Absorptive Capacity and Innovative Capability: An Approach to Estimation

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Abstract

The concepts of absorptive capacity and innovative capability have been introduced to describe abilities of a country to imitate and, accordingly, to create more advanced technologies. In this paper we suggest new indicators of these two abilities. To calculate them, we develop an endogenous growth model and an estimation procedure that combines both calibration and econometric approaches.

The choice of parameters is based on WDI, ICRG and Barro–Lee statistical data for the period of 1981-2005. As a result, the model generates trajectories of about 70 countries and, for most of them, gives qualitatively correct pictures of their evolution dependently on their initial states as well as on their absorptive capacity and innovative capability indicators. In particular, club convergence is demonstrated. The calculations affirm our hypotheses about shapes of absorptive capacity and innovative capability dependence on the relative productivity level, human capital, institutional quality and some other factors.

1. Introduction

Each developing country tries to catch up with the developed world. Unfortunately, only few economies were able to reach this purpose during last sixty years. Well-known Gershenkon's argument – "advantage of backwardness" – does not work properly in most cases (Gershenkon (1962)). Though imitations of technologies and governance methods are much cheaper than innovations, the imitation process is also costly and requires sophisticated approaches of choosing and harmonizing different kinds of economic policies.

Different abilities of countries to imitate and to innovate are reflected in the concepts of absorptive capacity and innovative capability.

The concept of absorptive capacity has been originally introduced as a characteristic of a firm, namely its "ability to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen, Levinthal, 1990). Later on, this concept was applied to a country as a whole. The imitation process is understood in a broad sense including a choice of technology (or a method of governance), an acquisition of the rights to use it, its adaptation to the conditions of the recipient's country, its modification and, possibly, some improvements.

L. Suarez-Villa was probably the first one who has used (in 1990) a concept of innovative capability (see http://www.innovativecapacity.com). In Furman, Porter, Stern (2002, p.1), it is defined as "the ability of a country – as both a political and economic entity – to produce and commercialize a flow of innovative technology over the long term".

Imitation and innovation processes are main determinants of economic growth (see Barro and Sala-I-Martin (1995), Aghion and Howitt (1998) for surveys). However, different factors play different roles at different stages of development. Successful catching-up is possible only if appropriate policies are implemented at each stage and switching from one policy over to another one is made in time (Acemoglu, Aghion, Zilibotty (2002*a*), Полтерович, Попов (2006a,b), UNIDO (2005)). Possibilities to arrange good policies depend on our knowledge of absorptive capacity and innovative capability of a country[1].

There are a number of researches that suggest indicators of these or related abilities. Five of them are described and compared in Archibugi, Coco (2005). All of the indicators are based on a set of country characteristics and on "arbitrary weighting schemes with limited theoretical or empirical bases" (World Bank, 2008).

For example the index of innovation capability is published by the United Nations Conference on Trade and Development (UNCTAD) and consists of an unweighted average of an index of human capital (a weighted average of tertiary and secondary school enrollment rates and the literacy rate) and a technological activity index (an unweighted average of three per capita indicators: R&D personnel, U.S. patents granted, and scientific publications).

In UNIDO (2005), weights were chosen by factor analysis that was carried out on 29 indicators, and five principal factors were labeled as knowledge, inward openness, financial system, governance, and the political system. The first factor correlates highly with R&D and innovation, scientific publications, information and communications technology infrastructure, production certifications and education. Inward openness means imports and inward FDI. Financial system composite indicator reflects market capitalization, country risk and access to

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[1] "Both policy analysts and academic researchers need new and improved measures of technological capabilities on the performance of nations to understand economic and social transformations. With regard to policy analysis, this has relevance for public and business practitioners. Governments constantly require information about the performance of their own country, and this is often better understood in comparison to the performance of their partners and competitors" (Archibugi and Coco , 2005, pp.175-176).

credit. These factors as well as nine geographical, cultural and natural resource indicators were taken as regressors for growth rate. The sample included data on 135 countries for two three years periods: 1992-1994 and 2000-2002. Only financial system, governance, knowledge and/or their increments were found to be significant.

