An Evaluation of Innovation Policies in the Netherlands

An Empirical study on innovation and its drivers

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ABSTRACT

This is an empirical study on innovation. A lot of research has been trying to find out what the drivers of innovation really are, though there has not formed one consensus. The special focus on the Netherlands grounds from it being an interesting case: government expenditures on innovation have tremendously increased over the past years, though statistics show innovation in the Netherlands hasn't improved. In order to be able to pass judgement on the Dutch innovation policy, this paper constructs its own model of innovation. After testing this model, one variable sticks out on having a powerful positive effect on innovation: R&D Expenditure. To give the final evaluation, the governmental budget on innovation has been analysed in order to see if enough is done to augment innovation. It is concluded that the current innovation policy has the right allocation of funds over different policy instruments. Yet the answer to the question what does make innovation decline in the Netherlands remains unclear.

Preface and Acknowledgements

Before you lays the paper that completes the master study International Economics for Martijn van de Sande. It is the final piece of his student career at the Erasmus University in Rotterdam. The topic of this paper is innovation. Its drivers are empirically determined and the policy regarding it is evaluated.

The writing of the thesis went fluently and without major problems. This is mainly because of the good assistance I received from the university and from the Dutch Court of Audit in the process. I am thankful to Peter Kemkes of the Dutch Court of Audit for making time and shedding a different light on the topic. Also, I would like to thank Martin Bøg as my university supervisor for being a methodological and statistical help during my research. Finally I would like to thank my girlfriend Tina and my parents for their mental support and their occasional nudge when I started losing focus.

Table of Contents

1. Introduction

Innovation is a hot topic. Since WWII growth in most wealthy countries has been high for a long time. There have been some fluctuations in the end of the 1970s but if you look at this total period from the end of the 1960s to the year 2010, the average annual (per capita) growth rate for the OECD countries is 2,3%[1]. However, the amount of growth is decreasing. The period from 1961 to 1985 shows an average annual growth of 3,0%, where the period from 1986 to 2010 shows an average annual growth of 1,6%. The foresight of no more growth in the future is unwanted. Mankind wants to move forward and improve its wealth. Improving wealth is achieved by economic growth. This economic growth in turn, is determined by technological change (or innovation). At least, this is what the economic theorists and politicians have come to believe. With these linkages in mind the Dutch government has been focussing on improving innovation in the Netherlands. In the year 2003 the innovation policies were overhauled to face a more modern policy framework. However the increase in effort to enhance innovation hasn't been fruitful yet. The Netherlands has not or has very little improved according to different rankings that are made. For example, the European Innovation Scoreboard showed that for the period 2004-2009 the Netherlands was ranked 11th (of all EU countries) where the Dutch government aims to reach the top 5. In some way, Holland can't manage to get to be an innovation leader instead of a follower. Is the Dutch government doing to right thing in trying to improve this? Is the best allocation of funds made? This is the central problem of this thesis.

This paper approaches the problem the Netherlands is facing by generalizing it into making an estimation of the contributing factors to innovation. In doing this, the National Innovative Capacity (NIC) framework is used as it has been described and tested in a previous study by Furman, Porter and Stern (2001). This framework looks at innovation from three perspectives and takes these three into consideration in identifying the determinants of innovation. In order to specify the framework for this study, an empirical evaluation over 29 years and 34 countries the framework is tested and completed. With the framework in place, one can determine what factors are key drivers of innovation and which do not have an effect as was anticipated. This model shows that R&D Expenditures is the most influential variable. For every 1% increase in R&D Expenditures, around a 1,2% increase in innovation is the effect. The next step of the research is to look at the Dutch policy on innovation. The governmental budget on innovation shows that most of the funds are allocated to either directly to R&D or to making

[1] Source: World Development Indicators and Global Development Finance, indicator: GDP per capita growth (annual %)

firms invest in R&D. So the largest share of funds paid by the government goes in the right way: enhancing firms to invest in R&D. The main recommendation for the Dutch government is to focus on making firms invest in R&D and they are on the right track in doing this.

The rest of this chapter focuses on the background information and tries to set a framework on which is built in this paper. First, a brief history of innovation in an economic sense is given. This is followed by an elaboration on previous studies which have the same subject, but are not quite the same.

1.1 History

In history technological advance has always gone hand in hand with economic prosperity. Look, for example, at the first agricultural revolution, which caused a great increase in the production of food or at the ancient Roman Empire which had a flourishing economy due to Greek advances in technology. Another example is England during the Industrial Revolution; the invention of the steam-engine led to great productivity gains and boosted the economy. The opposite is also true, when there is no technological development there will be no economic growth. In this context, one can look at the middle ages in which little economic advancement was made and economic growth rates were low.

Inventing has not been interpreted as something governments should focus on. Although Adam Smith knew knowledge creation had some effect on the economy, he could not think of the fact that a few centuries later governments actively tried to enhance innovation environment. The first approach in the direction of the National Innovation System framework was made by Friedrich List.

Friedrich List made the first mention of a national system in 'The National System of Political Economy' (1841). His main concern was for Germany to be able to take over England in being a more developed country. He devised several policies which should boost the German economy. These policy recommendations focussed on technological education and also on the protection of infant industries. According to some (Prais, 1981) the higher productivity of Germany nowadays is caused by the foundations laid out by List's National System of Productivity.

1.1.1 Innovation theory

While not being credited for his contributions in his time, Schumpeter has launched the debate on innovation being a driver of economic growth. With the theory of creative destruction (that has previously been described by Marx), he argued that through radical inventions, temporary monopolies will come into existence which offers great profits. This should give firms the incentive to conduct decent research. With these radical innovations, other previous inventions become less useful and commercially attractive. So the new invention basically destroys the profits that the previous invention has to earn.

Another thing that became clear in the 1950s and 1960s is that innovation did depend on more than just being the first to invent something, diffusion of technology also became an important factor. The 1970s and 1980s proved to be the time in which the linkages were found as drivers of innovation. Interaction between firms but also with universities and other formal institution were found as influential systemic aspects of innovation. Japan and the USSR were compared by Freeman (1995) and what has been found proves this case. Both governments try to achieve to be innovative and spend a lot of money on it, though in the USSR it had almost no effect on growth and in Japan it did. Main cause for this was that USSR had a battle with the USA on the military and space subjects of innovation. There was not a lot of money to be made from these technologies. It is also argued that Japan got this good score as innovative country because Japan was excellent at making copies of American and European products. However, over time, the Japanese products increased in quality and got better than the American and European products. Another case of opposing economies where innovation played a decisive role, is that of Latin America and the 4 Asian tigers in the 1980s. Initially the Asian tigers were behind in matters of industrialisation, but due to strong social changes, they caught up and passed Latin American countries in level of innovativeness and GDP.

In the middle of the 1980s, researchers mentioned 'the innovative capability of the national system of production' several times. Finally Lundvall (1992) along with other writers, wrote a book on technological change related to the economy and introduced the term National Innovation Systems. Since then the term National Innovation System has regularly appeared in discussion over enhancing factors of innovation.

1.2 Previous research on this topic

Some previous studies have tried to roughly do the same thing as what is done in this paper. For instance Nelson (National Innovation Systems: a comparative analysis, 1993) gives a comparison of the systems of innovation of a number of countries. And gives a sort of case study for every country he describes. This analysis however does not contain a quantitative analysis, but only a qualitative one, in the sense that the case studies for different countries are compared. He tries to do the same as what this paper does, he wants to find out what the drivers of innovation are. Yet, he does it in a totally different way. So compared to Nelson, this paper is unique in a way that most of the research is conducted with statistics over a great set of countries and years. An advantage of the statistical way of the interpretation of this problem is that you will get numbers as a result and numbers are useful for comparison. For instance when comparing drivers of innovation, policy instruments or country performance you need numbers. One of the main findings of Nelson's book is that countries differ very much in their system of innovation. A regularity he finds however are that linkages are very important for the functioning of innovation. This finding could not be statistically proved by this paper. The numbers that are used for linkages in this paper don't prove the relevance of this factor. In the regression is a small positive coefficient with a very low significance.

Another paper that may look very similar to this one is the Furman, Porter and Stern (2001) paper. This paper has been used as a guide for this paper and may look very much alike. However, it differs in a sense that different data has been used. This different data requested some additional modelling and delivered a slimmer model. The essentials are the same, but the presentation differs. Another addition this paper has and the Furman, Porter and Stern paper has not, is the addition of a qualitative analysis of the Dutch government. This paper examines the Dutch innovation policy and tries to pass judgement on it. Therefore, this paper also emphasizes the evaluation of government policy instead of the sole search for drivers of innovation. Further elaboration on the difference in results of this paper compared to the Furman, Porter and Stern paper is given in section 4.3.

1.3 Composition of this paper

This paper is build up as follows. First the theoretical background for this research is given. This is formed out of three perspectives, which separately will be discussed in Chapter 2. Chapter 3 describes the variables that are used in this thesis. Next to that it describes the regression model as it is used in this paper. In Chapter 4, a first glance at the data is given. After this, the regression results are presented. Another regression on ranks is also described and a first set of policy implications is given. Chapter 5 focusses on innovation policy and zoomes in on the Dutch innovation policy in particular. In this chapter the Dutch policy instruments are tied to the variables of the regression and are evaluated based on the amount of funding each policy instrument gets. Chapter 6 concludes the paper with a summary of the findings and gives recomendations for further research.

2. Theoretical Framework

Innovation cannot be regarded out of the system that surrounds it. In its own, you cannot get to know how innovation works. Innovations must be seen in its environment, where it has a set of complex relations which aren't mapped and differ for every country. This environment with innovation at its centre will be further decomposed and analysed in this chapter.

The specification of the NIS as it has been introduced by Furman, Porter and Stern (2001) forms the framework for this paper, it is called the National Innovative Capacity. These researchers tried to explain the differences in innovation intensity across countries and over a set of years. They took the amount of patents as a variable to be explained by certain independent variables. They went on a search for possible explanatory variables. They found theories linking to the innovation subject from three distinct researchers in three distinct fields. First, they viewed the problem from a macroeconomic perspective and used Romer's endogenous growth theory on economic growth. Next, a more micro-based stance was taken and they used Porters model for the understanding of the cluster specific innovation environment. Thirdly, they used Nelsons empirical work on innovation systems in countries as a point of entrance for finding explanatory variables. In the next section, an elaboration on these three theories is given. Further elaboration on these three perspectives will be given in the next paragraphs.

2.1 Macroeconomic perspective

The predecessor of the Romer's endogenous growth theory is the model introduced by Robert Solow (Solow, 1956). Solow's growth model tried to explain Kaldors stylized facts. These facts are empirical observations which are common in different countries over different time periods. They concern all kind of macroeconomic facts, such as the fact that shares of GDP by labour and capital in a country earned stay roughly the same over time. In trying to explain these common observations, Solow would want to answer the question whether long term growth could be caused by capital accumulation. Solow set up a heavily stylized model in which there are three types of inputs to the production process: labour, capital and technology. In this model labour earns a wage and capital earns interest. Technology enhances the productivity per worker. Other assumptions are that the production function has constant returns to scale in effective labour (AL) and capital (K), there are no other inputs to the economy except for effective labour and capital and that it's a continuous model with constant growth rates for labour (n) and technology (g). To summarize, the production function in a Cobb-Douglas setting looks like this:

$$Y(t) = K(t)^{\alpha} A(t) L(t)^{1-\alpha} \quad (1)$$

The steady state of this model is reached when the capital depreciation equals the savings rate in an economy. In this steady state there is no increase in economic growth and no change in capital per labourer. But there is one factor that can cause economic growth: technological change (A). But this variable was left exogenous in this model, so it could not be influenced or predicted. Solow concluded that his research question could not be answered positively: long run economic growth cannot be explained by capital accumulation.

