the author

Disclaimer: According to OECD, Japan revised its measurement method three times in this period, in 2008, 2013 and 2018. For South Korea, the definition differs between the years 2000 and 2007. The same is true from Taiwan between 2000 and 2002 with another revision happening in 2003. (OECD 2021)

Percentage of Government Financed R&D (% per year)			
	Japan	South Korea	Taiwan
2000	19,58	23,94	33,39
2001	19,01	24,96	33,34
2002	18,36	25,38	35,20
2003	18,02	23,86	35,23
2004	18,07	23,14	33,62
2005	16,76	23,02	31,54
2006	16,18	23,07	31,41
2007	15,63	24,80	29,89
2008	15,62	25,41	28,04
2009	17,67	27,40	28,85

2010	17,17	26,75	27,51
2011	16,41	24,90	26,36
2012	16,84	23,85	24,72
2013	17,30	22,83	23,47
2014	16,02	22,96	21,86
2015	15,41	23,66	21,25
2016	15,02	22,68	21,36
2017	15,00	21,58	19,77
2018	14,56	20,56	18,79
2019	14,67	20,68	18,17

Table 25: Empirical data for Government financed GERD
(OECD 2021) – created by the author

Disclaimer: For these numbers, the values of Japan are all OECD estimates, while, similarly to the previous cases, the South Korean definition is different between 2000 and 2007, and Taiwan for the years between 2000 and 2003. (OECD 2021)

Business Enterprise Expenditure on R&D (BERD) at current USD (Million) per year			
	Japan	South Korea	Taiwan
2000	70 193,68	13 714,66	5 824,74
2001	76 480,35	16 210,93	6 209,59
2002	80 520,98	16 856,10	6 784,08
2003	84 283,75	18 327,30	7 664,03
2004	88 322,46	21 407,07	8 847,77
2005	98 384,00	23 531,21	10 247,50
2006	107 015,66	27 349,28	11 760,16
2007	114 876,24	30 974,42	13 444,03
2008	116 687,77	33 090,85	15 264,25
2009	104 071,53	34 024,23	15 928,31
2010	107 552,61	39 019,75	17 928,93
2011	114 204,64	44 680,47	19 898,14
2012	116 716,33	50 559,80	21 358,76
2013	125 287,46	53 573,71	23 015,94
2014	131 839,75	57 180,54	24 460,28
2015	132 268,48	59 635,46	25 663,18
2016	126 216,39	62 822,38	26 622,03
2017	131 290,66	71 695,70	28 869,44
2018	137 229,76	79 511,05	32 395,16
2019	137 148,34	82 326,86	35 608,22

Table 26: Empirical data for BERD (OECD 2021)
– created by the author

Disclaimer: For the values of BERD in this dataset, the South Korean values between 2000 and 2007 use a different definition, and it is also true for the Taiwanese case in 2000 and 2001, with revisions happening in 2002 and 2003 as well. (OECD 2021)

Higher Education Expenditure on R&D (HERD) at current USD (Million) per year			
	Japan	South Korea	Taiwan
2000	14 371,37	2 088,85	1 114,33
2001	15 015,64	2 214,69	1 216,28
2002	15 015,18	2 334,58	1 343,36
2003	15 355,63	2 441,17	1 450,82
2004	15 771,63	2 807,67	1 576,88
2005	17 250,35	3 039,96	1 745,66
2006	17 607,18	3 523,55	2 131,69
2007	18 573,56	4 327,38	2 369,04
2008	17 306,13	4 893,29	2 624,14
2009	18 421,25	5 078,73	2 913,59
2010	18 094,11	5 644,77	3 085,58
2011	19 603,49	5 890,36	3 352,27
2012	20 344,89	6 172,66	3 339,19
2013	22 172,25	6 305,88	3 383,51
2014	21 326,72	6 614,41	3 298,88
2015	20 690,25	6 995,91	3 279,99
2016	19 741,35	7 382,18	3 226,66
2017	20 015,58	7 657,96	3 277,83
2018	19 973,50	8 143,97	3 585,77
2019	20 259,13	8 487,11	3 701,95

Table 27: Empirical data for HERD (OECD 2021)
– created by the author

Disclaimer: For this data set, the South Korean definition differs from the others from 2000 to 2007, while there are three revisions of the measuring method in the Japanese case, in the years of 2008, 2013 and also 2018. (OECD 2021)

Number of R&D personnel per thousand employed			
	Japan	South Korea	Taiwan
2000	13,67	6,52	11,02
2001	13,30	7,67	11,48
2002	12,91	7,75	12,69
2003	13,30	8,38	13,33
2004	13,42	8,56	14,16
2005	13,69	9,43	15,00
2006	13,80	10,25	15,95
2007	13,71	11,43	17,11

2008	13,29	12,38	17,76
2009	13,38	13,05	19,18
2010	13,40	13,95	20,13
2011	13,29	14,73	20,72
2012	13,06	15,87	21,06
2013	13,20	15,87	21,31
2014	13,58	16,64	21,66
2015	13,21	16,89	21,91
2016	13,05	16,94	22,23
2017	13,20	17,63	22,48
2018	13,07	18,69	22,94
2019	13,04	19,38	23,62

