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DANISH PRODUCTIVITY, WHAT IS THE PROBLEM?

This master thesis looks at what has been called a productivity paradox in Danish context. Danish productivity growth has been declining since the mid-1990s. Therefor it has been subject to a lot investigation, one of the most debated was made by the Danish economic councils. Therefore their report is used for the initial understanding of what the problem is with Danish Productivity. This thesis starts out with a theoretical discussion of the theories behind the mainstream economic understanding of productivity, and thereby also the Danish economic councils. This is done with help from authors like Robert M. Solow, Paul Romer and Charles I. Jones. This is done to understand one of the main reasons why there is low growth in productivity, which is suggested by the Danish economic councils, and the reason is total factor productivity (TFP). This discussion of TFP in the theoretical section, leads to the understanding that TFP has been seen as a knowledge input, but the mainstream economic theories understanding of knowledge creation is very limited, and mostly translates into research and development and education. Therefore the Danish Economic councils also stick to these two variables when discussing the problems with Danish productivity. Which is not enough, therefore the national innovation system thinking is introduced in the theoretical section as well as the empirical investigation. The national innovation system (NIS) thinking is presented with the use of authors like Bengt-Åke Lundvall, Jan Fagerberg and Chris Freeman. The NIS allows for a better understanding of how knowledge works, and thereby also where the problem with Danish productivity is. The empirical investigation that follows shows, with help from a community innovation survey, that there are a lot of small companies that have problems with their TFP and also ability to innovate. The deeper reasons that this thesis offer as explanations for this, is that the lack of collaboration and availability of venture capital. Therefore this thesis suggest that policies focusing on “know-who” should be implemented. This could be in the form of offering consultants for free, networking conventions, or alternatively helping companies to setup within close proximity of each other via offering cheap accommodations.

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1. Introduction

The world is still recovering from the recent recession, especially south European countries are struggling with high unemployment and public debt. Their infortune has meant that the EU has to keep an eye on other countries, to make sure the problems spread. They do this by looking at a set of indicators, which are supposed to show macroeconomic imbalances. Denmark is not quite at southern levels yet, but the European commission pointed out, in its latest critical report, that Danish export has lost 15% of its export market share. The reason for this is according to the European commission is "*Denmark price competitiveness has deteriorated somewhat due to high nominal wage agreements in a period of overheating and weak productivity growth*" (European Commission, 2012).

Before the financial crisis Denmark enjoyed very low unemployment, as low as 1.9 % in 2008 (Hansen, 2009), which put a lot of pressure on the wage level. Both the wages and productivity affect the price of the products produced in Denmark, however because of "sticky wages" there is hardly ever decrease in nominal wages, only a slowdown in their increase, therefore there is little that can be done to affect the wages other than in an upward trend. Productivity is however another discussion, which is what this this thesis will focus on.

But as with wages, productivity is also affected by the state of the marked, some years there will be more increase and some years there will be decreases, this is also to some extend a result of which type of productivity you choose to look at. In 2010 when the Danish Economic Councils (DEC) released their report looking at the Danish productivity it was a big topic, because the countries Denmark is usually compared with, have had higher growth in their productivity. This might be a result of the fact, that they worked with data from 2007-2009. Because already the same year as the report came out, the productivity had risen greatly from being negative the three previous years, to being positive. However the European commission report was released in 2012, and it somewhat still proclaims that Denmark have a problem with its productivity, which is difficult to say, since the numbers for 2011 has not be released yet.

But what is productivity? There are different interpretations of what it is, the perhaps most common way of thinking about a productivity increases, would be the ability to do something at a faster rate, but that is not always the case. In economics it is more the value increase you look at, this is measured by comparing output, to the initial input of resources, such as capital and labor. In the DEC report, they also talk about Total Factor Productivity (TFP), which looks at the unexplained value increase, this has up until recently been thought of as knowledge, which translated into R&D and education. This was in an attempt to explain why

the output changed, when the input did not change that much. The conclusion was, that the knowledge used to handle the process from input to output changes.

This way of thinking was introduced by the neoclassical synthesis and brought on by New Growth Theory (NGT), which has been the mainstream economic way of thinking the last couple of decades. Therefore it is no surprise that the DEC also thinks like this. But one of the problems is, that not all Danish companies do R&D, only about 30% of Danish companies do some form of R&D (Jensen, Johnson, Lorenz, & Lundvall, 2007), which means that the results and recommendation from an analysis will be off. Therefore an alternative or supplemental theory of or the National Innovation System (NIS), could be used to give more accurate policy recommendation, when it comes to knowledge and how to foster it.

But the matter of the fact is, that Denmark has had a problem with its productivity growth the last couple of years, where 2010 was the exceptions, whether it persist or not is not known yet. But the EU seems to think, so the research question of this thesis will be:

"What is the problem with Danish productivity"

This thesis will start with some methodical thought. First some general thoughts on the basic economic models. Also since there are different ways of understanding and measuring productivity, there will be a discussion of what productivity is, and how it is measured, this will mainly be done by looking at the OECD manual on the topic. And since this thesis will pursue the idea, that the innovation system thinking will provide a better alternative for fostering knowledge, than what the DEC suggest, the link between productivity and innovation will be discussed.

In section three of the thesis, the theories will be presented and discussed. The first theory that will be presented is the neoclassical growth model, by Robert Solow and then after that, NGT will be presented using authors such as Paul Romer and Charles I. Jones. This is because it is a part of the framework for the DEC report, and for that matter, a lot of other contemporary reports. But NGT focuses on R&D and education, as the main drivers behind knowledge is insufficient, when it comes to real world implication. Therefore the National Innovation Systems (NIS) thinking will be presented.

However in the DEC report, they compare Denmark to other countries as a part of the convergence discussion. This thesis will not go deeply in to that discussion, since there are different reasons for each other countries performance, and it is beyond the scope of this thesis to explain them, it is however relevant because it to a certain degreed determines whether Denmark has a problem. A different approach with more focus on knowledge will be presented, as an alternative to why there is a difference in the productivity level

and growth of countries. This will be done by using a combination of leapfrogging theory and lock-in theory. This is also to show there are structural issues that bind and commit countries to a certain way of production. And thereby it is not as easily changed as it is suggested in the DEC report.

The alternative to NGT will be the NIS approach, which takes a wider look at things than NGT, and in this case might be seen as supplemental to the NGT, or alternative, because both theories sees knowledge as something essential to economic growth and productivity. However NGT hardly defines knowledge in any particular way, other than discussing whether it is a public or private good, and NIS is able to shed some light on this aspect.

Since this thesis works with the DEC report, their empirical data will also be up for scrutinizing. However instead of arguing about their results, and the way they have obtained them, this thesis will try to hold it up against what authors working Community Innovation Surveys (CIS) find. Authors such as Bengt-Åke Lundvall and Jan Fagerberg. But the thesis will also have a look at data from the European innovation scoreboard, because it looks at the development of different innovations indicators in Danish context, and compares Denmark with other countries, which it can do because it takes a more quantitative approach.

In the end, the thesis will hopefully be able to shed some light on where Denmark has problems with its productivity, and maybe to give some careful suggestions on how to help them.

2. Methodical thoughts

When working with economic models, there are certain things you must consider while doing so. The first is that it is a model, it should contain the main features of what happens in the real world, but not everything, since the idea is that it should give a more clear view of how the world functions. According to Jesper Jespersen (2007), Carl Popper (famous scientific philosopher) worked with tree worlds when it comes to doing research. The first world is the reality that we wish to understand, it does not matter if you are studying natural science or social science, the ambitions are the same. However there is a limit to how much a person can perceive in a dynamic world in motion. Therefore the second world takes the main features of what they wish to analyze, and make a model which then is tested to see whether it fits to the real world . If it is not able to be tested or falsified, it can only remain a hypothesis, and should therefore not be used in the third world, where the mode is used to say something about world one, for instance give policy recommendation (Jespersen, 2007).

When looking at the models used in the DEC report, they come from neoclassical and NGT with reference to Robert Solow and Paul Romer. Their models will be looked at to see why the DEC argue as they do, however the final presentation of the model, will be done by using Charles I. Joneses model, because he was able to falsify the Romer model, by using an empirical measurement of R&D and show that the growth in the respective countries was far lower than what Romer suggested it would be.

NGT works with closed systems/models, this is to help the understanding of specific mechanisms in a closed environment. This resembles what they do in natural sciences, where you have a controlled environment (laboratory) to do tests in, where you exclude outside interference. This might work in when you are testing medicine, but the further you get in the process of developing it, the more you will realize, that at some point you will have to taking in more variables. In the real world, you usually cannot lockup a person, and make sure they only intake what you prescribe.

The same line of thought is used in some aspects of economics, especially in classical theory and intermediate economic textbooks. A known example that goes back to Keynes, was when looking at changes in the labor market, where there was little consideration of the fact, that it will have an influence on other markets such as the goods marked. For instance when unemployment is too high, classical theory argues that it is because the wages are too high. So their conclusion on this should be to lower wages, and then employers will demand more labor. However if you look at the demand side on the goods marked, when the costumers lose some of their purchasing power because their wage is lowered, their demand for goods will also fall, which then again results in a lower demand for labor, because the employers will not need to pro-

duce so much, and then it is a vicious circle with decreasing demand (Davidson, 2011). One could argue that the goods gets cheaper when the wages are lowered, and then the goods become easier to export, but also relatively more expensive to import, which can either be a good or bad thing. But the matter of the fact is that the use of closed models has been dominating the last couple of decades. And they have a tendency to stay in Poppers second world, because they have a hard time being falsified. As an alternative or supplement to the NGT discussion, the NIS will be presented, because it sees the economy as a system, this will be discussed further later in this section of the thesis.

In many ways you can see the aspiration from economics to be able to give more accurate answers, than what can be safely advocated, such as in natural science (Jespersen, 2007). This is presumably also the reason why the use of math in economics is so comprehensive. It makes it easier to give policy recommendations, and it is seemingly more pedagogical, and no one should be in doubt these days that economics is very important in politics. Especially when forecasting how a policy implementation will affect the economy in years to come. These forecasts can at times be rather naive, when they look up to ten years ahead, in situations like this it should be better just to admit "we simply don't know" (Keynes, 1936).

The same goes for the productivity debate, which has been increasingly focused on the aspect of Research and Development (R&D) and to some extend education, to explain the development in productivity or that is Total Factor Productivity (TFP), which is the part of productivity or value increase we cannot explain by the change in labor or capital. This is why this thesis will incorporate the NIS to give further alternatives than R&D and education.

But there is still the discussion about productivity, because there are different ways of seeing productivity, and a lot of different ways of calculating it. Therefore in the next section there will be a small discussion about what productivity is, and how it could be calculated.

2.1. Productivity discussion

The OECD has made manual for measuring productivity, which states productivity in general is a measurement of the output compared to the amount of input such as $\frac{Gross\ output\ or\ Value\ added}{Input\ such\ as\ labor,\ \ capital\ or\ KLEMS}$

This is a bit at odds with what you might normally think. Since this means that it will be a value increase that is look at more than the ability to do something faster. But even within economic there are different ways of measuring and presenting productivity which is where the OECD manual comes in handy, because Denmark is a OECD country and is using similar taxonomy.

Type of output measure	Types of input measure			
	Labor	Capital	Capital and labor	Capital, labor and intermediate inputs (energy, materials, services)
Gross output	Labor productivity (based on gross output)	Capital productivity (based on gross output)	Capital-labor MFP (based on gross output)	KLEMS multifactor productivity
Value added	Labor productivity (based on value added)	Capital productivity (based on value added)	Capital-labor MFP (based on value added)	-
	Single factor productivity measures		Multifactor productivity (MFP) measures	

Table 1 Productivity measurements (OECD , 2001)

Looking at table 1, there are several variants of productivity. In the first column we have labor productivity, which is not as suggested, a measurement of the productivity of the labor force only, but also depends intermediate inputs and capital. It looks at the gross output and the divide it by the labor input. Alternatively it can be done by value added instead, as shown in column two, this is less sensitive to changes in the composition of production, because it does not include them in the measurement. This means that labor productivity is not an aggregate of the personal capabilities of the individual worker, but a way to see how much value increase is per worker. It can still be somewhat relevant when trying to compare wealth between countries. Therefore labor as an input, is usually measured in hours, because the average work hours differs from country to country, however the way which work hours is calculated can also be different in between countries, so therefore a bit of caution is needed (OECD , 2001).

The payment is also necessarily to look at, since wages can make up for a significant amount of the cost related to producing the product, but again a bit of caution is needed, it is not necessarily enough to look at how much the employees gets per hour, it should be the cost the employer has in connection with the employee, things such as pension and medical care should therefore also be counted in. A last thought on labor as an input, it is sometimes relevant to have a differentiation of the labor, according to skills, because there are many different professions in the world and none of them are easy to compare. It also allows for a better view of how the productivity fairs. The same is done in the DEC report, because if you are able to determine there is a problem with the productivity, then you might also want to be able to give a more specific explanation to why there is a problem, there might be some areas there are slowing down the general growth of productivity.

In the case of the DEC report, they also compare Denmark with other countries, but other than USA the most of them are European. But why compare Denmark to other countries? The research question of this thesis was “What is the problem with Danish productivity?”. If Denmark was the only country in the world its productivity would not matter, but as stated in the introduction, Denmark is very dependent on its trade, therefore whether it is a problem also depends on if the other countries productivity have followed a similar pattern, if they have, they do not have any advantages when trying to sell their good, at least not in that manner. Therefore the thesis will from time to time look at how other countries fair.

The measurement of capital productivity is calculated in the same way as labor productivity, however the measurement for capital as an input is a bit different, and is given by “the flow of services adjusted for changes in the quality of investment goods” (OECD , 2001). In this sense they talk about stock and flow, some of the properties of capital entails that it is not a static number, because there is investments in new capital and depreciation of the old.

Capital may lose its value over time as a result of wear and tear, or because new capital renders the old inefficient. However even though a car is worn down, does not mean that its capacity might be reduced, it might simply require more maintenance than that of a new variant, which off course puts it worse off, but it is hard to measure such alteration of work capacity, and is usually just a value decrease. Think about a new car, it might lose some of its value over the first year, but it does not result in an equals loss of functionality.

Robert Solow also encountered a problem with the utilization of capital, which will be discussed in the next section. The matter of the fact is that even if the amount of capital is known, it is necessarily the same as the amount that is actually being used, a way around this could be to look at machine hours instead, but there is no such data available. Therefore capital can be somewhat elusive, because there is a lot of different ways to measure it, however in the interest of comparing countries, most OECD countries have an adopted standard called “The System of National Accounts” (SNA) formulated in 1993 and again in 2008. The DEC report works with data from statistic Denmark and EU KLEMS, and OECD. Statistic Denmark uses a system called ENS95 which is fully comparable with the American SNA93, but is more precise, because of requirements from the EU to be able to compare its countries more efficiently (The European Union, 2012).

The multifactor productivity (MFP) measurements are a bit different, since it requires a combined index of labor and capital, but otherwise the approach is the same as described above.