Not satisfied with the exogeneity of technological change, Romer (1990) came up with an endogenous growth model. This model endogenizes technological change and tries to explain it. The model is expanded to include an additional production sector: the R&D sector. In this sector an idea (or knowledge) is produced. The production of this sector can be viewed as technological progress. This new sector impacts the model in a way that choices have to be made about how to distribute the resources (A and K) over the two sectors. The production function of the 'normal' goods, when applying it in a Cobb-Douglas setting, looks as follows:

$$Y(t) = [\left(1 - a_K K(t)\right)]^{\alpha} [A(t)(1 - a_L) L(t)]^{1-\alpha} \quad (2)$$

The determining factors for the production in the R&D sector (i.e. the change in technology), is the following:

$$\dot{A(t)} = B[a_K K(t)]^{\beta} [a_L L(t)]^{\gamma} A(t)^{\theta} \quad (3)$$

In these equations, a_k and a_L respectively stand for the weights of total capital and labour spend on the R&D sector. *B* is a shift variable that accounts for all changes in other parameters that have an effect on technological change but that are not in the model. It is not clear and not determined if there exists diminishing, constant or increasing returns to scale in the technology production function. The important thing we can derive from this equation is that the absolute value of *K*, *L* and *A* together with the shares a_k and a_L make up the change in technologies according to this model.

The knowledge stock (A) build up in the past also has an effect on the production in the R&D sector as follows from the R&D sector production function. This is channelled by the last term in Equation 3. The theta on top of this argument decides upon the effect that knowledge stock has on the production of technology. In a sense, this could be negative or positive. Both ways could be logically argued.

Knowledge stock could enhance knowledge production, if previous inventions are used to discover new ones. Knowledge stock could also deprive knowledge production, since a high knowledge stock means inventions have already been done, and with high probability, the inventions that are easy to come by, have been done first.

The macroeconomic theory on growth plays an important role concerning the selection of variables. In order to make a decent empirical analysis, some theoretical grounds should be used. Growth theory has helped in this way. As has been shown in the Romer model of economic growth, resource commitments towards R&D as well as knowledge stock are of great importance when trying to map technological change. In this research, R&D Expenditure is used as a proxy for the resource commitment to the R&D sector in a country. Knowledge stock is not a thing one can explain or measure by a single variable, therefore GDP per capita and Patent Stock are used to proxy for this value of knowledge stock. Further elaboration on this choice can be found in Chapter 3.

2.2 Microeconomic perspective

Another perspective that can be used to review innovation is a microeconomic one. From this perspective innovation is seen as the product of an innovation enhancing environment. All kinds of factors play a role in determining if a firm will be successful in innovating. These environments in which innovation mainly takes place are called clusters.

A good example of an environment that is very pro-innovation is Silicon Valley. In the beginning of the 80's a number of high-tech computer companies clustered on the west coast of the United States. These companies performed very well and grew. This attracted more IT-related labourers and other firms. These firms were other IT companies, but also venture capitalists, who would gladly lend money to new IT start-ups. This concentration of high-tech firms, well educated technicians and venture capitalists willing to lend money, made the area very popular. So even more technicians tried to find jobs in this area and even more high-tech start-ups were made. In this case, the environment, founded by a few IT firms, was very beneficial to innovation.

Porter created his Diamond model in the beginning of the 90's, so in the same time Silicon Valley started to build up a name. He created his model by researching clusters and looking at the competition within these clusters. In doing this, he came up with four drivers that enhance the production of private sector innovation. These four drivers are:

The first force that has an effect on innovativeness in the clusters is the factor inputs. This encompasses everything the firm needs as an input to be innovative. For instance, this concerns the quality and quantity of the workers a firm is able to hire in the cluster. A clear example of a place that attracts IT business through the abundance of IT personnel is Bangalore in India which has acquired the name to be "The Silicon Valley of India". But the inputs also include the research structure in a cluster. This, for instance, means the division of the research conducted between the private and the public sector, but also the use of private sector funds to commercialize public sector inventions. What is also important is the presence of risk capital. Without the capital, firms will not get funded and ideas will not get developed.

The second force concerns the local rivalry between firms. Fierce competition is good for the invention of new ideas. When having a rival close by, firms get pushed into doing just a bit extra or have just a lower price to beat the competition. A thing that is very important for competition to work properly is IP Protection. When the inventions are not properly protected, ideas would get stolen and the incentive to invent would go away.

The third factor that shapes the Diamond model is to be found on the demand side of the economy. A large and well educated local customer base will enhance the incentive to innovate, yet it can also be critical of new inventions and give useful feedback on the product.

The last element of this framework is the links between firms. A high interconnectedness of geographically close horizontal and vertical related firms boost innovation. It helps solve problems of high transportation costs, but another advantage is the spill over effect. The knowledge spill over effect could perhaps be two firms who closely work together in sharing their inventions. These kinds of relations are more common when groups of firms are connected and are geographically situated close to each other.

Macroeconomic factors are left out of the Diamond model. So, one could argue that when all four factors are well developed in a cluster, innovation could still decline. The example of the Silicon Valley earlier was not only caused by the innovation enhancing environment described by Porter. The environment was beneficial for sure, but without the economic climate, which was very favourable for investment, things wouldn't have developed the way they have. Next to that, IT was booming in that time, it was very easy to find money for an IT investment, not exclusively in the Silicon Valley.

2.3 Research on National Innovation Systems

The third building block of the National Innovative Capacity idea is to look at innovation as a National Innovation System. This NIS approach has been researched and discussed by Nelson (1993). He finds differences and similarities in approach that countries take on the account of innovation. He compared the innovation systems in a set of 15 countries and drew a clear picture of what factors are important in the NIS. Next to this he argues which infrastructural variables have shown to have a clear impact on innovation. Clear conclusions are not made in the book except for the fact that all countries approach innovation in a different way and this is probably needed because the settings of the countries also differ.

The essence of the NIS is to look at the direct and active role a government can play in enhancing innovation in a country. This active role could among others be concerning IP Protection or the possibly slow and bureaucratic way of starting up a business. Also the relations between private, public and semi-public firms, governments and other institutions play an important role. In describing this role of the relations Nelson argues the example of the US and Germany which both differ in their setup of the NIS. While in the US almost all innovations have the university system as an intermediary, in Germany innovations happen more direct, direct links exist between the public and the private sector. So this approach also includes the nature of the university system and the way that most innovation comes to be.

Nelson argues the word 'system' must not imply the NIS is a consciously man made system. It is the set of institutions that are interconnected that has grown to be the system. If one would just set up the world's best universities and make as much money available as needed, it wouldn't necessarily be a good innovation system.

Another import thing about the National Innovation System approach is the fact that nations are used as the boundary between different systems. In this time of globalization in which countries boundaries are becoming even more symbolical, this approach specially focuses on the innovation system per country and not for example a geographical area (e.g. Europe, the NAFTA or South East Asia). This is caused by the fact that the system cannot be viewed in another country than in the country that it is in. University systems and government policies are still very domestically oriented. A good example is the study in which Edquist and Lundvall (1993) show the difference between the NIS' of Denmark and Sweden which superficially seem very similar countries. The analysis proves that the systems show many differences.

In the European Union, progression has been made towards a unified innovation policy, but this still doesn't mean the national systems of innovation connect to each other.

Another aspect of the National Innovation Systems that hasn't been specified as such by Nelson is the linkages. The linkages are the relations that exist between all parties that corporate in innovation. The interaction between firms, users, research institutes and universities are the cause of many improvements to products and services. Von Hippel (1976) proves with a statistical analysis that in most cases the innovation process is user-dominated. He studied a sample of innovations and mapped the innovation process. Firms will only come in to play a role to diffuse and commercialize the idea. Gibbons and Johnston (1974) argue that it is up to the firms to recognize the added value that comes from basic science performed by universities. The diffusion of the knowledge from universities to the firms doesn't happen by itself. Gibbons and Johnston cannot describe the exact relationship between firms and universities but they emphasize the importance of the existence of interaction between them.

3. Data and Methods

In deciding upon which variables would be good estimators in explaining innovative output, three perspectives are chosen. These three views combined make a good 'system of innovation' proxy, which is tested. In the coming part, argumentation is given for the decisions on what variables from what sources are used. The model as it will be used in this paper will also be shown and described.

3.1 Time span

This research has not been built around the happening of an economic event at some point in time, rather innovation is a constant process that has developed as a main point of interest in the theory on economic growth. So for selecting a time span, there was not an aim for a certain period. The only thing that is tried to achieve is to get the sample as big as possible, but with keeping in mind that a complete dataset is essential when doing the analysis. The biggest bottleneck for selecting the time span was data availability. In order to get the dataset as big and complete as possible, it is a logical choice to focus on the most recent data. Data before the 1960s is very hard to come by (for some variables harder than for others). From the beginning of the 1980s data is better registered and available. The only downside on having the beginning of the 80's as a starting point for this research, is that some of the countries used in this paper didn't yet exist by then. They were part of the Soviet-Union or another bigger entity. This spoil on the data completion is taken for granted and kept in mind when analysing.

3.2 Country choice

In order to get some interesting results from this study it was clear that innovative countries needed to be the main focus of this research. Though, the sample should be large enough to have some variation in innovation output, so not the top performing countries alone could be included. The 34 OECD countries were chosen as the subject set because they comply to the above requirements. Another nice thing about the OECD countries is the data availability. Since all of these countries are fairly high developed, data availability is good. Next to this, there is the OECD iLibrary which contains a lot of data on the OECD countries. This data is used often throughout the (academic) world and therefore is expected to be reliable. A bit of a downfall in choosing these countries is the fact that some of these countries are young republics. For example, Czechoslovakia, which existed until 1993 and then was divided between the Czech Republic and the Slovak Republic. Same goes for the Republic of Slovenia, which until 1991 was part of Yugoslavia. Another negative point is that most of the Newly Industrialized Countries (NICs) are not included in the sample. These countries have to make their first steps on the innovation ladder, so they would also have been an interesting subject. However, because (most of) these countries are no member of the OECD and are not transparent concerning data, they were not included in the analysis. All these gaps in the data are a pity, but are taken account of.

The total list of countries that participate in this research can be found in Table 5 in the Appendix.

3.3 Variables

Theory was the starting point for selecting the variables. A lot of indicators were identified when analysing Romer's, Porter's and Nelson's work. Some of these variables however have not made it in the regression. This is caused by the lack of data available. For some indicators this lack of data could be compensated with creating a proxy of the variable trough some other variable that has similar characteristics. Others unfortunately were left out of the regression.

Since data completion was such an issue, in Table 6 in the Appendix, a summary of the data completion statistics can be found.

3.3.1 Patents

Technological change is the factor analysed and explained in this paper. At first growth economists saw this variable as exogenous. Since Romer introduced his model of endogenous growth, it is known how to interpret this 'technological change'-factor. Nowadays, it is the phenomenon that policy makers will try to enhance with the goal to improve economic growth.