Table 28: Empirical data for R&D personnel (OECD 2021)
– created by the author

Disclaimer: According to the description of the OECD dataset, the Japanese data works with different definitions all the way from 2000 to 2018, when it is changed, resulting in the value for 2019 being an OECD estimate. For South Korea, the same is true from 2000 to 2007, and then again for the last value from the year 2019. The Taiwanese data has a similar condition in 2000 and 2001, and was then changed in 2002 as well as 2003. (OECD 2021)

Section two: Tables for full regression output

Table 29: Complete regression output tables for Shareholder value (Japan, South Korea, Taiwan) – performed by the author

SUMMARY OUTPUT for Shareholder Value (Japan)

Regression Statistics	
Multiple R	0,884253661
R Square	0,781904537
Adjusted R Square	0,591071006
Standard Error	5,388038139
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	7	832,6421854	118,9488836	4,097312116	0,032982216
Residual	8	232,2476399	29,03095499		
Total	15	1064,889825			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-82,85626537	281,7990679	-0,294026045	0,776222245	-732,6860812	566,973551	-732,6860812	566,9735505
GERD	-0,002518811	0,014242434	-0,176852571	0,864019543	-0,035361923	0,0303243	-0,035361923	0,030324301
GERD per capita	1,701284227	0,499379958	3,406793161	0,009266946	0,549711978	2,85285648	0,549711978	2,852856476
GOV Performed GERD	-13,44744989	40,71237808	-0,330303719	0,749654298	-107,3303621	80,4354623	-107,3303621	80,43546232
GOV Financed GERD	-3,494860563	23,02789867	-0,151766369	0,8831287	-56,59729012	49,607569	-56,59729012	49,607569
BERD	-0,012134183	0,016904771	-0,717796368	0,493307745	-0,051116654	0,02684829	-0,051116654	0,026848288
HERD	-0,011465966	0,02235362	-0,512935514	0,621856363	-0,063013507	0,04008158	-0,063013507	0,040081575
RD Personnel	21,78468051	12,82514666	1,698591141	0,127825127	-7,790160736	51,3595217	-7,790160736	51,35952175

SUMMARY OUTPUT for Shareholder Value (South Korea)

Regression Statistics	
Multiple R	0,95045756
R Square	0,903369574
Adjusted R Square	0,818817951
Standard Error	4,529513514
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	7	1534,421488	219,2030698	10,68423698	0,001673732
Residual	8	164,1319414	20,51649267		
Total	15	1698,55343			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-317,94854	149,8609737	-2,121623343	0,066656555	-663,528565	27,631485	-663,528565	27,63148501
GERD	-0,044977325	0,0232304	-1,936140767	0,088874285	-0,098546724	0,00859207	-0,098546724	0,008592074
GERD per capita	2,022258805	0,860375139	2,350438447	0,046649318	0,038230177	4,00628743	0,038230177	4,006287434
GOV Performed GERD	17,95094589	18,04288286	0,99490453	0,348918954	-23,65601659	59,5579084	-23,65601659	59,55790838
GOV Financed GERD	3,270937876	5,62019638	0,581997079	0,5765976	-9,689258218	16,231134	-9,689258218	16,23113397
BERD	0,013274514	0,01196917	1,109058794	0,299628679	-0,014326443	0,04087547	-0,014326443	0,04087547
HERD	-0,012279538	0,022035241	-0,557268162	0,592589459	-0,063092896	0,03853382	-0,063092896	0,038533819
RD Personnel	-13,55071694	4,944181422	-2,740740233	0,025420128	-24,95201975	-2,1494141	-24,95201975	-2,149414137

SUMMARY OUTPUT for Shareholder Value (Taiwan)								
							Regression Statistics	
ANOVA							Multiple R	0,956511154
	df	*SS*	*MS*	*F*	*Significance F*		R Square	0,914913589
Regression	7	344,2489604	49,17842291	12,28886626	0,001031399		Adjusted R Square	0,840462979
Residual	8	32,01494547	4,001868183				Standard Error	2,000466991
Total	15	376,2639059					Observations	16

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-95,87464499	60,56246853	-1,583070296	0,152063477	-235,5319479	43,7826579	-235,5319479	43,78265787
GERD	-0,019513881	0,027779695	-0,702451219	0,502321579	-0,083573972	0,04454621	-0,083573972	0,044546211
GERD per capita	0,371722128	0,587488202	0,632731222	0,544566129	-0,983028094	1,72647235	-0,983028094	1,72647235
GOV Performed GERD	-2,552320947	2,26988136	-1,124429229	0,293434731	-7,786676751	2,68203486	-7,786676751	2,682034856
GOV Financed GERD	3,524694674	2,219475764	1,588075315	0,150931726	-1,593425616	8,64281496	-1,593425616	8,642814964
BERD	0,006071959	0,008292316	0,732239183	0,484919239	-0,013050156	0,02519407	-0,013050156	0,025194074
HERD	-0,01977637	0,011994244	-1,648821704	0,137795216	-0,047435148	0,00788241	-0,047435148	0,007882407
RD Personnel	4,419224249	3,573001102	1,236838199	0,251222197	-3,820131068	12,6585796	-3,820131068	12,65857956

Table 30: Complete regression output tables for Export market share (Japan, South Korea, Taiwan) – performed by the author