The last column is where the combined inputs are used, capital, labor, energy, materials and service (KLEMS). This is the same measurement used in the DEC report. Again you divide the gross output with the

combined inputs. This is a newer technic of growth accounting, in the next section the thesis will look at the Solow model, which was one of the first models use growth accounting (OECD , 2001). In the Solow model he however only worked with capital and labor, and ended up with a residual as the unexplained factor of growth, which he speculated was because of technological growth. There were several reasons for this as we shall see in the next section, but one of them could also have been the lack of data and computing power, which is less of a problem today. Therefore the KLEMS measurements are used since they contain more different aspects, and thereby lower the unexplained part of growth or TFP. But the more different variables there are, the more will you be able to get different results. When it comes to input output analyses, the OECD suggest that outputs is excluding net taxes on the products, but includes subsidies and excludes transport (called basic price). Whereas inputs are best valued with net taxes on the product, also including trade and transport margins. To give an overview there is Figure 1, which also gives the suggested SNA/ENS measures for input and output.

However there are some general problems with the input and output approach to measuring productivity. One of them is the time lag there is between the year of observation and the publication of the results, that can be anywhere between tree to ten years (OECD , 2001).

Also as shown in figure 1, taxes and subsidies differs from country to country, which obviously makes it a powerful policy tool.

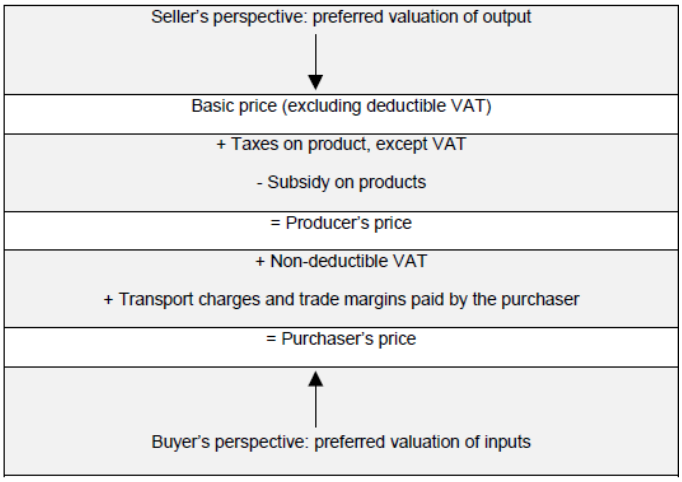

Figure 1 How to calculate prices (OECD , 2001)

Overall productivity is not a simple measurement, the problem is to some degree the availability of data, detailed data is very expensive and hard to gather, therefore researchers make do with what is available, even though it is not perfect. But maybe in time there will such measures will become available.

2.2. Innovation and productivity

Before continuing the thesis, there is also a small need to discuss the linkage of innovation and productivity. Since this thesis will suggest that when it comes to the NIS thinking, it offers better explanation of how to promote knowledge, than what the DEC suggest in their report. There are several report, showing the effect of different innovation indicators on productivity and economic growth (Fagerberg & Srholec, 2008) (Danish Economic Councils, 2010). But the terms innovation can be just as elusive as productivity, because what is innovation? In general it is viewed as something new, such as an invention, however there is a dif-

ference between inventions and innovations, innovations are the attempt to carry out the invention, bring it to the marked for instance and make it commercial success. There is however a time lag between the two, as will be shown in the example with lock-ins and QWERTY later in the thesis, and the lag can be several years or more (Fagerberg, 2005). The person who makes a commercial success out of an invention, is not necessarily the same as the one who invented it. It has often been seen that even though an engineer has made a superior invention, he lacks the knowledge about the marked to make it a commercial success. In this case the "entrepreneur" is needed, which is seen as the person who is able work with the factors needed to make it a success, such as market knowledge and the ability to secure finance. The role of the entrepreneur differs from theory to theory, but the general rule thumb is that they facilitate innovation and create growth.

Jan Fagerberg and Martin Srholcec made a paper in 2007 called " National innovation system, capabilities and economic development", as the title suggest, it looks at four different aspect that influence the development of a country. The four aspects are; innovation system, governance, political system and openness. According to Fagerberg and Srholec (2007), innovation system and governance are particular important for economic development. They selected a sample of 100 countries and used 25 indicators that show "technological indicators", which could be understood as innovation capacity (Fagerber & Srholec, 2007). Even though they would have liked to have more indicators, the lack of data from developing countries limited them and they were forced to use data such as scientific publications, R&D and education. However the regression showed that when tested against GDP per capita, was a positive correlation, and it was significant at the one percent (Fagerber & Srholec, 2007).

Product innovation is only one form of innovation, there are different types, each measured in a different way, and it is not easily measured. This is because of the intrinsic novelty of innovation, classifications are sometimes hard to come by, and takes time to develop (Fagerberg, 2005).

Looking at Innovation from a broad perspective there are some different types of innovation the most obvious one is product innovation, that comes in form of new product, but there are others, such as process innovation, organizational innovation, marketing innovation and changes in design. When thinking about increasing productivity, in the sense of doing something faster, process innovation is properly the one that will help the most. However when looking at productivity, as the increase in value, innovation in the all manners have something to say, either because they increase the value of what is produced, or because it can cut costs.

2.2.1. Measuring Innovation

When measuring innovation capacity, it might not be as "simple" as looking at input and outputs. Looking at innovation input, the most widely used measurement is still R&D and to some degree education. The way to measure R&D was formalized in 1963 by the OECD, in the so called Frascati manual, which has been improved on since then, and the latest version from 2002 and is the seventh. However even though there is a lot of detailed data, the aggregated gross expenditure on R&D is still widely used to be pinned against numbers such as productivity (Smith, 2005). The increased focus on R&D will be discussed later in the thesis.

Another alternative is to look at the output of innovation, but in most cases there is only one type of innovation that yields easy accessible data, and that is product innovation. Therefore an option is to look at how many products the companies have release, such as in the DISKO survey. Alternatively you can look at patents. Which have the advantage of having a long time line, therefore allowing to see the development through time. But as with R&D, you are not guaranteed anything. Patents are for invention and not necessarily something that is going to enter the marked and give a payoff, therefore it might not give the clear view one could hope for.

But as will be shown in this thesis, the DISKO survey offers another perspective on indicators of innovation capacity. The DISKO survey is a new kind of method of measuring innovation called Community Innovation Survey (CIS), which looks at disaggregated data of innovation indicators, made with help from the Oslo manual (Made 1992 the Oslo manual was an attempt to look at how innovation actually can be measured, the newest version is from 2005 and is the third edition), such as "*Expenditures on activities related to the innovation of new products (R&D, training, design, market exploration, equipment acquisition and tooling-up etc.*)" (Smith, 2005). Therefor they do not solely looking on R&D, they also look at the output of the firms, whether it is radical innovation or incremental and their sales. This also lead to a need to know, how new an innovation indeed was, the Oslo manual divided it up in to different degrees, such as "new to the firm", "new to the industry" or "wholly new". Because it says something about the quality of the innovations, if it is wholly new then it would properly classify as a radical innovation, while if it was only new to the firm, it would be classified as incremental. They also look at the collaborations within the industries to do innovation, which is something the DISKO survey also does, because often it takes a team effort to make an innovation a success.

In the methodical section, the general thought about how to do research has been described, and why a more broad view of innovation needed. Also the question about how to perceive productivity has been discussed, revealing the fact that it is more of a value increase, than doing something faster. And last the

link between productivity and innovation has been discussed, as well as the most common ways to measure innovation. In the next section, the theories used in the thesis will be presented, to give a deeper understanding of why NGT works as it does, and why NIS can help expand on the discussion of productivity.

3. Theoretical basis

In this section of the thesis, the framework for understanding the models they use in the DEC report will be laid out, furthermore the theoretical thought behind the NIS will also be described to give a better understanding of what knowledge is, and how do we foster it. First up is the Solow growth model, this model will be described because Solow was one of the first to link the residual in growth accounting to knowledge, which eventually lead to the Romer model, which was the first to endogenize knowledge in the model, and therefore it makes the basic for their understanding of how to treat growth and knowledge. This presentation of the model will however be done by using Charles I. Jones (2002), because he criticize the Romer model for not being in line with empirical evidence, and thereby falsified the model. And according to the adopted macroeconomic methodology, that means it should not be used in a policy context, which is what the DEC is about. Jones proposed some changes to the model which supposedly makes it more realistic, and thereby a bit more relevant in a policy context.

A great deal of the problem presented by the DEC, revolves around the fact that Denmark is doing worse when it comes to productivity compared to a lot of other countries. There can be a great deal of reason for this, the one this thesis will present as an alternative explanation is the leapfrogging and lock-in aspect, this is also to show that things are not as easily changed as the DEC report would like it to be.

However as mentioned there is still a gap in NGT and its ability to explain knowledge and how in functions on a national level. Therefore the last section of the theoretical section will be on the National Innovation System and the thought behind knowledge and innovation.

3.1. Solow Growth model

The Solow growth model was in itself not a new way of thinking, since it built on the Harrod Domar growth model, while relaxing some of the assumptions, however the empirical investigation that followed was. The investigation challenged the predominant way of thinking, which was you needed more capital to get growth. He however showed that alone was not enough, by showing what happens if there is no technological change.

The model is simple, it has one sector, that produces one good, which can be used for either investments or consumption. No foreign trade or public sector, money is neutral and prices are flexible, meaning in the

long run, a change in the amount of money available in the marked will not affect the interest rate. And last, changes in population, technology and in capital are exogenously given, meaning they are not explained within the model (Snowdon & Vane, 2005). Even though some of the assumptions are rather unrealistic, and thereby not following what was described in the methodology section, they allowed him to prove a point, since he could then focus on the production function.

The simple production function is given by Y = F(K,L), in a Cobb-Douglas form it looks like this; $Y = K^{\alpha}L^{1-\alpha}$ where 0 < α < 1. α is how much a factor contributes to the entire production "Y", where "K" is capital and "L" is labor. "α" will be different from country to country, implying that the more developed a country is the more capital it will have. This comes from the understanding that when countries, or more specifically, its inhabitants got richer, their savings would also rise, which in this model automatically leads to investment in capital (Mankiw, Romer, & Weil, 1992).

The production function is presumed to have constant returns to scale, so if you double capital and labor output will also double. Which should be understandable, since there is no technological advancement in this mode, all that they can do is produce more, by the same means as they are used to.

Countries differ in size, so it should only be natural that we look at it from a per. capita view. So dividing the output and capital by the size of the labor force; Y/L= y and K/L = k, and rearranging the former equation to get $y = k^{\alpha}$.

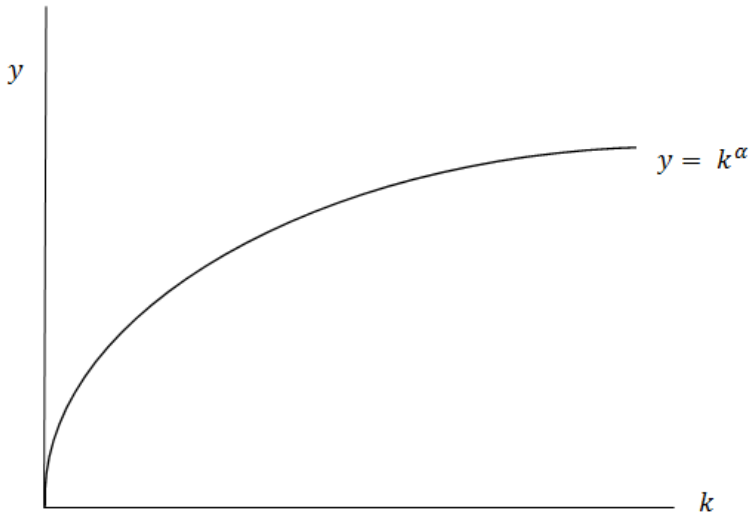

Figure 2 Decreasing returns to capital (Snowdon & Vane, 2005)

Graphically this is shown in figure 2. The notion is that there are decreasing returns to capital. For example if you give a man a shovel, he will be able to dig faster than if he did not have it, but there is not much point in giving him an extra shovel, which would be the only possibility in a model without technological ad-

vancement. Were they two people to share the same shovel, the shovel would be more used, since they have to take turns using it, allowing the other person to rest in the meantime, and thereby having a larger marginal utility of the shovel , but it will still not be as effective as if they both had a shovel. The idea is graphically shown in figure 2, and shows that with an increase in k, the output also falls, showing diminishing returns.

Following the argument above, capital is clearly important, therefore the change in capital is showed by; $\dot{k} = sy - (n + d)k$. Were "sy" is the savings rate per capita, since what people save is automatically turned in to investments in new capital. And as in the example with the shovel, more people having to share the same amount of capital is affecting performance negatively, therefor the growth rate of labor force "n" is seen as negative. The same goes for "d" which is the depreciation of capital, since nothing lasts forever.

Graphically this is showed below in figure 3.

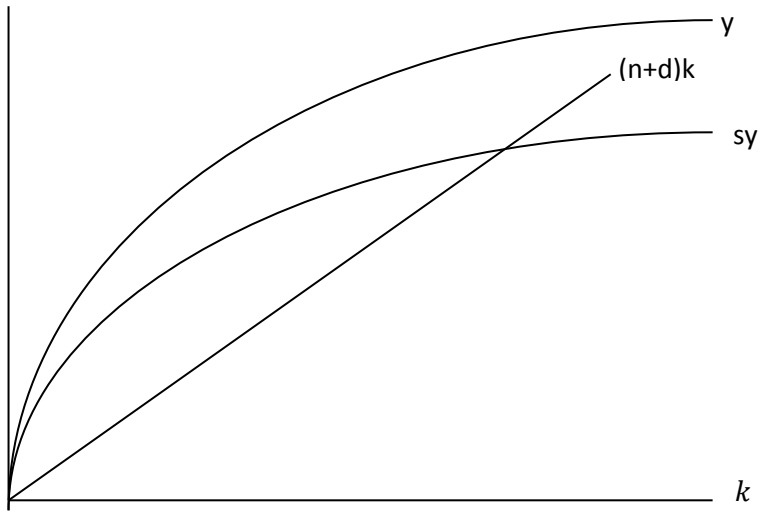

Figure 3 Steady state in Solow Growth model (Solow, 1956).

Where the "(n+d)k" crosses "sy", is called steady state, according to neoclassical theorem the economy will automatically move towards steady state, if left alone, this has in broad terms breed a political understanding, that the economy will performer at its best if left alone. Making a laissez-fair environment that usually flourishes while the economy is doing well, but as we have seen the opposite moves into effect when the economy breaks down. And as will be shown later, it is also in contrast to the thinking of the NIS.

It is the movement towards "steady state" that is considered growth, when the economy reaches steady state everything will be static, and there will be no more economic growth, which was the point he tried to make. In "steady state" everyone produces the same amount and consumes/saves the same amount, the only way to move above this point, is by saving more so you can get more capital. But as we saw in figure 2

there are diminishing returns to using capital, so at some point the growth will come to a hold if there are no technological advances (Solow, 1956).

3.2. The expanded Solow model.

Last section showed the theoretical aspect of what happens if there are no technological advancements, which seems rather obvious when looked at from a perspective, but then again, economic growth as have been experienced in the last 200 years was unheard of in the past (Verspagen, 2005). Using the same model, Solow expanded it, to show how it would work if containing technological advancements. In this case technology is also exogenously given, like "manna from heaven" so to speak, other than that he also brought the time aspect in to the model, so he ended up with a new equation; $Y = A_t K^{\alpha} L^{1-\alpha}$ $0 < \alpha < 1$. Where "A" is the technology available in the society and "t" is time. Again looking at it from a per capita view by dividing it with "L" it becomes; $y = A_{t0}k^{\alpha}$ (Snowdon & Vane, 2005), which results in a new figure 4. In this model the technology at a given time, is able to increase productivity. Otherwise it is the same as figure 3. Now instead of giving a person an extra shovel, we might give him an excavator instead. This allowed for continues growth in the society as long as there is technological advancement, but this was only in theory, he still had to prove it empirically, and the fact that technology was exogenously did not strengthen the model. In the next section the empirical support for his paper will be looked at.

