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The Effects of Financial Openness on Innovation
An Empirical Study

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Abstract

Using data from 33 OECD countries for the years 1980-2014, we estimate the effects of financial openness on innovation through the use of fixed effects panel data regression. After establishing innovation as a core factor in technological growth, we derive, with the help of Schumpeterian models of growth, an argument that the financial system has a significant role in the development of innovations. The development of a country's financial system should therefore lead to an increase in innovation. One particular way to increase the efficiency and competitiveness of the financial system could be to open the borders to the international financial community, which would allow for international transactions and increase the efficiency of the financial system. By using patents as a measurement for innovation and the Chinn-Ito Index for financial openness we run a regression which confirms our theory that openness indeed has an effect on innovations in a country.

Key words: financial openness, financial development, innovation, technological growth, economic growth, patents, Chinn-Ito

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1. Introduction

1.1 General Introduction

Technological growth is considered to be amongst one of the most important factors in long-term economic growth. There is a considerable amount of research and models regarding the determinants of technological growth. Among the models, we can find the Schumpeterian growth model which states that technological growth is a product of the probability and increased utility of new innovations (Jones & Vollrath, 2013, pp. 122-123). The model further states that innovations are the component that pushes technological growth. In the article “Finance, entrepreneurship and growth” King and Levine (1993) links innovation to how well developed the financial system is. They argue that the financial system channels capital into promising investments. To be able to channel capital, the financial system has to be able to identify possible investments and mobilize capital.

We can find further confirmation of the importance of innovations in the research by Feki and Mnif (2016) whom in their article “Entrepreneurship, Technological Innovation and Economic Growth, Empirical Analysis of Panel Data” where they look at the relationship between innovation and the technological growth rate. Together they study the link between entrepreneurship and innovation and show how closely connected they are. Furthermore, Feki and Mnif expand upon Schumpeter’s argument that entrepreneurs are those who are introducing new technology an idea Schumpeter advocated 1934 in his article “The Theory of Economic Development”. Feki and Mnif confirm the argument that entrepreneurship, through the discovery of innovations, are vital to the technological growth rate.

While Schumpeter, Feki and Mnif study the link between innovation and technological growth, others have taken the next step and studied what it is that drives innovation. The process of identifying promising innovations is an established concept, and is also a key component in “Financial Developments and Economic Growth” by Levine (1993) where financial intermediaries act as information brokers and are able to find the entrepreneurs with the highest probability of success to capitalize on their ideas. This is argued to boost the rate of discovering new technologies. This process of identification is called screening and has since Levine’s article been researched by several other economists. Some choose to focus on how financial institutions' evolution have a hand in a country's technological growth rate (Laeven, Levine & Michalopoulos, 2015; Levine, 1997). Other focus on how the institutional and legal framework of the financial sector influence the financial systems efficiency in finding and investing in promising innovations (Beck, Chen, Lin, Song, 2016; Giordani, 2015; Chinn, Ito, 2005).

1.2 Purpose

As can be seen, there are several articles examining the relationship between technological growth and the financial system. There are those who examines the link between the financial system's screening process, its ability to evolve the screening process and economic growth through innovation. Those who study the legal and institutional framework of the financial sector and how it can affect innovation. Others have found a relationship between the deregulation of the financial sector and an increase in technological development (Amore, Schneider & Žaldokas, 2013). Yet none of these have yet to breach upon the subject of the relationship between financial openness and innovation. It is therefore that we in this paper will continue the research on the link between financial systems and innovation. But instead of looking at the development of the financial system or its screening process, we will look at the link between the openness of the financial system and innovation.

With the support of previous research it can be seen that the financial system has a hand in the technological growth rate through their ability to find and encourage innovations. By opening up and increasing the size of the financial institutions, the knowledge in the country will expand with the now shared knowledge of other international financial institutions. Innovations should, in theory, be affected by this change. Within previous research we find much support for the link between innovation, technological growth and economic growth. But to prove a relationship between financial openness, technological growth and economic growth we need to provide our own pieces to the puzzle. Therefor we will study the relationship between financial openness and innovation. Knowing this, we ask ourselves:

- What is the relationship between the financial openness of a country and its rate of innovations?

2. Literature Review: Growth Through Technology and Innovation

2.1 The Roots of Endogenous Growth Theory

The main theoretical framework we derive our research from is commonly attributed to Romer's ideas of endogenous economic growth. Although theories of what drives an economy mostly had been answered by Solow in his "Technical Change and the Aggregate Production Function" (1957), the main idea was that one of the most important determinants for economic growth, the technological growth rate, was driven by exogenous forces. Solow describes the factors of economic growth with an equation usually written in a relative simple form. Let the GDP of a country Y be given by Capital, Level of Technology and Labour respectively denoted as K, A and L (Solow, 1956, p. 1). This will give us equation 1.1

$$Y = K^{\alpha}(AL)^{1-\alpha} \qquad (1.1)$$

Where α is equal to the share of income that goes towards capital. As stated, A is exogenous and simply given at all times in the basic Solow model and is usually measured by measuring everything else and then taking A as the rest product. Technology would then be denoted as Total Factor Productivity and would be the unexplained parts of the economy; the efficiency in GDP that was unseen and unexplained (Jones & Vollrath, 2013, p. 44). The importance of the basic Solow model with Technology comes to light when deriving the steady state growth rate of a given country. In the Solow model, we would find that the technological growth rate would be the only factor in steady state that would increase a country's GDP per capita in a sustained fashion (Jones & Vollrath, 2013, p. 38). This implies that technology is one of the most important variables for sustained growth, yet it, within the model, is unexplained.

