Why some developing countries are more technologically advanced than others?

Abstract:

A country's innovation capacity and technological advancement is considered the driver of its economic development. Drawing on this supposition, the inquiry of what makes a developing country more technologically advanced than another has gained greater theoretical and empirical grounds in recent years. This research aims at drawing the causes of the differences in innovation performance within developing countries. Through pinpointing the deficiencies, the areas that need improvement can be tackled. Accordingly, the research uses data from 22 developing countries between low and high middle income economies. Data envelopment analysis is undertaken as a comparative tool to show the best and least performing among this group of countries. The Causes of Inefficiencies are then revealed within a National Innovation system Framework. As a first step, the absorptive capacity of developing countries is examined before investigating their ability to innovate. Results show that absorptive capacity can be improved relative to the best performs of developing countries through increasing the high-technology export rather than FDI, reducing natural resource rent, increase in the market size, increase in gross capital formation and a reduction in the enrollment in tertiary education in the presence of unemployment. It was also found that innovation capacity can be enhanced through an increase in the company spending on R&D, the increase in university industry collaboration, higher protection of property rights and a reduction *in favoritism in the government decisions*

1-Introduction:

In present time, innovation is considered a key factor for any economy's competitiveness particularly in a world where knowledge is the essence of growth and development. For developing countries in particular, finding a way to enhance innovation could be a challenge. One reason could be that they are trying to follow the same steps as developed countries, which had different global circumstances in their development process. It could be more convenient to take one step at a time by comparing the least performers to the best performers within the group of developing countries before looking up to the innovation systems of the developed countries. Henceforth, the paper attempts to investigate why some developing countries are more likely to be technologically advanced compared to others, using panel data spanning the period 2006 to 2014.

The answer to this question could be important to policy-makers to pinpoint (highlight) the areas that need the primary focus to enhance technological competitiveness in countries falling behind.

The objective of the paper is two-fold: First is to understand by *how much* some countries are more technologically advanced than others. Data envelopment analysis is conducted to decide which countries are performing better than others and benchmarking the best performing ones. Second, *why* some are performing better than others, is then studied under the National Innovation system (NIS) theoretical framework. The NIS is defined as a "historically grown subsystem of the national economy in which various organisations and institutions interact with and influence one another in the carrying out of innovative activity'' (Balzat & Hanusch, 2004).

This paper is contributing to the literature by focusing on the least performing of the developing countries. Most of the previous research was oriented toward comparing the developed countries with the high performers of the developing countries. This was intended to help those economies upgrade from a developing to a developed one. Little attention was given to the least performers economies of the developing countries. To the author's knowledge, this paper aims to fill this gap.

This paper is structured as follows. Section 2 reviews the determinants of the national innovation system and discusses the importance of data envelopment analysis. Section 3 highlights the conceptual framework and the method that drives the analysis. Section 4 outlines the empirical results. Section 5 offers concluding remarks and policy recommendations.

Literature Review:

2.1 The determinants of the national innovation system:

The road to technological advancement is debated in the literature. The Neoclassical affiliates explains technological advancement as a combination of capital, labour and knowledge (Romer, 1990; Barro & Sala-i-martin, 1991; Salai-Martin, 1995). The Schumpeterian and the industrial competitive advantage theories on the other hand, describe technological advancement as a product of a framework that does not only include capital and labour, but also institutions and social factors (Dosi, G., Freeman, C., Silverberg, G., Soete, 1988; Lundvall, 1998; Aghion, 2013; Lepp, 2015). From the above streamline, the National Innovation System (NIS) has been introduced to study the creation and the flow of technology and information among individuals, enterprises and institutions. The efficiency of the system is considered an important driver of innovation process. For this paper, NIS is considered as the best choice for developing countries. Since, at this stage of development, the supportive environment to technological advancement plays a critical role in establishing a culture of innovation.

On identifying the NIS framework, some argued that NIS is a country-specific approach that cannot be standardized (Hobday, 1995; Mathews, 1996). In this sense, Wong (1999) used a descriptive analysis to explain the divergent evolutionary pattern of Taiwan, Korea and Singapore. The paper offered a criticism that the NIS model doesn't fit all countries since systems are unique and specific within each country. On the contrary, others' argued that comparisons between countries are preferred in an integrated framework. Although the NIS might not explore the specific potentials, it would at least standardize the comparison (Furman & Hayes,2004; Hobday, 1995; Mathews, 1996). The NIS framework could change according to the type of countries in comparison, or the degree of analysis and research. Henceforth, there has been several proposition within the framework of the national innovation system and the different factors that can affect it[1]. However, in most of these propositions, three entities have been essential for the framework: Firms, public institutions, and their linkages. Also, there are limited number of studies that have proposed the inclusion of absorptive capacity in the framework (Hu & Mathews, 2005). In this paper, absorptive capacity is included as considered essential for developing countries.

Firms are considered at the center of the national innovation system framework. They are the main drivers of the innovative activity. However, these profit-maximizing firms are at the end responsive to the existing market conditions (Godin & Godin, 2009). Furthermore, the patterns of consumer demand may encourage the producer to increase firm's investment in R&D or not. More demand and a higher standard of living mean a greater incentive for firms to increase the quality of their products (Furman, Porter & Stern, 2002). Moreover, Firms Clusters allow the vertical and horizontal interconnectedness of firms from different industry thiies (Bell, 1999). Clusters thus help in the absorption of externalities both from knowledge spill-over, transnationally and internationally due to proximity. The effectiveness of this proximity is, however, dependent on the firm's willingness to invest in R&D. (Slaper & Ortuzar, 2015)

Also, institutions can be directly intervening in the innovation activity or may consist of indirect policies that can hinder or enhance innovation (Furman et al., 2002; Nelson, 1992). The indirect policies might be related to the interest rate, the openness of the economy, taxes incentives and subsidies or property right protection (Furman et al., 2002). Direct intervention by the institutions can take several forms. The amount of government expenditure provided to education and R&D expenditures are the most important and the most basic. The availability of venture capital that are normally willing to undertake innovative project of SMEs is

[1] The reader can refer to the appendix for the illustration of the frameworks presented by previous researchers.

also vital particularly in developing countries (Brancati, 2015). The creation of clusters and public research centers can be a more advanced step (Slaper & Ortuzar, 2015). In fact, Institutions have to be able to enhance the country's potentials. The comparative advantage of the economy may have an important implication on the ability of the economy to innovate. However, a country may have an equal opportunity between two comparative advantages. Choices could be done according to what activity would have the higher backward and forward linkage and what would increasingly allow the economy to gain a hedge in the international market (Porter, 1990).

Finally, the networks and interlinks created between the institutions and the private sector aims at providing a link between the fragmented components of the economy for knowledge creation. The most obvious and direct links in this process are a collaboration between universities, research centers and industries. Public research centers in particular can help those with the least R&D funding ability (Chang & Chen, 2004; Kafouros, Wang, Piperopoulos, & Zhang, 2015).