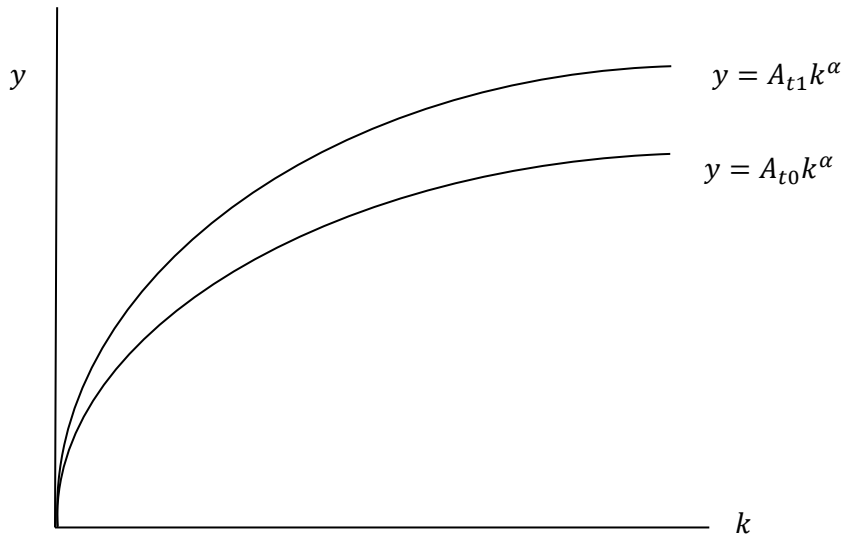

Figure 4: Output pr. capita with technology (Snowdon & Vane, 2005).

3.2.1. The Solow residual

In 1957 Solow came with an empirical investigation of the model, he did this with data from 1909-1949 in the US. After he wrote his paper, there was a lot of debate concerning the results, and the way he achieved them. As we saw in last section there are three things that affect growth in GDP which is capital, labor and

technological advancement. It is possible to measure changes in labor and capital and see how much the rise in GDP is result of it, however there is no exact ways of measuring technological change. However if you have four variables, and the three of them are known, you will be able to calculate the last one, which is what Solow did, and it became known as the Solow Residual or Total Factor Productivity (TFP) (Snowdon & Vane, 2005).

Solow knew that his data was not perfect, one of the first problems he ran in to was how to "handle" capital, and what was capital. He used Raymond W. Goldsmith's estimates which eliminated the state, farming and long-termed consumer products from the model. But that was not the only problem he had to overcome, even though he could measure all the capital in the US, it was not necessarily the same as what was actually being used, some of it may be idle. He tried to work around this, by removing an amount of the capital equal to the unemployment rate, he felt that it would be better than doing nothing (Solow, Technical Change and the Aggregate Production Function, 1957), and as discussed in the methodology section, today there are still difficulties working with capital, so even though it is more than fifty years since Solow had trouble getting an accurate measurement of the capital actually used, there is no such number yet.

One of the ways to achieve growth, as specified in the simple Solow model, was a change in the capital-labor ratio, however this was on average neutral, so there was not any changes. (Solow, Technical Change and the Aggregate Production Function, 1957) This left the remaining growth in the period, to be claimed by technological advancement. Empirically this was shown by the fact that from 1909-1949 output per work hour increased from 0,623$ to 1,275$. The residual share of this was 1,809, which is the same as 0,705$ that was on the account of technological changes, which leaves 0,08$ or 8 cents, to be from increases in capital, which is the same as technology is responsible for 87,5% of the increase in GDP growth per hour. Solow himself was astonished by this result, but as mentioned afterwards he received a lot of criticism for the study, because it was highly speculative to presume that the residual was because of technological changes. One could speculate that this was intentional, because it lead to an increase in the research in growth accounting, which again led to a discussion about the fact, that technological change was exogenously given. The reason why Solow did not go deeper into a discussion of technology/knowledge, was according to himself that he would not pretend to know what he was talking about. However the years went by and economist continued to keep the technological change exogenous, until Paul Romer tried to make it endogenous, and after a couple of attempts succeeded, which will be the topic of the next section.

3.3. The Romer and Jones model

It took thirty years before anyone really succeeded in making technology endogenous, at least in the case of the Solow model, since within Schumpeterian economics it was implemented earlier. After knowledge was made endogenous, models containing this aspect was referred to as New Growth Theory (NGT).Paul Romer's attempt to make technological change endogenous was done through two articles. The first is from 1986 and the second came in 1990. His 1986 model tried to explain technological change as an unplanned consequence of capital accumulation within the firms, as a form of learning by doing. So that the employees become more productive as they work with the capital. As such, an increase in capital therefore leads to more knowhow in the firm. And since knowledge is seen as a public good, it automatically becomes available for everyone, even though the company does everything possible to keep it for themselves. Therefore the production function would display increasing returns instead of constant return (Snowdon & Vane, 2005). However the model still depended on capital for growth and for a bigger part, knowledge was still exogenous, therefore Romer was not that pleased with it, so in 1990 he wrote a new article trying to correct it.

He worked from three premises that allowed him to build a growth model with endogenous technological growth. The first was that he followed the Solow model from 1956, in that sense that the raw materials being used in production are in large terms the same, but the way they are being handled differs, and as time passes it becomes more and more complex. And through technological change and capital accumulation, the output per hour worked increases (Romer, 1990).

The second premise was where it stood apart from the Solow model, since it states "that technological change arises in large part because of the intentional actions taken by people who respond to market incentive" (Romer, 1990). This was in the effort to make the technological growth endogenous, instead of being "manna from heaven". This did not mean that all innovation would be made on the basis of private entrepreneurs seeking profits, he acknowledge that the public would also play a role, using the example of how the basic understanding of electromagnetism came from research conducted in the academic world, but magnetic tape and the videocassette was a result of private firms seeking profits.

The third premise, and the one that allowed Romer to move in to the field of endogenous growth models, was the concept, that once the cost of creating knowledge was paid, the marginal cost of reproducing it would be cero. This meant that it to some extent could be non-rival, since it can be used of more than one person at the time, because the cost of making one more copy is so low, that it can be said not to exist.

3.3.1. Knowledge as an economic good.

When talking about economic goods there are two different parameters discussed, to what degree is it excludable, and to which degree does its usage rival with others. For instance if a good is completely rivaling in it use, it means that if one person is using it others cannot, where the opposite goes for non-rival goods, it can be used by multiple people at the same time. The excludability of the good refers somewhat to the legal aspect of the good, in the sense to what degree can you prevent others from using it, this could be done by putting a lock on the item, putting up a fence or discourage other by threatening to take legal actions if they use it, such as the case with patent, copyright and trademarks (Romer, 1990).

Figure 5 puts the way of thinking into a perspective. The conventional economic good is rivalrous and excludable. In the opposite end you have public goods, which are non-rivalrous and non-excludable, these goods are usually provided by the public, because of their nature, private individuals have a hard time making a profit from them. Take for instance a piece of road, more than one person can use it at the time, and it is possible to exclude others from using it by putting up a wall or fence, that way you can charge people for their usage of the road. But the cost of keeping people from using it is too high compared to the profit they will be able to make, and not making it excludable will result in people will become "free riders", in the sense that they will not pay for it, but will still use it. Therefore road construction is usually maintained by a form of government, which makes it accessible to everyone and also makes everyone pay for it through taxes.

	Excludable	Non-Excludable
Rivalrous	Private good	Common Pool Good
Non-Rivalrous	Club/toll Good	Public good

Figure 5 Goods taxonomy (Jones, 2002).

The interesting thing is the goods in between public and private goods, as mentioned knowledge is non-rivalrous in the sense that once created, it can be reproduced at low cost, but to what degree is it excludable? Looking at the tree premises, the second one clearly states that it should be on private entrepreneurs that are seeking profit, that initiate researcher of new knowledge, however this becomes a problem if they cannot get rid of the free rider problem. But as mentioned there are ways to make knowledge your property, this has often been in the aspect of patents or other Intellectual Property Rights (IPR). This has the effect, that those who try to use the knowledge have to pay for the usage, and thereby the entrepreneur still gets his profit and thereby the entrepreneur retains his motivation to innovate (Romer, 1990).

This is obviously an ideal thought, there are some problems with it, even though you can argue that knowledge is not rivalrous, the paper or disk which it is written on is, but it does indeed not take much effort to replicate it. Another aspect is, that the person inventing it might have transfer what he knows to a paper, but that does not mean that he instantaneously forgets it the moment it has been written down. This aspect of human capital is important, because together with the application of a patents, it helps spread the knowledge in the society, which is needed for the production function to get increasing returns. The way that patent help do this, is because when someone applies for a patent, they have to put the specifications for the product forward and thereby allow others to be able to study them, and if they find it attractive and want to produce it, they can make alterations so that they do not violate the patent.

Human capital is another way of knowledge transfers can occur, however in some cases, employers makes contracts that state if the employee leaves the company, he or she is not allowed to work for a competitor for a certain amount of years crippling their ability to pass their knowledge on. These are however illegal in some parts of the world, for instance in Californian because they are seen as a hindrance to the knowledge spread, here the most effective way to keep the employees and their knowledge, is to bid the highest for their services. Related to the human capital discussion is the aspect of absorptive capacity, you might be able to describe the design of a product but it can take some education to actually understand it, not everyone will be able to understand the design of a nuclear bomb, even though the blueprint is not hard to come by. The fact that human capital helps knowledge transfers, could mean that the interest in educations as a proxy for knowledge from the NGT perspective, is not only based on the fact that it increases knowledge stock in the economy but also helps the spread of knowledge, but that also depends on how the labor marked functions and cultural aspects. But the knowledge aspect of growth will be discussed further later in the thesis.

Romer´s model therefore ends up having Neo-Schumpeterian qualities (Snowdon & Vane, 2005), since the main idea is that the individual entrepreneur will want to invest in new knowledge, because they can be sure to reap the benefits from it, this is because of the legal settings that allow them to maintain their ownership over the knowledge. Through time many people have indeed made great discoveries, for instance Isaac Newton´s gravitational theory must have benefited him in several way, but compared to what society has gain as a whole, it hardly registers. And in the Romer model the same thing goes, there has to be a balance of how much the entrepreneurs can protect their innovations and how easily it spreads so the production function can display increasing returns (Romer, 1990).

The Romer model however ran into some critique from Charles I. Jones in 2002. Because it could not be empirically proven. Therefore it will be Jones's model that will be used in this thesis and not the original Romer model.

3.3.2. The Jones model

Charles I. Jones´s model is expressed like this; $Y = K^{\alpha}(AL_Y)^{1-\alpha}$, Jones´s model is labor augmented since the "A" empowers labor, this does not always have to be the case, it can also be capital augmented and both labor and capital augmented, this is known as Hicks neutral, which resembles the Solow model a bit more, but the important thing is that it makes the model have increasing returns instead of constant .

"A" is stock of ideas or knowledge that have been made through the ages, changes in "A" can be described as $\dot{A} = \bar{\delta} L_A$, where the amount of new ideas depend on the amount of people that tries get new ideas L_A, and the rate at which they get the new ideas is given by $\bar{\delta}$. However in this model the rate also depends on the stock at hand, so as time goes by, it becomes harder to get new ideas since they have properly already been thought of. But on the other hand, it can also help the idea rate because of the fact that some of the ideas might have a positive influence on the productivity of the "idea makers", for instance the invention of the personal computer has inevitable had an increasing effect on the productivity in many areas. Therefore the rate of new ideas is expressed as $\bar{\delta} = \delta A^{\phi}$, where δ & ϕ are constants (Jones, 2002).

If ϕ > 0 it indicates that the efficiency of which you get new ideas increases with the stock of ideas, such that you get an effect of "standing on the shoulders of giants". Vice versa ϕ < 0 it becomes harder to get new ideas as the stock increases instead you get a "stepping on toes" effect (Jones, 2002).

Jones also suggest the use of the notation ${L_a}^{\lambda}$, where λ is a way to deal with the duplication effect. When a lot of people try to get new ideas, some are bound to get the same ideas, but if someone already have had that idea and patented it, it would be redundant, or if we argue that it is a public good, the person working on his idea could see it when the other person finishes his. Adding these things together in one equation, it becomes: $\dot{A} = \delta {L_A}^{\lambda} A^{\phi}$. In the original Romer model the $\lambda = 1$ & $\phi = 1$, because it allowed for long termed growth. Another area Jones distinguishes himself is in the fact that he assume that constant fraction of the population is in charge of Research and Development (R&D), in Romer´s original model this was determined by the marked, and in itself it is hard enough to measure R&D, therefore this paper will do the same.

However as premise 1 state, growth comes from technological advancement, but in Jones model, the growth in technology is linked to the growth in the population. This gives some problems, as it did when technological growth was a result of accumulation of capital in the earlier Romer model. This means that if

the population stops growing, so does the technologic advancement, because the amount of new ideas becomes smaller relative to the stock of ideas as time passes by.

Romer did not have that problem since $\lambda = 1 \; and \; \phi = 1$, which meant that the scientists productivity would increase as a result of the increasing stock of knowledge. Which should result in much larger "A", but that was also its downfall, since as Jones (2002) showed it could not be empirically confirmed, because it would mean that countries with high spending's on R&D would have higher growth rates which is not the case in western civilization, which is why Jones suggest $\phi < 1$. Otherwise as premise one said, it is in large terms the same as the Solow. So according to the models, the production function only shows growth ceteris paribus, when there is technological advance in the economy. So not changing the inputs other than knowledge, they expect that the output will increase more, which is what was defined as productivity growth in the methodology section. But Solow defined the residual as knowledge without any form of explanation of how this knowledge came to be. Romer expanded on this by making it endogenous and adding R&D as the main factor behind it. This is similar to how the DEC does but they also take education into account, but it is still insufficient. Since Solow, the residual has become less unexplained, by the introduction of measurements such as KLEMS, and still they argue that R&D is still the only way to measure knowledge, this is not satisfying, therefore this thesis will look at it from the NIS perspective, to help expand what knowledge is.

But neoclassical theory suggests that the economies move toward a certain steady state. Which also suggest that if capital moves freely in the world, then at some point all the countries of the world will be equal at some point. This is also the assumption of the Danish Economic Councils work with, and is known as convergence theory. This paper will however not go into that discussion, because empirically it simply does not look like it is happening (Jones, 2002). There is however another aspect that suggest it should be possible to catch-up and even overtake other countries when it comes to economic growth. This comes from the aspect of technological "leapfrogging", which will be the subject of the next section, before looking at the NIS.

3.4. Lock-in and leapfrogging.

In 1993 an article was made with the title "Leapfrogging in International competition: A theory of cycles in National Technological Leadership by (Brezis, Krugman, & Tsiddon, 1993). It connected the aspect of trade, growth and technological advancement, and tried to give an explanation to why some countries switch places when it comes to economic growth. This relates in terms to the discussion of convergence or divergence. The paper suggest that technology and knowledge play an important role when it comes growth, just as it did in the previous section, but going a bit deeper and suggest that learning by doing have an important aspect to why some countries lead and other follow. Looking at it from a historical perspective, the

same countries have not always been economic leaders, before USA it was the UK and before that it was the Holland.