It wasn't enough until the early 90's when economists finally decided to take it upon themselves to incorporate technology into existing models. One of the economists whom expanded upon this is Paul Romer. Romer expanded upon the Solow model by creating a model which endogenized technological growth and in his paper "Endogenous Technological Change" (1990), an expression for the growth rate of technology was created. A function finding the main factors of technology was described as:

$$Y = K^{\alpha}(AL_Y)^{1-\alpha} \qquad (1.2)$$

$$g_A = \frac{\lambda n}{1-\phi} \qquad (1.3)$$

Meaning that the growth of Technology, g_A would depend on three notable factors.

- λ, describing the externality one gets from previous research.
- ϕ, explaining the externality one gets from previous ideas.
- n, the population growth.

In Romer's "Endogenous Technological Change" (1990), Lambda and Phi are written as 1 and 0 respectively which in turn implies a nominator of "n" and a small denominator that is reduced to 1. This simply implies that researchers perfectly use previous research when researching new things, as the numerator grows the smaller Lambda is, and that no one would research the same thing since the denominator. These assumptions lead to the growth in population being the determinant of technological growth, which in turn leads to a higher number of researchers, which generates a higher number of innovations and new ideas. The policy implications and economic effects of this would strongly imply that the long-term growth of a country could be affected by simply increasing the share of researchers relative to the population (Jones & Vollrath, 2013, p. 104). Yet economic growth is never that clear cut. The simple assumption that Lambda = 1 and Phi = 0 does not hold in reality. In "R & D-Based Models of Growth" (1995) Jones shows that the empirics behind this is shaky to say the least, and that according to Romer's assumption of Lambda and Phi we should've seen a much larger effect of technological growth. Assume a country doubles their researchers, then their steady state long-run GDP should've doubled (Jones, 1995, p. 760). In reality it's much more likely that both Lambda and Phi take on a number between 0 and 1. Nevertheless, the impact of R&D on long-term growth shouldn't be understated. It is without a doubt that R&D influence short-term growth (Jones, 1995, pp. 761-764), but due to a lack of consensus in what R&D does long-term, it is with a certain caution we should approach defining R&D as the main variable of growth.

2.2 Technological Growth and Innovation: Schumpeterian Growth Models

From Romer's expression of what constitutes the determinants of technological growth in (1.3), we could, with the necessary control variables, model and predict the steady state level of the long-term economic growth. Yet we can see considerable variance when measuring GNP-growth in a country, something which is unexplained when modelling with the Romer-function (Aghion, 1989, p. 2). Long-term economic growth should in theory be unaffected by shocks and the business cycles of the economy, and when it comes to long-term growth the only effect on growth is the technological growth. In a model where technological growth is endogenous and the only determinant of long-term economic growth is the growth in technology, we should be able to explain why this variance persists.

Philippe Aghion and Peter Howitt explain the variation in GDP in their article "A model of growth through Creative Destruction" and their work is further fleshed out by Gene Grossman and Elhanan Helpman in "Endogenous Innovation in the Theory of Growth". Together they create the models usually named as the "Schumpeterian Growth Models". Because despite the name, Schumpeterian growth theories weren't formulated by Schumpeter himself. Aghion and Howitt simply use concepts derived from Schumpeter when creating their model (Aghion, Howitt, 1992). Schumpeter's "Creative Destruction", serves as the fundamental concept of Schumpeterian growth theories and further explains what role research and innovations have in long-term technological growth. Creative Destruction implies that research not necessarily has to build upon itself, but that it also replaces and destroys existing technology (Schumpeter, Alois, 1994). The consequences of this is that the economy moves in steps (Jones & Vollrath, 2013, p. 119) from one level of technology to another, or in other words, from innovation to innovation.