A similar methodology, based on factor analysis, has been used in World Bank (2008).

This methodology seems to be better than the arbitrary choice of weights. Even in this case, however, the economic meaning of the received indicators remains not quite clear.

The short survey above shows that up to now there are neither general strict definitions of absorptive capacity and innovative capability nor convincing methodology to measure them. This paper tries to fill in this gap.

2. Main concepts

In this paper we try to build indicators that could not only serve for comparisons of different countries technology levels but also could help to choose most efficient direction to invest.

Having in mind this goal we introduce the following definitions.

The absorptive capacity is defined as the cost of 1% TFP increase of a country's capital unit through technology imitation of other economies.

Analogously, the innovative capability is defined as the cost of 1% TFP increase of a country's capital unit through technology innovation.

In these definitions, technology is understood in a broad sense as a method of production, trade, governance, etc.

Different kinds of policies and institutions are required to increase absorptive or innovative abilities. If, for example, absorptive ability of a country is much higher than its innovative ability then it is reasonable to invest into imitation projects. Thus, it is important to measure both abilities. This is particularly important for Russia, where policymakers and economists intensively debate the role of imitation and innovations in the Russia’s development strategy (see, for example, Концепция (2008), Полтерович (2009)).

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3. Methodology

To be reliable, a measurement method has to be based on a model which is able to reproduce a general picture of the world economic development. This picture is complicated enough. Advanced economies seem to converge to each other. Another converging group includes a number of Latin American and some other countries with 15-30% of the USA GDP per capita.

These two groups are growing with similar rates whereas most of African countries fall behind. It looks like the world per capita income is moving toward a distribution with two peaks. This observation gave birth to a number of research about "club convergence".

Some explanations of this phenomenon may be got in the framework of underdevelopment trap theories (see Azariadis and Drazen (1990) and Feyrer (2003) for a survey and references). Some authors consider interactions among innovation and imitation processes and institutional development as main determinants of the club convergence behavior (see Barro and Sala-I-Martin (1995), Aghion , Howitt(1998) for surveys, and also Acemoglu, Aghion, and Zilibotti (2002a,b), Howitt and Mayer-Foulkes (2002)).

In this paper we consider two modifications of the model developed in Polterovich, Tonis (2003, 2005)[2]. Our model has a number of attractive features that make it a good instrument of measuring absorptive capacity and innovative capabilities.

The analysis of the model shows that, under stationary exogenous conditions, there could be three types of stable stationary states, where only imitation, only innovation or a mixed policy prevails[3].

We calibrate our model using data from WDI (2008), ICRG (2004), Nehru and Dhareshwar (1993), Barro and Lee (2000). The calibration procedure includes econometric estimation of the imitation and innovation cost functions which measure, respectively, the absorptive capacity and the innovative capability. We find how these capabilities depend on a broad set of indicators such as the level of development, investment risk, international trade, human capital and some others. The estimated cost functions and a few other parameters are used to reproduce the actual growth dynamics of about 70 countries from 1981 to 2005. This methodology permits to check, at least partially, hypotheses 1)-6).

Our estimation of the cost functions for innovation and imitation is based on how we separate the impacts of the innovation and imitation activities using proxies based on the royalty receipts and royalty payments of a country. We use two alternative assumptions: growth-based separation (ratio of rates of growth induced by innovations and imitations is proportional to royalty receipts over royalty payments) and cost-based one (ratio of royalty receipts to royalty payments is proportional to the ratio of innovation to imitation costs). We also use two ways of describing the evolution of human capital: exogenous one, based on the data on the average years of schooling (Barro and Lee, 2000), and endogenous one, using a dynamic equation for human capital. So, we suggest four alternative specifications to be estimated. Comparing these specifications allows testing the robustness of our results.

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[2] Another modification was developed in Пикулина (2009).

[3] A description of the model and its analysis is available by request.

4. Measuring Absorptive Capacity and Innovative Capability

As a result of the calibration procedure, we obtain the best-predictive values of the parameters. In particular, the cost functions of imitation and innovation are estimated. The dependence of the normalized costs on different factors under different specifications is shown in Table 1.