Discussing the NIS in developing countries, the relationship between absorptive capacity and the imitative capacity has to be examined. This is because, the elasticity of a developing country's innovation increases with its ability to absorb the external pool of knowledge (Becheikh, 2013). Archibugi & Pietrobelli, (2003) found a direct and almost instant relationship between the absorptive capacity and the imitative capacity. With the existence of a minimum threshold size of educated population, and thus absorptive capacity, higher levels of productivity should be reached. Moreover, Abramovitz (1986), proposed that countries with an economic environment that match that of the country it is imitating will have a better technological understanding and can incorporate convergence.

However, Narula and Marin (2003) and Xu (2000) also specified that FDI knowledge couldn't be spilled over without the pre-condition of possessing educated workforce. Also, Becheikh (2013) showed that absorptive capacity can be firm specific, its dissemination to the rest of the economy is conditioned by the availability of the strong interlinks. Accordingly, the measurement of absorptive capacity has also been a matter of debate. The ability of the economy to understand a new information is formed, established and increased over the years and is not an instance matter. This is why knowledge stock as measured by the capital stock is a starting point. This stock formed through investment not only in private R&D but also in public R&D so that knowledge would spread nationally. Nevertheless Fracasso & Marzetti, (2014), argued that basic education is more important for developing countries. Investment in education is thus considered the most significant aspect of absorptive capacity in these countries (Nelson et al., 2007). There are arguments on which level of education is considered the most important to enhance innovation. Tertiary education is found to represent the stock of specialized labour and main driver of innovation.

Moreover, FDI and trade are the main channels of technology spill-over. It seems that this source of technology spill-over would change with the level of development of the economy (Alvarez & Marin, 2013). Imported technology could be the first step for a least developed economy to even explore the existing knowledge abroad and imitate it. Unless this economy has a minimum threshold of human capital, it will not be able to reverse engineering the knowledge transferred by foreign firms. Exporting, however, is the most powerful channel of transfer. The feedback loop of the quality of the goods exported emphasises firms investments in R&D and learning from previous mistakes. It also means maintaining a hedge in the international competition. (Pino, Felzensztein, Zwerg-villegas, & Arias-bolzmann, 2016)

2.2 Estimating the NIS empirics:

Henceforth, and after the building blocks of the national innovation system are introduced, the two main methods (qualitative and quantitative) under which this framework is treated are discussed.

The majority of the qualitative studies are descriptive of the nation's specific system. With the emergence of the quantitative method, comparative approaches are more accurately conducted and aimed to serve policy-oriented studies (Patel, 1994). Furman & Hayes, (2004) are the first to present an empirical analysis of the NIS as presented in (Furman et al., 2002). The study attempts to investigate why some emerging economies are able to achieve successful technological catch-up while some innovative countries experienced relative declines in the innovative productivity in OECD.

Hu and Mathews (2005) modified Fruman and Hayes (2004)'s framework to include East Asian countries. Their results show that there is an important difference between the developing and developed countries in the NIS. As, the NIS of developing countries goes from the imitation stage to the innovation stage. This is why, other important variables have to be controlled for, such as the knowledge spillover through international trade.

Dosi et al (1990) also support the relationship between the innovation activity and the export performance for the East Asian latecomer countries. Most importantly, the paper makes use of the new to the country innovation as their dependent variable rather than the new to the world innovation: A developing country is more concerned about learning and absorbing already existing knowledge in the world rather than creating new ones and competing on the world's technological frontier.

Furthermore, Krammer (2009) tries also to explore why some developing countries might be more innovative than others. The analysis is conducted on sixteen eastern European emerging economies by exploring the patent performance. Karmmer draws several hypothesis retrieved from the NIS and confirms that R&D

commitment of public and private institution, property right protection, openness and FDI increases innovative capacity.

This aforementioned studies mostly use a subjective categorization based analysis: comparing the innovation systems of the countries according to their level of development. This can be convenient in describing how the national innovation system evolves at each development level. Indeed, the comparison between the different developmental stages will require running different models by dividing countries according to their level of development as Fruman did earlier. However, although it is argued that a more developed economy might be more innovative, this assumption does not necessarily hold between countries in the same level of development and particularly for developing countries. Therefore, a subjective categorization has deficiencies in showing the incremental differences in the innovation performance between countries from *the same level of development*.

This deficiency is more obvious when exploring the idea of frontier analysis. In fact, in recent years, new models introduced with the aim to provide a comparative framework. The general ideas of those models are to draw a frontier of the best performing countries according to an input-output analysis: The country that is using its resources the most efficiently will be on the frontier. The more far away a country is from the frontier, the larger will be the gap and the greater will be its relative inefficiency (Trick, 1990).

Frontier analysis carried by either a stochastic frontier analysis or a Data envelopment analysis (DEA). The DEA which is considered a mathematical model can be more flexible than the stochastic frontier analysis which is a regression that needs a model specification (Kotsemir, 2013).

A summary of the studies conducted using the DEA is found in Table (1) of the appendix. From this table, some limitation of the DEA are observed. Some of these studies did not use further econometric analysis to explain the inefficiencies of the countries. The difference of the efficiency between countries remains unexplained and only a ranking of countries presented. Others use the Tobit model as a tool to explain the determinants of the inefficiency score. This is because, the inefficiency scores retrieved from the DEA are censored and hence using the OLS regression analysis could lead to biased results.

It is observed that there are important differences in the results of the studies. The different choices of the input and output for the study of the DEA and the time of the study explain the different results: In Abbasi et al (2011) China was considered efficient, while in Shama and Thomas (2008) was considered partially efficient. Another important factor that may contribute to these divergent results is the choice of the countries included. Indeed, the DEA is a benchmarking technique and hence, the inclusion of one country can reduce the relative efficiency of another. Furthermore, it is noticed that in almost all of these studies, developed countries were included (Rousseau R & Rousseau S., 1997; Arcelus, 2003; Seema Sharma, 2008; Cullman, Schmidt-Ehmcke, Zloczysti, 2009; Abbasi, Farhad, Hojatolah, Hajihoseini, & Haukka, 2011; Guan, Chen, 2011). Another important observation of the DEA model is that several studies has used the super-efficient DEA model. This is considered a way to conceal the existence of outliers. The DEA is sensitive to the existence of outliers. The small size of countries is also another important limitation to the studies used (Naser & Afzal, 2014).

3. Identification Strategy: Empirical Approach and Data:

In an attempt to evaluate the differences in the innovation capabilities between developing countries, a two-stage analysis is used. As a first step, this paper inquires *how* the innovation capabilities of countries are different and is there a tendency for convergence or divergence. This is measured through a data envelopment analysis (DEA) technique. The second step investigates *why* this differential occurs. A Tobit model is thus used.