This movement between innovations is captured with the model.

$$Y = K^{\alpha}(A_i L_Y)^{1-\alpha} \qquad (2.1)$$

The production function, very much similar to the Solow Production Function, differs in one aspect, A now has a subscript *i*. This is a way to capture the movement innovation A_i when i = 0 to A_i when i =1. This movement represents the "gap" between technology 0 and technology 1 (Grossman & Helpman, 1994, p. 28). This is simply a way to express how we move from one innovation to another. Just like how we moved from horses to cars or floppy discs to CD's. Thus, we measure the size of the movement between the innovations by simply subtracting A_1 with A_0. The growth would then simply be measured as (2.2)

$$\frac{A_1 - A_0}{A_0} \qquad (2.2)$$

This would be a way to measure the growth rate between two innovations, but by adding a dimension a dimension representing the growth in a continuous time span we will have to redo the expression. It can be shown with the help of some algebraic manipulation and introduction of a few variables (Jones & Vollrath, 2013 p. 121-123) that the expression for the growth of innovation over time eventually would end up as:

$$g_A = E[\frac{\dot{A}}{A}] \qquad (2.3)$$

The only real difference in the outcome of Schumpeterian Growth would be that it in contrast to the Solow Model that considered technology as a constant exogenous variable and Romer who assumed a constant growth given research and development, instead it is the expected value of the technological growth rate that describes how technology grows (Jones & Vollrath, 2013, p. 122). Thus, the technological growth rate adheres to a certain level of probability, the probability of creating an innovation.

2.3 Innovation and Financial Openness

With the importance of innovations to sustain a country's long-term technological growth established it follows that, within our theoretical framework, any exogenous variable which affects the growth of innovations inadvertently would have an effect on the technological growth rate. The Schumpeterian growth model states that using innovation as a process to increase the technological level is the basis for growth. A recent study by Salagado-Banda (2007) confirms the Schumpeterian argument by confirming a link between successful entrepreneurship and economic growth. We also know that the growth of the technological level is determined by the probability of new inventions and the increase of the technological level from the old innovation to the new innovation. To increase the technological growth rate, we have to at least increase either the probability of an invention or increase the surplus utility from the innovation. A prime example of such a change could be when a country opens up its financial and economic borders.

There have been many studies of the relationship between innovation, the availability of capital to finance innovation and the financial system. Amore, Schneider, & Žaldokas (2013) argue that the supply of credits through development of the banking system is key to the innovation performance of companies. The development of the banking sector can be done by financial entrepreneurship as Giordani (2015) as well as Beck, Chen, Lin and Song (2016) shows. But financial development can also be done by opening the financial system for transactions. Chinn and Ito (2005) finds a relationship between financial openness and financial development and Serdaroğlu (2015) finds a relationship between financial openness and an increase in total factor productivity in Turkey.

Zhang, Zhu, and Lu (2015) study financial development in China which follows by increase financial and trade openness in their article "Trade openness, financial openness, and financial development in China". In the article, they decide to split up financial development into three parts and study the effect on them separately. The three parts are size (total credits), efficiency (allocation of credit to the private sector) and competition (competition between banks). They find that both financial and trade openness has a positive relationship with efficiency and competition whereas size mostly has a negative relationship.

3. Data and Method

3.1 Data

Variable	Number of observations	Mean	Standard deviation	Min	Max
patentratio	1.089	0.884048	2.413143	0.000341	16.00753
kaopen	1.027	1.366743	1.361693	-1,894798	2.389193
trade	1.115	0.757471	0.465657	0.075899	2.863029
hc	1.115	3.009932	0.438435	1.469023	3.734285
nrrgdp	1.102	1.403784	2.69411	0	21.44035
pop	1.115	33.78908	2.69411	0	21.44035
PR	1.071	1.330532	0.929773	1	7
CL	1.071	1.564897	0.947816	1	5
interest	844	7.340024	4.446062	0.551138	29.74167
CMFRGDPPC	910	14.60392	57.35708	0	695.217
pcpc	944	41.44225	54.77194	0.309129	518.9181

Table 1. Table displaying summary statistics of the variables used in this paper.
For an explanation of the variables look at table A1 in appendix.

In the empirical study, we are using data from 33 OECD countries. The OECD countries we have date for are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. The OECD countries Slovakia and South Korea has not been included since there were not enough data to do statistical analysis on them. The study is limited to OECD countries since these countries have comparable and available data. The data used is limited to the period 1970-2014 since this period of time is the longest time we could retrieve data for at the same time as we can include as many countries and variables as possible.

The data is retrieved from several sources, Bank of International Settlements, Chinn-Ito index for financial openness, Comparative Political Dataset, Freedom House, Penn World Tables, World Bank and World Intellectual Property Organization. In the appendix table A1, you can find which variables are retrieved from which data base. An important note regarding our data is the data collected from Freedom House index for political rights and civil liberties where they changed the dates on which they conducted their survey between 1981 and 1989, which led to 8 surveys over 9 years. To make the data consistent we have added a year, 1981, which is blank.

3.2 Method

In this paper, we will use panel-data regression with fixed effects to determine whether financial openness leads to increased innovation. When dealing with statistical models, it is fundamental to have a big enough sample size to gain confidence and reduce the margin of error in the sample, but also to have enough variables to get explanatory power behind the model. Many of the control variables we collected or tried to collect data for were financial variables such as *credits to non-financial* sector or *return on assets* and *return on investments*. The first example was a variable we could collect data for, but the two following were variables which required access to a specific database, which we did not have access to.