Working with two types of innovation, incremental and radical, they hypothesize that because of radical innovations countries are able to overtake one and another. They argue that because of learning by doing and incremental innovation, some countries who are set on a path of one technology, and continues to improve upon it are not interested in new radical innovations. This is because the radical innovation initial marginal return is much lower than what they already have. This was the case with Holland that in the 18th century, were they leading in shipping, trading and banking, and were therefore not interested in cotton spinning, because it yielded much less than what they were currently doing, it was the English that started utilize the technology, with the higher potential (Brezis, Krugman, & Tsiddon, 1993).

Their model builds on the theoretical foundation of the Brian Arthur model among others, in which the lock-ins in society is because of positive feedback from the usage on one specific technology. In his model these positive feedbacks are created as externalities. Some countries seem to gather increased knowledge in specific some areas, and thereby find it hard to switch to other technologies. There is a general tendency that in some cases technologies become locked in to a specific design, whether it being optimal or inferior.

A classic example of this is the QWERTY keyboard design, which has been handed down through the ages from the typewriter design. Most people do not think about it in their everyday lives, but can this design really be the best way to arrange the keys? If you are looking for typing speed it certainly is not, here another design dominates, which was put forward by August Dvorak and William L. Dealy. In 1932 they patented their "Dvorak Simplified Keyboard" (DSK) that has held the record for speed typing for many years. But we still use the QWERTY design that was patented in the US in 1909 and in the UK in 1924 (David, 1985). There were many reason for the design of the QWERTY keyboard, the biggest reason was the mechanics behind the typewriter. If you were to press two keys at the same time, the clamps delivering the ink to the paper could get stuck together, and that resulted in a lot of difficulties, therefore keys often used were not placed near each other to minimize this error from occurring. Another reason for the design was because of a marketing feature, the top row letters on the QWERTY keyboard are able to write "typewriter" so that sales men could utilize this when displaying it for potential customers. However the making of this design did not happen overnight, the first typewriter patent was filed in October 1867 by Christopher Latham Sholes, but it took six years before he had perfected it enough through trial-and-error, to set it in to production in collaboration with E. Remington and Sons (David, 1985). Even though they struggled to sell the expensive piece of hardware during the downturn in the 1870's, by the start of the 1880 they had sold about 5000 pieces across the US, which were not that many, but it was enough to establish a foothold in

the marked. In the period 1895-1905 it became apparent that the QWERTY arrangement, also known as "the universal", was the dominant design and was here to stay. This happened for several reasons, most of them reinforcing, but to some extend also random. During the 1880s private and public organizations started teaching typing, and this was done on QWERTY designs, so the employees would specify that they were able to use the QWERTY keyboard at a certain speed. Therefore the employers would buy QWERTY typewriters instead of having to train the staff to another typing set.

Brian Arthur modeled this in a simple way. First you have two different types of technologies A and B, they are competing with each other, to be the preferred product of user R and S that have different preferences, toward each product. The value of the product for each user is determined by two things the value of the product in itself and the number of previous user, a network value given by $n_A \; and \; n_B$. So for agent R, technology A will have a value of $a_R + rn_A$ and technology B, $b_R + rn_B$ (Arthur, 1989). For user S, it looks similar for technology A, $a_S + sn_A$ and B, $b_s + sn_b$. The users now have to choose one at the time which product they will select. Arthur put in a "no-regrets" criterion so that once the choice is made, they cannot alter it. In the start of the process it may to some extend be random what products the users chose, as with the QWERTY example, but at some point the network value will be so great of one of the products, that both types of users will chose it. There are examples of how policies might affect how random the initial stages are.

The US nuclear energy industry has been dominated by light-water reactors, this can be linked to the cold war effort, because these light-water reactors were originally adapted from the ones used in submarines, and therefore was a lot of money flowing towards that development (Arthur, 1989). As a result most nuclear reactors in the west today, are of some type of light water design. Today it is the most efficient way to utilize nuclear energy, however other variants are suggested to have a higher potential, but the amount of money already invested in researching light-water reactors, commits them continue using the technology. As mentioned this is the result of externalities, in the case of lock-ins, the problem will be biggest if it is not he optimal design, i.e. QWERTY like situation. How can the public help getting out of these situations? There are some ways of doing this. During world war two, the US navy had an experiment where they trained their typist in Dvorak to see what effect it would have on the productivity, had the entire US armed forces switch during this period of war, the keyboard might have looked differently today, simply because of the fact that the network value of the Dvorak would have risen so much it could force QWERTY out. In the same sense government can through subsidies make other products more attractive, and thereby try to move users.

The other option is to let the marked work, following Schumpeter's "creative destructions" principle, and at some point a new technology will emerge, that is able to render the old one useless or less attractive (Dolfsma & Leydesdorff, 2009).

In the case of QWERTY, you might not need a keyboard in the future, at least not for typing, the telecommunications industry must noticeably Apple and Google have made software that is able to identify words. This is not the first time this has been tried, industries such as the car industry has tried, but it has never really been a success. Even though it is not the first time it has been made, it can de describes as a radical innovation, which is what is needed to break out of a lock-in situation, the keyboard has only experienced minor innovations to some extend and therefore it is only incremental, and will have a hard time breaking the network externality.

There are known cases where the users of the technologies try to avoid lock-ins by selecting inferior technologies, just so that a monopoly will not be made. This can be seen in the airline industry, the same companies buy both from Airbus and Boeing (Dolfsma & Leydesdorff, 2009), so they will not end up with a monopoly capable of charging overprice. But the fact that a whole country be locked in to use one specific type of technology may be a think of the past. Today most countries are on the lookout for "that" new piece of technology that is going to become the next golden goose. An example of this could be the Danish attempt to make wave energy a feasible alternative to other renewable energy, such as the windmill. Which have previously been a great success for the Danish economy. Both these technologies received support from the government, which goes against neoclassical theory that usually comes with a Laissez-faire attitude towards the government involvement. But government involvement is needed if you want to break out of a lock-in. The reason why, is that in most cases lock-in are caused by people, even if you remove Arthurs no regret choice, people might not want to change because they have invested to much in a particular area.

In the DEC report, they argue that great productivity increases can be archive by moving people from low productivity areas to high productivity industries. Even if an industry is in the low productivity area, does not mean that it is not needed. And though Denmark is good at reeducating and skill development (because of its generous social security), it does not mean that it should be done, but the thesis will return to this discussion later. In the next section however, the idea of national innovation system will be introduced, which implies taking policies and using them to foster innovation and growth, in contrast to laissez faire society.

3.5. National Innovation System

In this section, the thesis will look at the NIS, even though it is not an economic theory in the same sense as NGT, but more an approach or conceptual framework for dealing with knowledge and innovation, which hopefully can offer insight on the area of TFP. For it to become an economic theory on pair with for instance NGT, it would need to be conceptualized, that is however easier said than done, even though many authors use the concept, there are still disputes on what it actually means and the boundaries of the term. Bengt-Åke Lundvall sees it as containing everything that in some way influence innovation while Richard Nelson and others focus on organizations that promote the creation and dissemination of knowledge, because it is seen as the main source of innovation (Edquist, 2005). The "narrow" approach suggested by Nelson has the advantage that it is a more tangible approach, offering a variety of measurable areas affection innovation, without resolving to the NGT approach with only few determinants for innovation. But when looking at it in a narrow perspective, you might also lose some important aspects of innovation, as Edquist (2005) points out, even though scholars have moved forward in the understanding of knowledge and innovation, compared to what Solow and Romer suggested, there are still things not understood about innovation. Therefore it is hard to determine the boundaries of the system, but it needs to be done if any empirical investigation is to be made. But the investigation needs to be off the national innovation system, and not just a technological innovation system, which it is in danger of becoming when degrading to a very small focus. The NIS needs to be holistic, this is done by using a more evolutionary approach, that takes history in to account, and utilizes interdisciplinary work. Opposing to NGT, there are no state of equilibrium the economy will automatically move towards. Each country will have different settings, therefore different tools are needed foster knowledge. So for instance even though Denmark and Sweden have a lot in common, they are still worlds apart when looking at their systems (Edquist, 2005), therefore there are no one size fits all when it comes to NIS.

As mentioned there are different opinions amongst scholars what definition to use when it comes to NIS, be it narrow or wide, Edquist (2005) suggest "all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion, and use of innovations", which is also pretty wide. In this sense there are two main components of the NIS that can be identified as organizations and institutions. Organization are usually understood as formal structures that have an explicit purpose, therefore they are they are consciously created. Whereas Institutions are less tangible, such as habits, routines, norms, rules/ laws or established practices that helps mediate the interaction between the organizations, which is equally important. These will be different from country to country, in some aspects the thesis already touched on the subject in the previous section, there are different structures in countries, and thereby different incentives to choose policies to boost creation knowledge. A more tangible way of view-

ing the interaction, is using the triple helix model, that focuses on the interaction of university, government and industry (Etzkowitz, 2003). In the triple helix approach, the universities are seen as entrepreneurs whose purposes has gone from being teaching and doing research, to produce new knowledge, that when combined with the industry will produce new product. The government supplies the contractual setting in the three-way interaction. The interaction between industry and university have had different success depending on where you look , and that is because there are different settings and contexts playing a big role in how big a success it can be. In some parts of the world spinoffs from universities has been a great success such as California, and it other parts, universities have had great success patenting their knowledge, but that is not the case in all cases (Etzkowitz, 2003). But it is still a new idea in many areas, therefore the adaptation process is still in progress, and will presumably always be.

In the next section of the thesis the historical background of the NIS will be described to give a better understanding of why it presents things as it does.

3.5.1. History of National Innovations System and Policies.

Looking back, the terms was first used by Christopher Freeman in 1987, but the idea went all the way back to Freidrich List and his concept of "The national system of political economy" from 1841 (Freeman, 2002). List concern was the gap in wealth between England and Germany at the time. He was able to see what needed to be done for Germany to be able catch up. He found the economic wellbeing of a country was a "*result of the accumulation of all discoveries, inventions, improvements, perfections and exertions of all generations which have lived before us: the form the intellectual capital of the present human race, and every separate nation is productive only in the proportion in which it has know how to appropriate those attainments of former generations and to increase them by its own acquirements*" (Freeman, 2002). This resembles what the new growth theory describes 150 years later, as the accumulation of knowledge. List saw the advantages of having ties between the public institutions such as universities, the educational system and the private organizations. This system thinking enabled Germany to adopt technologies from abroad (mainly Britain), there is a great deal of tacitnes to the learning of new technologies, and therefore the Germans enlisted the help of English craftsmen, this did not just happen as a result of functioning markets, the German government played a big role in this, supporting the development in every way they could, for instance sending officials abroad to inspect how things were done in other countries. However there was one country that at the time that did even better in the race of catching up with Britain, the USA. There were several reasons for this, instead of focusing on industrial training such as Germany, they had focused on education on a wider scale, also the abundance of cheap raw materials, land and the continued

immigration from the rest of the world, meant that at the time they had a favorable position. Again there are no correct way to do things, it depends on the context.

However Germany was the first country to have companies that used R&D, this was in connection with the German chemical industry, they found out that it could be profitable to use a more concentrated effort in developing new products, instead of just stumbling on it (such as it had been the case with for instance penicillin). Soon other countries followed, but it was not until world war two, that the public realized the power of science when focused on a single task, things such as the Manhattan project and sputnik were a testament to this. This was mainly an innovation push strategy, and at that time it was a linear model, where you had first had the invention that was made by doing R&D, then it was designed, manufactured, marketed and sold. This was without thinking about the feedback loops that also are present. But this was the way innovation was viewed up until mid-1960s, and it was driven by some sort of science policy, that focused on the production of scientific knowledge, this was a result of the faith science had gain by harnessing the power of the atom and putting a man on the moon, there was nothing science could not solve. The policies therefore sought to give positive incentives to do R&D, be it in in laboratories, universities or research centers. This was done by supporting higher education and giving tax incentives to firms and IPR (Lundvall B.-Å. , 2004). This is also in accordance with what the DEC suggest to some degree, and will be discussed later in the thesis.

But that development is also one of reasons for the increased usage of the R&D, as a way of measuring the knowledge stock in a country. It was formalized in 1963 with the so called Frascati manual, in the manual they focused on R&D and education of technical origin, which does represent some of the knowledge creation in a country, but not all of it. And it lead to the development of technology policy, which was an attempt to "pick winners" (Lundvall & Borrás, 2005). The companies in focus was usually the ones engaged in R&D because this could be measured, and there was some prestige in having a big R&D department in a country. But the bottom line is, it was a more active role of the government then what had previously seen. In the aspect of laissez- faire and innovation policy, only basic research and general education should be supported and to uphold property rights, therefore a more active role was an improvement away from the ideological world of laissez-fair (Lundvall & Borrás, 2005).

The way that technology policy supported knowledge developments were many, one way was public procurement, in the US for example, this was done via the military demanding state of the art weaponry, this can also be seen as an innovation pull strategy. Subsidies to specific sectors were another alternative to foster knowledge. There was also a big effort to build bridges between the research world and the industries, for instance the collaboration between university and firms, both in research and education. However

there are some problems with this way of making policies, one of the most relevant is the question of which industries/companies to support. In the US and the big European countries they had a preference for supporting R&D intensive industries, again maybe as an old habit, where Japan and small European countries had focused more on upgrading their old industries.

This also sets some requirements to their ability to forecast what technologies/industries are going to be a success. Even if an industry gets support, it might never "takeoff", and some might not survive when the subsidies are removed. Therefor making these policies work in reality, can be hard. But when targeting the whole economy, the two previously described polices will not do, according to Lundvall it only as part of solution (Lundvall & Borrás, 2005). The policies needs to target the whole system, and thereby the organizations and institutions. There may be innovative entrepreneurs seeking profit, but their ability to make profit depends a lot on the system settings in the country. Lundvall and Borrás (2005) calls for an opening of the "black box" of the economy, to tell what parts of the system needs to be focused on as a part of promoting knowledge creation and diffusion. There are many means to do so, again it depends on the setting or context of the country. Some general examples could be the improvement of organizational performance and learning, by establishing standards and having quality controls. Another example and a basic one, is the improvement of the labor force skill by education and qualifications.

So far the thesis has discussed knowledge and innovation only in the aspect of whether it is public or private good, and a small discussion about the ability to measure it. Despite of the fact that it is relevant to both NGT and NIS, therefore in the next section it will be covered in more detail.

3.5.2. Knowledge

In this section the focus will be on the basic taxonomy of knowledge. It should by now be apparent that knowledge is important for the economic growth in a country. Many historians tend to agree, the world economy started to grow around the year 1000 AD, but was not noteworthy before the period 1600-1800 (Verspagen, 2005). This was the result of some historical events, such as the industrial revolution, and the technological and organizational changes that followed, that keeps growth running. Looking back at the Romer and Jones model, there are some problems regarding the technological development they describe, since it is a model, they can obviously not describe everything in a one to one scale with the real world. But it does seem like lacking, looking back at Solow, the residual also known as TFP has sometimes been described as "a measure of our ignorance", because there are other things contributing to growth than R&D. And even today we do not know everything about TFP (Lundvall & Borrás, 2005).

Looking at how knowledge is supposed to create growth can also be somewhat puzzling. New growth theory does not cope well with uncertainty, because the agents in their model are said to be rational. What this means is, that they are unable to make the same mistake twice, and since they learn from each other, once someone has made a mistake no one else will make it, which seems a bit farfetched. Also the way the deal with uncertainty is different, in most cases, it is possible to calculate the economic consequences of their decisions by using a probability distribution for instance, in these situations Verspagen (2005) describes it as weak uncertainty, opposing there is strong uncertainty, which is what Keynes would describe as "We simply do not know".