It is very hard to quantify technological change or innovation. It cannot be shown with some variable that is widely available. There has been a lot of debate on what variable or what set of variables are the best representation of innovation. Annual innovation rankings are made by INSEAD, the World Economic Forum and Innometrics. But these three parties do not agree on which variables to use to explain innovation. They create indices composed of a set of variables. Previous research has been critical of using patents to represent innovation. Not all patents have the same impact and not all inventions are patented. Though, since the good availability and the seemingly obvious relation, this variable is expected to be a good proxy for the innovativeness of a country. All countries face the lack of their great inventions getting a greater weight. This difference per country should grossly equal itself out across countries. These lacks in quality are taken notice of and are kept in mind. The patent data originates from the World Bank dataset containing worldwide patent applications filed through the Patent Cooperation Treaty (PCT). Another problem that arises, when using patent data that is divided into countries, is the question which country is the real innovative country. If for example a Dutch professor writes a patent in Germany for a French company. The professor would have been educated in the Netherlands, but the real incentive to write a patent comes from the firm he works for, which is French. The most likely path a situation like this follows is that the PCT filing will be done in Germany, since this is the most geographically direct related patent bureau. In the World Bank dataset, the data is sorted per country on the basis of the nationality of the bureau that processes the application.

3.3.2 Gross Domestic Product (GDP) per capita

The first of two variables measuring knowledge stock is GDP per capita. Knowledge stock is another hard thing to quantify and GDP per capita is an acceptable proxy for it. In itself, knowledge stock still has a mysterious effect on innovation. No hard empirical evidence has shown whether the effect is positive or negative. From a theoretical point of view, the effect isn't clear either, it can go two ways. A positive effect would be possible if you would look at knowledge stock as the matter of advancement of the toolkit inventors have. If they had the tools of today in the period of the enlightenment, it would be a lot easier to come by new inventions. It is also possible to logically argue that a negative effect can exist. When knowledge stocks are high, the big fish have all been caught. This makes it harder to come up with new innovations. So no predictions are made on the effect of knowledge stock on patents, but previous researchers all agree on the fact that there exists some effect. They just can't agree on whether it is positive or negative (Jones, 1995, Porter and Stern, 2001) GDP per capita is specifically chosen because this variable captures the current economic state of a country. This is important in explaining the ability of inventors to develop their inventions and to commercialize them. It is of critical importance that the companies in a country are able to 'translate' their inventions into prosperous businesses. This variable tries to display this capability.

3.3.3 Patent Stock per capita

The second variable that has the role to represent knowledge stock in the regression is the Patent Stock. This measure displays the amount of knowledge stock in another way than GDP per capita does. While GDP per capita shows more the economical side of the invention, Patent Stock tries to represent the technological side of the invention. The effect of this variable is also not clear for the same reasons as GDP per capita has.

This variable also has a methodological argument for being in the regression. Because when a time series regression is performed, a chance exists that autocorrelation deteriorates the results. Autocorrelation means that the errors of the observations over time are correlated with each other. By inserting a variable that is a lagged version of the dependent variable, or a variable build up out of lagged versions of the dependent variable (as is done here), the possibility for autocorrelation gets minimized. So the Patent Stock variable has been build up from lagged values of the Patents variable. The variable basically is the cumulated version of the Patents variable and starts running at the beginning of the time span of this research. This variable is made per capita.

3.3.4 Population

Romer's theory of endogenous growth claims that technological change is caused by interaction of the knowledge stock and the size of the knowledge sector. These two factors together form the Ideas Production Function. Knowledge stock is represented by GDP per capita and Patent Stock, the size of the knowledge sector is given by Population and the amount of R&D Expenditures. So in order to make the size of the R&D sector play a role, population is added. However, during the regression it turned out to be better to not include population, but rather to take all variables per capita. So the data on population is incorporated in the regression, but not in the same direct way as the other variables.

Data on population count was downloaded from the World Bank's World Development Indicators.

3.3.5 R&D Expenditure per capita

The last variable that makes up the representation of the size of the knowledge sector is the R&D Expenditure. R&D Expenditure can be thought of as one of the most often used indicators to represent the innovativeness in a country. However, the example in the first chapter on the comparison between Japan and the USSR showed, that spending a great deal of money on R&D doesn't mean that a lot of technological development takes place and not necessarily leads to economic growth.

The R&D Expenditure data consists of both public and private investments in R&D. The official term used for this data is Gross Expenditure on Research and Development (GERD). The data has been extracted from the OECD iLibrary. After the extraction, this indicator is made per capita by the population data described in 3.3.4.

3.3.6 Education Expenditure per capita

The NIC also includes policies and economic characteristics that can have an effect on innovation. The first of this group is education. Education gives a boost to the productivity of workers. Another thing education does is create high skilled workers. The type of worker that is capable of inventing and is needed as input for innovative firms. This makes it obvious that a positive relation should exist between the quality of education an average person in a country collects and the amount of patents that are generated in a country. Data on quality of education in longitudinal form is very scarce. Therefore expenditure on education is taken to represent the efforts that governments make for education.

In order to collect the data on this variable, the database of the UNESCO was used. Most ideal would be to have data on the public expenditures of only the higher education types, because this represents the quality of education 'the inventive class' faces, even better. But facing the trade off between having the exact right data or a good proxy of it and a higher data completion, the higher data completion was chosen. This means not the expenditure on secondary and tertiary alone has been used, but the expenditure on total education (so primary, secondary and tertiary). To make the Education Expenditure data comparable across countries and to eliminate the level advantage for bigger countries, the data on Education Expenditure is taken per capita.

3.3.7 Openness

Openness of an economy is another factor that has explanatory power with respect to innovation. At a first glance, the relation between openness and innovation might not be very clear. A very open country makes its firms internationally competitive. This worldwide competitiveness has the effect that the incentive to create a new and better product becomes bigger. One can clearly see the advantages (with respect to innovation) of having an open economy if one looks at, for example, the Netherlands. The Netherlands has a small domestic market. If innovations would only be sold on the local market, very little profit is to be made and incentives to be innovative are low. The Netherlands has an open market and this gives the innovative firms (for example TomTom or ASML) the possibility to commercialize inventions and make a good profit out of it.

The data on the openness of the domestic markets are extracted from the World Development Indications database by the World Bank. The World Bank has built this indicator by summing up all international trade (imports and exports in goods and services) and dividing this by the GDP.

3.3.8 Intellectual Property Protection

An important thing about innovation is to look at it from a legal perspective. Legal rights on intellectual property intuitively have a positive effect on innovation. Because when intellectual property is secured, the incentive to invent new things becomes greater. This is one of the contributing factors to having a good innovation infrastructure in a country.

Data on Intellectual Property Protection is not widely available. Only in some surveys, this variable is taken into consideration. Because of this limited data availability, it is assumed that IP Protection is fixed and only varies in an interaction with the R&D Expenditure (as will be argued in section 3.4). In this research, the value scored on the International Property Rights Index of 2008 is used to proxy for the fixed value.

3.3.9 University R&D Performance

To account for the linkages between the common innovation infrastructure and the industrial clusters in this empirically tested model, the University R&D Performance is included. It should show the intensity of the relations between the R&D sector and the universities, or systems of universities in the country. These linkages have proven necessary to create an environment for firms conducive to innovation.

The data for this variable comes from the OECD iLibrary. It shows the percentage of GERD performed by the higher education sector. So this includes all the research conducted by universities funded by all possible (public and private) parties.

In order to clearify all the previous used terms and variables, the following figure is included.

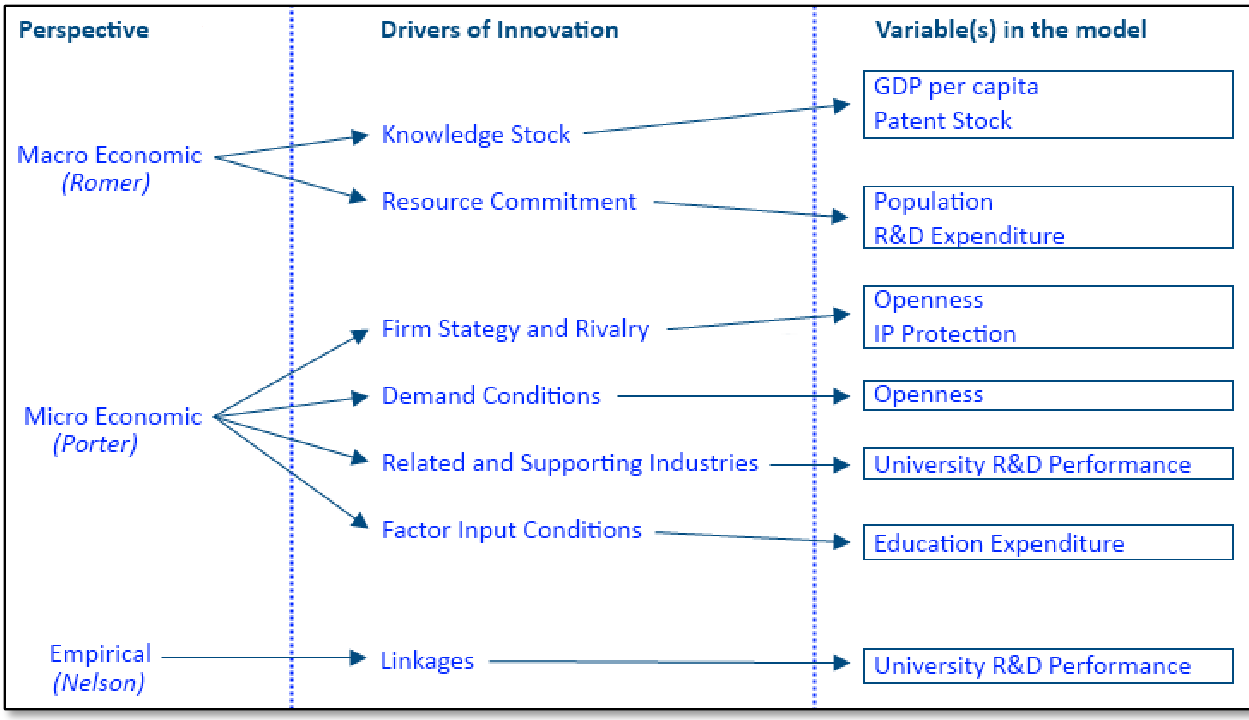


Figure 1: Variables in relation to their origin

3.4 The regression model

The following equation represents the regression model as it will be tested:

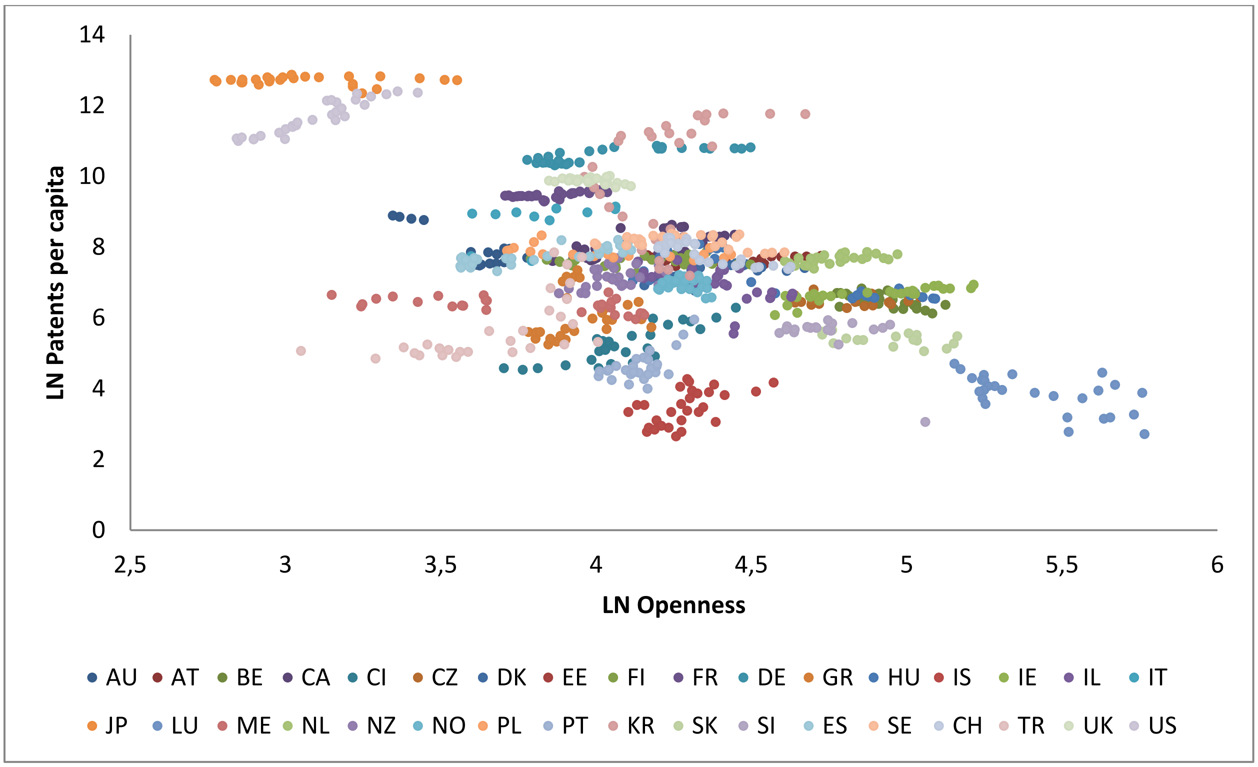
$$ln(Patents\ per\ capita)_{it+3} = \alpha + \gamma_2 W_{2t} + \cdots + \gamma_{34} W_{34t} + \delta_2 Z_{i2} + \cdots + \delta_{29} Z_{i29} + \beta_1 * ln(Patent\ Stock\ per\ capita)_{it} + \beta_2 * ln(GDP\ per\ capita)_{it} + \beta_3 * ln(R\&D\ Expenditures\ per\ capita)_{it} + \beta_4 * ln(Openness)_{it} + \beta_5 * ln(Education\ Expenditure\ per\ capita)_{it} + \beta_6 * ln(IP\ Protection)_{it} + \beta_7 * RDIP_{it} + \beta_8 * ln(University\ R\&D\ Performance)_{it} + \varepsilon_{it} \quad (4)$$

In Equation 4, t denotes time (from 1 to 29) and i denotes country (from 1 to 34).

All variables mentioned in section 3.3 are implemented into the regression model[2]. Regression Equation 4 shows the relations in the National Innovative Capacity framework. The dependent variable will be

[2] In an earlier instance, the number of FTE as Scientist or Engineer was also included in the regression, but this variable is left out because the model showed signs of multicollinearity due to this variable. The function of the FTE variable in the model was to account for the size of the R&D sector. R&D Expenditure will hopefully compensate for this. Another variable that has been dropped during the modeling of the regression is Private R&D Expenditure. This variable showed too much correlation with R&D Expenditure.

explained by the independent variables which all have their effect β. This coefficient β shows what the magnitude and the sign (positive/negative) of the effect is. An assumption that is made when running a regression is that the intercept (α) and the slope (all β's) are constant for all countries and all years. This seems logical, since one aims to get a general rule which holds for all countries in all years. But to make it possible for the intercept to vary over time and over country, dummy variables are added. These dummies incorporate the individual effect of every country or year in the regression. The necessity of dummy variable can be shown by the following graph which plots Patents per capita versus Openness.



Graph 1: Country clusters in a scatter plot of patents versus openness

This graph shows that there are clear clusters of dots in the data. In the top-left we have Japan and the US, relatively closed countries with high patent output. In the bottom right is Luxembourg with high openness and a relatively low patent output. To level out these country specific differences the country fixed effects are added. The same is done for year fixed effects. In the regression equation W_{it} and Z_{it} are the dummy variables which can be either 1 or 0. They only turn 1 when the coefficient moderator should have an effect on the intercept. This effect is saved in γ_i and δ_t and vary respectively by country and year.

Another thing that is tried in creating the best possible model, is introducing interaction terms. Interaction terms show whether variables have some significant effect on the dependent variable when they are in interaction with another variable. This interaction term is created by multiplying the logs of both variables. An interaction term is made for IP Protection and the R&D Expenditure per capita[3] (in the regression named RDIP). This interaction needs to be made. Since the data on IP Protection is limited, it is assumed that this variable is fixed over time. So, when adding country fixed effects, the IP Protection variable loses its effect because it does not vary over time. IP Protection has a unique value in regressing innovation, as has been proven in previous empirical studies (Kanwar and Evenson, 2003). Therefore it should be in the regression. A solution to this problem is to make an interaction variable. This way IP Protection in itself would not be adding value when country fixed effects are added, but the interaction term would stay, since it has unique values for every year. The link that exists between the R&D Expenditure per capita and IP Protection that must exist in order to make an interaction, can be seen as follows. A highly developed IP Protection mechanism means the incentive for firms and governments to invest in R&D is higher. All the intellectual property they develop will be guarded by a good functioning legal system and therefore the risk of IP theft is minimal. This will contribute to the return on the R&D investment.

The effect of the explanatory variables that is expected is not a direct effect. Because most variables are on the macroeconomic level, there doesn't seem to exist an immediate relation between these explanatory variables and the patent output. Since the indicators' change doesn't directly affect patents, a time lag is taken in the model. A three year lag is taken, as is commonly done in other similar regressions (Furman, Porter and Stern, 2001, Popp, 2001). The time lag is included in the regression in the form of giving the dependent variable a three year forward lag.

In the regression equation, "LN" shows that the variables are in natural logarithms. The variables have been transformed in logarithms to create a log-log model. The big advantage of this mode of regression is that the variables can be interpreted as being elasticity's. So, when for instance a coefficient (β) for a variable is 2 in a regression, this means that a 1% increase in this variable results in a 2% increase in the dependent variable.

[3] There has also been tried to make an interaction term for Patent Stock and GDP per capita, but this interaction term did not change much to the regression and was therefore not included in the final model.

4. Analysis and Results

This chapter focuses on the empirical results that were obtained from the data. At first an overview of the points of interest that were found in the data is given. All deviations from what is expected in the data are explained. Next, the central regressions of this paper are shown. This is followed by an explanation on the coefficients and the deviations from the Furman, Porter and Stern paper. This chapter concludes with a paragraph in which a broad set of policy implications are made.

4.1 Exploration of the data

In this section, a first glance at the data is given. It is argued which strange patterns are formed in the data. Also, some unexpected points in the data are displayed.

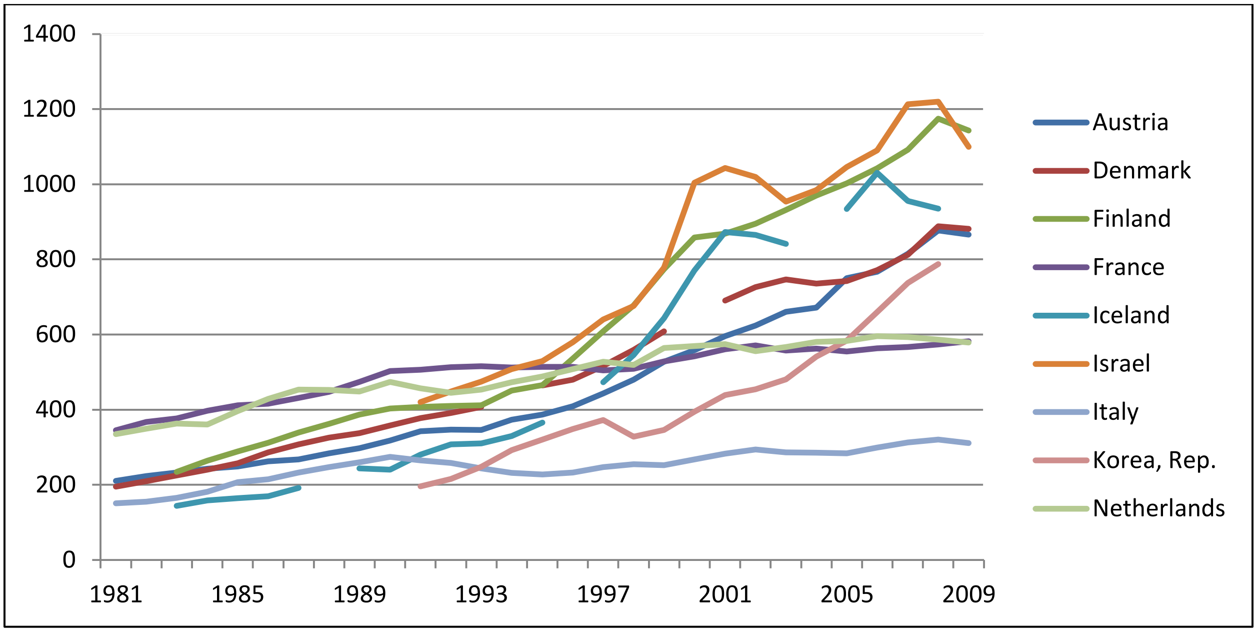
Since Patents is a very important, if not the most important, variable in the regression, this variable will get some extra attention. The data shows that for all countries an increase in patent output per year is realised over the sample period. However, over the last few years of the sample the growth of patent applications dropped and the amount of patent applications got even smaller than the year before from 2008 on. The probable cause for this is the financial crises making firms reluctant to innovate. This decrease in growth exists to some extent in all countries.

In GDP per capita, one can clearly see that some countries are catching up over the sample period. For instance, South Korea has 3,6 times higher GDP per capita in 2009 than it had in 1981[4]. Other countries which have very high growth rates are Chile, Ireland, Poland and Turkey. However a drop is to be recognized in the year 2009, also due to the bad economic climate. This drop is felt the greatest by the developing economies.

Another interesting variable to discuss is R&D Expenditure. R&D Expenditures in itself says most about the size of the country. When it is corrected for population count it becomes more interesting. South Korea leads in being the fastest growing country concerning R&D Expenditure per capita. Especially in the last decennium it has generated high growth rates. Other countries with high growth rates are Iceland, Finland, Denmark and Austria. Others did well too, but these countries have surpassed a lot of the other countries in the taken time span. One of the outstanding countries in doing bad is the

[4] GDP per capita 1981: $ 5.544, GDP per capita 2009: $ 25.517 (PPP adjusted, constant 2005 $). Source: World Development indicators, World Bank.