3.1 Data envelopment analysis

The data envelopment analysis is a comparative study of the efficiency of the productive performance of homogenous decision-making units (DMU). This non-parametric linear programing technique developed by Charnes, uses the distance function as an assessment of technical efficiency. This later can be measured as:

$$\boldsymbol{Technical\ efficiency(TE)} = \frac{\sum \boldsymbol{WO}}{\sum \boldsymbol{WI}} \qquad \textbf{\textit{(1)}}$$

WO= weighted output, WI= weighted input. Or can be written as

$$E_k = \frac{\sum_{J=1}^{M} U_j O_{jk}}{\sum_{i=1}^{N} V_i I_{ik}} \qquad \textit{(2)}$$

Where, = for the DMU (between 0 and 1), K=number of DMU in the sample, = number of inputs used (i=1,L,N), =number of outputs (j=1,L,N), O= the observed level of output j, I= the observed level of input ,V=the weight of input I, = the weight of output (Greene, 2004).

As observed in the equation above, technical efficiency is a ratio that is restricted to unity. Thus, a totally inefficient DMU will have a score of 0 while a completely efficient country will score 1. As a result, DMUs are compared to the best performer DMU that will be benchmarked. Consequently, this paper does not include a sample of developed countries. By including developed countries, the answer to the research question will be missed as most of developed economies will be on the frontier relative to the developing ones, as was noticed in previous studies.

Moreover, the inquiry of this paper gives interest to the output oriented analysis because, it focuses on the maximization of innovative output rather than on minimizing the cost of production.

The process of technological advancement cannot be measured in one point in time (Thomas, Jain, & Sharma, 2008). Technological efficiency should be studied over a long period to pinpoint its evolution. The usage of a panel data analysis could yield better results (Henningsen, 2014).

One option within the DEA analysis is to use, the Malmquist index, to estimate each T time period separately for all producers. This gives a frontier for each year and the regressions of the progression of regions observed accordingly. A convenience of this approach is the potential volatility of the efficiency estimated that may occur when temporally independent periods are chosen (Kaoru Tone, 2000). This difficulty can however be overcome by choosing consecutive years that covers from 2006 till 2014.

Once the efficiency scores of the DEA analysis retrieved, the estimation of a linear regression in the presence of censored data is not relevant. This is because, when data is censored to the right or to the left, the ordinary least square (OLS) will yield inconsistent and overestimated parameters.

3.2 The Tobit Model:

The Tobit model serves as a censored regression analysis:

$$
\begin{aligned}
Y_t &= X_t\beta + \mu_t \qquad if\ X_t\beta + \mu_t > 0 \\
&= 0\ if\ X_t\beta + \mu_t \leq 0 \qquad \textbf{(3)} \\
t &= 1,2, \ldots, N
\end{aligned}
$$

Where N = number of observations, y_t = the dependent variable, X_t = the vector of independent variable, β = vector of common coefficients, μ = the independently distributed error terms assumed to be normal with constant variable and 0 mean.

(Naser & Afzal, 2014)

The data envelopment analysis results are always censored to the left because they range between 0 and 1. Hence, when the model is run on Stata software, the option censored to the left is chosen.

3.3 The choice of the variables for the DEA model and the Tobit model:

For the absorptive capacity DEA model, two input and two outputs are chosen to study the efficiency scores. The public expenditure on education and the investment in the ICT infrastructure chosen as inputs, while GDP and labour productivity are the outputs. The intuition behind choosing those two inputs is that on the one hand education has the most influential impact on learning and knowledge absorption (Abbasi etal, 2011). On the other hand, the stronger the ICT infrastructure is, the higher the expected spread of the information in the economy becomes (Naser & Afzal, 2014). While the choice of the output variables focused on the aspect of the knowledge applicability in general. In the case of developing countries, the growth of the economy can also refer to imitation, which are lagging compared to developed countries. This explained choosing gross domestic product as one of the output variable. The second output; the total factor productivity variable is considered a novelty as it is rarely used in the Malmquist index. It is important because it reflects the acquisition of new knowledge and the understanding of new technology.

Similarly, to evaluate the innovative capacity of the developing countries, two inputs and two outputs are chosen in the DEA model. The variables chosen as an output for innovation capacity are as follows: the production of patents, the quality of scientific research. While, the variables selected to be inputs in the DEA model are the lagged values of the R&D expenditure and the number of researchers (Guan &. Chen, 2011; Cullman, Astrid; Schmidt-Ehmcke, Jems; Zloczysti, 2009)

The variables that influence the NIS are also taken form the literature, they are used to explain the inefficiency scores of the DEA model. For the absorptive capacity model, the following equation is regressed.

capacity model, the following equation is regressed.

$$EAC = \alpha + \beta_1 EHT + \beta_2\, FDI\ in + \beta_3\, GCF_{t-2} + \beta_4 UER + \beta_5\, ALT + \beta_6 MS + \beta_7 NCA + \beta_8\, TED + \beta_{10}\, NRR \quad \textbf{(4)}$$

EAC= efficiency score of absorptive capacity, $EHT =$ Export of high technology, $FDI\ in =$ FDI inflow, GCF_{t-2} = Gross Capital Formation, UER= Unemployment Rate, ALT=availability of latest technology, MS= Market Size, NCA= Nature of Competitive Advantage, TED = Tertiary education, NRR = Natural Resource Rent

The innovation capacity efficiency scores measured as follows:

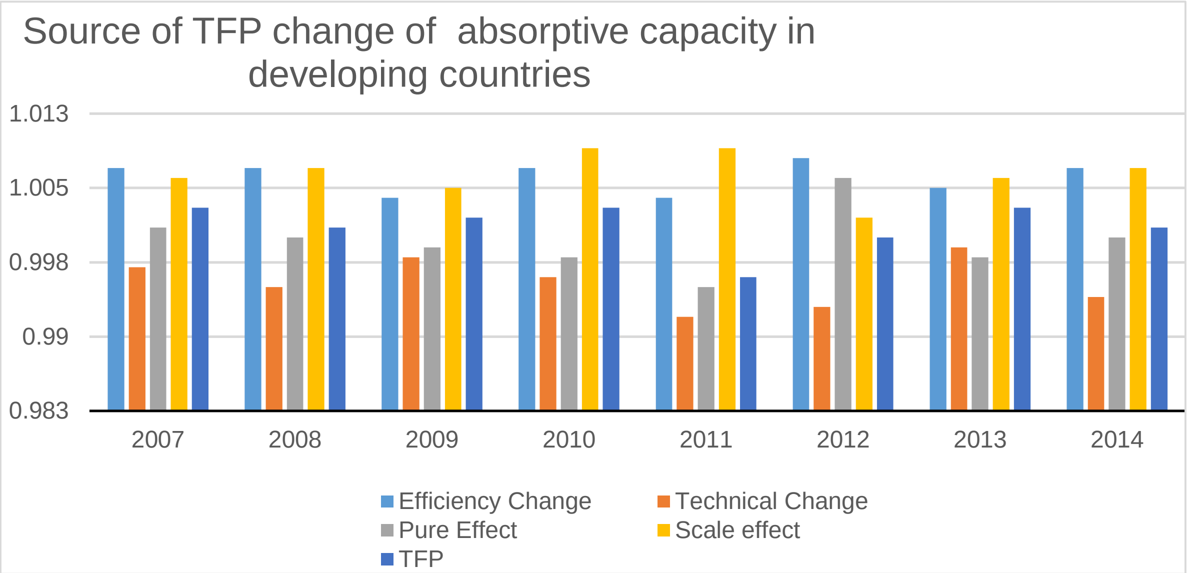
$$EIC = \alpha + \beta_1 UIC + \beta_2\, SCD + \beta_3\, PRP + \beta_4\, VCA + \beta_5\ R\&D + \beta_6\, FGD + \beta_7\, ILC + \beta_8 AML + \varepsilon. \quad \textbf{(5)}$$