Technological advancements are hard to predict, which way will they go, and at what pace. Take for instance this quote by Thomas J. Watson Sr. who was CEO of IBM at that time, and expressing his thoughts about the future of the computer. "*the one SSEC machine which was on exhibition in IBM's New York offices could solve all the scientific problems in the world involving scientific calculations*" (Verspagen, 2005), this gives some indications on how hard it is for "profit seeking entrepreneurs" to spot these radical innovations. However once the marked got going, doing incremental innovations, it became apparent that there was a bigger marked for things like this, every time Intel or some other manufacture release a new chip, there are already someone ready to buy it. So there is strong uncertainty tied to technological advancement, the trial and error aspect of for instance QWERTY, setup does not cope well with the (NGT).

But when is an innovation radical and when is it incremental? The first computer was indeed a radical innovation, but what about the Personal Computer (PC)? Even though it was "just" a downsized and cheaper version of the room sized computers, it was still a marked success, more than what can be said about the other giant computers. And there is also the time aspect, even though the first computer was developed during world war two, by the American military, the first personal computers did not arrive before the 1970´s. The time aspect is indeed important. There is a lot of adaptation before a product becomes a success. And looking back at what was described in the policy discussion, picking winners is not easy. Another example of time lag, could be the maglev train, even though the first patent for the design was granted in 1907 in the US to a German named Alfred Zehned and described the basic idea behind the magnetic driven train. It was not until 1984 the first commercial version was put in to service between Birmingham and its airport, running at a speed of 42 km/h. Today the world's fastest train is a maglev, and has a record of 581km/h, and was set in Japan, and its full potential is not yet reached (Hellinger & Mnich, 2009).

In NGT there is a tendency to use R&D as a measurement of knowledge growth in society, it does indeed enhance the innovation capabilities of the organizations. But they treat it like there is low uncertainty related to R&D, and that you can calculate the probability of success according to the amount of R&D you

spend, which is not the case, you are not guaranteed a certain amount of innovation output by using R&D (Tidd & Bessant, 2009). And as described earlier, Jones also showed that the growth in western countries is not nearly high enough if you look at the model and the amount or R&D in the countries, or more specifically the amount of scientist and engineers engaged in R&D, this is also known as the "Jones Critique" (Jones, 2002).

An alternative to NGT is looking at the technological advancements as coming through wave, where a new technology gets developed, and then there is an adaptation period. During this adaptation period there is low growth because the development of the old technology stops/slows down, and focuses on the new technology. When the adaptation is over, the new technology is able to outperform the old one. In Verspagen (2005) this technology is called General Purpose Technologies (GPT), and it focuses on the radical innovation and the adaptation of capital after. It uses elements from the leapfrogging model mentioned earlier, but in this model it happens within the same country. The switch does not happen from one day to the next, and the old GPT is not necessarily discarded completely. Looking at figure 6, we can see the that a period usually last 50 years, Verspagen (2005) describes it as being 50-60 years, but again it is difficult to measure since they overlap. Take for instance the period 1950-2000, which among other things was known for the increased production of cars, which was not changed by the entrance of the ICT, but there has also been a mix of the two technologies, the production of cars has been become increasingly mechanical. Robots do a lot of the work which require precision, or are monotonous, such as painting. But also the cars themselves have gotten more ICT imbedded in them, it manages things such as airflow, transmission and steering.

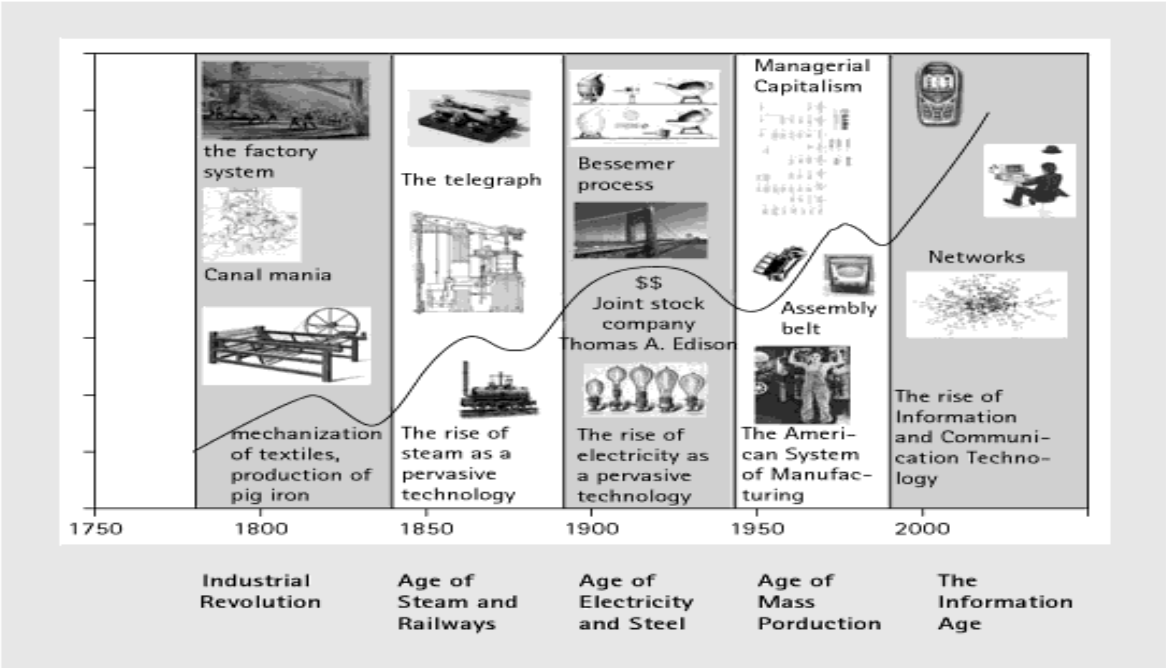

Figure 6 Technological waves (Verspagen, 2005)

In this model, there are constantly added new smaller innovations as derivate of the GPT, that way growth continues. But knowledge is still a rather "fluffy" term, therefore the thesis will continue to go a bit deeper into the discussion.

3.5.3. Knowledge Types

As put forward earlier in the thesis, knowledge has usually been looked at as a public good, this discussion goes all the way back to Alfred Marshall. He perceived the knowledge spread in the case of agglomeration of production, and talked about the "hereditary skill". Most of his work was based on observations, as it was at that time, the way he put it was "The mysteries of the trade become no mysteries; but are as it were in the air, and the children learn many of them" (Marshall, 1920), which signals, that he thought knowledge is a public good. But as discussed, it cannot be completely a public good, if the organizations have to bear the initial high costs there are to for instance R&D, it must be excludable, therefore the usage of Intellectual Property Right (IPR) are important. However the theory is that the marginal profit of an organization increases, if it does R&D and if the IPR is in place. However the marginal profit for society as a whole is much larger, because everyone gets an opportunity to develop it differently.

Using IPR requires that you have the ability, to write what it is you want to protect down on a piece of paper, that is however not always so easy. To see why, two distinctions will be made of knowledge, tacit and codified.

There are different understandings of what tacit and codified knowledge is, the paper by Breschi and Lissoni (2001) sees tacit as a mode in which knowledge is transferred, in the sense that if it is tacit, you need some kind of prerequisite to understand it (usually education), for instance a correspondence between two engineers discussing a design, will in large terms be incomprehensible for "ordinary" people or those without an engineering background (Breschi & Lissoni, 2001). But that is not the only way to interpret tacit knowledge, authors like Bengt-Åke Lundvall believe that tacit knowledge is contextual and embodied in the individual, such that it is linked to the individuals experience, and codified knowledge is therefore anything that can be written down, which can be troublesome, because in most cases, knowledge can be codified. So in the case of the two engineers, if what they discuss is a design that is written down, then Lundvall would consider that to be codified. However the cost of codifying a piece of knowledge can be expensive, to see why, knowledge will divided in to four different categories proposed by Lundvall (2004).

The first is **Know-what**, this refers to basic knowledge and facts, things that can be found in an encyclopedia, for instance, the size of a continent or the name of a president. Basically everything that can be put in to databases (Lundvall B.-Å. , 2004).

Know-why goes a bit deeper, and describes knowledge that allows one to explain the underlying assumptions for something, e.g. the laws of physics, and why the apple falls from the tree? Know-why is correlated with R&D, because some answers does not come cheap. But it is still becomes available to many because as Lundvall (2004) puts it " academics have strong incentives to publish and make their results accessible", but as Breschi & Lissoni pointed out, the understandability of it depends on the educational level of the receiver, this relates to the discussion of absorptive capacity, which states that for an organization to be able to successfully diffuse new knowledge, it must either already have knowledge within the area to successfully or invest in knowledge allowing them diffuse the knowledge and utilize it (Cohen & Levinthal, 1990).

Know-why and Know-what are the knowledge that is easiest to write down, and therefore more easily codified. Therefore they also have the ability to be treated like a good that can be traded, but also protected under patents and other IPR.

Know-How differs in that aspect, Lundvall (2004) explains it as the ability to work on the basis of previous experience and intuition, therefore there is a certain time aspect to it. If you have looked for a job at some point in your life, you will know that having experience in a certain field, makes you more attractive than those without. That is also a result of the fact that it is not something that you can easily come by, for instance while reading a book. That is because it is hard to codify experience and intuition, "*attempts to use information technology to develop expert systems show that it is difficult and costly to transform expert skills into information that can be used by others*" (Lundvall B.-Å. , 2004), for instance if you think about musicians or other expert artisans, they might be able to write down, or in some way communicate what it is that they are doing, but it still takes years of practice to reach their level.

From the firm perspective, this means that to get access to this knowledge, they might need to hire these experts to a premium salary or merge with companies that already hold this knowledge, which can be an expensive matter if it needs to be done frequently.

The last aspect is the **Know-who,** this covers the idea that hardly any knowledge is created within an individual firm or organization, but is spread out across different scientific fields. A person or organization therefore needs to have some connections, that allow them access different kind of knowledge than what they themselves might possess. Having someone in your network that can explain something to you, also helps mediate tacit knowledge, because it can help speed up the understanding. This was also the case with Germany, as List described, in their case they used English craftsmen to help them understand how the machinery worked. The know-who aspect is also tacit in nature, even though you can pick up a phonebook and find a person, for instance a consultant, there will always be the problem of asymmetric information

and to which degree the person is reliable. The only way to be sure, is if you know the person and thereby trust them. Personal relationships are by definition, not public (Lundvall B.-Å. , 2004), therefore they must also be tacit, which makes the same disposition as before, access to this kind of information can only be gained by hiring the individual with the contacts or merging with other companies.

These are the types of knowledge Lundvall works with, and by his taxonomy there are two way of acquiring it which will be looked at in the next section.

3.5.4. Knowledge creation

There are two ways to create knowledge according to Lundvall, Doing, Using and Interacting (DUI) and Science, Technology and Innovation (STI). The DUI is in special related to know-how, or at least the Doing part, this is where you gain experience and thereby become able to continually making incremental improvements to the product. In the Using and Interacting area this can refer to the usage of customer experience, in some areas the manufactures collaborate closely with their customers, this can for instance be by using "expert" to develop better products, this can be seen in sports goods, or again the US army, but it can also be in general when companies listen to the needs of their users. This is in turn can be related to the know-who since this also about having the right connection and network (Jensen, Johnson, Lorenz, & Lundvall, 2007)

The STI mode of learning, is on the other hand build up around the decisive search for new knowledge, often meaning R&D, because it is when the companies look for a specific answer to increase their stock of knowledge, in terms of know-what and know-why. In relation to the discussion about tacit and codified. The idea is, that STI consist mostly of codified knowledge, but there that is not true in all cases, when a researcher is on the forefront in his field of science, the moment he discovers something new, it is tacit, since only he or his team knows about it, but as mentioned earlier, most public researchers have great incentives to publish their work, and those done within a private firm, will most likely take out a patent.

However IPR is not always the best solution to protecting knowledge, there are several flaws with it. The first one is that it can expose the product to competitors, which then may copy it partly or wholly, this all in all depend on in which country it happens to be in. It is not uncommon that in some Asian countries, patents are not respected and cannot be protected, this has been apparent in the medicine industry and car industry among others. Even if they go to court and sue them for patent infringement, there is no telling if they can win. Therefore the companies need to be sure of to what extend they will defend their patent. In some industries there are no reasons to take out patent, because the development goes so fast that the

process of applying for a patent takes too long, it is estimated that companies apply for patents in 66-87% of cases were they have a new invention (Tidd & Bessant, 2009).

Also and during the process of applying for a patent, the product cannot be further developed, therefore sometimes the best way to protect the knowledge is to simply keep it a secret, such as coca cola have done with their recipe all these years. Another aspect of patents is the fact that it can be used as a bargaining tool, in some industries you can talk about patent wars, one of the more famous at the moment is in the telecommunication where dealing with lawsuits is a big part of running a company. In this situation a gentleman's agreement is sometimes arranged, in the sense "we will not sue you, if you do not sue us" or simply help settle an agreement. In the same kind of struggle, companies have been known to take out patents in technologies or knowledge they are not going to use, just so that their competitors cannot gain access to it, this is known as an offensive patent strategy, it is estimated that 40%-60% of all patents are actually used (Tidd & Bessant, 2009).

In the theoretical section of the paper, topics such as new growth theory, lock-in and the national innovation system have been treated. This was done to in some part, to show the difference between the different approaches, and how they may supplement each other. The NGT is still the mainstream economic theory, when talking about productivity. And the way they look at productivity increases, as being able to do more, with the same kind of input. Their determinant for this growth has been knowledge and in that matter R&D and education. These two aspects do indeed have influence on the knowledge in the country, but it is only the top of the iceberg. Therefore this thesis suggests the National Innovation System approach as an alternative or supplement to NGT. But as the section where lock-ins was discussed, it should be clear that changes do not happen overnight, and there are structural bindings that makes radical changes hard to come by. This is still in theory, so in the next section of the thesis, the DEC report will be up for debate. This is because they are appointed by the Danish government to give advice how to deal with problems in the economy, and their theoretical thoughts align with that of NGT.

4. Empirical investigation

In this section the thesis will look at the DEC report, because they try to explain what is wrong with the Danish productivity from a NGT perspective, and it does reveal some interesting facts, but it is still very abstract, especially when it comes to the problem solving. Therefore a paper called "Forms of knowledge and modes of innovation" from 2007, will be presented after the results of the DEC report. This paper contains an empirical investigation, made with the use of CIS, which helps provide an insight into the composition of Danish knowledge creation, and other useful data, which could allow for a better understanding of

the problems. And the European innovation scoreboard from 2011 will also be presented to give a more qualitative approach, and give the opportunity to compare Denmark with other countries.

The DEC report is divided in to two chapters, it is the second chapter that deals with productivity in particular, therefore that will be the focus of this thesis. However since the chapter is stretched over 124 pages, subsequently it is also divided in to subsections, where they address four different problems.

The first problem is whether it is a Danish problem only, or other countries also struggle with their productivity. As described earlier this is not a discussion this thesis will go deep into, but on the other hand it is hard to avoid because of two reasons. The first is, that it is somewhat relevant because if other countries also struggle, it might not be that easily fixed. The other reason is that it is hard to maneuver around, because it is an ongoing theme in the DEC report. But there are still different contexts in the countries being compared, and therefore different dispositions, which is why the thesis will not go deep in to the discussion, but only describe the results.