The reason for the data not being freely available is easily understood if we examine economic theory. In economic theory, we expect actors to collect information and use this information to make decisions. This assumption holds whether we believe in strict rationality or bounded rationality (Schilirò, 2012). Based on this we can conclude that economic actors use information as a base to their financial decision making and hence it is possible to earn money on selling information. Since this is the case there are data which we are not able to get access to unless we pay for the information, which we have been unable to.

Another obstacle is the availability of the data. There are several databases which only go back to the early 90’s or 20’s. An example of this is several OECD databases, such as number of people employed in R&D or indicators measuring innovation in the OECD countries. It is plausible that the reason for this is that a lot of the data started to be collected during the digitization in the 90’s and early 20’s. Some data is most likely available as records in archives all around the globe, but to collect this data is out of our scope for this paper.

4. Model and Variables

In this part, we will do an empirical study of the relationship between financial openness and innovation with a sample of 33 OECD countries for the period 1980-2014 as discussed in the Data and Method parts.

4.1 Econometric Model Specifications

(Eq. 1)

$$patentratio_{it} = \alpha_i + \beta_1 kaopen_{it} + \beta_2 hc_{it} + \beta_3 nrrgdp_{it} + \beta_4 pop_{it} + \beta_5 PR_{it} + \beta_6 CL_{it} + \beta_7 interest_{it} + \beta_8 CMFRGDPPC_{it} + \beta_9 pcpc_{it} + \varepsilon_{it}$$

(Eq. 2)

$$patentratio_{it} = \alpha_i + \beta_1 trade_{it} + \beta_2 hc_{it} + \beta_3 nrrgdp_{it} + \beta_4 pop_{it} + \beta_5 PR_{it} + \beta_6 CL_{it} + \beta_7 interest_{it} + \beta_8 CMFRGDPPC_{it} + \beta_9 pcpc_{it} + \varepsilon_{it}$$

Where *i* = 1, … ,33 and *t* = 1980, …., 2014.

β_1…. β_9 are the estimated parameters

α is the individual-specific effect.

4.2. Variables

4.2.1 Measuring Innovation

Griliches (1990) discusses in his article "Patent Statistics as Economic Indicators: A Survey" the use of patents as a measure of innovation, as technological change. In his article, he shows that patents are a common measure of successful innovation. The reason for patents being such a good measure is that to successfully register a development or idea as a patent, it has to go through scrutiny and are required to contain a certain level of invention to be registered as a patent. Hence, we can consider each patent to increase the technological level. By connecting patents as a measure to the Schumpeterian growth model we can regard a patent as a successful innovation which contributes to technological growth. A patent would then be the foundation of innovation.

When we use patents as a measure over time and across counties we have to assume that the average patent contributes an equal amount to the technological level. Patents are widely used to measure innovation on company and sector level which Griliches (1990) discusses. In his paper, he discusses the use of patents as a measure of innovation on company level. But patents can also be used at country level to compare, both over time and between countries as Feki and Mnif (2016) shows in their empirical study of the link between entrepreneurship, technological innovation and economic growth.

In our model, we are using the number of patents per GDP per capita, which we have decided to name *patentratio*. We do this since it would be logical for a richer country to develop more patents since they are able to invest more money in R&D, this relationship is also supported by our data as can be seen in figure 1. The graph depicts all the countries' numbers of patents and real GDP per capita for the years 2012 to 2014. In the figure 1 we can see a trend where a country with a higher real GDP per capita also has a higher number of patents.

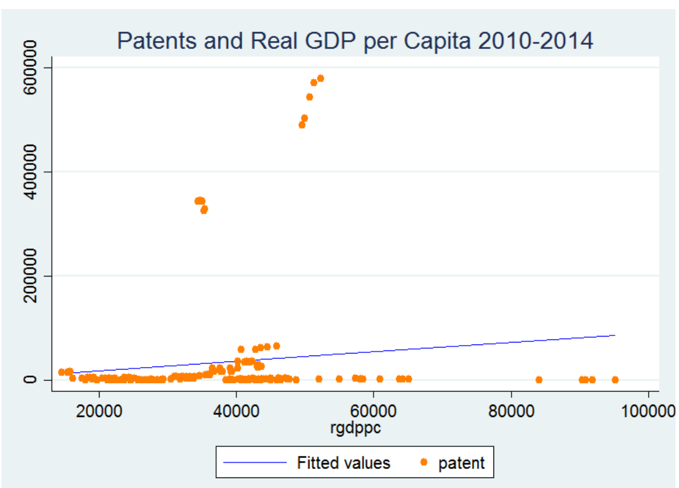

Figure 1. Number of patents and real GDP per capita for each country and year between 2010 and 2014.