Netherlands. This could be the heart of the problem that some traditionally developed countries lack in the development of innovation. To make the comparison between outperforming countries and the underperforming countries more clear, the next graph is added.



Graph 2: R&D Expenditures per capita, outperformers and underperformers

Unfortunately, the lack of observations somewhat compromises the clarity of the graph. It is however clear cut that some countries do have high increases in R&D Expenditures per capita and others nearly stand still in their development. Mainly France and the Netherlands were having very high R&D Expenditures per capita in the beginning of the time span, but in the end, this lead disappeared.

The rest of the data didn't bring up any surprises. There are no other large deviations that need explaining.

4.2 Important contributing factors to innovation

The model created in the previous sections is empirically tested. The results of this test are given here. Not all regressions are shown, because not all of them turned out to be relevant for the purpose of this paper. In Table 7 and Table 8 in the Appendix, one can find the basic summary statistics on the variables and the pair wise correlations that exists between the variables.

The regressions are divided into three groups as is done in Furman, Porter and Stern (2001). This way, there is a gradual approach in the addition of new variables. This helps to be able to best interpret the effect of the variables. The first regression is the Ideas production function as it has been discussed by Romer, in this regression only GDP per capita, Patent Stock per capita and the R&D Expenditure per capita are used. The year and country fixed effects are included as well. Next the focus is on the broader Common Innovation Infrastructure which adds Openness and Education Expenditure per capita to the mix. The full model, which is named the National Innovative Capacity, adds on top of the previous: IP Protection, the interaction variable between IP Protection and R&D Expenditure per capita and the University R&D Performance.

	Ideas Production Function	Common Innovation Infrastructure	National Innovative Capacity
Ln Patent Stock per capita	0,3764 (0,0946) **	0,4421 (0,1017) **	0,4173 (0,1006) **
Ln GDP per capita	-0,3093 (0,1990)	-0,5631 (0,2315) *	-0,4973 (0,2747) *
Ln R&D Expenditure per capita	0,3777 (0,0841) **	0,3382 (0,1142) **	1.1853 (0,6857) *
Ln Openness		0,1169 (0,1435)	0,0835 (0,1586)
Ln Education Expenditure per capita		0,2517 (0,1264) *	0,1953 (0,1441)
Ln IP Protection			(ommited)
Interaction lnRD * lnIP			-0,4354 (0,2979)
Ln University R&D Performance			-0,0643 (0,1418)
Year fixed effects included	v	v	v
Country fixed effects included	v	v	v
R-squared	0,9653	0,9681	0,9684
Number of Observations	598	461	444
Standard errors in parentheses, * = significant at the 10% level, ** = significant at the 1% level			

Table 1: Regression on Ln Patent per capita (t+3) with robust standard errors

4.2.1 Ideas Production function

The first regression that is considered is the Ideas Production Function. The idea behind this model is that all the ingredients that make up the production of new ideas (using the interpretation of Romer) are included. A positive sign for all three indicators was expected. This expectation was not right according to Table 1.

The Patent Stock per capita (which proxies for the amount of knowledge available in the economy) has the coefficient 0,3764 with a standard error of 0,0946. When interpreting the variables, one has to take into consideration that all variables are in the form of natural logarithms of the original value. This means that the coefficients represent the ratio of percentage change for the variables. In this case, it means that a 1% increase in the Patent Stock per capita, would make a (roughly) 0,38% increase in the amount of patent applications (under the PCT treaty) according to this model. The relatively small standard error argues that the variable has a high significance and can be trusted. The R&D Expenditure per capita has almost the same coefficient as Patent Stock per capita has thus has roughly the same effect on the amount of patent applications. So according to this model, more investments in the R&D sector do pay off in a sense that more innovation takes place. All variables except the GDP per capita turn out to have a positive effect on patent applications in this setting. The negative effect of GDP per capita would seem odd a first sight, but as has already been mentioned in the elaboration on the variables, it is perfectly arguable. The effect of knowledge stock has been broadly discussed by scientists (Jones 1995, Porter and Stern 2001) and can be viewed from two perspectives. First, it can be seen as a factor augmenting innovation in a sense that a higher knowledge stock provides more and better tools for inventing new things. Second, it can also have a negative effect in a sense that all inventions that have been done, can't be done again. Still, the well of inventions can't be exhausted, but it can be less full. The V's in the fixed effect-rows indicate that fixed effects for year and country are used. Furthermore the R-squared can be interpreted as good. The R-squared shows the explanatory power of the model. The amount of variation of the observations that can be explained by the model in this case is about 96,5%, which is fairly good.

4.2.2 Common Innovation Infrastructure

In the second regression, the Common Innovation Infrastructure is modelled. The Common Innovation Infrastructure portrays the surroundings that firms have to deal with when trying to be innovative. Next to the variables that were included in the previous regressions, this means that the Openness and the Education Expenditure per capita variables are added. For both these newly added variables a positive effect is predicted.

The newly added variables show to have a positive effect. The variables which were already in the regression show no change in sign, though GDP per capita has got a bit greater negative effect. The fact that the variables that form the Ideas Production Function show almost no change contributes to the robustness of the coefficients estimated. The Openness variable has a positive effect on Patents per capita. This could be argued by the reasons given in 3.3.8 or by the fact that a higher openness causes new technologies to better diffuse between countries. When a country is open to inventions from other countries, science in the country can import these technologies and develop them further. However, while other research (Almeida and Fernandes, 2007) showed strong evidence for the relation between openness and innovation in developing countries, this can yet not be said for developed (OECD) countries because in the regression Openness shows to be not significant. The last variable that is added to form the Common Innovation Infrastructure is Education Expenditure per capita. This variable is a little (0,01 < p < 0,1) significant and has a small positive effect on Patents per capita. A logical reasoning behind this, is the fact that more expenditures on education means better education, and better education means more high skilled workers and this means that the likeliness to be inventive is higher. The R-squared has improved a little compared to the Ideas Production Function. This is caused by the addition of variables which will always bring something extra information to the table that enhances the explanatory power.

4.2.3 National Innovative Capacity

The last regression models the National Innovative Capacity. This regression includes all variables and tries to take all aspects of innovation into consideration. Therefore it is the best shot at representing the innovation determining factors in a country. To produce this model, the Common Innovation Infrastructure variable set is taken and the following variables are added: IP Protection, the interaction term between IP Protection and R&D Expenditure per capita and the University R&D Performance.

The variables that were also in the previous model turned out to not change sign when adding the new variables. Equally, not much changed to the strength and significance of the variables with the exception of R&D Expenditure per capita. This variable increased from having a coefficient of 0,3382 to having a coefficient of 1,1853. This increase is caused by the inclusion of the interaction term, which in part represents R&D Expenditure per capita as well. One can calculate the marginal effect[5] of the R&D Expenditure per capita in this model and find that it is around 0,33 which is the same as in the previous models. R&D Expenditure per capita experiences a small drop in significance caused by newly added variables which probably overlap R&D Expenditure per capita in explanatory power.

Of the newly added variables, IP Protection is omitted. This is caused by the fact that country fixed effects are used in the model. This way the (fixed over time) IP Protection does not vary and gets omitted. To compensate for this, the interaction term was introduced. As can be read in the Data and Methods chapter, the interaction includes R&D Expenditure per capita and IP Protection. This variable shows the combined effect of IP Protection and R&D Expenditure. This variable shows a non significant, negative coefficient. Since most of the explaining power R&D Expenditure per capita has, is already in its own variable, the possible cause of this negative effect comes from the IP Protection part of the

[5] Because R&D Expenditure per capita is used in two expalanatory variables, the marginal effect can be determined by adding the effect R&D Expenditure has on its own with effect of the interaction term times the average IP Protection score. The p-value for this marginal effect is 0,0514, so it is fairly significant.

variable. IP Protection was expected to be positive since it increases the incentive to invent. However, in the literature, Bessen and Maskin (2009) have argued that under certain assumptions IP Protection can have a deteriorating effect on innovation. They say sometimes it is good to have fierce competition, even with imitations. The imitations are complementary and are incentive to create more inventions by other inventors. IP Protection (or patents at all) would block this copy-enhancing process. Openness, Education Expenditure per capita and the University Performance of R&D turn out to be insignificant in this regression and have very small coefficients. For this dataset we can conclude that no significant relationship exists in this setting between these variables and the amount of patents a country applies for.

The R-squared of the final regression did increase a little opposed to the previous regression. Overall, the adjusted R-squared (R-squared corrected for the amount of variables added) did not deviate much from the regular R-squared. This indicates that the high R-squared is not caused by the number of variables added.

The decreasing number of observations in the regression can be explained by the increasing number of variables that are added. Each added variable had some holes in the data and therefore the incomplete observation was left out of the regression. This might have hurt the amount of observations the regression is based on, but it has improved the trustworthiness of the given coefficients.

4.3 Retrospect: Comparing the results with Furman, Porter and Stern (2001)

Next, the (National Innovative Capacity) regression performed in this paper is compared to the regression performed by Furman, Porter and Stern (2001, Table 7, Regression 7.2, page 924). The regressions aren't exact copies of each other, so a comparison cannot be given for all variables.

When looking at GDP per capita, a difference can immediately be observed. While the regression in this paper shows a negative relationship, the Furman paper shows a positive relation. As been mentioned often in this paper, scientists are able to argue GDP per capita as to have a positive or negative effect. Now is shown that in an empirical sense, it also isn't clear which effect GDP per capita has. R&D Expenditure per capita in this paper has a larger positive effect as in Furman. This might be caused by the extra variables that are included in the Furman regression and not in this paper's regression. Education Expenditure per capita also shows the same signs, however in this paper the coefficient is a bit larger. However, Education Expenditure per capita is still too small to be a significant driver of innovation. IP Protection in the Furman paper also shows a negative effect, it is very small, but is negative. This could explain why the interaction term in this paper is negative: because of IP Protection. The next variable is Openness. Openness has a very small negative coefficient in the Furman regression, where it has a very small positive relation in this paper. This might be caused by the difference in time period. The Furman paper looks at an earlier period (1973 to 1996). This difference in time might be the cause for the difference in the effect of openness. A reason for this change of effect over time could be that in earlier times when IP Protection wasn't as developed as it is today, openness would mean more competition and imitating and therefore, the incentive to innovate would be smaller. However, the effects of openness in both papers are very small and insignificant, so a relationship cannot be proven. The last variable that is up for comparison is the University R&D Performance. This variable turned out to be insignificant in both regressions. The sign of the effect is the same: very small negative. It can be concluded that this variable is not of much value when looking for the drivers of innovation. Alternative variables should be looked at to account for the linkages in explaining innovation.

The explanatory power of the models in this paper as well as the model in the Furman paper is high. This means that a lot of the variation that exists in the Patent per capita data is explained by the variables that are included in the regression. The Furman regression has a slightly higher R-squared, though it also has a larger number of explanatory variables. The adjusted R-squared showed not much deviation from the regular R-squared.

4.4 OLS on ranks

Pursuing a more direct approach to the Dutch problem, another regression is made. For the Netherlands it seems to be a problem to gain in rank. They have set as a goal to be in the top 5, but are still far removed from this goal. When you look at ranks, not only your own contribution to innovation counts, but also the contribution of your competitors. So doing a regression on the rankings, could give different results. In this paper a ranking has been made by using the patent data, the country with the highest patent per capita get rank 1, the rest follows. For the regression, not the absolute ranks are used, but rather wether the country increases in rank. When a country increases in rank, it gets a one, if a country decreases in rank, or stays equal, it deserves a zero. On these ones and zeroes, a linear estimation model is applied in the form of an OLS regression. This way, the coefficients can be interpreted as the difference in chance you increase in rank. For the explanatory variables, the differences have been used.