The second question raised, was how changes in the terms of trade could affect the productivity, however interesting question it is, it is not that relevant to this thesis research question, therefore it will not be included in the thesis. The third question was how much of the Danish hourly productivity is a result of changes in the capital intensity, labor force qualifications and the TFP. This is relevant to the research question, because as explained in the Solow section of the thesis, any changes in the mentioned factors would result in a change in the productivity, for instance if the amount of capital dropped, it should lead to lower productivity. Therefor the thesis will look at their results to see if the problem could come from such changes.

The fourth and last question they raise, is related to the labor marked, even though this thesis has not been dealing with this topic, it is still rather relevant, therefore the this aspect will also be covered in the thesis. Their question is how efficient is the Danish labor marked at allocation real capital and labor from low productivity areas to high productivity areas.

4.1. The Danish Economic Councils report

In their report the way they measure productivity is by using the value added approach, with data from EU KLEMS database. This also means that they use the gross value added (GVA) as their aggregate measurement of productivity which enables them compare Denmark with several other countries such as UK, US A, Holland, Sweden and Germany. The UK, the US and Germany are not usually countries Denmark is compared with, because the difference between the countries and their context is big, while it is supposedly smaller when looking at Holland and Sweden. The DEC reason for looking at different countries is to see

whether it is only Denmark that is struggling, or other countries also have problems. Their results, obtained with data from EU KLEMS database, show, that up till the mid-1990, Denmark was doing well, but after that it changed, as can be seen in figure 7. Countries below the 100% have higher productivity than Denmark, which inevitably means that only Italy, Spain and the UK have a lower productivity than Denmark, and the UK seems to be gaining.

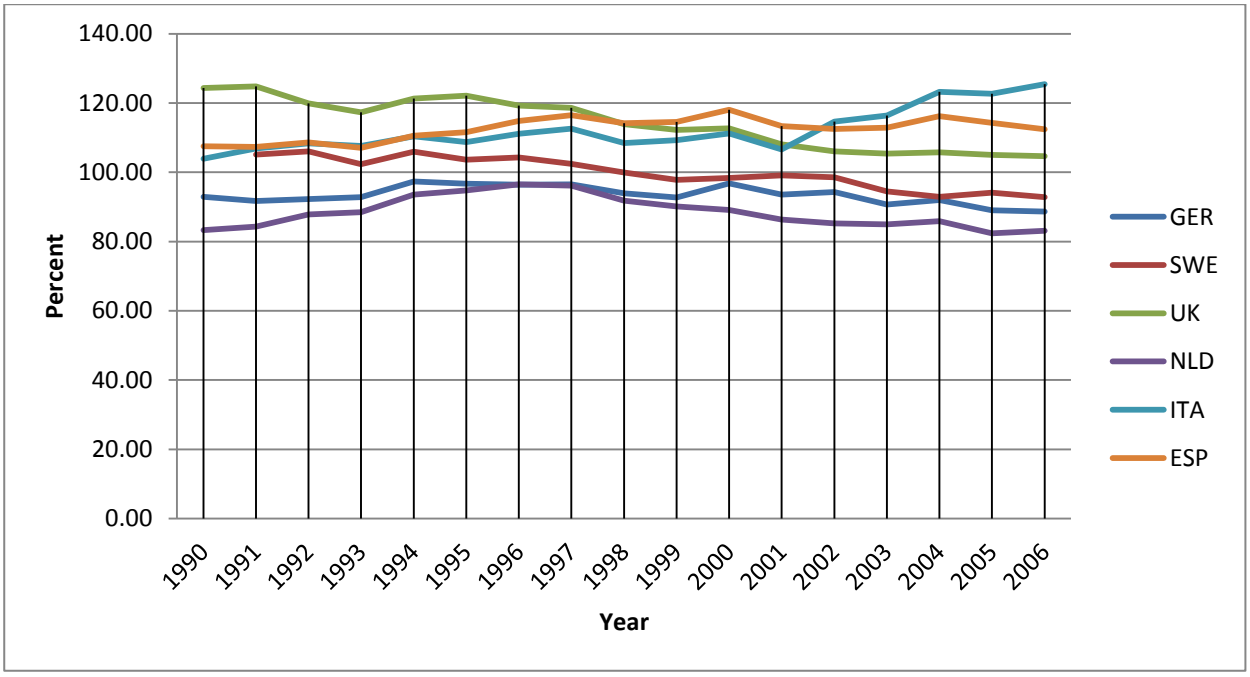

Figure 7 European countries productivity, relative to Denmark (Danish Economic Councils, 2010)

Therefore in this perspective, Denmark has a problem with its productivity. And as mentioned there are several things that can affect the productivity of a country, the DEC use a slightly altered version of the production function, where the quality of the labor is also taken into account, and instead of Gross Domestic Product, Gross Value added. Otherwise it is a Cobb-Douglas function is given by; $GVT = AK^{\alpha}(QH)^{1-\alpha}, 0 < \alpha < 1$. A is still the residual or TFP, K is capital intensity, Q is the quality of the labor and H is the amount of hours worked. But because it is not easy to compare countries like this, they look at it from a productivity per hour perspective, which is obtained by dividing the equation by H. And they and they assume there is perfect competition, however they relax this assumption later in the thesis. And they only look at organizations that are operating on the marked, therefore government activities are excluded.

Therefore when they look for problems with the productivity they look at, the quality of labor i.e. education, TFP and capital intensity. They look at two periods, before 1995 and after. The first period was from

1981 to 1994 where Danish hourly productivity growth was 3.4% on average. Here 1.7 percentage points was from capital, education was 0.3 percentage points and TFP was 1.1 percentage points.

However in the period 1995-2006, the hourly productivity growth was only 1.4 on average, where capital was responsible for 1.2 percentage points, education 0.2 percentage points and TFP was not helping the growth (Danish Economic Councils, 2010). Obviously when dealing with longer time periods, you will get a different average depending on where you make the cut for the next period. They are however well aware off this fact, arguing that the since 1994 was a "good" year, it would have raised the average if placed on the other side. But in the end it would not alter the result significantly. The DEC then turns its attention to TFP because it is the factor that has made the productivity decline to the biggest extent. Though capital and education has also fallen, compared to what other countries have experienced it was to be expected. But obviously that does not mean, that an effort to increase it should not be made.

But the focus of the DEC falls on TFP, and they separate the productivity into five industries, production, service, construction, agriculture and raw material processing. Their individual contribution to productivity is showed in figure 8, and as can be seen the biggest contributor is service, the second is production and the third biggest is construction.

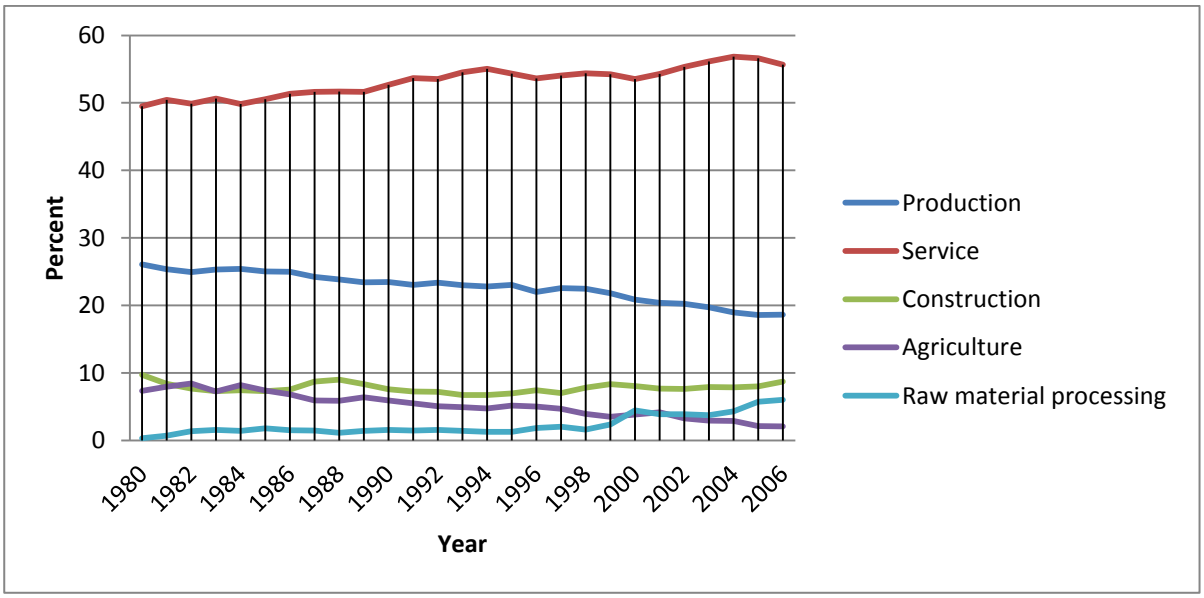

Figure 8 Danish productivity by industry (Danish Economic Councils, 2010)

In figure 8 it is apparent that production has been steadily decreasing, the same goes for agriculture, whereas service and raw material processing has increased. A more detailed overview is given in table 2, where the different industries are broken down into the three factors. Production has gained more capital and education, but TFP is still negative, going even deeper, the decline in TFP in the later period looks to be

a result of a fall within the food, drinks and tobacco industry, as well as in the production and processing of metal industry, while the only positive TFP comes from the chemical industry (Danish Economic Councils, 2010).

Service has a mentioned become a bigger part of the total gross value added, but its performance has decreased from an average of 3% growth to 0.9%, when looking at the TFP a little closer, the only two areas contributing positively was wholesale trade and insurance and financing, while areas such as rental companies and business service, and hotels and restaurants saw a big decrease in TFP (Danish Economic Councils, 2010).

Construction seems to have been rather steady in its size when looking at figure 8, it is still the third biggest, and therefore it is still rather important for the Danish economy, therefore it is troublesome that in the second period, it has had trouble with its productivity. The DEC points out that it has fared better compared to other European countries, but again it still pulls the overall productivity of the economy down (Danish Economic Councils, 2010).

	Production	Service	Construction	Agriculture	Raw material processing
Period 1995-2006	**In percent**				
Capital intensity	1.4	1.0	0.2	1.1	6.2
Education	0.4	0.2	0.0	0.0	0.0
TFP	-0.1	-0.3	0.2	1.1	1.2
Period 1980-1994	**In percent**				
Capital intensity	1.2	1.8	0.4	1.7	8.0
Education	0.2	0.3	0.4	0.5	0.3
TFP	-0.4	1.9	0.6	5.4	13.2

Table 2 Industry productivity factor overview (Danish Economic Councils, 2010)

The agricultural and raw material processing have had a massive decline in their productivity, this has to great extend been because of the drop in TFP as with the other sectors, even though the two sectors are keeping the overall productivity up, they are also responsible for the overall decline in productivity. The raw material processing is in large terms the oil and gas brought up from the North Sea. The DEC suggest that in this sectors TFP is also related to how accessible the oil is, meaning the easier it is to get a hold of, the higher the TFP, therefore seen a drop in TFP could suggest that it has become harder to getting to the oil and gas.

4.2. Suggested reason for low productivity.

The DEC suggest that some of the problems could come be a result of the fact that Denmark was not so good at relocation the resources from low productivity to high productivity areas. But that is not the case, their empirical investigation show that within the industries Denmark is best at relocating capital and labor (Danish Economic Councils, 2010). However there is hardly any movement between the main industries, which is to be expected, because it takes a lot of investment to retrain personal to be able to do something completely new, as opposed to something different, this is properly a result of the Danish social security and labor marked makes it easy to retrain people.

The fact that they are unable to prove that relocation is the problem, makes them move on to R&D and education. These have been known to affect the TFP, which seem to have trouble in all the industries. But it also seems to be a standard solution when it comes to NGT, which this thesis has already described. Therefore they use R&D as a third input, but as mentioned earlier in the thesis R&D is not that easy to measure, especially if you try to compare countries, which they do, as can be seen in figure 9. So even though there is an OECD manual for how to measure R&D, there is will always be the issue of firms writing in ordinary operating costs instead of R&D, perhaps as a result of support schemes from the government side to subsidize R&D efforts. They start out looking at how much the R&D expenses make up for in productivity in the different countries, but that gives a skewed picture, because the industries are not the same, and some industries are more R&D intensive than others. Therefor they adapted the data so it would correspond with the Danish industry composition (showed in figure 8), and the result can be seen in figure 9.

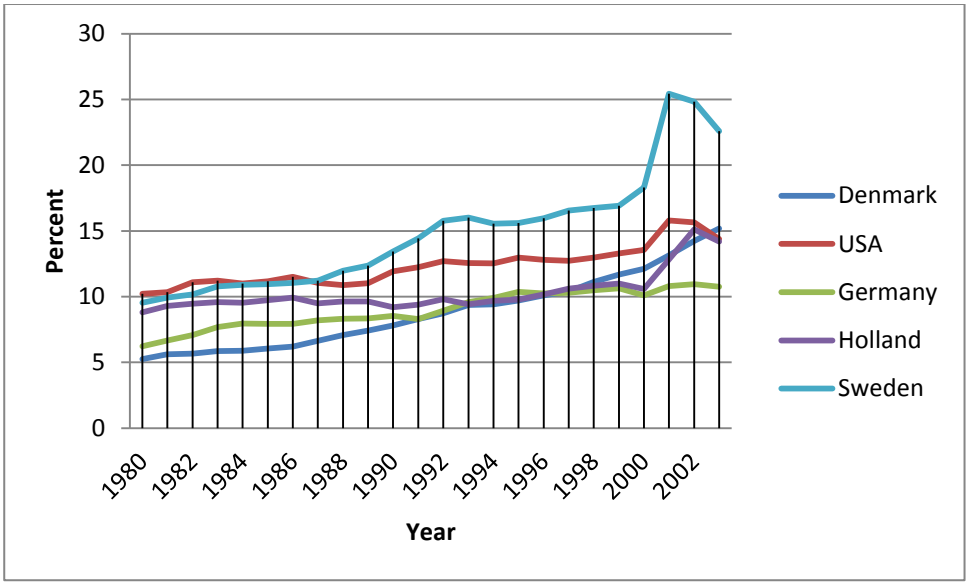

Figure 9 R&D as share of productivity, in Danish industry ratio (Danish Economic Councils, 2010).

Observing figure 9 it becomes apparent that Denmark is not that low on R&D, when they have weighted the other countries R&D expenditures with Danish industry composition, only Sweden seems to have extraordinary high R&D ration. Therefore R&D does not seem to be a problem, therefore they move on to discussing education.

But when it comes to education, they have to loosen up a bit on their assumption of perfect competition, because under perfect competition, everything is paid its marginal product, but if that was the case, the extra value that an education would create would fall to the person, and nothing would go to TFP. But if the company is able to pay a person under his marginal product, they are able to increase their TFP. And this is only possible if there is not perfect competition on the labor marked, or for that matter on the goods marked. If they have a monopoly, as a result of for instance some knowledge they own, it could also let them charge a large markup and thereby get lager productivity. Under these assumptions they look at the educational level in Denmark.