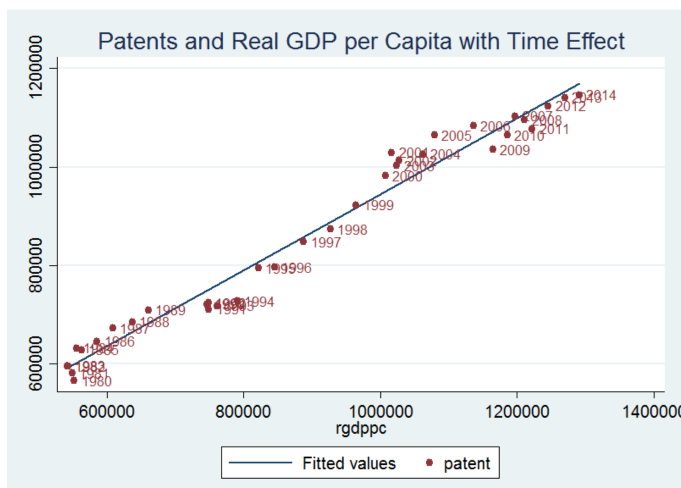

Figure 2. Total number of patents and total sum of real GDP per capita for all countries for the years 1980 to 2014.

In figure 2 we illustrate the relationship between the sum of all the countries' patents and real GDP per capita. From the figure, we can see that the two variables have a high correlation over time, but that real GDP per capita grows as a slightly faster rate than the number of patents. By the nature of how the data, which the graph was created, single years can stand out since the number of observations of which the yearly sums are created are not the same. This is most easily understood by looking at table A2 in the appendix. There you can see that for example the for the year 1983 there are 27 observations for number of patents and 29 for the real GDP per capita, which might lead to a higher real GDP per capita in relation to number of patents.

The underlying issue, which we have controlled for with figure 2, is whether there seem to be a time effect which makes patents or real GDP per capita grow apart over time or not. From the figure we can conclude that there does not seem to be such an effect. Hence, the assumption, that number of patents and real GDP per capita is correlated, holds over time as well.

Graphs 2 and 3 below, show how our patent data, population data and real GDP data change over time. In both figures we have chosen to take the average of all the countries per year. The calculations are done by summing up the total amount of the variables for all countries per year, divided by the number of observations each year. The reason the data is shown like this is because for some years we are missing more observations than for others. By taking an average of the observations we can compare the data over time. However, as we can see in graph 2 this comes with its own problems. For years 1989 to 1990 the number of observations changed from 29 to 33 which is the cause for the sudden drop of the line. However, a trend line can still be seen from these figures. To see the number of observations per year for the relevant variables see appendix table A2.

From figure 3 we can see that the total number of patents increase steadily over time, while at the same time *patentratio* is declining. By comparing figure 3 with figure 4 we can see that there is a steep increase in real GDP per capita during the same time. figure 3 says that *patentratio* is increasing by 83 percent from 1980 to 2014. figure 4 says that real GDP per capita is increasing 105 percent which would explain the decrease in *patentratio* shown in figure 3.

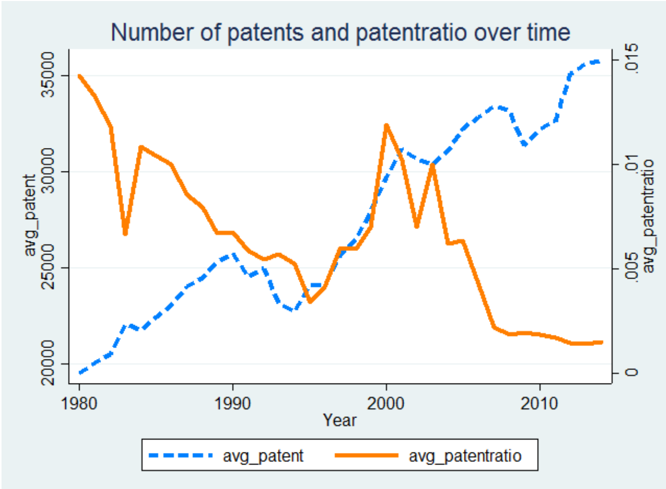

Figure 3. Average number of patents and average patentratio over time.

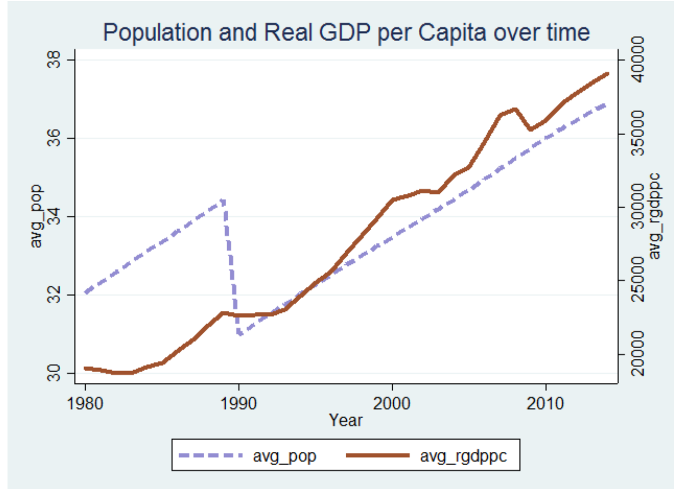

Figure 4. Average number of patents and average of real GDP per capita over time

4.2.2 Measuring Financial Openness

Financial openness, how open and accessible the financial market of a country is, can be measured by the Chinn-Ito index for financial openness, in our model named as *kaopen*. The Chinn-Ito index measures how restricted a market is to cross-country transfers using data from IMF's annual report on Exchange Arrangements and Exchange Restrictions (Chinn & Ito, 2006). Chinn and Ito (2006) lists the variables the index is built on. It is constructed by four dummy variables;