Here "+" and "–" mean positive and negative dependence; *, ** and *** mean 10%, 5% and 1% significance levels, respectively; 0 means insignificance. Table 1 is consistent with hypotheses 1)–5) at almost all points: absorptive capacity is high (and the cost is low) in countries with relatively low level of development, active international trade of manufactures and good investment climate; absorptive capacity is high in more developed countries with much human capital. Though, the impact of institutional quality (investment climate) on the innovative capability is not shown by any of the specifications. FDI contribution in both abilities is insignificant as well as the coefficients for bank credits.

Table 1. Signs of the coefficients of the cost functions

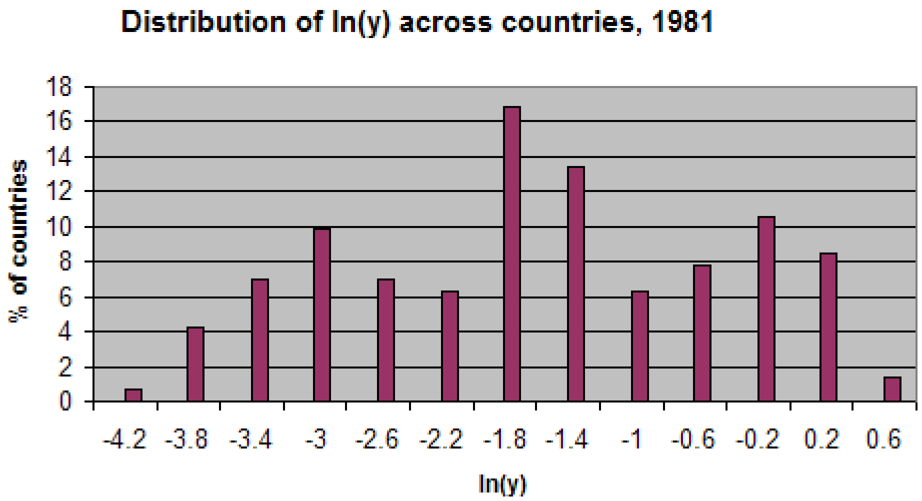
Specification	Growth-based separation; exogenous human capital		Growth-based separation; endogenous human capital		Cost-based separation; exogenous human capital		Cost-based separation; endogenous human capital	
Normalized cost of	imit.	innov.	imit.	innov.	imit.	innov.	imit.	innov.
Relative level of development	$+^{***}$	$-^{**}$	$+^{***}$	$-^{**}$	$+^{***}$	$-^{***}$	$+^{***}$	$-^{***}$
Population	0	$-^{***}$	0	$-^{***}$	0	$-^{***}$	0	$-^{***}$
Human capital	0	$-^{***}$	0	$-^{***}$	0	$-^{***}$	0	$-^{***}$
Investment climate	$-^{**}$	0	$-^{**}$	0	$-^{***}$	0	$-^{***}$	0
Investment/GDP	0	$+^{***}$	0	$+^{***}$	0	$+^{***}$	0	$+^{***}$
Manufactures Trade	$-^{***}$	0	$-^{***}$	0	$-^{**}$	$-^{**}$	$-^{*}$	$-^{**}$
Bank credits	0	0	0	0	0	0	0	0
Foreign investment	0	0	0	0	0	0	0	0
Scientific papers	N/A	$-^{***}$	N/A	$-^{***}$	N/A	$-^{***}$	N/A	$-^{***}$