SUMMARY OUTPUT for Export Market Share of Electronics (Japan)								
							Regression Statistics	
ANOVA							Multiple R	0,98891571
	df	*SS*	*MS*	*F*	*Significance F*		R Square	0,97795429
Regression	7	131,9904367	18,85577667	76,04622168	5,45686E-09		Adjusted R Square	0,96509429
Residual	12	2,975418305	0,247951525				Standard Error	0,49794731
Total	19	134,965855					Observations	20

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	21,30274773	17,21513042	1,237443296	0,239589686	-16,20579929	58,811295	-16,20579929	58,8112947
GERD	-0,000272461	0,00048975	-0,556327214	0,588211352	-0,001339534	0,0007946	-0,001339534	0,00079461
GERD per capita	0,057395196	0,031380134	1,829029667	0,092340784	-0,010976242	0,1257666	-0,010976242	0,12576663
GOV Performed GERD	1,13876679	1,202923248	0,946666208	0,36248258	-1,482177816	3,7597114	-1,482177816	3,7597114
GOV Financed GERD	-1,635759129	1,124505912	-1,45464698	0,171420541	-4,085847036	0,8143288	-4,085847036	0,81432878
BERD	-0,000402337	0,000406466	-0,989840853	0,341791563	-0,00128795	0,0004833	-0,00128795	0,00048328
HERD	3,47828E-05	0,000500449	0,069503135	0,945733924	-0,001055602	0,0011252	-0,001055602	0,00112517
RD Personnel	1,551669386	0,730740421	2,123420767	0,055197856	-0,040477219	3,143816	-0,040477219	3,14381599

SUMMARY OUTPUT for Export Market Share of Electronics (South Korea)								
							Regression Statistics	
ANOVA							Multiple R	0,77262369
	df	*SS*	*MS*	*F*	*Significance F*		R Square	0,59694737
Regression	7	2,721351735	0,388764534	2,538969543	0,07489746		Adjusted R Square	0,36183334
Residual	12	1,837428265	0,153119022				Standard Error	0,39130426
Total	19	4,55878					Observations	20

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	0,142848608	6,414314737	0,022270284	0,982598387	-13,83274263	14,11844	-13,83274263	14,1184399
GERD	-0,001373184	0,000862362	-1,592352266	0,137290274	-0,00325211	0,0005057	-0,00325211	0,00050574
GERD per capita	0,102279029	0,040115124	2,549637643	0,025482684	0,014875683	0,1896824	0,014875683	0,18968238
GOV Performed GERD	0,378198077	0,535717679	0,705965273	0,493688162	-0,789030474	1,5454266	-0,789030474	1,54542663
GOV Financed GERD	-0,067170601	0,196697335	-0,341492178	0,738638516	-0,495737278	0,3613961	-0,495737278	0,36139608
BERD	-0,000431543	0,000563087	-0,766387421	0,458257552	-0,001658405	0,0007953	-0,001658405	0,00079532
HERD	-0,001065382	0,001254215	-0,849441565	0,412261941	-0,003798082	0,0016673	-0,003798082	0,00166732
RD Personnel	-0,73309649	0,346985513	-2,112758205	0,056255028	-1,489112977	0,02292	-1,489112977	0,02292

SUMMARY OUTPUT for Export Market Share of Electronics (Taiwan)								
							Regression Statistics	
ANOVA							Multiple R	0,741343055
	df	*SS*	*MS*	*F*	*Significance F*		R Square	0,549589526
Regression	7	1,22924216	0,175606023	2,091766346	0,124864711		Adjusted R Square	0,286850082
Residual	12	1,00741284	0,08395107				Standard Error	0,28974311
Total	19	2,236655					Observations	20

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	12,60191271	6,017813186	2,094101682	0,058150607	-0,509775862	25,713601	-0,509775862	25,71360129
GERD	0,001840712	0,003436726	0,535600585	0,602020358	-0,00564727	0,0093287	-0,00564727	0,009328694
GERD per capita	-0,012793524	0,065769799	-0,194519728	0,849023225	-0,156093606	0,1305066	-0,156093606	0,130506559
GOV Performed GERD	0,269772072	0,320645477	0,841340645	0,416608327	-0,428854407	0,9683986	-0,428854407	0,968398551
GOV Financed GERD	-0,344050005	0,308410218	-1,115559682	0,286452501	-1,016018145	0,3279181	-1,016018145	0,327918135
BERD	-0,001365625	0,001098313	-1,243384371	0,237470294	-0,003758642	0,0010274	-0,003758642	0,001027393
HERD	0,00061094	0,001032847	0,591510668	0,565155225	-0,00163944	0,0028613	-0,00163944	0,00286132
RD Personnel	-0,592346418	0,410357647	-1,44348819	0,174477692	-1,486438925	0,3017461	-1,486438925	0,301746089

Table 31: Complete regression output tables for Total exports (Japan, South Korea, Taiwan) – performed by the author

SUMMARY OUTPUT for Total Exports of Electronics (Japan)

ANOVA

	df	SS	MS	F	Significance F
Regression	7	4551105898	650157985,4	6,413574026	0,002670996
Residual	12	1216466169	101372180,7		
Total	19	5767572067			

Regression Statistics	
Multiple R	0,888304691
R Square	0,789085224
Adjusted R Square	0,666051605
Standard Error	10068,37528
Observations	20