UIC= University industry collaboration, PRP = Property Right Protection, VCA= Venture capital availability, $R\&D$= Company spending on R&D, FGD = favouritism in government decision, ILC= intensity of local competition, AML= anti-monopoly law

4. Empirical Results:

4.1 Data envelopment Analysis for the Absorptive Capacity:

Figure 1: Malmquist index results for absorptive capacity



Source: authors' calculations

The findings of the absorptive capacity in selected countries reveal progression. The graph shows that TFP growth is due to the scale and efficiency change effect. There is greater usage and greater efficiency in the usage of the ICT infrastructure and the public education. This is explained by the spill-over and the multiplier effect of those investments. A higher efficiency means that one unit of investment is serving an increasing number of individuals. Investment in ICT and public education are normally expensive but once settled can generate economies of scale (James & Taylor, 2002). Moreover, their multiplier effect is obvious because of the active integration of the private sector in both the private education sector and the internet services and related activities (i.e. internet based businesses).

In the meantime, one of the most prosperous fields of investment in the developing countries is the internet related activities. For example, (Boor, Oliveira, & Veloso, 2014) show that the diffusion of the usage and access of information and communication technology has a higher rate of growth in developing countries than in OECD .They also argue that the relative performance of SME that uses ICT is better than the non-users. Hence, the greater absorptive capacity as measured by education and ICT infrastructure allow greater labour productivity or else greater imitation of foreign technology and innovations.

Technical change however has the least contribution in the TFP growth in the absorptive capacity of these countries. This is also an expected result as it shows that developing countries have underutilized resources and are thus far from pushing away the limit of their potentials.

From the results, a regional trend is observed. The efficiency scores of the absorptive capacity show that China is on the frontier and thus plays the function of 'enveloping' the other countries. In this sense, all other countries are compared to it. It also seems that the other countries of the BRICS and Asian countries are at least 80% efficient from the frontier. On the other hand, there are heterogeneity in the range of Latin American Economies; Mexico and Colombia can be compared to the East Asian countries in knowledge absorption while the other Latin American Economies are less efficient. The Middle Eastern economies have also a lower efficiency, which range between 70% and 80% efficiency. Further explanations of the sources of these differentials revealed through the Tobit model.

4.2 The Tobit model of the absorptive capacity:

The findings of the Tobit model (appendix Table 4) reveal, that attaining a score of 100% (i.e. reaching the frontier), can be achieved if, export of high technology as a % of manufactured exports increased by 0.04% the market size increased by 4.5%, %, gross capital formation as % of GDP increased by 0.32% and FDI inflow as a % of GDP decreased by 0.32%, The enrollment in tertiary education fell by 0.1%, natural resource rent as a % of GDP fell by 0.8%, the unemployment rate fell by 0.14%.

From the analysis above, it seems that the transfer of knowledge to this group of developing economies will no longer be done through FDI but rather through export of high technology. As economies grow and become quality oriented, their cost of labour increases. They no longer attract FDI that searchers for unskilled low paid workers. FDI becomes an increasingly obsolete source of knowledge. The amount of knowledge that they have acquired would also allow them to export (Sheridan, 2014; Alvarez & Marin, 2013). As they export high-tech they are transferring an important amount of information through a feedback loop. For instance, although Xiong & Qureshi, (2013) discuss that the quality of the Chinese high tech export is still not up to developed country's standards, they show how the types of exports have upgraded from low-value added labour intensive product to ICT products.

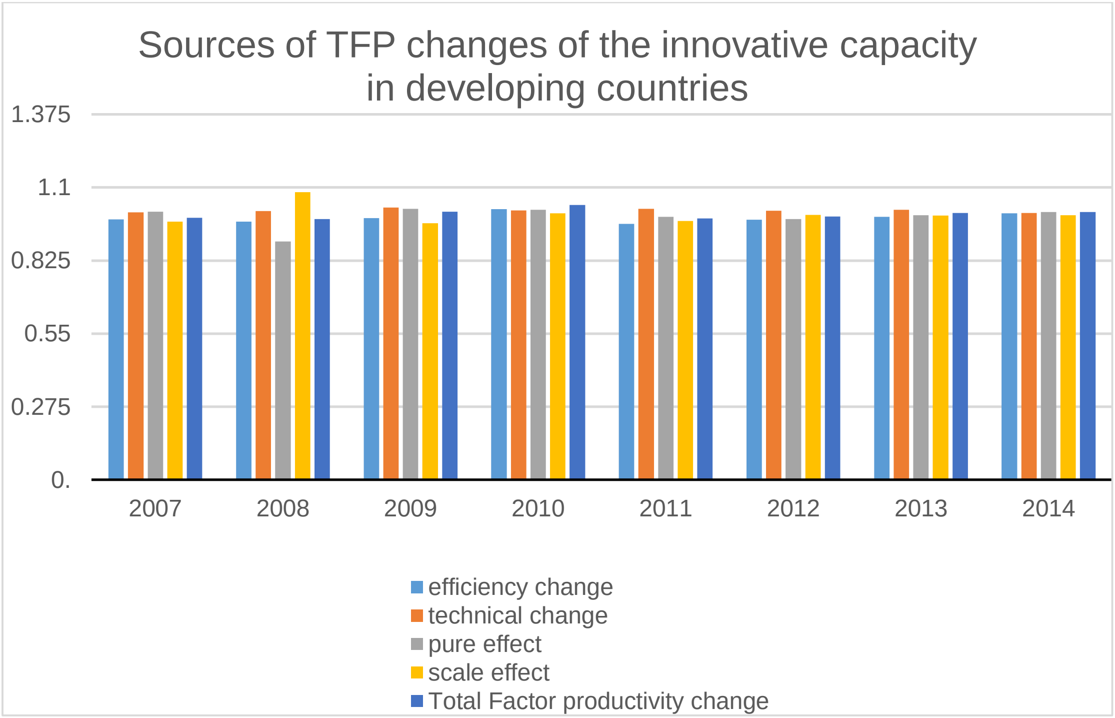
Furthermore, in many of these developing countries, unemployment can be a structural problem that is due to the mismatch between the education requirement and the labour market. This means that the education system might not be servicing the absorption of the existing external pool of knowledge that can, if enhanced, increase the competitiveness of the country (Mccaleb, 2012).

The negative and significant sign of the natural resource rent coefficient shows how the availability of natural resource can make a country less induced to take the harder developmental choices. Natural resources allow countries to enjoy a standard of living that is not consistent with their productivity which makes it unsustainable (Apergis, El-montasser, Sekyere, Ajmi, & Gupta, 2014). This is particularly relevant in the sample of countries from the MENA region due to their proximity to the oil producing countries (Apergis et al., 2014).