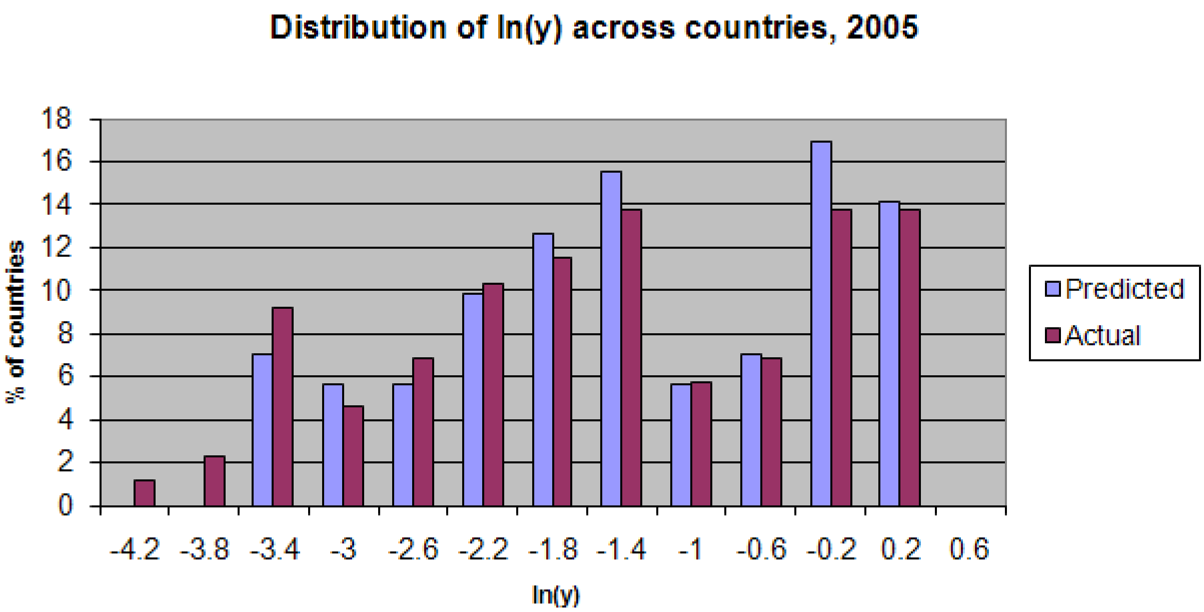
Additionally, international trade may enhance the innovative capability, as the cost-based specifications show. Fundamental research (measured by the number of scientific publications) predictably improves the innovative capability. The share of investment in GDP does not affect significantly the absorptive capacity and negatively affects the innovative capability. The latter effect may occur due to decreasing rate of return: the larger innovative efforts are already done the more difficult it is to get further positive effect.

Coincidence of almost all signs for the four specifications shows that our main conclusions are robust with respect to the choice of specification.

To measure the quality of the calibration, we compare the countries' distributions by the relative level of development y which is defined as the ratio of country's per capita GDP to that of the USA. We start from the actual distribution of y in 1981 and, using the model, try to predict y in 2005. The initial, predicted and actual distributions (under cost-based separation and endogenous human capital) are depicted in Figure 1.