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	520381,5793	348085,8102	1,494980732	0,160745503	-238032,2498	1278795,41	-238032,2498	1278795,408
GERD	16,25425117	9,902623818	1,641408527	0,126641911	-5,321712651	37,830215	-5,321712651	37,83021499
GERD per capita	-485,0882939	634,4987849	-0,764522022	0,459326853	-1867,542387	897,365799	-1867,542387	897,3657991
GOV Performed GERD	34616,99595	24322,81971	1,423231203	0,180144777	-18377,87569	87611,8676	-18377,87569	87611,86758
GOV Financed GERD	-55354,69943	22737,23997	-2,434539087	0,031470407	-104894,8896	-5814,5093	-104894,8896	-5814,509282
BERD	-17,12449638	8,218643334	-2,083615955	0,059242092	-35,03138192	0,78238916	-35,03138192	0,782389158
HERD	-0,420698765	10,11895603	-0,041575313	0,967520999	-22,46800999	21,6266125	-22,46800999	21,62661246
RD Personnel	24748,84046	14775,39615	1,675003514	0,11977428	-7443,982224	56941,6631	-7443,982224	56941,66315

SUMMARY OUTPUT for Total Exports of Electronics (South Korea)

ANOVA

	df	SS	MS	F	Significance F
Regression	7	26982323510	3854617644	40,4652611	2,05644E-07
Residual	12	1143089417	95257451,45		
Total	19	28125412927			

Regression Statistics	
Multiple R	0,979467926
R Square	0,959357417
Adjusted R Square	0,935649244
Standard Error	9759,99239
Observations	20

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-70946,13101	159987,1757	-0,443448862	0,665330608	-419528,242	277635,98	-419528,242	277635,9799
GERD	-52,07922604	21,50921334	-2,421252011	0,032243647	-98,94377602	-5,2146761	-98,94377602	-5,214676066
GERD per capita	3259,297241	1000,559778	3,257473779	0,006860696	1079,26476	5439,32972	1079,26476	5439,329723
GOV Performed GERD	8099,468223	13361,98205	0,606157694	0,555703153	-21013,78969	37212,7261	-21013,78969	37212,72614
GOV Financed GERD	-3014,563648	4906,065937	-0,614456407	0,550386687	-13703,96305	7674,83576	-13703,96305	7674,835758
BERD	-5,312773951	14,04463951	-0,378277702	0,711831232	-35,9134147	25,2878668	-35,9134147	25,28786679
HERD	-11,54620336	31,2828951	-0,369089988	0,718490848	-79,70577655	56,6133698	-79,70577655	56,61336983
RD Personnel	-19127,88457	8654,585019	-2,210144627	0,047268143	-37984,60545	-271,1637	-37984,60545	-271,1636997

SUMMARY OUTPUT for Total Exports of Electronics (Taiwan)

ANOVA

	df	SS	MS	F	Significance F
Regression	7	22496687837	3213812548	55,17404841	3,49674E-08
Residual	12	698983520,1	58248626,67		
Total	19	23195671357			

Regression Statistics	
Multiple R	0,984817637
R Square	0,969865778
Adjusted R Square	0,952287481
Standard Error	7632,078791
Observations	20

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	265883,6252	158514,2933	1,677347951	0,119307519	-79489,35082	611256,601	-79489,35082	611256,6012
GERD	-87,56069167	90,52626386	-0,967240754	0,352514037	-284,8004768	109,679093	-284,8004768	109,6790934
GERD per capita	2884,660597	1732,43219	1,665092933	0,121765269	-889,9848863	6659,30608	-889,9848863	6659,30608
GOV Performed GERD	11661,04077	8446,073284	1,380646412	0,192561748	-6741,372058	30063,4536	-6741,372058	30063,45361
GOV Financed GERD	-16596,89846	8123,786215	-2,043000397	0,063653108	-34297,10809	1103,31117	-34297,10809	1103,311169
BERD	-33,82147805	28,93048424	-1,169060212	0,265078142	-96,85558829	29,2126322	-96,85558829	29,21263219
HERD	3,949060813	27,20606497	0,145153693	0,886999086	-55,32786258	63,2259842	-55,32786258	63,22598421
RD Personnel	-10621,93852	10809,1678	-0,982678659	0,345163874	-34173,092	12929,215	-34173,092	12929,21496

Table 32: Complete regression output tables for Output of citable scientific papers (Japan, South Korea, Taiwan) – performed by the author

SUMMARY OUTPUT for Number of Citable Documents (Japan)

ANOVA

	df	SS	MS	F	Significance F
Regression	7	2688787812	384112544,6	18,09151823	1,72927E-05
Residual	12	254779641,9	21231636,82		
Total	19	2943567454			

Regression Statistics	
Multiple R	0,955743315
R Square	0,913445285
Adjusted R Square	0,862955035
Standard Error	4607,780032
Observations	20