From 1988 to 2007, the average length of education has increased from 2.6 years to 3.4, however none of this development comes from construction. In the same period the amount of people with higher education has risen from 17% to 29%, this development has mainly been a result of a decrease in unskilled labor. In the service sector the shift has been the biggest, while construction still has not able to change that much, only in the movement from unskilled to skilled workers has there been a change. But since service is the biggest sector it shines through. And overall the Danish educational level is pretty high with 23% of the private labor force having a higher education, and they find that TFP rises with higher education (Danish Economic Councils, 2010). However there is a bit of a discussion on whether companies with high productivity hire people with high education, or companies that employ people with higher education gets high productivity, so which came first, the chicken or the egg. In the DEC they believe that companies that have employees with higher education gets higher productivity as a result of it, but there is no telling how the composition is in the real world, and therefore it has some problems with the methodology discussed earlier in the thesis.

They also find that the first couple of years of experience are very important to when it comes to productivity, which makes good sense when looking at it from the DUI perspective, where the gained experience results in people getting more efficient. But it could also mean that the companies are paying people more than their marginal product for instance as a result of asymmetric information, this could be get worse as unemployment gets lower. The DEC does look at this, because the DEC observes that the other countries also have been submitted to the state of the economy without it affecting their TFP. They argue that the effect it had on the TFP in Denmark would also be minor. However unemployment does affect the produc-

tivity, because it affects the labor cost which is part of the calculation, but measuring whether or not employees are paid their marginal product, is at this time not possible to do.

Their general conclusion is, that Denmark has problems in specific areas, where one of them is construction. The DEC suggest that this can be a result of a marked errors, meaning that some companies use obsolete technics that make them inefficient, and because of inertia in the marked, they do no close down. If this where true, it also raises the questions, why they do not adopt the practices of the companies that are doing better? Could it be a result of knowledge not spreading fast enough in the economy or simply because they do not have the absorptive capacity to utilize the knowledge? Other things described in section three of the thesis, could suggest maybe knowledge does not get codified or if it does, breaking the patent is too hard. There are many possible reasons why. Their reasoning leads them to believe that it is a result of lacking competition, which hinders the "creative destruction" in taking place. Therefore they look at the TFP spread within the companies of the different sectors (iron and metal processing, wholesale firms and knowledge intensive service), which are at a sufficient size and homogenous. They find that around a quarter of the companies are responsible for between 70% and 90% of the TFP growth, in this relation they also find that organizations with 100 or more employees have four times higher TFP than those with 10-25 employees, and twice as high as those with 25-50 employees. This could be a result of the fact that the bigger the companies are, is also reflect their marked power, and thereby it allows them to sell their products with a higher markup. But since the majority of the Danish companies are small to medium size, there are obviously not many of these high TFP firms. But the thesis will return to this discussion later. For now their suggestions of how to solve these problems will be discussed.

4.3. Fixing Danish productivity

The DEC suggests a three step solution, to in which the Danish productivity problem may be fixed. The first step of doing so would be to increase the productivity of the different companies. They suggest that the top 5% of companies in the high end of the TFP scale, by 10%. Thereafter the next 45% of "second best" companies have to increase their overall productivity with 10%, which allegedly should happen as a result of increased competition on the goods marked or increased innovation.

The final step involves closing down the lower half of the TFP companies, this is still when only looking at the three subsectors. They argue that it would release resources, that then can be used in the surviving companies, this would result in 10-18% of the labor force would be out of a job, in these three sectors, but their argument is that the last 50% of companies do not contribute to the increase of productivity at all. But it is only a thought experiment, the effect it would have on TFP can be seen in figure 10. In most aspects this form of approach will classify as picking the winners, but how to do so in the real world, does not say.

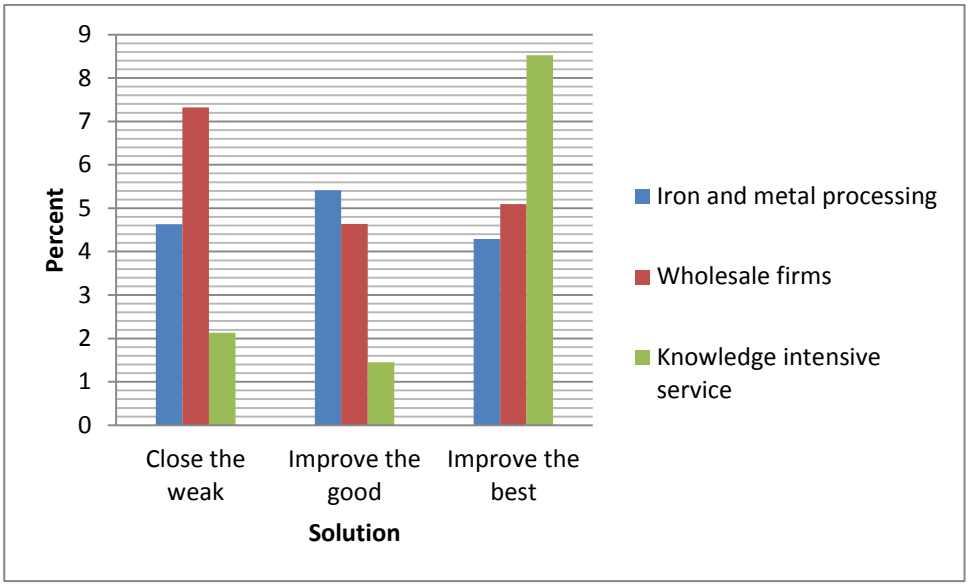

Figure 10 Effect of change on TFP in 2007 (Danish Economic Councils, 2010).

But there is an alternative to closing the weak companies. Not all companies stay in the same segment of TFP growth, some may move, be it for the better or the worse. Some of the weaker companies might just have entered the marked, or is in the phase of adopting to the changes in the marked, and as discussed earlier changes does not come over night, and also for some they do not come easy. Therefore they look at if any of the companies move from one segment to another. But their investigation shows that it is mainly companies on the borderline between the "weak" and the "good" that exchange places. There are also in the good group, about 7-13% of companies disappearing, this may be a result of mergers, change of company mode or simply they close, even though there is some movement between the segments, they conclude that it is not worthwhile, and the best solution is still to focus on the best companies.

However they did only look at from one year to another, which is not that much time considering the adaptation times presented in section three, where a general purpose technology wave takes about 50 years to get situated in the economy. And hardly any companies start out with more than 100 employees, these high TFP companies have to come from somewhere, dismissing low TFP companies seems to be bad advice.

Also this could resemble the lock-in situation, where there is a possibility to forgo a possible superior technology on the basis of focusing on an older yet higher yielding technology at the moment, therefore it might not be the best solution. This is off course hard to say, since it would require a more in-depth analysis of the companies, they argue should have extra support. But even if that is the case, it is very hard to predict in which way the development goes, as mentioned earlier.

In the next section of the thesis, an attempt to go a bit deeper in the composition of the Danish companies will be made, this is to see how effective an focus on R&D/STI is in Danish terms would be, because as explained earlier, R&D is only one way to do innovation, there is the whole DUI aspect, and therefore it relevant to see how much the different areas cover. This will be done with an empirical investigation, in the form of a CIS performed on Danish companies.

4.4. CIS of Danish companies.

In mainstream economic theory, there has been a tendency to focus on R&D and education when it comes to giving advice on how to increase the innovation capacity, and thereby get higher growth rates. Last section there was another example of this. There are several reasons for this, one of them is the fact that STI is considerably easier to measure than DUI. As mentioned earlier this because it works with data from areas such as patents, R&D costs and education, which also allows for a comparison between countries, and to some extend measure the effect, but it still only represents part of the way to do innovation.

Jensen et. al. (2007) gives some reasons for why this might be the case, other than STI is easier to measure. They argue that it is because of political initiatives ongoing from the post-war period. The fact that measuring STI is easy, also means that DUI is hard to measure, to some extend that is true, since the informal nature of DUI learning does not make it ideal for large survey based research (Jensen et. al. 2007), however things are changing and the DISKO survey is a testament to this.

In the paper "Forms of knowledge and modes of innovation" by Jensen et.al (2007) they make a suggestion to use a set of indicators for measuring the DUI mode. They do this by looking at product innovation as an output. They then look at in which way the firms have organized themselves, so that they promotes DUI learning.

They do this because they are interested in showing that firms with a stronger science base are more innovative than those without, which enhance the focus on R&D from last section, but equally important they want to show the performance the firms with both DUI and STI enjoy, since they believe that doing both makes them excel in product innovation.

The fact that they measure product innovation can to some extend be seen as biased, since there is also others, like process innovation, organizational innovation and service innovation, all of them can in some way help to increase TFP, because they can add new value. Unfortunately the survey only looks at product innovation, and to some extend the usage of organizational structuring, leaving the other forms out, but it still affects the value on a positive way.

Their empirical analysis is based on a survey where all Danish companies in the private sector were invited to partake, this does not include agriculture, and companies with less than 25 employees. This also means that some of the companies from the DEC report is not represented, but it was never a perfect fit anyway. It was send out to 6991 firms, and in return they got 2007 usable responses from the management of the firms. A response analysis showed that it had an "acceptable response rate". This first survey was carried out in 2001 and was then supplemented in 2004 by an additional survey which left them with a sample size of 1141, integrating it with register data available from the labor force.

For it to be completely compatible with the data from the DEC report there would be some things that needed to be done. One of the first things that does not matchup is the timeline of the two sets of data, the DEC work with a period of years, while their DISKO survey was made in 2004. There are two solutions to this, either pick an average for some representative years, or to take the numbers for 2004. After that you would also need to identify the companies from the DISKO survey to find their GVA, but with the right access to databases it could be done. The fact that this has not been done also mean that some of the comparisons and discussions are speculative at best. But as mentioned in the paper they use different measurements for DUI and STI innovation.

For the STI-mode they used three different measures as a benchmark for the development in STI, "*expenditures on R&D; the employment of personal with higher education in science or technology*" and the last one was the amount of cooperation with researchers from universities or institutes (Jensen, Johnson, Lorenz, & Lundvall, 2007).

For the DUI they have 7 indicators inspired by other authors, the indicators are: Interdisciplinary workgroups, to see if there are any knowledge sharing within the organization. Quality circles, which also looks at the efficiency of the organization, since it looks at how they chose to deal with work related problems. Systems for collecting proposals, as it says, do the company have any systems in place for collecting proposals that might lead to better efficiency etc.? Autonomous group says something about the general organizational structure, and its ability to diffuse knowledge. Integration of functions means to what extend do people in production help with sales etc. Softened demarcations look at whether the distinction between service and production has become more blurred. And to what length do they have cooperation with customers. By using a latent class analysis they become divided into four sub sectors or clusters according to their characteristics, the result is shown in table 3, that is borrowed from the article.

	Low learning cluster	STI cluster	DUI cluster	DUI/STI cluster	All firms
Makes use of interdiscipl workgroups	0.1155	0.0143	0.5448	0.9888	0.3960
Makes use of quality circles	0.0159	0.2670	0.5054	0.5483	0.2890
Makes use of systems for proposals	0.1481	0.3554	0.6253	0.5757	0.3931
Makes use of autonomous groups	0.2145	0.4427	0.5320	0.6139	0.4090
Makes use of integration of functions	0.1346	0.2254	0.5545	0.6392	0.3642
Demarcations more indistinct/invisible	0.2709	0.4879	0.5671	0.6256	0.4494
Cooperation with customers high	0.2582	0.4292	0.5512	0.4970	0.4090
R&D expenditures positive	0.1002	0.9875	0.2977	0.8742	0.4017
Cooperation with researchers positive	0.1088	0.8586	0.2195	0.9550	0.3829
Employs scientifically trained personal	0.0854	0.3544	0.1091	0.6826	0.2341
Unconditional probabilities for each cluster	0.4050	0.1099	0.2974	0.1877	1.0000

Table 3 Stats for making each subsector (Jensen, Johnson, Lorenz, & Lundvall, 2007)

Inspecting table 3, it becomes apparent that the are great deal of companies within the low learning cluster, about 40% of the of the sample, these companies hardly spend funds on R&D, nor do they cooperate with researchers, this is probably because they also have a small chance of employing people with higher education. Looking at table 4 which gives an overview of the data from each cluster, there is a couple of things that becomes noticeable, the first is might be the size of the companies, the majority of companies with less than 50 employees are in the low learning cluster, the same goes for companies with 50-99 employees. But looking at which industries are represented in the categories it makes more sense, since there is an overrepresentation of construction, trade and other services which are low skilled areas. And that it is mainly Danish groups of single firms. Without any concrete evidence, one could speculate this is the companies with low productivity, this is mainly based on the size of the companies represented in the different subsectors, and the weight of industries such as construction and trade.

Going to the STI cluster and looking at table 3, companies within this specification have a high usage of cooperation with researchers and spend on R&D, they are mostly represented in the 50-99 employees section, however the +100 is not far behind. Looking at table 4 it is noticeable that the industries representing this status, are the manufacturing both high-tech and low tech, these industries presumably represent the large medical industry and perhaps even at that time, telecommunication. However it is hard to determine whether if there is more Danish firms or foreign when looking at the frequency, but in nominal numbers there are more Danish. However it is hard to determine a relationship with the DEC data. Because looking at the manufacturing sectors, it is seemingly well represented in all four segments.

The DUI cluster is the second largest represented in the sample at about 25%, it is however hard to determine in which categories the cluster is best represented, since the spread is not as large as in the previous two. Looking at the variables that exceeds the others, it noticeable that most of the companies have 50-99 employees and they are related to the foreign group of firms.

Here the most conspicuous thing is the high share of companies in this segment, because it means that most of the companies would not get any benefits from a support scheme targeted towards STI, like R&D and higher education, which was what the DEC focused on.

The last cluster is with the mix of DU and STI, within the "100 and more employees" they are represented in larger terms, and within the high tech manufacturing and business service they are highly represented. According to table 4 they are somewhat represented in foreign group firms. These should be high performance companies, but they only represent 18% of the firms in the sample, and together with the STI cluster bring about 30% of sample, which is the same as the DUI cluster alone. Looking at the policy implications for this, support should be equally distributed between the two modes of learning STI and DUI.

Speculative, the DUI/STI cluster is properly in the group of companies representing the good or best TFP. Looking at the size of the companies in this segment, and thinking back to the DEC data, where it was also the companies that were big that had high productivity. Furthermore if you follow Jensen et. al (2007) arguments these companies are also the most innovative, which should translate into high productivity.