The ability to absorb external innovations is indeed conditioned by the previously formed knowledge within the economy (Hoarau & Kline, 2014). This is why, the lagged value of investment in capital has a positive and significant impact. The market size has also a positive relationship with the frontier. This is because with a larger market, business would increase and hence the possibility of agglomeration and learning (Pino et al., 2016).

4.3 Innovative capacity:

Figure 2: Malmquist index for innovative capcity



Source: author’s calculations

The total factor productivity of innovation capacity did not change in the sample of years studied. Indeed, a technical change in the TFP of innovation means that the economy has outpaced its innovation resources. A case that is unlikely to happen within this group of countries as their absorptive capacity has been under exploited. A closer look to the case by case innovation capacity scores in appendix Table (5) would show that most of the countries have been regressing in their relative innovative capacity and only a few have been progressing which explains why on average their capacity remained the same. Furthermore, Table 5 indicates that if any of the following occurred; university industry collaboration increased by 5%, the property right protection by 4.32%, company spending on R&D by 20% , and favoritism in the government decision fell by 15.4%, efficiency will reach 100%.

It is obvious from the analysis that it is rather the enhancement of innovation culture than the economic activity that would explain the difference between countries. The state of cluster development has an insignificant effect. This means that proximity between businesses is not the main target for this group of developing countries. It is more important to take advantage of this proximity through collaboration (Wong, 2011). This is why the university industry collaboration proved to have a significant impact (Wang, Chen, Wang, Ning, & Vanhaverbeke, 2014). Indeed, The Indian institute of science (IISC), the Indian institute of technology and the Indian institute of management (IIM) has produced some of the most brilliant minds in the worlds. Hence, collaboration between universities and industries have worked as a feedback for the education system on the type of skills needed for the prosperity of the industry. Also, the difference between the Asian and Latin American countries show the importance of the linkages in the innovation process. Arocena and Sutz (2000) indicate that it may be easy to build an organization that would foster innovation in Latin America, but it is difficult to make these organizations operate as bridges between different economic entities.

The significance and the sign of the property right protection coefficient is also another policy focus that can enhance or hinder innovative capacity. Indeed, among this group of countries, the Indian case is one of the most important examples that can be given. Policy makers in India are mystified between the protection of property rights for private profit making and the catering of social needs through knowledge dissemination. This has resulted in a relatively weaker property right system. As a result, the filling of patents fell in recent years (world Bank, 2015).

The favoritism in government decisions has a negative and a significant effect as it shows the low quality of governance. This can reduce the credibility of the government to investors and particularly the SMEs (Laperche & Liu, 2013).

5. Conclusion:

The recent development of the Asian tigers and several other late industrialized economies has greatly inspired economic literature. Although important contributions are made to analyse these economic miracles, little effort is done to show why some other developing countries are unable to achieve the same level of technological progress. This research thus attempted to pinpoint the areas that can be enhanced, among the upper and lower middle income group, to increase their innovative capacity and hence technological advancement.

the results conducted on the 22 developing economies between upper and lower middle income countries, in the Middle East, Europe, America and Asia reveal that, absorptive capacity can be enhanced relative to the best performers among developing countries through the following: increasing the high-technology export rather than FDI, reducing natural resource rent, increase in the market size, increase in gross capital formation and a reduction in the enrollment in tertiary education in the presence of unemployment. It is also found that innovation capacity can be enhanced through an increase in the company spending on R&D, the increase in university industry collaboration, higher protection of property rights and a reduction in favouritism in the government decisions.

This research has however several limitations. The NIS does not take into consideration the country specific circumstances. Henceforth, although the results show areas of deficiencies for the countries away from the frontier, this does not mean that all the possible opportunity related to each country has been exploited. Another limitation to internal validity here could be the span of time chosen. For example, in the sample taken FDI inflow could have a positive and significant relation with innovation potentials if the time span is different. However, this may not truly affect the results because the question this study is trying to answer is only limited to the difference between absorptive and innovative capacity over this span of time and is not related to how it changes with the development level. This is why, the results of this research have external validity only for countries of the same income group (upper and lower middle income countries) and hence the same level of development. External validity can also be threatened by the reactive effect to selection. This is because, the DEA is a comparative study, including one more country could lead to a change in the relative distance of another to the frontier. The larger the sample of countries within this income group, the higher will be the external validity. However, data on developing countries particularly for R&D expenditure and researchers is incomplete and missing for most of the countries.

The quality of data chosen can also cause limitation to this research. Only the Global competitiveness index provide data on innovation that are relatively complete for developing countries and only for the years 2006 till 2014. However, most of the data are collected through questioners and survey which might have a subjective point of view. For example, on the existence of state clusters, a survey was conducted on how common is to find a cluster in your country. Thus, the significance of the variables included in the Tobit model can be generalized to the middle and high income group of developing countries. The magnitude of the coefficient however can be only related to the sample chosen.

From the discussions prevailing in this paper, the importance of the intra-national knowledge spill over for the enhancement of the aggregate economy has been stressed several times. The size effect of SMEs increases their need for the creation of social and economic networks. They are thus considered an essential element in the spread of knowledge. The newly presented knowledge spill over theory of entrepreneurship (KSTE), if integrated within the NIS, could ameliorate the framework and its ability to draw policy recommendations for the enhancement of innovation competitiveness. Researchers can thus proceed with the discussions on the construction and applicability of this KSTE within the NIS.

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Appendix:

Table 1: Literature Review

Author	Choice of input/output	Method used	Sample of countries	Main Results
(Rousseau R & Rousseau S., 1997)	Input: Active population and R&D expenditure Output: scientific publications and Patents	Output oriented constant return to Scale DEA model.	18 countries: 2 Asian, 16 North American and Western European,	The Efficient economies are Austria, Canada, Germany Sweden, UK, Switzerland and Netherland

(Arcelus, 2003)	Input: Public expenditure on Research, Private R&D, Import of goods and Services, Employment in R&D, Education Expenditures. Ouptut: Patents, National Productivity, External Patents by Residents	Input-oriented, CRS DEA model	46 Countries: 1 African, 15 Asian and Oceania, 4 Eastern European, 21 Western European and Northern American,6 Carrabin	Argentina, Germany, Hong Kong, Venezuela Mexico are partially efficient while Japan, Taiwan and Switzerland are fully efficient.

(Seema Sharma, 2008)	Input: R&D expenditure, GDP, researchers per million population	Variable Return to Scale (VRS) and CRS input oriented DEA model.	22 countries: 12 Western European and North America, 4 Eastern European and 6 Asian and Oceania	Slovenia, South Korea and Japan are fully efficient while Australia, China, Denmark Russia, Spain and Portugal are partially efficient.

(cullman, Astrid; Schmidt-Ehmcke, Jems; Zloczysti, 2009)	Input: Researchers and Government expenditure on R&D Output: Weighted and Unweighted Patents	VRS, output oriented DEA model	28 countries: 3 Asian and Oceania, 19 Western European and north American, 4 Eastern European, 2 Latin American and Caribbean	Germany and Sweden are considered as the most efficient and USA, Finland, Belgium and Netherlands are less efficient.