The reason for taking differences is that this way, the coefficient will show what effect a change in the explanatory variable has on the dependent variable.

The result of this regression is the following:

	OLS on Ranks (no fixed effects)	OLS on Ranks (country fixed effects)
Ln Patent Stock per capita (t+2)	-0,0044 (0,0166)	0,0523 (0,0728)
Difference: Ln GDP per capita	2,3574 (1,2992) *	2,3130 (1,4349)
Difference: Ln R&D Expenditure per capita	-2,8862 (3,3666)	-2,4912 (5,2207)
Difference: Ln Openness	1,1616 (0,4178) **	1,1711 (0,4523) **
Difference: Interaction lnRD * lnIP	1,6016 (1,8496)	1,4191 (2,9194)
Difference: Ln Education Expenditure per capita	0,6492 (0,3480) *	0,7014 (0,3466) *
Difference: Ln University R&D Performance	0,1295 (0,1186)	0,3819 (0,5099)
Country fixed effects included	x	v
R-squared	0,0602	0,1439
Number of Observations	241	241
Standard errors in parentheses, * = significant at the 10% level, ** = significant at the 1% level		

Table 2: Regression on Rank (t+3) with robust standard errors

In this regression, the main reason for Patent Stock to be in it, is for controlling for the height of the current ranking, because if you would have a high rank, it would be hard for you to increase even more. The most surprising variable of this regression is Openness, which has a coefficient of 1,1711 and is highly significant. Also Education Expenditure surprises, since it was not a really relevant variable in the previous regression.

This regression also contributes to the robustness of the R&D Expenditure per capita variable in a sense that R&D Expenditure has a stable positive effect. The marginal effect for this variable in this regression is around 0,28. This offcourse cannot be compared to the marginal effect that was calculated for the first regression, since they both have a different meaning. In the first regression it is a plain coefficient that can be interpreted as an elasticity, while in this regression it is the increase or decrease of the chance of gaining a rank. The marginal effect however has lost in significance. Where before the p-value was 0,0514, it now is 0,6590. The relationship is not as strong in this regression as it was in the previous one.

So the thing that can be concluded from this model is that when ranking and the increase in a rank is concerned, the two biggest significant variables to focus on as a government are Openness and Education expenditure. However, the R-squared is low, so far from everything is explained.

4.5 Policy Implications

From the first regression (Table 1), R&D Expenditure per capita comes forward as most reliable positive estimator of innovativeness. It has a marginal effect of about 0,3 which also is found in the second regression. Therefore it can be concluded that this variable according to the data is import in determining innovation. The total R&D Expenditures per capita can be influenced by governments by making private firms invest in R&D (for instance with tax incentives) or by investing in R&D themselves.

Patent Stock proves to be a reliable and robust estimator of Patents per capita as well. A thing this variable proves is that innovativeness is also self-enhancing. If a country has a rich history concerning innovation, more innovation can be expected in the future. However, since this variable is build up out of the Patents per capita data, it is hard to make policy implications out of it. The only recommendation that can be made on the account of Patent Stock is to improve the 'innovativeness' of the country, but the way how to do this is the exact question this paper tries to find out and therefore in this stage cannot be given.

In the regression on the ranks (Table 2), Openness and Education Expenditure both come forward as being important in increasing the chance that the country goes up a rank. A possible explanation for these variables being of more in importance in the regression of Table 2 is because differences are taken or because they are regressed on a dichotome variable.

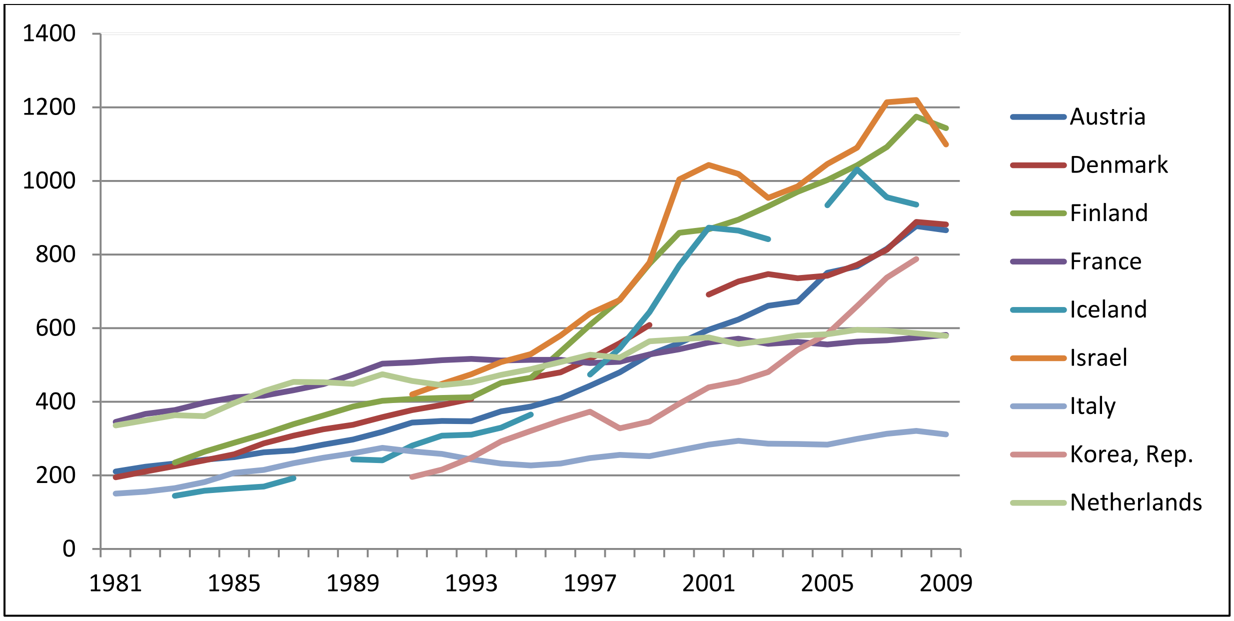
5. Dutch Innovation policy

This chapter works toward an evaluation of the Dutch policy. First, a short description of the problems that exist in the Dutch innovation framework is given. After this description of the problems, a theoretical discussion on government intervention in innovation is given. After this the European framework for policy in innovation is explained. Next, an elaboration on the Dutch innovation policy is given. To conclude this chapter, these policy measures will be evaluated given the outcomes of the regressions in Chapter 4.

5.1 Problem

The Dutch innovation system has been evaluated before. These evaluations (OECD 2005, Technopolis 2007, UNU-MERIT 2007) brought forth some problems that exist in the Dutch innovation framework. Some of the most troubling points are summarized here:

- Investment in R&D: After reaching a peak in the late 1980s, both R&D intensity and the rate of private investment in R&D (BERD) dropped over the years. This problem can be partly attributed to globalisation, which made some research disappear from the Netherlands but also made some research come to the Netherlands. There is also another problem with attracting foreign R&D investments. The Netherlands has great geographical advantages for companies, but these are however not clear to the firms. The Netherlands needs to put more focus on 'branding' the country as an attractive place for R&D. Another point that eventually causes underinvestment is the lack of the sense of urgency at the governmental or firm level. Therefore the Lisbon Treaty experts that reviewed the Netherlands (Technopolis, 2007) applauded the Innovation Platform, if only for the raising of awareness among the stakeholders of the worrisome situation. However, the Innovation Platform turned out to have some disadvantages of its own. Also at the entrepreneurial level, there are troubles in the investment in R&D. New innovative start ups are having a tough time finding capital. This causes the high-tech sector to be small and not profit enough from knowledge spill over. Recall Graph 2 which visually shows the problem the Netherlands is facing in terms of declining R&D investments:



Graph 2: R&D Expenditures per capita, outperformers and underperformers

- Interactions: Interactions are recognized for in playing an important role in innovation. The spillovers generated by these interactions can function as the input firms need to innovate. The Chemistry and Electronics sectors do have quite close relations between firms and research institutes. However, this doesn't hold for the rest of the sectors.
- Commercialization of research: While Dutch universities are highly regarded concerning the amount of journal citations, the actual patenting and commercializing of ideas turns out to be harder to achieve. A cause for this problem can be found in the mindset of a lot of University Researchers. They are not trying to come up with a commercial idea but rather with new (non-commercial) theories. (Technopolis, 2007)
- Shortage of skilled personnel: This problem is maybe not as troubling right know, but will cause complication in the future. What is a concerning factor in this, is that a very small share (compared across countries) of business personnel is working in science and technology sector. There is a lack of professional scientists and engineers in the Dutch labour market. This is according to some (Technopolis, 2007) caused by the low quality of teachers and the disaffection of youth to pursue a career in science and technology.

Most of these problems are known and are also described by the Dutch government as point of focus in their policy description. However, the question remains whether the policy put in place really has its focus on the right spot.

5.2 Policy

This paragraph starts with a theoretical discussion on the arguments for government intervention in the innovation sector. After this, an explanation of the European efforts to enhance innovation is given. The last part of this chapter focuses on the actual policies that are in place in the Netherlands.

5.2.1 Theoretical argument for government intervention

The role a government can play in enhancing innovation has been discussed in economics since the dawn of innovation. Francis Bacon (1626) first opted for a strong central institute in which all innovations would be brought together. This 'knowledge-house' should be the centre of all research. Later, Friedrich List pointed out in a response to Jean-Baptiste Say, who argued that government intervention had no or a negative effect on innovation, that governments can play a positive role (Freeman and Soete, 1997) in enhancing innovation.

Nelson (1959) made a clear theoretical justification for government intervention. The common tone of the time was to reduce public expenditures as far as possible, so this paper was controversial. However, it made an economically sound argument for government intervention and it changed the tendency of economists to dislike public expenditures on innovation. The point Nelson made in his paper was that the equilibrium reached without government funding was not the optimum. It was lower because firms would only want to invest in R&D that would pay out after a few years and bring in much money. The problem is that the larger, more fundamental, longer running research that had to be done isn't paid for. This research doesn't pay off as fast and much as the smaller innovations do and no one knows who will reap the benefits of the research. This makes it commercially very risky and unattractive for firms. The government does see the social benefit from this research and has no interest in commercializing inventions, so it does invest in it.

Another case that is made in favour of public funding of research is that firms would gladly attract fresh graduated students which have up-to-date knowledge of the latest research techniques (Pavitt 1990). These students must be trained at good universities to be able to handle the latest methods and techniques, and these universities need funding that firms will not offer. So this is also a point in which government should invest to enhance innovation.

There have however been critics on this government expenditure to help innovation. First, there is the traditional argument. A government shouldn't use taxes, raised from civilians, in order to fund industries doing research while industries could fund it themselves. More arguments were brought by Terence Kealey (1996). He argued that public funding of basic research is a thing that should only be done when there is an abundance of wealth, it should be viewed as a luxury good. He points out that R&D should be left to the power of markets. Whenever a certain research is needed, the price of this research will increase and some scientist will be able to accept and conduct the research. This way an efficient outcome is reached and no unnecessary research is performed. The arguments made by Kealey have been countered by some economists who argue that Kealey does not understand the economic value of the basic (fundamental) research (David, 1997).

