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International spillovers in a world of technology clubs

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ABSTRACT

The technology club literature suggests a tripartite segmentation of countries into an innovation, an imitation and a stagnation club. We use a Benhabib–Spiegel type growth model embedded in a threshold regression framework to test for non-linearities in the impact of the technology gap on economic growth as suggested by the technology club hypothesis. Using human capital as the threshold variable we are able to identify three country groupings. In line with the technology club hypothesis we find the strongest effects of the technology gap on economic growth in the intermediate group which we associate with the imitation club.

1. Introduction

Technology is a key component of long-term growth and successful economic development. In an international context this implies that countries' economic growth does not only depend on domestic technological progress but also on technological developments abroad. If one assumes that technological progress – be it by way of innovation or by imitation of existing foreign technologies – is a costly process, not all countries will grow at the same rate. Therefore the level of technology (and hence productivity) differs greatly across countries, a fact which is hardly disputed.

One of the objectives in this paper is to use technology and human capital related indicators to classify countries according to their technological capacity. A country's technological capacity, in a broad sense, depends on both its capability to undertake research and development (R&D) and innovate and its ability to absorb foreign technologies that have been developed abroad. R&D and imitation represent two distinct activities that both feed into technological progress. While innovations add to the existing (global) technology stock and shift the (global) technological frontier outward, imitation is the process of being able to make productive use of existing innovations. The ability to imitate and adopt foreign technologies for local use must be assumed to be a highly human capital and knowledge intensive process (as are original innovation and R&D). For this reason we follow Nelson and Phelps (1966) in assuming that the capacity to benefit from foreign technologies via international spillovers depends primarily on the level of human capital available in the country. Hence, while it is true that countries with low levels of productivity have a high potential for receiving technology spillovers, de facto, they may find it hard to benefit from such spillovers because of the lack of human resources required for the imitation process. In this case Gershenkron's famous "advantage to backwardness" is counteracted by a lack of absorptive capacity.

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Countries will perform neither innovation nor imitation activities if their levels of human capital do not meet the required threshold to undertake R&D and/or imitate foreign technologies. For example, R&D and patenting are highly concentrated activities with the EU, the US and Japan alone accounting for more than two thirds of the global expenditure on R&D in 2007 while the Sub-Saharan countries undertake very little R&D, a mere 0.5% of global R&D expenditures (UNESCO, 2010).

Countries undertaking either innovation, imitation or none may diverge on different growth paths and/or end up at different income levels. This constellation gives rise to the notion of convergence clubs suggesting a tripartite world consisting of an "innovation group", an "imitation group" and a "stagnation group". The innovation group includes countries that perform R&D and innovate thereby pushing the global technological frontier outward. Countries in the imitation group do not undertake R&D themselves but take on new technologies developed abroad through the absorption of foreign technologies. The stagnation group has insufficient endowments of human capital and skills in order to adopt and implement new foreign technologies. Therefore the countries in this group have very high technology gaps, that is, the difference in their productivity level to the country with the highest productivity.

As pointed out above we will use technology (R&D expenditure) and human capital related variables (literacy rate, years of schooling) to cluster countries into technology clubs. As it turns out, we find three rather distinct clubs which fit well the idea of innovation, imitation and stagnation groups.

In the second part of the paper, we test whether we can detect catch-up effects – that is growth effects from an existing technology gap – in a growth regression framework and to what extent these catch-up effects are associated with a country's absorptive capacity. Our simple growth equation contains, next to the traditional factors of production, a technology gap variable which is intended to capture the growth effects associated with international technology spillovers.

We employ the threshold regression approach developed by Hansen (1996, 1999, 2000) to allow for non-linearities in the catch-up effects of countries, splitting the sample along the human capital dimension. We find that for countries with intermediate levels of human capital there is a large catch-up effect, i.e. countries can to some extent translate their technology gap into higher growth. At the same time such a catch-up process cannot be taken for granted as countries with very low levels of human capital enjoy only limited growth effects from their technology gaps – though their technology gaps tends to be large. The contribution of the paper to the existing literature is threefold. First of all, by choosing a threshold regression approach we do not need to define the convergence clubs a priori but can let the data search for and determine the boundaries between the different the clubs. In our view this approach improves the validity of the argument in favour of distinct growth regimes for different groups of countries. Secondly, we show that the resulting convergence clubs are very similar irrespective of whether these clubs are defined using human capital or an R&D related indicator (patent applications). This is also true for the 'mixed' threshold model, where the threshold between the stagnation and the imitation club is based on human capital (absorptive capacity) and the threshold between the imitation and the innovation club is based on the countries' R&D capacities. Thirdly, in addition to the differences in the growth effects from the technology gaps between the clubs we trace the development of these growth effects over time and show that they have been increasing in the case of the imitation club but not for the stagnation club.

The paper proceeds as follows: Section 2 discusses some of the related literature. Section 3 gives the data sources used in Sections 4 and 5 which contain the results of our cluster analysis and the growth regressions respectively. Section 6 concludes.

2. Related literature

The conceptual background for this paper is the endogenous growth literature though the emergence of technology clubs may also be motivated by evolutionary approaches to economic growth. The endogenous growth literature explicitly models the law of motion for technology and productivity instead of assuming it to be an exogenous process.

Howitt (2000) provides a multi-country version of a vertical growth model à la Aghion and Howitt (1992) in which firms push the technological frontier by investing in R&D and rival firms can build on innovations of previous innovators. In this model, R&D performing countries with lower productivity will grow at the same pace as the leading country though it will not catch-up in terms of per capita income. The mechanism that ensures growth convergence is that if a firm innovates successfully, it brings the sectors productivity up to the *global* technological frontier. However, not all countries necessarily perform R&D so that some countries will not innovate. Since innovation is the sole source of technological progress the non-innovating countries will stagnate. Therefore there will be two groups or clubs of countries which differ in their growth regimes. However, there will be convergence in growth rates within the clubs.

In an extension of the Howitt (2000) growth model Howitt and Mayer-Foulkes (2005) develop a model with two types of technological advances: (i) R&D activity leading to innovations and (ii) imitation which is the process of implementing existing foreign technologies. Both innovation and imitation are skill intensive activities. In the convergence club model of Howitt and Mayer-Foulkes (2005) – which is our main theoretical reference model – countries select themselves into three groups, depending on their technological capabilities. A group of technologically advanced countries will perform R&D and come up with new innovations. This innovation club pushes the global technological frontier. A second group of countries, the imitation club, is successful in imitating and adapting existing technologies previously developed by the innovation group. In contrast, their level of productivity and human capital does not allow them to undertake original