> "[T]he first indicating the presence of multiple exchange rates, the second indicating restrictions on current account transactions, the third indicating restrictions on capital account transactions and the fourth variable indicating the requirement of the surrender of export proceeds" (Chinn & Ito, 2006, p. 5).

One possible issue with the Chinn-Ito index is that it could be said to only measure political regulation of the financial system and not financial openness as a whole. To make sure we cover the whole spectrum of financial openness we have decided to use a complementary variable, *trade*, which we put into a regression instead of *kaopen*. The variable *trade* is constructed by summing the absolute values of export and import as a share of GDP, the data is taken from Penn World Tables. This way to measure openness is more commonly used when measuring the openness of the economy (Vogiatzoglou & Nguyen, 2016), but has been found to correlate with financial openness (Rajan & Zingales, 2003). Hence, we can use trade as a complementary proxy for financial openness.

In theory increased trade might reduce the number of innovations due to the domestic market's exposure to competition and influx of foreign innovations which leads to firms absorbing foreign technology instead of innovating themselves (Santacreu, 2015). Our findings however, does not support this theory and instead indicates that as trade grows so does *patentratio*. It is worth mentioning that it is possible that both financial and economic openness are affected by the same underlying variable or that they simply come in pairs, but this will not affect our model since we do not use them at the same time. We chose to use *trade* as a complement to *kaopen* with the reasoning that trade and financial openness often follow each other and should affect *patentratio* similarly.

4.2.3. Control Variables

In our model, we have 8 control variables, long-term interest rate (*interest*), human capital per capita (*hc*), rent from natural resources as percent of GDP (*nrrgdp*), population in millions (*pop*), political rights (*PR*), civil liberties (*CL*), market capitalization of listed domestic companies as a percent of GDP per capita (*CMFRGDPPC*), private credit to the private non-financial sector per capita (*pcpc*).

4.2.3.1 Openness and Availability of Credit and Capital

CMFRGDPPC and *pcpc* are both proxies for availability of capital but in theory there is a risk of both variables increasing due to a country opening up its financial system and economy. This means that as financial openness increase so does *CMFRGDPPC* and *pcpc* but possibly with a time lag. The relationship between the capital variables and *kaopen,* financial openness, is intuitive since *kaopen* in essence measures how unrestricted transfers of capital into the country are. This means that it is likely that the capital variables have a spurious relationship with patentratio. Hence, we decided to run a panel-data regression with fixed effects on *CMFRGDPPC* and a regression with *pcpc* where we let *kaopen* be the explanatory variable.

Capital Formation as a Ratio of real GDP per capita

Dependent variable: CMFRGDPPC (Y_{it})	
	(1)
kaopen	0,7667*** (0,2709)
hc	0,9998 (1,5740)
nrrgdp	0,2318 (0,1455)
PR	-2,1667** (0,8533)
CL	0,2592 (0,4079)
interest	-1301* (0,0670)
Constant	2,9143 (5,1019)
Observations	614
R-square	0,0840

*, ** and *** denote significance at 10%, 5% and 1% respectively

As can we can see *CMFRGDPPC* has a positive relationship with *kaopen* and is significant at the 0,5 pecent level. The test does not have an overall high explanatory power with a R-square of 0,0840. But there is a relationship between financial openness and *CMFRGDPPC*.

Private Credits to the Private Non-Financial Sector per Capita

Dependent variable: pcpc (Y_{it})	
	(1)
kaopen	-5,3403*** (1,4103)
hc	152,6361*** (8,6919)
nrrgdp	9,5853*** (0,8718)
PR	9,3880* (4,9825)
CL	2,4745 (2,3380)
interest	-0,8030* (0,3743)
Constant	- 434,6259*** (28,8907)
Observations	701
R-square	0,2456

*, ** and *** denote significance at 10%, 5% and 1% respectively

From the regression, we can see that *pcpc* has a negative relationship with *kaopen* and significant at the 0,1 percent level. The explanatory power for the test, R-square is 0,2456, is higher than that for the regression for the regression of *CMFRGDPPC* but still not very strong.