5.2.2 European framework for innovation

In Europe, the real introduction of innovation as an important factor came with the new economic strategy that was set in action in the year 2000, this was the Lisbon Strategy. Before, there had been smaller R&D enhancing projects like the European Strategic Program on Research in Information Technology (ESPRIT). However, this was not a cross-country plan of action like the Lisbon Strategy was. The Lisbon Strategy was founded by the European Council in order to boost the competitiveness of the European firms on the world market. The strategy was put in place to protect European firms from those in highly developing countries. In order to give the goal some concrete measures, it was decided that (among others) in 10 years time, the countries should spend 3% of their GDP on R&D and the employment rate shouldn't be lower than 70%. In an intermediary evaluation of the progress, it was clear that the objectives were not going to be achieved. By 2010 (the last year of the strategy), the goals were still far from reached. Some say it was caused by the open method of coordination that was used in implementing the Lisbon Strategy, others say the goals were not realistic. With the end of the Lisbon Strategy a new strategy was launched: Europe 2020. This plan has roughly the same indicators (spend 3% of GDP on R&D and have an employment rate of at least 75%). Learning from the weakness in the Lisbon Strategy, the Europe 2020 strategy has implemented tighter method of coordination. Part of this tighter coordination is the annual evaluation of progress that takes place. In order to give innovation a better and more concrete measure, the European Union also aims to create a new indicator used for tracking innovation. If a country is not doing its best at achieving the goals set, it is possible to receive a warning or even sanctions from the EU. The annual growth survey for 2012 did again point out that the efforts of the member states were not good enough. Following the annual growth survey, new recommendations have been made by the European Council, though if these will help the lack of motivation of the member countries to comply to the European strategy remains to be seen.

5.2.3 Dutch Innovation Policy

Dutch innovation policy has been heavily revised and modernised in 2005. From 2005 the expenses on innovation policy also increased much. Where in 2005 € 1,9 bln was spent on innovation policy, by 2010 this increased to € 3,7 bln[6]. Dutch innovation policy can be divided in generic and specific policy. The specific policy has its main focus on nine appointed so-called Top-sectors which should develop to globally-competitive clusters. The generic policy should help all firms in innovating more and should increase the amount innovating firms. Now, in order to determine where the emphasis of the Dutch innovation policy is on, the governmental innovation budget on innovation for the year 2012 is summarized[7]. In the following table, an overview of the innovation budget[8] is given:

Generic policy (x € 1.000.000)	
Fiscal policies:	
-WBSO	872
-Innovation box	625
Innovation performance contracts	41,2
Innovationfund: innovation credit	56,7
Innovationfund: risk capital	27,5
Syntens	30,9
Eurostars	7,6
Contribution to organisations (WIPO, AWT)	1,3
Remaining policy	0,0
Total	**1662,2**

Specific policy (x € 1.000.000)	
Institutional research	207,6
Aerospace	81,7
International Innovation	3,8
Innovation programs (Top-sectors), Ministry of: -Economic affairs, Agriculture and Innovation (244) -Health, Welfare and Sports (106) -Infrastructure and Enviroment (12) -Defence (20)	382
Remaining policy	42,2
Research and Assignments	3,9
Total	**721,2**

Table 3: Overview of Expenditures on innovation

As can be observed from Table 3, the total of the innovation policy is € 2383,4 million. This amount can be divided into the generic policy (70% of the budget) and the specific policy (30% of the budget). So from this point of view, the emphasis of the policy is on the generic policy.

In the next part, the policies with the higher weights (concerning budgets) are elaborated on. Their goals are described and a link will be forged between the policy and one of the indicators that has been used in the regression. The linkages between the variables of the regression and the policies might not seem very obvious; however, the best is done to make a good proxy for representing policies.

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[6] Source: Dutch Court of Audit (2011), *Innovatiebeleid*

[7] Only the budget of the Ministry of Economics, Agriculture and Innovation under the heading 'a strong innovation power' (*Een sterk innovatievermogen*) together with the other ministerial departments' contribution to the Top-sectors has been analyzed. The decision to only analyze this arises from the fact that there is a certain gray area in which it is not clear whether the policy is put in place to enhance innovation. This way, all the policy included in the analysis has the sole purpose of enhancing innovation.

[8] Source: http://www.rijksbegroting.nl

5.2.3.1 Wet Bevordering Speur- en Ontwikkelingswerk (WBSO)

The WBSO is a fiscal measure aiming to improve R&D. The wages that are spent on R&D are supplemented by the government. This way it becomes cheaper for firms to hire scientists and engineers. When more scientists and engineers are hired, more innovation is performed and this might pay off in commercial ideas.

The amount of money spent on this measure is relatively high compared to the other measures. The government really emphasizes on this policy measure. Around 37% of the total innovation budget goes to this measure.

When trying to tie this policy measure to a variable of the regression, the R&D Expenditure per capita variable is the best choice. The aim of the government with this measure is to induce firms to spend more on innovation, by lowering the wages spent on R&D personnel. This higher investment of the firms in R&D will have a direct effect on the variable.

5.2.3.2 Innovation box

The Innovation box is the other fiscal measure in place. This policy measure reduces the amount of tax that has to be paid over the revenues made from innovations. When the firm can prove that innovation is the cause of the revenue, by showing the patent or the certificate of participation in the WBSO program, the amount of corporate tax is reduced from 25% to 5%. The Innovation box also is an important measure if one looks at the money it has allocated. It forms around 26% of the total budget spent on innovation.

This measure encourages firms to invest in R&D, since the net profits will be higher. However, another thing that can be argued as important is the power of firms to turn an invention into a profitable product. This power to convert a good idea into a profitable business is represented in the regression model by the knowledge stock. More specifically by the economic side of the knowledge stock, that is represented by the GDP per capita variable. So the two variables most targeted with this policy is the R&D Expenditure per capita and GDP per capita.

5.2.3.3 Innovation Performance Contracts

The Innovation Performance Contracts (IPC's) are in place with the goal to let different firms be innovative together. The government is willing to give financial support for this corporation and for the central branch organisation to find new fruitful corporations. The funding for this measure isn't as extensive as for the two previous two; however, it still concerns a great amount of money.

Since knowledge spill over is such a central argument in the desire for firms to work together, the variable for this policy measure is to be searched in the linkages section. The linkages represent the knowledge spill over generated from corporation. Although the linkages in the regression performed in this paper only support the firm-university link, it would still be the best fit for the IPC's to put them in this section.

5.2.3.4 Innovation fund

The Innovation fund is split in two in the budget overview, but is here described together since they roughly have the same effects and goals. This policy measure tries to improve the funding issues firms have to cope with by lending risk capital to these firms. This is not a subsidy, so the firms will have to repay the amount they borrow. The amount lent by the government is extensive. However, they hope to see most of the money coming back at the end of the duration of the loan.

This measure on one side helps firms to develop new ideas which carry risks and can't get financing from private investors. And also in improving the risk capital markets which make it easier for firms to get the capital they need for their firm. Both these results will have an effect on the amount of R&D Expenditures, so this variable is chosen to tie this measure to.

5.2.3.5 Syntens

Syntens is government-funded organisation which supports firms in innovation. At current times it accepts around 30 mln in subsidies yearly. However, the government has already decided in 2010 that the subsidy for this organisation is gradually decreasing.

Syntens tries to improve innovation as a whole. It mainly focuses on the Small and Medium Enterprises (or SME's). Since Syntens hasn't got a specific target or measurable goal, it is hard for this part of the innovation policy to tie it to a variable of the regression. Because of the small magnitude (30,9 mln or 1,3% of the innovation budget), decreasing character in funding and the limited possibility to tie Syntens to a variable, this policy is not further included in the evaluation of the policy.

5.2.3.6 Institutional Research

The institutional research on the budget overview relates to the expenditures that are done to a number of big research institutes in the Netherlands. These (mostly technical) research institutes perform research that has been asked for by the government. They also try to make research ready for firms to use through TTI's (Technologische Top Instituten, Technological Top Insitutes). The amount of funding they get in 2012 amounts € 207,6 mln which is nearly 9% of the total expenditures on innovation. These research institutes also get funding from other governmental departments. These have not been included since only the policy with the main goal of enhancing innovation are included and this might not be the case with the other money flows toward the research institutes.

The research institutes highly contribute to the knowledge stock that exists in a country. They perform research which brings technological advancements. Next to this, they also try to help firms in making abstract research into a product which can be exploited which contributes to the commercial side of the knowledge stock. So both sides of the knowledge stock are involved, which are GDP per capita (commercial side) and Patent Stock (technological side). But aside from the knowledge stock, the research institutes also contribute to improving the relations between the university research and the practical usage of this research for firms. Therefore these research institutes contribute both to the variables of knowledge stock and the linkages.

5.2.3.7 Aerospace

The funding on Aerospace directly goes to the ESA and the division of the money is not the responsibility of the Dutch government. This makes it hard to evaluate the Dutch government on the basis of these expenditures. However, a reasonable amount of money is involved (81,7 mln or 3,5% of the innovation budget) which makes it a point of focus for this government. The funding for Aerospace is used to perform research that is relevant for the Aerospace industry. This might not seem to be relevant for the Dutch innovation climate. But this research also develops tools for other research, it increases the knowledge stock. Next to that, it is plain innovation that is being funded in the Aerospace research centres. Therefore, this expenditure is connected to Patent Stock per capital and to R&D Expenditures per capita.

5.2.3.8 Innovation programs (Top-sectors)

The innovation program considers the funding of the Top sectors. The idea behind this funding is that when in a certain cluster a lot of companies from the same sector settle, these companies experience synergy effects from being 'close' to each other. A good way to explain this effect is by taking a look at Silicon Valley. This High-Tech cluster in the USA has become very useful for start-ups or already existing High-Tech companies to settle in, since there are plenty of skilled workers available and the same goes for risk capital. The place attracts all necessary input factors for being a healthy cluster. This is what is trying to be achieved by the Dutch government. They want to do this in nine different sectors (Agriculture/Food, Horticulture, High-Tech, Energy, Logistics, Creative Industry, Life Sciences, Chemistry and Water). For this cause they reserved a great deal of the budget. Where it now amounts € 382 mln (16% of the innovation budget), the plan is made to have a funding for the Top-sectors of € 500 mln by 2015 (which the government aims is to be privately funded for at least 40%).

The goal of this policy is to create sectors which highly induce the incentive to innovate. The government also aims to create such an attractive location in order that foreign firms will establish R&D facilities in the cluster. So it mainly aims at increasing the level of R&D Expenditure per capita by creating an environment that makes it attractive for firms to do so. So the variable tied to this policy measure is the R&D Expenditure per capita.