(Abbasi, Farhad, Hojatolah, Hajihoseini, & Haukka, 2011)	Input: number of scientists in R&D expenditure on education and R&D expenditures. Output Variable: Royalty incomes, high technology exports and manufacturing exports.	VRS, output oriented DEA model	42 countries: 1 African, 13 Eastern European, 15 Western European and North American, 3 Latin American, 10 Asian and Oceania,	China, Hong Kong, Ireland, Israel, Japan, South Korea and Thailand are fully efficient. USA, Netherland, Kyrgyztan are not fully efficient.

Pan T, Hung S.V Lu.W.M (2010)	Input: Expenditure on education and R&D, Direct investment stock abroad, total R&D personnel nationwide. Output:Patent granted, High technology and ICT service exports, Publication	VRS, input oriented DEA model. Bilateral Comparison DEA model Supper efficiency DEA	33 countries: 16 Western European and north American, 10 Asian and Oceania, 7 Eastern European countries	Czech republic, Greece, Hungary, India, Poland, UK, Turkey, Slovak Republic, Russia, Singapore and Taiwan are considered efficient.

(Cai, 2011)	Input: R&D expenditure stock, Total R&D manpower. Output: Patents, Scientific publication, Royalty and Licensing	CRS and output oriented DEA model	24 countries: 12 Western European and North American countries, 2 Latin American and Carriban, 4 Asian and Oceanian and 6 Eastern European	Hungary, USA, UK and Israel are fully efficient while Argentina, Finland, Italy, South Korea, Spain, Slovenia, and Netherlands are partially efficient

Guan J. Chen K (2011)	Input: full time employed in R&D, R&D expenditure, Knowledge stock, Number of Scientists and Engineers, Output: Number of patents, International Scientific papers, added value of industries, high tech exports	VRS and CRs output oriented DEA model and Super efficiency DEA model	22 countries: 4 Asian and Oceania, Western European and North American, one Latin American and one Eastern European	Ireland and Greece are fully efficient while Canada, Finland, Hungary, Mexico, Turkey, Portugal, New Zealand and Japan are partially efficient.

(Naser & Afzal, 2014)	Input factor: Demographic structure, ICT infrastructure, R&D education, Cost of doing business, openness, and Natural resource endowments. Output: High tech export as a % of total manufacturing exports.	DEA Bootstrapping technique And Tobit Model	20 emerging and developed countries	The DEA efficiency scores can be improved through: increase labour force as a % of total population Enrolment in Secondary education and domestic credit expansion by the business sector

Figure 3: (Furman et al., 2002)'s first proposition for empirical investigation of NIS