It is not easy to explain why *pcpc* has a negative relationship with *kaopen*. But without the variables *CMFRGDPPC* and *pcpc*, our regression of the relationship between innovation and financial openness loses explanatory power of the main control variables *kaopen* and *trade*. A fair question to ask is if not the reason for this is that the variables has a spurious relationship and what *CMFRGDPPC* and *pcpc* on a theoretic level contributes to the regression. The reason the two variables are important to the regression is that there might be a country which already has large amounts of credit and capital available which might lead to the explanatory variables *kaopen* and *trade* to not have as great effect. By including *CMFRGDPPC* and *pcpc* we can make sure that this is accounted for in the regression.

5. Innovation Measured by Patents per real GDP per capita

In this section, we present the result from our two panel-data regressions. Both regressions use number of patents per GDP per capita as proxy for innovation. The first regression uses *kaopen* as a measure of financial openness whereas the second regression uses *trade* as a proxy for financial openness.

Dependent variable: patentratio (Y_{it})		
	(1)	(2)
kaopen	0,0857** (0,0369)	-
trade	-	0,1178 (0,1146)
hc	-14847*** (0,2638)	-1,2697*** (0,2457)
nrrgdp	-0,1361 (0,0203)	-0,0008 (0,0188)
pop	-0,0601*** (0,0145)	-0,0654*** (0,0136)
PR	-0,0415 (0,1157)	-0,0375 (0,1131)
CL	-0,1771*** (0,0505)	-0,1786*** (0,0499)
interest	-0,0024 (0,0087)	-0,126* (0,0075)
CMFRGDPPC	0,0020 (0,0052)	-0,0008 (0,0009)
pcpc	0,0029*** (0,0010)	0,0018*** (0,0007)
Constant	7,4084*** (0,7577)	6,9624*** (0,7201)
Observations	604	633
R-square	0,5756	0,5851

*, ** and *** denote significance at 10%, 5% and 1% respectively

5.1 Financial Openness

Regression 3 uses *kaopen* as an explanatory variable and eight control variables. We find that financial openness measured by *kaopen* has a positive relationship with innovation measured by *patentratio* and is significant at the 5 percent level. Among the control variables *hc*, *pop*, *CL* and *pcpc* are significant at the 1 percent level whereas the rest of the variables are not within the 10 percent significance level. Out of the significant control variables only *pcpc*, private credit to the private non-financial sector, gave the expected positive relationship with *patentratio*. Human capital per capita, *hc*, were expected to increase *patentratio*. One explanation to the surprising result might be that a higher *hc* is correlated with a higher real GDP per capita and hence negates the increase in number of patents. Civil liberties, *CL*, were like *hc* expected to have a positive relationship with *patentratio*. The explanation for *CL* having a negative relationship with *patentratio* might be the same as for *hc*, an increase in civil liberties correlates with a higher real GDP per capita. It is however harder to explain how population, *pop*, can be negatively related to *patentratio*. An increase of pop, ceteris paribus, would lead to a lower GDP per capita and hence a higher *patentratio*. The overall test has a high explanatory power with a R square of 0.5756.

The positive result we find from the regression is in accordance with the theory. As a country opens the financial system we do find a causal relationship between openness and innovation. The mechanics behind this relationship confirms the link from financial openness to financial development and from financial development to innovation. Continuous financial de-regulation measured by *kaopen* implies development of the financial system and that financial development through various ways improve upon the ability to acquire funding to innovate and get a patent.

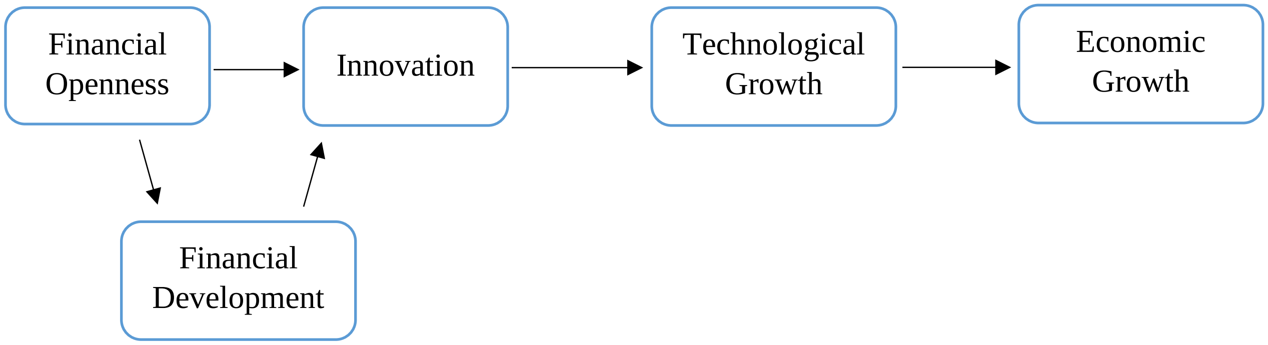

Figure 5. The Mechanism of financial openness effect on innovation and the effect of innovation on economic growth

5.2 Openness of the economy

After the regression with *kaopen* as proxy for financial openness, we did a regression where we substitute *kaopen* for *trade* as a proxy for financial openness. As has been said in the discussion of the variables, *trade* is not commonly used as a proxy for financial openness but correlates with financial openness. Hence, we use *trade* as a complement to *kaopen* and expect *trade* to have a positive relationship with *patentratio*.