Variables	Low learning cluster	STI cluster	DUI cluster	DUI/STI cluster	*N*
Less than 50 employees	0.5605	0.0855	0.2566	0.0973	339
50–99 employees	0.3314	0.1775	0.3018	0.1893	169
100 and more employees	0.2457	0.1257	0.2686	0.3600	175
Manufacturing, high tech	0.2231	0.2645	0.2314	0.2810	121
Manufacturing, low tech	0.3522	0.1321	0.2893	0.2264	159
Construction	0.6139	0.0495	0.2574	0.0792	101
Trade	0.5780	0.0462	0.3064	0.0694	173
Business service	0.2727	0.0909	0.2576	0.3788	66
Other services	0.6512	0.0465	0.2791	0.0233	43
Danish group	0.4073	0.1371	0.2460	0.2097	248
Foreign group	0.2903	0.1694	0.2903	0.2500	124
Single firm	0.4890	0.0789	0.2776	0.1546	317
Standard product	0.3574	0.1687	0.2851	0.1888	249
Customized product	0.4518	0.0871	0.2635	0.1976	425
All firms	0.4249	0.1171	0.2673	0.1908	692

Table 4 The frequency of the clusters by different factors (Jensen, Johnson, Lorenz, & Lundvall, 2007)

The fact that 42% of the companies scores low when it comes to product innovation, opens up for a different approach, than what is suggested by the DEC, by trying to help them instead of hoping that they close down (under the assumption that this segment contains low TFP firms). There are several ways of doing so, one that both NGT and the NIS approach agree is important, is helping the knowledge flow between different organizations. Looking at table 3, it should be apparent that they do not collaborate with researchers or employ scientific personal. Therefore it does not work well with for instance the triple helix model, but on the other hand, why should a carpenter or painter company employ someone with a university degree? In

this case they might not need to, an external consultant or perhaps setting up their physical business close to other companies could help with knowledge transfers, from successful companies to the less successful. Both NGT and the NIS approach agree that knowledge flow is important, and subsidizing consultants and offices parks might be a way to ensure best practices get spread. Cooperation between companies has been shown to help companies be more innovative (Carriquiry & Pedersen, 2010), this is a result of the fact that innovation is rarely done in solitude, and therefore it might be the lack of know-who that blocks the ability to do product innovation. Historically guilds have been a place where craftsmen could exchange ideas and thereby improve their trade, in agriculture in Denmark it happened via co-operative dairies and slaughter houses. There are many examples of how these organizations have facilitated knowledge transfers, a more recent one was when the Danish farmers started introducing corn, they were not sure what sorts where best for the Danish climate, so a wide variety was tested by different farmers, and their experience was reported back to the Danish agriculture and food council, which then reported which sorts had been a positive experience. In this case, it is shown just how important organizational structure and knowledge flow can be.

In the DEC report they measured R&D, and the educational level in Denmark, but as mentioned many times, even though they are important for productivity and innovation they are not the only aspects affecting innovation. Therefore the paper by Jensen et. al.(2007) was presented, because it contained a description of the Danish innovation system, and it suggested that a focus on R&D/STI would only benefit a small part of the economy, and therefore DUI should be more in focus. And since DUI focuses on the interaction between different organizations among other things, this thesis therefore suggest that improving the interaction between the different organizations would be an option to increase the productivity. As mentioned in the NIS section, the things that guide the interactions between the organizations are institutions, and some of them are tangible like rules or laws, while others are less tangible such as norms, and thereby also harder and take longer to change.

Pursuing the idea that the weak performance of the low innovation firms comes from lack of collaboration between other companies, or public organizations the thesis turns to the European innovation scoreboard which offers a quantitative overview of the Danish innovation capacity. The basis for this overview is their 2011 report, that looks at the EU27 countries innovation capacity based on different measurements, these measurements can be viewed in figure 11.

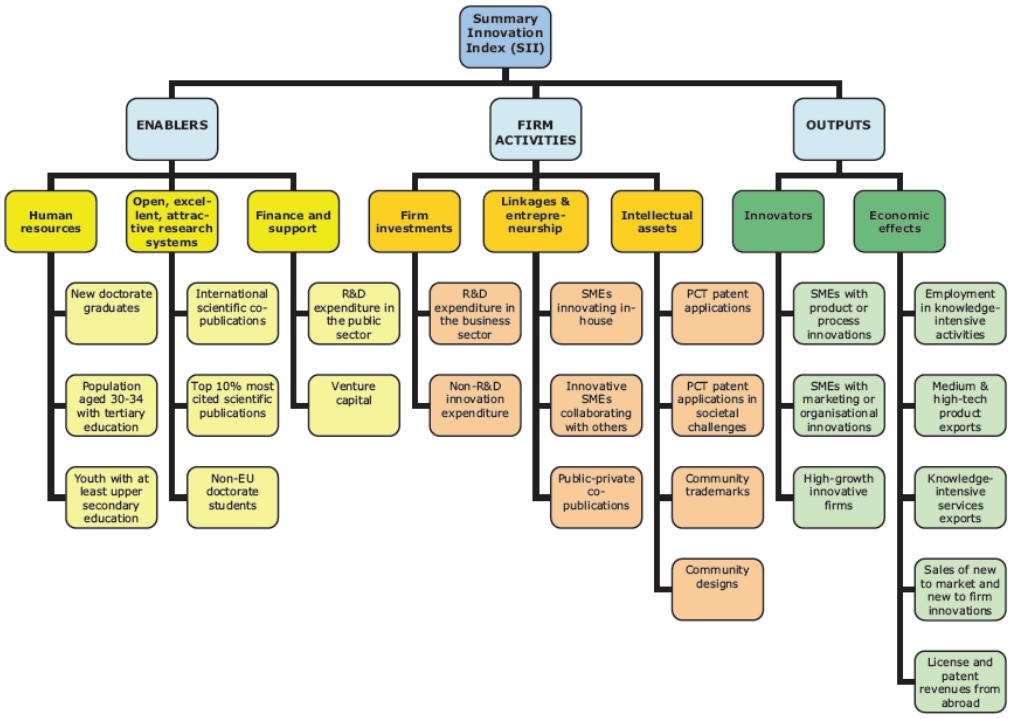

Figure 11 Framework of the innovation union scoreboard (European Commission, 2011)

The reason why the European commission is interested in innovations is because *"Innovation is a key factor to determine productivity growth. Understanding the sources and patterns of innovative activity in the economy is fundamental to develop better policies"* (European Commision, 2012B), the point that this thesis is interested in is the "linkages & entrepreneurship", however other areas will be look at as well, because they might give suggestions to other problematic areas.

Before looking at the specific areas within the report, it is worth noticing that Denmark is an innovation leader according to this report, meaning that it get a high overall average in 24 indicators, Denmark gets the second highest score, and is only beaten by Sweden.

Looking at the cooperation variables there are three, the first looks at "SMEs innovating in-house as % of SMEs" and the second "Innovative SMEs collaborating with others as % of SMEs" and the last one looks at "Public-private co-publications per million population". These measurements are biased towards firms that already are innovative, and therefore it says little about the how the low learning industries interact. But it expands on the fact that the innovative companies collaborate, not only with public scientific personal, but also in between companies. And in this area Denmark scores almost twice as high as the EU27 average, meaning that more than one in five SME collaborate. This can help to understand the importance of cooperation and knowledge sharing, but again says little about the low learning companies, other than if they perhaps increased their collaboration, they might get higher productivity.

But what areas do Denmark else have a problem in according to their report? The three main areas Denmark is under EU average is “Youth aged 20-24 upper secondary level education”, “Sales of new to market and new to firm innovations” and “Medium-high and high-tech product exports”. The first is the amount of people that gets a gymnasium education, which is a prerequisite of getting an university education, not only is Denmark below average, the share is also declining on average from 2006 to 2010 it has declined 0.9% per year. It is somewhat interesting because Denmark is still above average when it comes to people with a tertiary education, and it has been rising in the same period with 2.5% per year. This means, that even though less people get upper secondary education, those ration of those moving to get a tertiary education is getting higher. Those not getting an upper secondary education properly gets vocational education, because it was shown in the DEC report that the overall amount of unskilled labor has been declining. There are different way to go about this, one is try and get more students to take upper secondary educations, and another is improve the vocational education, so that the students become more innovative. But since you cannot force people to take an education, the best thing might be to make the education they take better.

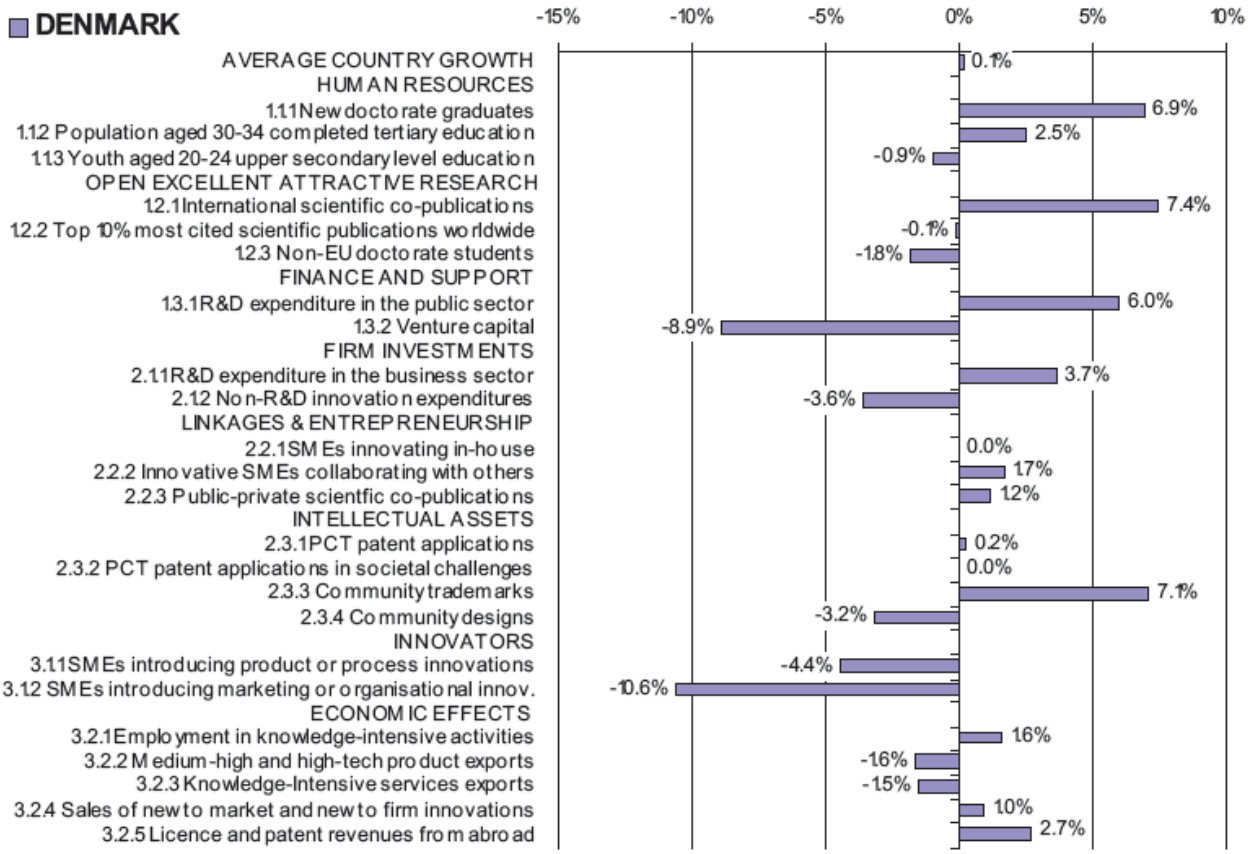

Figure 12 Annual average growth per indicator and average country growth (European Commission, 2011).

The second area “Medium and high-technology product exports” looks at the how much of the export share is within this area. It says something about the ability to commercialize R&D output, and to some extend the innovation capabilities. Also they put it describe the importance like this “*This is because medium and high technology products are key drivers for economic growth, productivity and welfare, and are generally a source of high value added and well-paid employment“* (European commission, 2012A). This sector has also been decreasing over in the period of 2006-2010, this might be a result of the recession, and therefore it can be hard to give any appropriate advice to what can be done about this, since already in the introduction of the thesis it was mentioned that Denmark had lost export marked shares as a result of low productivity and higher costs. The most obvious approach to take, would be to become more innovative, for instance by utilizing R&D spending better, and thereby getting a higher productivity. This might also be related to the drop in venture capital, which is displayed in figure 12. This has been a general problem in EU27 and as can be seen in figure 27, it may have had an effect on the ability to innovate since there has been a big drop in the introduction of product and process innovations and in marketing and organizational innovations. This might again relate to lack of know-who, this aspect can be important when looking for looking for venture capital, especially when it becomes more scarce

The last area is “Sales of new to market and new to firm innovations” which is measure as the percentage of the turnover, and relates to the quality of the innovations, because they are to some extend more radical, and even though Denmark is below EU average, there has been an increase as shown in figure 27.

Overall there seems to have been some problems with the Danish productivity over the past couple years. The Danish economic councils suggest that this is because of a large portion of the Danish companies are unproductive, showing that great TFP increases can be made, if they close down, and we focus on the “good” and “best” companies. The companies that where most unproductive where in general small, and comparing to the survey made by Jensen et. al. (2007), arguably not very innovative. The same companies lacked personal with higher education, and did not collaborate with researchers in any form. This could suggest that that the lack of know-who obstruct the ability to gain new knowledge, for instance adopting best practices. In hope of finding empirical prof of this, the innovation scoreboard of Europe for 2011 was analyzed, however it did not yield any concrete evidence of this. It did however bring the attention to other areas which are troubled, most notably the decrease in venture capital. This has been a problem all over Europe, presumably because of the recession, it has however meant that the know-who aspect of innovation might have becomes even more important. Because if you want finance, you best need to know the right people, otherwise you will be stuck doing what you have always done.

5. Conclusion

This thesis set out to investigate what the problem is with Danish productivity. An answer was presented by the Danish economic councils in a report from 2010, where they suggested that it was the lack of TFP growth in certain industries. To understand what TFP is, the thesis had started out with a theoretical discussion of neoclassical growth models and new growth theory. The discussion that followed showed that TFP was thought of as knowledge, but their understanding of knowledge was limited in the sense that it is poorly explained. Therefore the national innovation system thinking was brought in to the discussion, because it has a deeper understanding of how to breed knowledge. The aspect of Lock-ins was also brought forward, because there are structures in society that is not that easily change, contrary to what the Danish economic council seem to believe.

The study also showed that focusing on R&D would only result in an effect on 30% of the Danish companies because a big part of the companies actually only did DUI research or had very little innovation capacity when it comes to product innovation. Therefore an increased focus on DUI would be recommended, instead of STI.

The empirical investigations showed several things, among other that there were a lot of companies, especially small companies that had low TFP. These companies were presumed to be part of the low learning cluster presented from the DISKO survey calculations. This analysis showed that the cluster had little ties with researchers and did not employ people with higher education, both these aspect affect productivity negatively, this also lead to believe that they do not collaborate with other companies as such. Therefore the nearest conclusions to draw was that it was the lack of “know-who”, which mean that knowledge is not spreading sufficiently. However when the European innovation scoreboard was analyzed, it revealed that Denmark was one of the leading countries when it comes to innovation in Europe. And that one in five companies that are doing product innovation, are collaborating, which was above the EU average. It did however not address the fact that companies not doing well in product innovation, are not collaborating, but it stressed the fact that collaboration is important when looking at innovation.

The innovations scoreboard however revealed another area which was a problem all over Europe, namely the availability of venture capital, which is important if the companies are to move on, and not be stuck doing what they used to. Here this thesis again stressed the importance of know-who, because if venture capital is scare, it can depend on knowing the right people to get access to it.

Therefore this thesis suggest the implementation of polices to strengthen the knowledge flow. This could be in form of consultants provided for free, helping the spread of best practices and knowledge, so that the

companies might get a higher productivity. Another possibility would be to provide better proximity between the companies so that knowledge might flow indeliberately between organizations. This could be done by providing cheap housing for companies.

So “what is the problem with Danish productivity?” It would seem that a large portion of the Danish companies have low productivity, and it so happens that a lot of companies are also not very innovative. Through the discussion of total factor productivity, we know that it these two things are connected. We believe that their low ability to innovate comes from the lack of knowledge flow and transfers, and therefore it is also where the Danish productivity problem lies. Furthermore to correct this, it would not be enough to improve R&D spending, because the level it is currently at, is not far below that of other European countries, and according to Jensen et. Al. (2007), it would only affect 30% of the companies. Whereas helping those depending on DUI and those that are not doing product innovation, would affect more companies, and therefor hopefully help more.

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