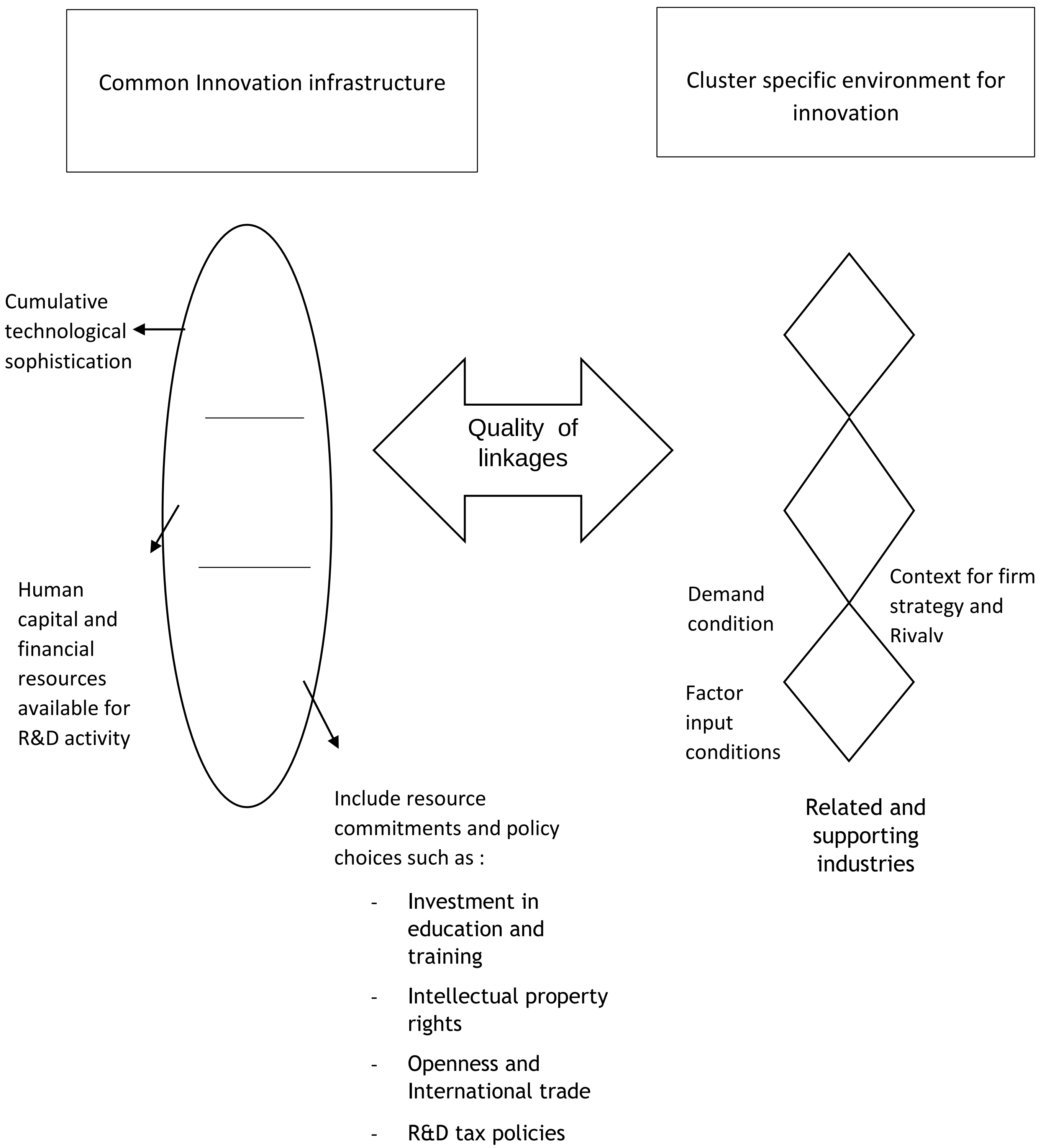

Figure 4: (Hu & Mathews, 2005) 's proposition for National Innovation system

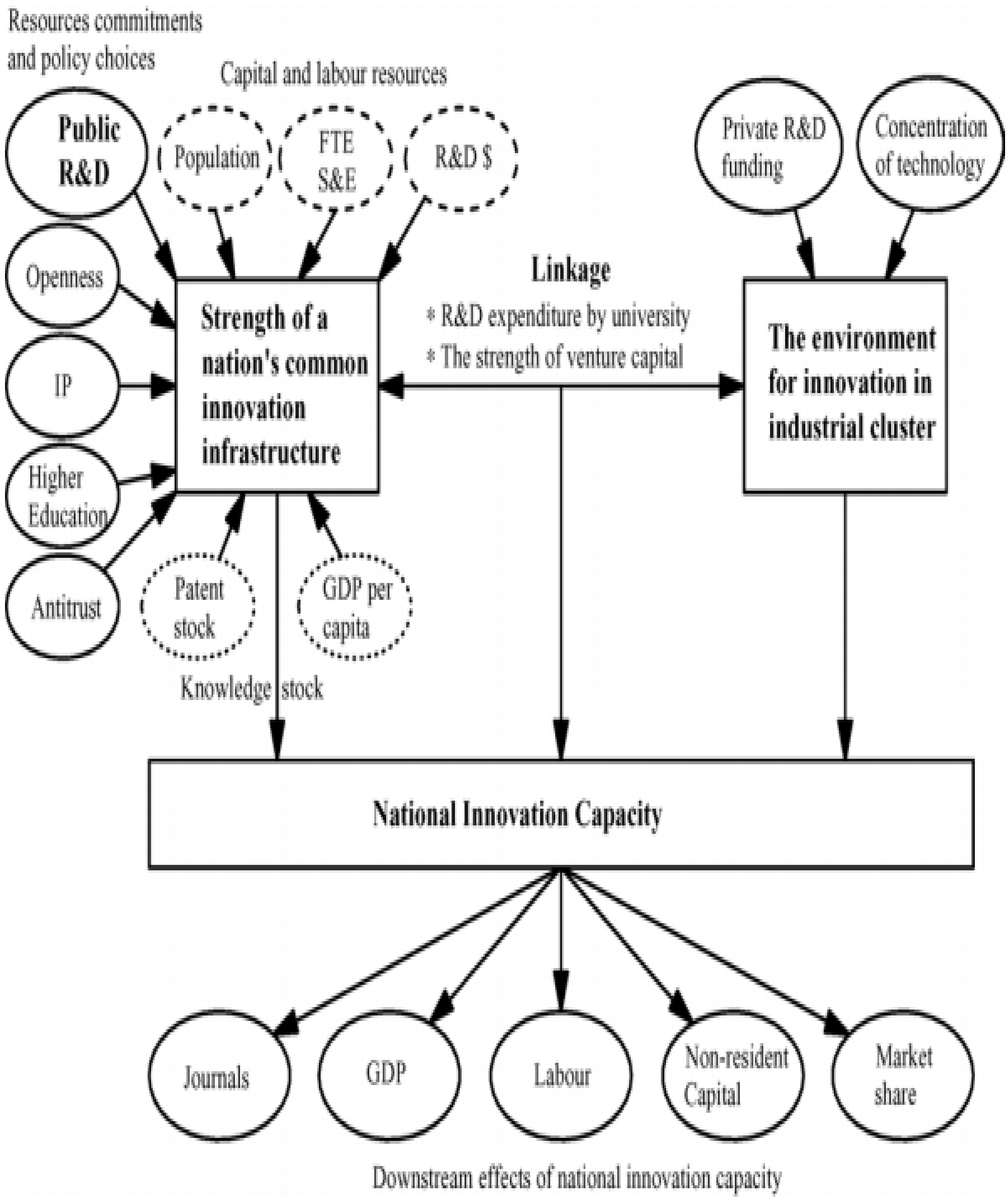

Figure 5: This paper's propostion for the National Innovation System

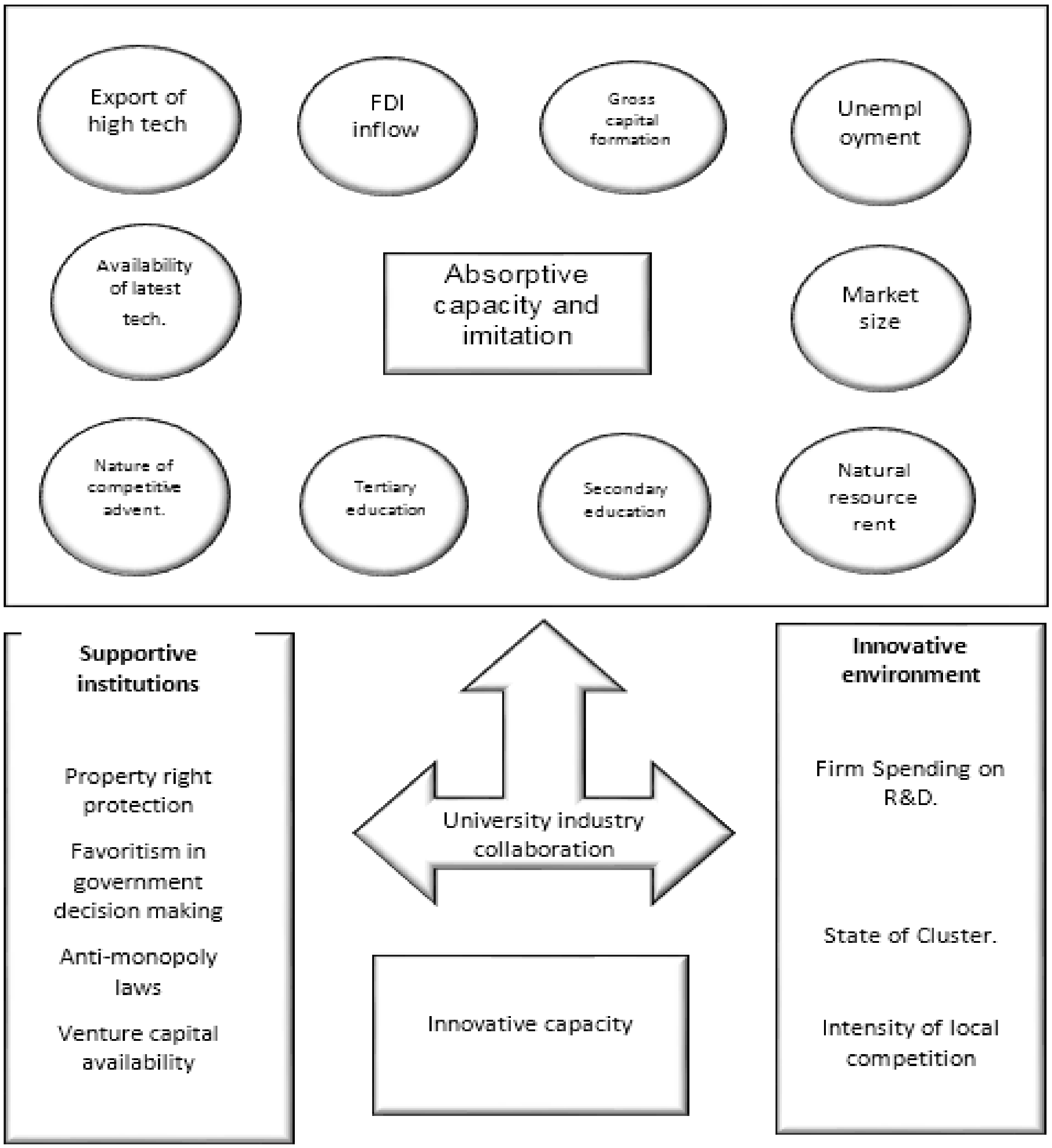

Table 2: Variables used and Data sources

Variable Name	Unit of Measurement	Source	Description
Intensity of local competition	Score form (1-7)	GCI	Survey: In your country, how intense is competition in the local market?
Market Size	Normalized scores from 1-7	GCI	(GDP + Imports of goods and Services- Value of exports of Goods and Services) normalized on a scale of 1-7
FDI inflow	% of GDP	World Bank indicators	The net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor.
Unemployment rate	% of total labor force	World Bank Indicators	Those seeking and available for work but without a job.
Natural Resource Rent	% of GDP	World bank Indicator	Includes sum of oil rent, natural gas, coal rent, mineral rent and forest rent.

State of cluster development	Score from (1-7)	GCI	Survey: In your country, how widespread are well developed and deep clusters (geographic concentration of firms, suppliers, producers, of related products and services and specialized institutions in particular fields?
University industry collaboration	Score from (1-7)	GCI	Survey: In your country, to what extent do business and universities collaborate on R&D?
Company spending on R&D	Score from 1-7	GCI	Survey: In your country, to what extent do companies spend on R&D?
Property Right	Score from 1-7	GCI	Survey: In your country, how strong is the protection of property rights, including financial assets?
High-technology exports	% of manufactured exports	World Bank Indicators	High-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery

Enrollment in tertiary education	% of total population	WBI	Total enrollment in secondary education regardless of age
Enrollment in secondary education	% of total population	WBI	Total enrollment in tertiary education regardless of age
Gross capital formation	% of GDP (Lagged Value of 1 year)	WBI	Consist of investment previously conducted in capital and the level of inventories.
Nature of competitive advantage	Score from 1-7	GCI	What is the competitive advantage of your country's companies in international markets based upon? (1=Low cost labor or natural resource,7= unique products and processes)
Availability of latest technology	Score from 1-7	GCI	Survey: to what extent the latest technology is available?
Venture capital availability	Score from 1-7	GCI	Survey: in your country, how easy it is for entrepreneurs with innovative but risky projects to find venture capital?

Anti-monopoly laws	Score from 1-7	GCI	Survey: in your country how strong are the anti-monopoly laws?
Favoritism in government decision	Score from 1-7. 7 never shown favoritism	GCI	In your country, to what extent do government officials show favoritism to well-connected firms and individuals when deciding upon policies and contracts?
ICT infrastructure	Internet users (per 100 people)	WBI	Individuals who have used the Internet (from any location) in the last 12 months. Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc.
Expenditure on Education	% of GDP %	WBI	Public government expenditure on education
Expenditure on R&D	% of GDP	WBI	Includes all types of research conducted privately and publically

Labor productivity	Per person employed	Total economy database (TED)	-------------