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	253663,1409	159301,0591	1,592350624	0,137290643	-93424,05052	600750,332	-93424,051	600750,3323
GERD	-2,895387243	4,531924072	-0,638886971	0,534901169	-12,76960155	6,97882707	-12,769602	6,978827068
GERD per capita	445,2680165	290,3776181	1,533410252	0,151106776	-187,4104632	1077,9465	-187,41046	1077,946496
GOV Performed GERD	28543,48377	11131,30966	2,564252065	0,024806648	4290,443478	52796,5241	4290,44348	52796,52406
GOV Financed GERD	-29631,76896	10405,67096	-2,84765577	0,01468654	-52303,77836	-6959,7596	-52303,778	-6959,759564
BERD	-2,243117653	3,761252396	-0,596375201	0,562006363	-10,43818263	5,95194732	-10,438183	5,951947324
HERD	10,08383602	4,630928254	2,177497787	0,050117862	-0,00608987	20,1737619	-0,0060899	20,17376192
RD Personnel	7326,571942	6761,942562	1,083501061	0,299876591	-7406,435264	22059,5791	-7406,4353	22059,57915

SUMMARY OUTPUT for Number of Citable Documents (South Korea)

ANOVA

	df	SS	MS	F	Significance F
Regression	7	10217688378	1459669768	977,5704932	1,79151E-14
Residual	11	16424766,87	1493160,625		
Total	18	10234113145			

Regression Statistics	
Multiple R	0,999197226
R Square	0,998395096
Adjusted R Square	0,997373794
Standard Error	1221,949518
Observations	19

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	57220,38704	15587,07082	3,671016043	0,003683092	22913,47548	91527,2986	22913,47548	91527,2986
GERD	5,110249882	2,218834634	2,303123362	0,041801578	0,22662778	9,99387198	0,22662778	9,993871984
GERD per capita	0,031372797	16,26647442	0,001928678	0,998495671	-35,77089601	35,8336416	-35,77089601	35,8336416
GOV Performed GERD	-1945,526288	1928,451331	-1,008854233	0,334721479	-6190,019048	2298,96647	-6190,019048	2298,966473
GOV Financed GERD	-2073,353485	763,0952266	-2,717031129	0,0200375	-3752,914754	-393,79222	-3752,914754	-393,7922153
BERD	-6,052406809	2,159127991	-2,803171852	0,017177037	-10,80461548	-1,3001981	-10,80461548	-1,300198142
HERD	-1,536671329	4,332606602	-0,354675942	0,729538584	-11,07267416	7,99933151	-11,07267416	7,999331506
RD Personnel	4466,77772	976,1469921	4,575927351	0,000795623	2318,292676	6615,26276	2318,292676	6615,262764

SUMMARY OUTPUT for Number of Citable Documents (Taiwan)

ANOVA

	df	SS	MS	F	Significance F
Regression	7	2052661366	293237338,1	353,8904709	6,19302E-13
Residual	12	9943325,256	828610,438		
Total	19	2062604692			

Regression Statistics	
Multiple R	0,997586707
R Square	0,995179239
Adjusted R Square	0,992367128
Standard Error	910,2804172
Observations	20

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	14803,18177	18906,04919	0,782986526	0,448812072	-26389,56077	55995,9243	-26389,56077	55995,92432
GERD	-20,2579403	10,79709572	-1,876239762	0,085147887	-43,78279097	3,26691038	-43,78279097	3,266910376
GERD per capita	528,2022242	206,6277276	2,556298859	0,025172351	77,99908042	978,405368	77,99908042	978,4053679
GOV Performed GERD	1272,447518	1007,365794	1,263143463	0,230528939	-922,4139984	3467,30903	-922,4139984	3467,309035
GOV Financed GERD	-2040,51114	968,926515	-2,105950357	0,056939919	-4151,620662	70,5983818	-4151,620662	70,59838181
BERD	-3,031415646	3,450547877	-0,878531686	0,396905549	-10,54951363	4,48668234	-10,54951363	4,486682338
HERD	9,79714765	3,244875852	3,01926733	0,010677447	2,727170513	16,8671248	2,727170513	16,86712479
RD Personnel	1149,835528	1289,212814	0,891889621	0,38998605	-1659,117892	3958,78895	-1659,117892	3958,788947

Table 33: Complete regression output tables for Patents (Japan, South Korea, Taiwan) – performed by the author

SUMMARY OUTPUT for Patents (Japan)

ANOVA

	df	SS	MS	F	Significance F
Regression	7	168231326	24033046,57	14,25354293	0,000103
Residual	11	18547214,09	1686110,372		
Total	18	186778540			

Regression Statistics	
Multiple R	0,949051862
R Square	0,900699437
Adjusted R Square	0,83750817
Standard Error	1298,503127
Observations	19

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	56699,05625	45189,02834	1,254708462	0,235588604	-42761,32452	156159,437	-42761,32452	156159,437
GERD	4,166417444	1,319452849	3,157685738	0,009116455	1,262321304	7,07051358	1,262321304	7,070513584
GERD per capita	-459,8174873	94,39994382	-4,870950858	0,000493959	-667,5903628	-252,04461	-667,5903628	-252,0446119
GOV Performed GERD	4043,146593	3290,794528	1,228623227	0,244850439	-3199,843329	11286,1365	-3199,843329	11286,13652
GOV Financed GERD	-6816,104274	3074,07607	-2,217285493	0,048595573	-13582,10009	-50,108462	-13582,10009	-50,1084621
BERD	-1,085614525	1,061879232	-1,022352158	0,328572554	-3,422794956	1,25156591	-3,422794956	1,251565907
HERD	1,627464211	1,31181785	1,240617522	0,240556087	-1,25982741	4,51475583	-1,25982741	4,514755832
RD Personnel	4116,068241	1917,942129	2,146085734	0,055020187	-105,293923	8337,4304	-105,293923	8337,430404