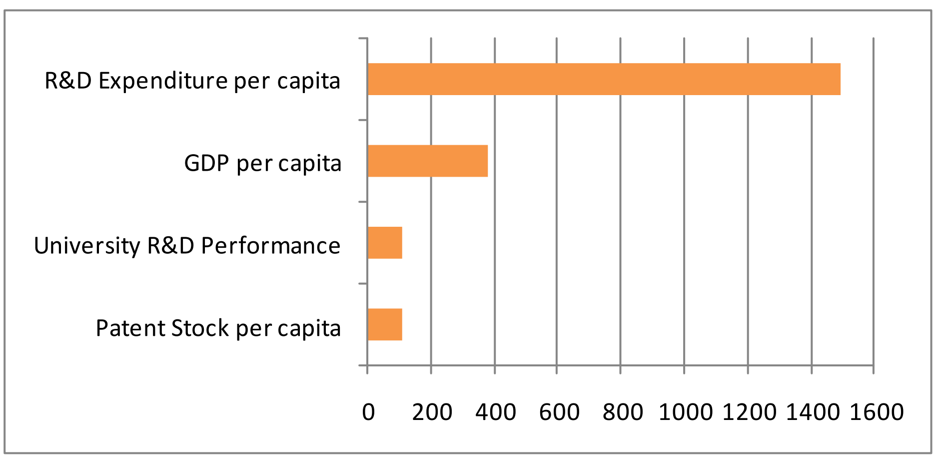
5.3 Evaluation of the Dutch innovation policy

In order to make an evaluation of the Dutch innovation policy, it is examined whether the focus of the Dutch government is on the right policies. A side note has to be made for the coefficients used. They are merely an estimation for relations as they exist in real life. So one should be careful when applying these to real world problems, all conclusions drawn from these statistics are based on estimations. This being said, an overview of the relationship between the policy instruments and the variables of the regression can be found in the following table:

Policy	Amount x € 1.000.000	Variable	Effect
Generic policy:			
WBSO	872	R&D Expenditure	1,1853
Innovation box	625	R&D Expenditure	1,1853
		GDP per capita	0,4173
IPC	41,2	Linkages: University performance	-0,0643
Innovation fund	27,5	R&D Expenditure	1,1853
Specific policy:			
Institutional research	207,6	GDP per capita	0,4173
		Patent stock	0,4173
		Linkages: University performance	-0,0643
Aerospace	81,7	Patent stock	0,4173
		R&D Expenditure	1,1853
Innovation programs	244	R&D Expenditure	1,1853

Table 4: Overview of the results

Table 4 shows an overview of the connections that are previously made between the policy measures and the variables of the regression. It also shows the effect that the money spend will have (according to the statistical results of this paper) on the amount of innovation output. It is clear that most of the money is well spend, yet some expenditures tend to have a negative effect on the innovation output. The following graph gives a better overview of the division of the money over the different variables:



Graph 3: Expenditure per variable (in millions)

In order to construct Graph 3 the budgets which were linked to more than one variable were equally split amongst these variables. From this graph can be observed that to get an increase in the R&D

Expenditure per capita is by far the biggest aim of the Dutch innovation policy. Unfortunately the other variables that were included in the regression cannot be linked to the division of public funds. For instance Openness and Education Expenditure (which turned out to have a positive effect in increasing in rank) don't have their expenses in the innovation budget, so they cannot be assigned with the division of funds.

With R&D Expenditure having the greatest positive effect on innovation, the funds on this variable are well spent. The fact that by far the greatest amount of funding goes to achieving this goal is an indication of a good division of the funds when one wants to increase innovation.

GDP per capita has got a negative effect on innovation according to the model. This means that the commercial side of the knowledge stock is not as important in determining innovation as one might think. This commercial side of the knowledge stock has often been referred to as valorisation, which means no more than the process of commercializing an idea. The Dutch policy has laid great focus on improving on this valorisation, though the positive effect of valorisation cannot be proved by the model in this paper. So it cannot be said that these expenses are helping or not in stimulating innovation.

Increasing Patent Stock (or technological knowledge stock) is the third biggest goal (ranked on budget) of the innovation policy. It mostly consists of research performed by institutions which are funded by the government. In the model it has shown to have a moderate positive impact on innovation, though it is very robust and therefore a reliable indicator. So the funds allocated to this goal turns out to be well spent.

University Performance of R&D has a very small negative coefficient. The insignificance of this coefficient indicates that in this data no good relationship between this variable and Patents per capita could be made. Therefore no statement can be made on the money that is spent concerning this variable.

6. Conclusion

The conclusion sums up all noteworthy findings of this paper. In the process some interesting facts came to light and these have led to the general conclusion presented here. After that, recommendations are given for further research on this subject.

6.1 General conclusion

The general question of this paper was, whether the right policy was put in place by this government to achieve a good performance on the subject of innovation. After first looking at the data, the problem for the Netherlands was clear. The commitment to R&D is low, both private and public expenditures are very low when they are compared with other countries. As Graph 2 shows very effectively, the Netherlands did pretty well in the 1980s and the beginning of the 1990s, but the highly innovative countries saw their investments in R&D increase in this time, where the Dutch rate was increasing only very little.

The statistical analysis proves that R&D Expenditures is the most import driver of innovation. However, the important factors when looking at the ranking are Openness and Education Expenditure. On these two variables the Netherlands score relatively good, so why the Netherlands aren't improving on the ranking can unfortunately not be explained in this paper.

Arriving at the Dutch policy, the allocation of funds dispensed by the government on improving innovation has been analyzed. The policy showed to have a strong emphasis on increasing the incentive for the firms to invest in R&D. Next to this, the government is actively investing in R&D themselves. Around 71% of the innovation budget goes either making private firms invest in R&D or investing in R&D directly. According to the model, the conclusion is that the money is well allocated and helps the Dutch innovation system where it is needed most. So the answer to the central question of this paper would be that the allocation of funds has been chosen wisely. Further policy recommendation would be to keep investing in the factors that increases the incentive of firms to invest in R&D and to make a larger budget available for investment in research.

6.2 Recommendations for further research

While performing the research of this paper, certain points could be improved for researchers who continue to perform research on the subject of innovation.

First, this research leaves out any judgement on the effectiveness and the efficiency of the policies put in place by the Dutch government. It merely considers the allocation of funds. Off course this allocation of funds isn't an assurance that the policies put in place are the right ones. Therefore a research into the effectiveness and efficiency of the policies would be an interesting extension to this research.

Another recommendation is taking another approach in achieving the same result. While conducting the research, it came up that taking another approach would have been more efficient. The other approach, opposing the current approach, would first give an overview of the Dutch policy and then search for variables which are able to represent this policy in a statistical model. This way the doubtful linkages made in section 5.2 would be established in a more solid way.

What is also an interesting point for further analysis is the role of the Multinational Corporations (or MNC's). Because of the small size of the Netherlands, these MNC's could have great impacts on the Dutch figures. One could research whether attracting foreign MNC's to settle in the Netherlands would not be more effective than the current policy.

In making a narrower recommendation for the Dutch government, it would be interesting to see which instruments work best in increasing the private R&D Expenditures. This could be done by in detail looking at countries that have very high private R&D Expenditure rates as for instance Finland or Korea.

Since one of the main questions why the Netherlands isn't improving on rankings isn't answered by this thesis, further research has to be done in which other fields (aside from government funds) are also considered. A thing as entrepreneurial culture could also turn out to be relevant in answering question on innovation.

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Appendix

Australia (AU)	Estonia (EE)	Ireland (IE)	New Zealand (NZ)	Spain (ES)
Austria (AT)	Finland (FI)	Israel (IL)	Norway (NO)	Sweden (SE)
Belgium (BE)	France (FR)	Italy (IT)	Poland (PL)	Switzerland (CH)
Canada (CA)	Germany (DE)	Japan (JP)	Portugal (PT)	Turkey (TR)
Chile (CI)	Greece (GR)	Luxembourg (LU)	Republic of Korea (KR)	United Kingdom (UK)
Czech Republic (CZ)	Hungary (HU)	Mexico (ME)	Slovakia (SK)	United States (US)
Denmark (DK)	Iceland (IS)	Netherlands (NL)	Slovenia (SI)	

Table 5: List of participating countries

	Real OBS	Total OBS	%%
Patents per capita	899	986	0.911765
GDP per capita	956	986	0.969574
R&D Expenditure per capita	718	986	0.728195
Openness	941	986	0.954361
Education Expenditure	708	986	0.718053
IP Protection	986*	986	1
University R&D performance	706	986	0.716024
Overall	5914	6902	0.856853

Table 6: Data completion statistics for the OECD countries in the period 1981-2009

*(*IP Protection is assumed to be fixed over time, for this variable the value for the year 2008 is this fixed value)*

Variable	Observations	Mean	Standard Deviation
Patents per capita	899	0,2901	0,4988
Patent Stock per capita	986	0,0034	0,0071
GDP per capita	956	23438,23	10107,34
R&D Expenditure per capita	718	405,08	283,86
Education Expenditure per capit	707	95175,66	65640,1
IP Protection	986	7,12	1,03
Interaction: RD * IP	718	16,54	4,01
Openness	941	77,38	44,35
University R&D Performance	706	24,19	10,79

Table 7: Summary Statistics of the variables

	Pat Pop	Pat Stock	GDP pc	R&D pc	Open	IP	Edu	RD * IP	Uni
Patents per capita (f3)*	1								
Patent Stock per capita	0.8233	1							
GDP per capita	0.5935	0.6923	1						
R&D Expenditure per capita	0.7677	0.7406	0.8576	1					
Openness	-0.1213	0.0169	0.1655	-0.0305	1				
IP Protection	0.5941	0.5472	0.6452	0.6469	0.0969	1			
Education Expenditure per	0.6892	0.7033	0.9132	0.6605	0.0254	0.7296	1		
Interaction: RD*IP	0.631	0.5668	0.5338	0.8956	-0.5068	0.5242	0.6016	1	
University R&D Performance	-0.3757	-0.3334	-0.2747	-0.3996	-0.0834	-0.1609	-0.1728	-0.222	1

Table 8: Pairwise correlation of the LN of the variables

(the value for Patents per capita is forwarded 3 years)*

	OLS on Ranks (no fixed effects) (f2)	OLS on Ranks (country fixed effects) (f2)	OLS on Ranks (no fixed effects) (f1)	OLS on Ranks (country fixed effects) (f1)
Ln Patent Stock per capita (t+1/t+0)	-0,0039 (0,0160)	0,1035 (0,0629)	-0,0069 (0,0147)	0,0661 (0,0531)
Difference: Ln GDP per capita	-1,2072 (1,2982)	-1,8790 (1,3997)	-0,6943 (1,2631)	-0,8229 (1,3831)
Difference: Ln R&D Expenditure per capita	-3,0172 (3,3221)	-2,6460 (4,6387)	-3,6021 (3,4189)	-2,4137 (4,9120)
Difference: Ln Openness	-0,7796 (0,3815) *	-0,9198 (0,4225) *	-0,2676 (0,4029)	-0,2947 (0,4195)
Difference: Interaction lnRD*lnIP	1,9132 (1,7964)	1,7096 (2,5455)	2,0203 (1,7550)	1,4815 (2,6126)
Difference: Ln Education Expenditure per capita	-0,5158 (0,3878)	-0,5228 (0,3623)	0,1310 (0,2851)	0,3624 (0,3116)
Difference: Ln University R&D Performance	-0,4157 (0,4339)	-0,8072 (0,4471) *	0,8411 (0,4353) *	0,7615 (0,5051)
Year fixed effects included	x	x	x	x
Country fixed effects included	x	v	x	v
R-squared	0,0348	0,1441	0,0255	0,107
Number of observations	259	259	277	277
Standard errors in parentheses, * = significant at the 10% level, ** = significant at the 1% level				

Table 9: Regression on Ranks for different time lags