GDP	In constant terms (2005 US dollars)	WBI	GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products
Patents	Patent application per resident	WIPO	a product or process that provides a new way of doing something or offers a new technical solution to a problem
Quality of scientific research	Score from 1-7	GCI	Survey: in your country how would you assess the quality of research institutions?

Table 3: Abbreviations of the Variable Names:

Variable Name	Abbreviation
Efficiency scores of Absorptive Capacity	EAC
Export of high technology	EHT
FDI inflow	FDI in
Gross Capital Formation	GCF
Unemployment Rate	UER
Availability of Latest Technology	ALT
Market Size	MS
Nature of Competitive Advantage	NCA
Tertiary education	TED
Secondary Education	SED
Natural Resource Rent	NRR
Efficiency scores of innovative capacity	ESIC
State of cluster development	SCD

University industry collaboration	UIC
Property Right Protection	PRP
Venture capital availability	VCA
Company spending on R&D	R&D
favoritism in government decision	FGD
intensity of local competition	ILC
anti-monopoly law	AML

Table 4: Tobit regression Results for absorptive capacity

Variable	Coefficient	Standard error	Z-statistic
Export of high technology	0.0004**	0.00015	2.49
Enrollment in tertiary education	-0.001**	0.00016	-5.94
Availability of latest technology	-0.003	0.00387	-0.74
Natural Resource Rent	-0.008**	0.00025	-3.10

Enrollment in Secondary education	0.0003	0.00019	1.49
Market Size	0.045**	0.00248	17.93
Unemployment rate	-0.0014**	0.00045	-3.11
Gross capital formation	0.0032**	0.00035	9.02
Nature of competitive advantage	0.0063	0.00628	-1.50
FDI inflow	-0.0032**	0.00118	-2.72

**5% significant

Table 5: Tobit regression results for Innovative capacity

Variable	Coefficient	Standard error	Z-statistic
University-industry collaboration	0.05*	0.02649	1.72
State of cluster development	-0.0082617	0.0283	-0.29

Property right protection	0.0432*	0.02333	1.85
Venture capital availability	0.0002	0.03585	0.01
Company spending on R&D	0.2**	0.04422	4.48
Favoritism in government decision	-0.154**	0.02566	-6.01
Intensity of local competition	-0.04	0.03346	-1.14
Antimonopoly law	-0.015	0.3278	-0.46

*at 10% significance **at 5% significance

Table 6: Descriptive Statistics of variables in DEA and NIS framework

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
Availability of latest technology	160	4.11	0.507	2.81	5.445
State of cluster development	160	3.82	0.613	2.442	5.277
University industry collaboration	160	3.56	0.611	2.349	5.326

Property right protection	160	4.29	0.6775	2.79	6.021
Company Spending on R&D	160	3.28	0.568	2.286	4.993
Venture capital availability	160	2.985	0.612	1.767	4.625
Anti-monopoly laws	160	4.026	0.650	2.504	5.491
Nature of competitive advantage	160	3.35	0.4413	2.381	4.82
Export of high technology	160	13.52	15.177	0.190	68.9
Favoritism in government decision	160	3.095	0.565	2.08	4.92
Market size	160	4.61	0.981	2.437	6.816
Intensity of local competitive	160	4.90	0.562	3.34	5.93
Enrollment in Tertiary education	160	33.07	15.76	3	77.19
FDI inflow	160	3.2	2.57	-0.205	16.23
Gross capital formation	160	26.57	7.155	14.34	47.68
Unemployment rate	160	9.37	5.80	0.7	28.6
Natural resource rent	160	10.51	11.58	0.432	56.17
Patents	160	20303	93986	2	801135
Quality of Scientific research	160	3.836	0.597	2.367	5.31
Availability of researchers and scientists	160	4.293	0.587	2.788	6.29
R&D expenditure	160	0.592	0.4125	0.082	2.015
Labor productivity	160	1.025	0.1152	0.5388	1.412

Expenditure on Education	160	3.95	1.53	0.454	7.285