SUMMARY OUTPUT for Patents (South Korea)

ANOVA

	df	SS	MS	F	Significance F
Regression	7	138551152,6	19793021,81	19,82015678	2,08171E-05
Residual	11	10984940,34	998630,9403		
Total	18	149536093			

Regression Statistics	
Multiple R	0,962569412
R Square	0,926539873
Adjusted R Square	0,87979252
Standard Error	999,3152357
Observations	19

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	22650,9895	16426,23447	1,378952036	0,195302631	-13502,90884	58804,8878	-13502,90884	58804,88779
GERD	-2,0702198	2,206112181	-0,938401874	0,36818596	-6,925839977	2,78540037	-6,925839977	2,785400368
GERD per capita	359,858471	111,037798	3,240864623	0,007861867	115,4659257	604,251017	115,4659257	604,2510169
GOV Performed GERD	-490,68034	1369,768858	-0,358221273	0,726957428	-3505,521272	2524,16059	-3505,521272	2524,160585
GOV Financed GERD	-1254,4376	503,4240493	-2,491811073	0,029938915	-2362,466483	-146,40876	-2362,466483	-146,4087589
BERD	-5,0588213	1,58748851	-3,186682174	0,008657529	-8,552859989	-1,5647827	-8,552859989	-1,564782683
HERD	-9,9981974	3,530549501	-2,831909715	0,016316317	-17,76888449	-2,2275104	-17,76888449	-2,227510371
RD Personnel	782,823287	901,4164032	0,868436923	0,403704674	-1201,180839	2766,82741	-1201,180839	2766,827413

SUMMARY OUTPUT for Patents (Taiwan)

Regression Statistics	
Multiple R	0,978151612
R Square	0,956780577
Adjusted R Square	0,929277308
Standard Error	406,5705038
Observations	19

ANOVA

	df	SS	MS	F	Significance F
Regression	7	40252958,61	5750422,659	34,78788541	1,20375E-06
Residual	11	1818295,32	165299,5746		
Total	18	42071253,93			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-12629,13	8733,704247	-1,446022205	0,176055174	-31851,88371	6593,62317	-31851,88371	6593,623166
GERD	-8,9660683	5,044744061	-1,777308866	0,103141618	-20,06947516	2,13733847	-20,06947516	2,13733847
GERD per capita	223,98187	98,38929641	2,276486143	0,043805732	7,428488631	440,535251	7,428488631	440,5352512
GOV Performed GERD	256,631669	450,2040211	0,570034155	0,580110479	-734,260701	1247,52404	-734,260701	1247,524038
GOV Financed GERD	-86,979079	434,8144306	-0,20003724	0,845101588	-1043,999188	870,041031	-1043,999188	870,0410305
BERD	-0,2801135	1,548641986	-0,180876879	0,859753736	-3,688651558	3,1284245	-3,688651558	3,128424501
HERD	-0,3751488	1,449776062	-0,258763286	0,800596021	-3,566084416	2,81578678	-3,566084416	2,81578678
RD Personnel	285,754957	581,1383201	0,491715908	0,632585012	-993,3218618	1564,83178	-993,3218618	1564,831775

Section three: Tables for full correlation output

Table 34: Complete correlation output tables for Shareholder value (Japan, South Korea, Taiwan) – performed by the author

CORRELATION OUTPUT for Shareholder Value (Japan)

	Share Price Average	GERD	GERD per capita	GOV Performed GERD	GOV Financed GERD	BERD	HERD	RD Personnel
Share Price Average	1							
GERD	0,166194503	1						
GERD per capita	0,181050347	0,999605868	1					
GOV Performed GERD	-0,403730782	-0,670426367	-0,673503014	1				
GOV Financed GERD	-0,39623421	-0,786730465	-0,791482969	0,95177952	1			
BERD	0,196938224	0,996781623	0,997246852	-0,716920138	-0,831797892	1		
HERD	-0,000716331	0,900308808	0,895656133	-0,423523532	-0,488718115	0,86523932	1	
RD Personnel	0,233571345	-0,474112114	-0,485027511	0,149173109	0,301535736	-0,4726496	-0,414593186	1

CORRELATION OUTPUT for Shareholder Value (Soth Korea)

	Share Price Average	GERD	GERD per capita	GOV Performed GERD	GOV Financed GERD	BERD	HERD	RD Personnel
Share Price Average	1							
GERD	0,821724741	1						
GERD per capita	0,822283735	0,999889203	1					
GOV Performed GERD	-0,713643333	-0,784955954	-0,783032072	1				
GOV Financed GERD	-0,48382414	-0,584274777	-0,57615651	0,871688309	1			
BERD	0,826744587	0,999250282	0,998779335	-0,804805646	-0,612464763	1		
HERD	0,792612119	0,981731405	0,983887821	-0,689930546	-0,429060783	0,97414612	1	
RD Personnel	0,776853842	0,978099784	0,980616152	-0,697196989	-0,431757534	0,9707791	0,9950646	1