Figure 1. Evolution of countries distribution



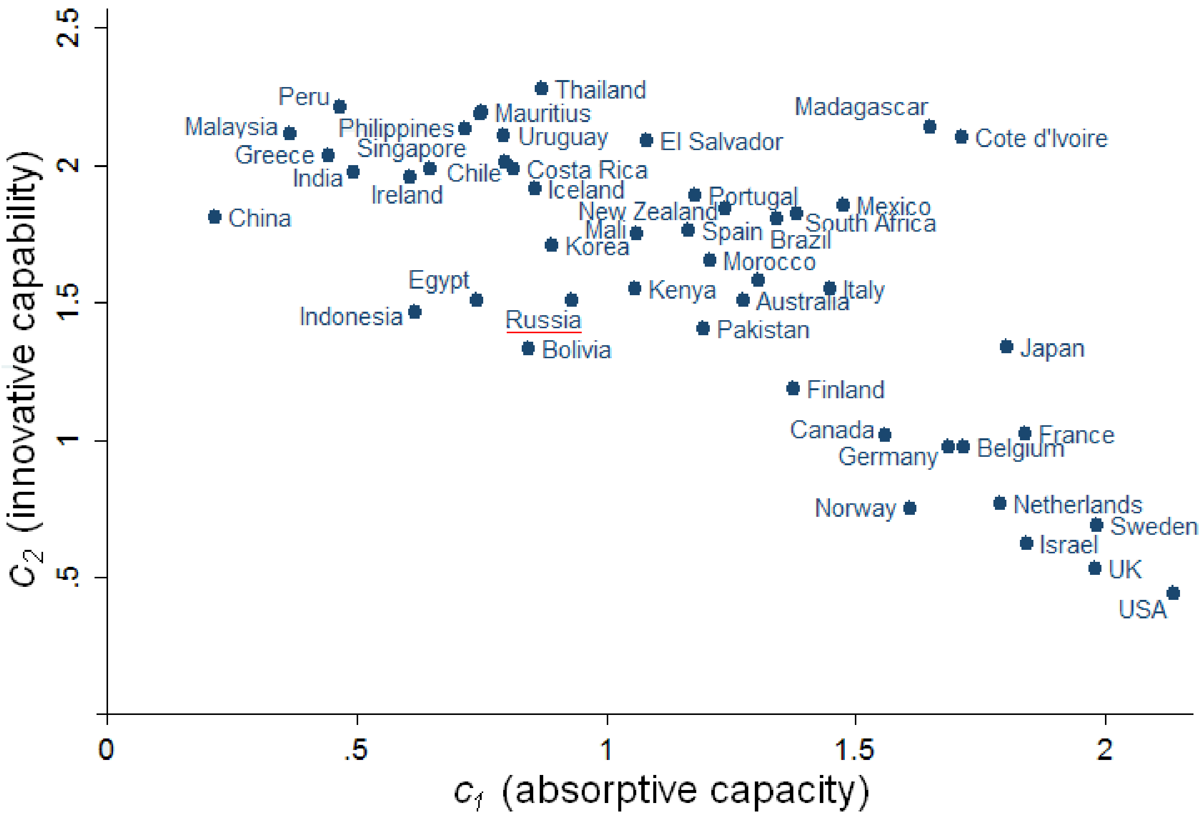


The model predicts main features of the real evolution of countries distribution by GDP per capita. However the distribution tail, containing four countries in 2005, is not predicted.

With the calibrated parameters of the model, one can estimate the absorptive capacity and innovative capability of various countries. We follow our definitions of these abilities, and denote the cost of 1% TFP increase due to technology imitation (innovation) by c_1 (c_2). Costs c_1 and c_2 are measures as % of country's capital stock. The higher is c_1 (c_2), the lower is the corresponding ability.

The estimations of the absorptive capacity c_1 and innovative capability c_2 are visualized by Figure 2.

Figure 2. Absorptive capacity and innovative capability.



The points in Figure 2 form a downward sloping cloud which is consistent with our main hypothesis and Table 1. The most developed countries (European Union, Japan, USA, Canada) have relatively high c_1 (low absorptive capacity) and low c_2 (high innovative capability). East Asian countries (China, India, Singapore, Phillipines, Bangladesh, Malaysia), along with some European countries (Greece, Ireland) base their growth mainly on the absorptive capacity. Madagascar and Cote d'Ivoire spend very much money on each per cent of their TFP growth, so they are in the upper-right part of Figure 2. Some countries (Bolivia, Pakistan, Egypt, Indonesia) seem to have unexpectedly low c_2, which may be explained by some part of the license receipts possibly irrelevant to the innovation (in particular, these licenses may include permits on natural resource extraction or tourism).

Russia is rather in the left side of the cloud in Figure 2, though closer to its center than the East Asian countries. This means that Russian TFP growth is more oriented to imitation, with innovation still having some impact. Of course, a significant share of Russian growth can be explained by the fuel export which is not included in our simple model.

5. Conclusion

In this paper, we develop an approach to the estimation of country absorptive capacities and innovative capabilities. The approach is based on new more precise definitions suggested. Therefore, both concepts get clear sense, and it is demonstrated how one can calculate both indicators. The method of calculation uses a simple dynamic model and combines calibration and econometric approaches. This gives a possibility to analyze how calculated indicators depend on different factors. Another important feature of our approach: the estimations are conducted not for each country separately but for a group of economies jointly. This gives us additional information which is not contained in data on a country alone.

There are a lot of possibilities to improve our approach. One could try to use an OLG model instead of one period model, and, in an explicit form, include labor markets with workers of different qualifications as well as sectors of education and research. Maybe, even more important task is to try different hypotheses to reach the separation of imitation and innovation costs and results.

In any case, we believe the approach may be improved and will be useful for economic decision making.

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