As expected *trade* has a positive relationship, like *kaopen*, with *patentratio*. But we also see that *trade* is not significant at the 10 percent level. We find that among the control variables *hc*, *pop*, *CL*, interest and pcpc are significant on the 1 percent level, whereas the rest of the variables are insignificant. The overall test has a high explanatory power with a R square of 0.5851.

Even though the regression does not confirm a positive relationship between *trade* and *patentratio*, since *trade* is not significant, we can see that the regressions are very similar and that *trade* might very well have been positive if better or additional control variables were added.

6. Conclusion

In our paper, we set to find a link between the financial openness of a country and the effects it has upon the growth of innovations. With Schumpeterian growth models and their emphasis on innovation as a foundation, our paper expands upon what it is that drives innovation. With the help of previous research to build on, we discover that there's a lack of research in one important aspect of innovation; the financial openness of a country. The reasoning behind further exploring this concept comes through understanding the role the financial system has in the development of new innovations. By screening potential innovations as financial intermediaries they are able to properly mobilize and allocate capital into the innovations that have the highest probability to succeed. As the borders of a country open up, it will thus be exposed to the international financial systems, which leads to increased efficiency of the financial system.

We therefore set out with the purpose of finding a positive relationship between a country opening up its financial borders and their innovations. Substituting innovation with patents as a ratio of GDP per capita and the Chinn-Ito index as a measure of a country's financial openness, we run a panel data regression with fixed effects and do indeed find a positive relationship that a country's number of patents increase as a country opens up its financial system. This implies that financial openness does affect innovation through financial development by more efficient processes when finding and funding new ideas, which then leads to an increase in innovation through patents. Having explained the mechanism behind financial openness and innovation we can now extend our argument and say that financial openness leads to economic growth since innovation leads to technological growth and technological to economic growth.

The main limitations of this study have been the time limit and resources available. With more time, more variables could be explored to improve upon our results for closer approximations, such as using alternative measurements for innovation. As an example, Feki and Mnif (2016) use "New Business Density" as a proxy for innovation. One could further critique the narrow definitions we make in this study by using only patents as an estimation of innovations and further explore other licenses or measurements of technological advancements. Finally, we believe the main addition of this study lies within its attempts to bridge the fields of financial progress and economic growth and could be a subject interesting enough to explore outside the scope of a Bachelor's thesis.

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Appendix

A1. Table of descriptions and sources for variables

Variable Name	Description	Source
Patentratio	Number of patents registered at WIPO relative to GDP per capita	World Intellectual Property Organization
Kaopen	Financial Openness	Chinn, M. D. & Ito, H. (2006)
Interest	Long-term interest rates on governmental bonds	Armingeon, K., Isler, C., Knöpfel, L., Weisstanner, D. & Engler, S. (2016)
hc	Human Capital per Capita	Feenstra, R. C., Inklaar, R. & Timmer, M. P. (2015)
rgdpe	Real GDP (Expenditure Side)	Feenstra, R. C., Inklaar, R. & Timmer, M. P. (2015)
Nrrgdpe	Rent from Natural Resources as percent of GDP	World Bank
pop	Population in millions	Feenstra, R. C., Inklaar, R. & Timmer, M. P. (2015)
PR	Political Rights	Freedom House Index
CL	Civil Liberties	Freedom House Index
CMFRGDPPC	Capital Market Formation Relative to GDP per capita	World Bank
csh_x	Share of merchandise exports at current PPPs,	Feenstra, R. C., Inklaar, R. & Timmer, M. P. (2015)
csh_m	Share of merchandise imports at current PPPs	Feenstra, R. C., Inklaar, R. & Timmer, M. P. (2015)
pcpc	Private Credit Per Capita	Bank for International Settlements

A2. Table of number of observations each year

Year	Number of Patents	patentratio	real GDP per capita	pop
1980	29	29	29	29
1981	29	29	29	29
1982	29	29	29	29
1983	27	27	29	29
1984	29	29	29	29
1985	28	28	29	29
1986	28	28	29	29
1987	28	28	29	29
1988	28	28	29	29
1989	28	28	29	29
1990	28	28	33	33
1991	29	29	33	33
1992	29	29	33	33
1993	31	31	33	33
1994	32	32	33	33
1995	33	33	33	33
1996	33	33	33	33
1997	33	33	33	33
1998	33	33	33	33
1999	33	33	33	33
2000	33	33	33	33
2001	33	33	33	33
2002	33	33	33	33
2003	33	33	33	33
2004	33	33	33	33
2005	33	33	33	33
2006	33	33	33	33
2007	33	33	33	33
2008	33	33	33	33
2009	33	33	33	33
2010	33	33	33	33
2011	33	33	33	33
2012	32	32	33	33
2013	32	32	33	33
2014	32	32	33	33