CORRELATION OUTPUT for Shareholder Value (Taiwan)

	Share Price Average	GERD	GERD per capita	GOV Performed GERD	GOV Financed GERD	BERD	HERD	RD Personnel
Share Price Average	1							
GERD	0,909058453	1						
GERD per capita	0,908055054	0,999972328	1					
GOV Performed GERD	-0,805402933	-0,956487552	-0,957745948	1				
GOV Financed GERD	-0,875565761	-0,986956842	-0,986734528	0,973191236	1			
BERD	0,917298405	0,999010377	0,998724343	-0,946038113	-0,985862654	1		
HERD	0,744179668	0,918645518	0,920986536	-0,973026701	-0,913953983	0,90089845	1	
RD Personnel	0,81684856	0,963550522	0,964690813	-0,988238276	-0,965250076	0,95164257	0,982527991	1

Table 35: Complete correlation output tables for Export market share (Japan, South Korea, Taiwan) – performed by the author

CORRELATION OUTPUT for Export Market Share (Japan)								
	Export Market Share	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Export Market Share	1							
GERD	-0,974628914	1						
GERD per capita	-0,973294779	0,999669298	1					
GOV Performed GERD	0,747675143	-0,810276	-0,810607826	1				
GOV Financed GERD	0,830540435	-0,88784102	-0,888470197	0,966196822	1			
BERD	-0,97003763	0,998160448	0,998073342	-0,83714749	-0,912587147	1		
HERD	-0,945099158	0,944753571	0,942172344	-0,660725111	-0,7190631	0,9258709	1	
RD Personnel	0,380515287	-0,2832131	-0,293506754	0,101938049	0,213781367	-0,2882219	-0,253516973	1

CORRELATION OUTPUT for Export Market Share of Electronics (South Korea)								
	Export Market Share	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Export Market Share	1							
GERD	0,510143281	1						
GERD per capita	0,515089628	0,999868023	1					
GOV Performed GERD	-0,425156439	-0,832810889	-0,832995249	1				
GOV Financed GERD	-0,246244916	-0,599969331	-0,592239236	0,803860803	1			
BERD	0,503153205	0,999380713	0,99887044	-0,845190329	-0,62420486	1		
HERD	0,537394235	0,985286656	0,987444951	-0,777488004	-0,472368427	0,979064	1	
RD Personnel	0,524139434	0,980236867	0,982968491	-0,789079923	-0,467485354	0,9739825	0,995614433	1

CORRELATION OUTPUT for Export Market Share of Electronics (Taiwan)								
	Export Market Share	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Export Market Share	1							
GERD	0,581650925	1						
GERD per capita	0,579774778	0,99996982	1					
GOV Performed GERD	-0,49418662	-0,968247837	-0,969247791	1				
GOV Financed GERD	-0,574489671	-0,984137374	-0,983600199	0,976341122	1			
BERD	0,596576235	0,998587755	0,998201592	-0,959656949	-0,986130958	1		
HERD	0,44604308	0,94430523	0,946421474	-0,976048289	-0,922363049	0,9269916	1	
RD Personnel	0,474153646	0,968153477	0,969564428	-0,979747687	-0,947264244	0,9541453	0,989784311	1

Table 36: Complete correlation output tables for Total exports (Japan, South Korea, Taiwan) – performed by the author

CORRELATION OUTPUT for Total Exports of Electronics (Japan)								
	Total Exports Electronics	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Total Exports Electronics	1							
GERD	-0,586392719	1						
GERD per capita	-0,594972573	0,999669298	1					
GOV Performed GERD	0,366428787	-0,810276001	-0,810607826	1				
GOV Financed GERD	0,426280807	-0,887841021	-0,888470197	0,966196822	1			
BERD	-0,582381534	0,998160448	0,998073342	-0,83714749	-0,912587147	1		
HERD	-0,592042702	0,944753571	0,942172344	-0,660725111	-0,7190631	0,92587086	1	
RD Personnel	0,655914501	-0,283213097	-0,293506754	0,101938049	0,213781367	-0,2882219	-0,253516973	1

CORRELATION OUTPUT for Total Exports of Electronics (South Korea)								
	Total Exports Electronics	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Total Exports Electronics	1							
GERD	0,930207628	1						
GERD per capita	0,93417003	0,999868023	1					
GOV Performed GERD	-0,812799738	-0,832810889	-0,832995249	1				
GOV Financed GERD	-0,504767681	-0,599969331	-0,592239236	0,803860803	1			
BERD	0,925562678	0,999380713	0,99887044	-0,845190329	-0,62420486	1		
HERD	0,944592972	0,985286656	0,987444951	-0,777488004	-0,472368427	0,97906404	1	
RD Personnel	0,941821751	0,980236867	0,982968491	-0,789079923	-0,467485354	0,97398247	0,995614433	1

CORRELATION OUTPUT for Total Exports of Electronics (Taiwan)								
	Total Eports Electronics	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Total Eports Electronics	1							
GERD	0,971620714	1						
GERD per capita	0,972258174	0,99996982	1					
GOV Performed GERD	-0,954844777	-0,968247837	-0,969247791	1				
GOV Financed GERD	-0,960396647	-0,984137374	-0,983600199	0,976341122	1			
BERD	0,967777472	0,998587755	0,998201592	-0,959656949	-0,986130958	1		
HERD	0,931417483	0,94430523	0,946421474	-0,976048289	-0,922363049	0,92699158	1	
RD Personnel	0,948388215	0,968153477	0,969564428	-0,979747687	-0,947264244	0,95414531	0,989784311	1

Table 37: Complete correlation output tables for Output of citable scientific papers (Japan, South Korea, Taiwan) – performed by the author

CORRELATION OUTPUT for Number of Citable Documents (Japan)

	Citable Documents	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Citable Documents	1							
GERD	0,921606193	1						
GERD per capita	0,921334175	0,999669298	1					
GOV Performed GERD	-0,747590591	-0,810276001	-0,810607826	1				
GOV Financed GERD	-0,827825582	-0,887841021	-0,888470197	0,966196822	1			
BERD	0,918814571	0,998160448	0,998073342	-0,83714749	-0,912587147	1		
HERD	0,883081764	0,944753571	0,942172344	-0,660725111	-0,7190631	0,92587086	1	
RD Personnel	-0,231399748	-0,283213097	-0,293506754	0,101938049	0,213781367	-0,2882219	-0,253516973	1

CORRELATION OUTPUT for Number of Citable Documents (South Korea)

	Citable Documents	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Citable Documents	1							
GERD	0,870228716	1						
GERD per capita	0,968506579	0,780830681	1					
GOV Performed GERD	-0,746687402	-0,905840878	-0,65754603	1				
GOV Financed GERD	-0,513734404	-0,798963231	-0,439094209	0,895199545	1			
BERD	0,867904374	0,999708922	0,781846157	-0,911923163	-0,809204938	1		
HERD	0,763514735	0,973757267	0,630438033	-0,883351794	-0,798327328	0,97100868	1	
RD Personnel	0,940873807	0,664508977	0,971306049	-0,526558835	-0,244141001	0,66223235	0,511369341	1

CORRELATION OUTPUT for Number of Citable Documents (Taiwan)

	Citable Documents	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
Citable Documents	1							
GERD	0,845752424	1						
GERD per capita	0,849286487	0,99996982	1					
GOV Performed GERD	-0,920413584	-0,968247837	-0,969247791	1				
GOV Financed GERD	-0,824540746	-0,984137374	-0,983600199	0,976341122	1			
BERD	0,81809549	0,998587755	0,998201592	-0,959656949	-0,986130958	1		
HERD	0,969076283	0,94430523	0,946421474	-0,976048289	-0,922363049	0,92699158	1	
RD Personnel	0,944669601	0,968153477	0,969564428	-0,979747687	-0,947264244	0,95414531	0,989784311	1

Table 38: Complete correlation output tables for Patents (Japan, South Korea, Taiwan) – performed by the author

CORRELATION OUTPUT for Patents (Japan)

	ICT Patents	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
ICT Patents	1							
GERD	-0,04339268	1						
GERD per capita	-0,06274392	0,999734057	1					
GOV Performed GERD	-0,13070154	-0,796120859	-0,796339675	1				
GOV Financed GERD	-0,08595825	-0,876535837	-0,876400026	0,966177075	1			
BERD	-0,03773878	0,998028775	0,997884254	-0,825155431	-0,903346375	1		
HERD	-0,03774336	0,946731458	0,945305285	-0,644434858	-0,706852458	0,92745596	1	
RD Personnel	0,602840978	-0,221997558	-0,230444491	0,036557239	0,140125373	-0,2254899	-0,21318265	1

CORRELATION OUTPUT for Patents (South Korea)

	ICT Patents	*GERD*	*GERD per capita*	*GOV Performed GERD*	*GOV Financed GERD*	*BERD*	*HERD*	*RD Personnel*
ICT Patents	1							
GERD	0,54709598	1						
GERD per capita	0,5574793	0,999858147	1					
GOV Performed GERD	-0,596794	-0,794175557	-0,795090674	1				
GOV Financed GERD	-0,2100078	-0,515689817	-0,507509787	0,761005873	1			
BERD	0,53649271	0,999354795	0,998843633	-0,807956712	-0,542449229	1		
HERD	0,60079291	0,984406319	0,986652802	-0,736005229	-0,37754736	0,97789318	1	
RD Personnel	0,64137057	0,97960546	0,982434767	-0,752797089	-0,376116562	0,97329374	0,99505342	1

CORRELATION OUTPUT for Patents (Taiwan)

	ICT Patents	GERD	GERD per capita	GOV Performed GERD	GOV Financed GERD	BERD	HERD	RD Personnel
ICT Patents	1							
GERD	0,79994573	1						
GERD per capita	0,80459539	0,999962778	1					
GOV Performed GERD	-0,8305619	-0,975648173	-0,976728146	1				
GOV Financed GERD	-0,7276535	-0,984297538	-0,983608666	0,976299968	1			
BERD	0,76876057	0,998451732	0,997982054	-0,96874285	-0,988460983	1		
HERD	0,90979692	0,950175985	0,952549099	-0,9738262	-0,916777133	0,93308889	1	
RD Personnel	0,89057115	0,975368339	0,976929506	-0,977697726	-0,943340199	0,96204696	0,988898709	1

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