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Innovation dynamics and labor force restructuring with asymmetrically developed national innovation systems

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ABSTRACT

The concept of National Innovation System (NIS) has gained a great deal of intellectual and practical attention over the past three decades. We present an endogenous growth model where the NIS of a country determines its accumulation of technological knowledge and the arrival rate of innovations depends on the distance from the technological frontier to the current technological development level (TDL) of the country. We show how, even *within an ideal common market environment* and despite the compensatory mechanism provided by migration and the advantage of backwardness enjoyed by the laggard countries, differences in TDLs among countries foster the economic stagnation of technological laggards. That is, the structural consequences derived from technological underdevelopment are persistent and not simply due to the depreciation of human capital, but to the absence of innovation incentives that follows. Numerical simulations and an empirical analysis are performed to illustrate the main results and relate them to the current European common market setting and the innovation policies of its members.

1. Introduction

1.1. Motivation and intuition

The economic literature has progressively recognized the fact that the assimilation of the most advanced technological capital by less developed countries constitutes a growth mechanism requiring important amounts of both physical and human capital investment (Aghion & Howitt, 1999, 2005; Howitt & Mayer-Foulkes, 2005; Sharif, 2006; Acemoglu, 2008; Borsi & Metiu, 2015). Consequently, quality and level of education asymmetry, as well as, institutional and trade frictions constitute the main divergent forces highlighted in the literature.

The importance of education in terms of human capital formation and accumulation, together with the institutional infrastructure of a country and its governance, have been empirically identified as determinants of innovation-induced growth by Varsakelis (2006), Giménez and Sanaú (2007), Fagerberg, Verspagen, and Caniels (1997), Chen, Hu, and Yang (2011) and Veugelers and Schweiger (2015). Moreover, the cumulative nature of technology is a widely recognized fact (Mukoyama, 2003), and the costs of learning a technology are known to be considerable (Engel & Kleine, 2015; Jovanovic, 1997). Thus, in an ideal common market setting without educational, institutional or trade barriers, all economic fluctuations should be caused by differences in technological development and assimilation levels among countries.

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Consider, for example, a world economy composed by two types of countries each of which is defined by its National Innovation System (NIS). Assume that both countries produce the same good (s), technological innovations are transferred immediately and with negligible cost between them, and no trade, educational, institutional or demand frictions exist between the countries. All labor is skilled and allowed to move freely according to the wage received based on its marginal productivity. Countries only differ in their technological development level (TDL), which, at the same time, determines their ability to assimilate the knowledge implicit in any newly developed technology and generate further innovations (Ballot & Taymaz, 1997; Castellacci & Natera, 2015). Thus, countries will be distributed in two different groups, one composed by technological leaders and the other one by laggards.

The above description corresponds to a textbook European common market subject exclusively to differences in TDLs across its members. We analyze the consequences derived from the corresponding technological adjustment process in terms of optimal labor allocation, migration patterns and technological evolution. We will identify the level of technological development of a country with that of its technological base. As illustrated by Furman, Porter, and Stern (2002) and Castellacci and Natera (2013), the technological base [infrastructure] of a given country limits its ability to innovate and learn through assimilation if it does not develop simultaneously to the level of technological knowledge acquired by the workers. That is, human capital is redundant if it is not complemented by an adequate technological infrastructure. The lower the level of development of the technological infrastructure, the lower the factor productivity obtained from any new technology and the probability of generating innovations (Silva & Teixeira, 2011; Teixeira, Silva, & Mamede, 2014).

As a consequence, the optimal allocation of labor across countries and their corresponding economic evolution would be directly determined by the level of development of their respective technological bases. However, despite the importance that innovation and the diffusion of technology have had for the European growth process through the 1980s, laggard countries failed to take advantage of the more advanced technology available due to a lack of their own R&D capabilities (Fagerberg et al., 1997).

In this regard, the pervasive effects inherent in an underdeveloped NIS become evident when considering several indicators within the technology and innovation-related pillars composing the global competitiveness index (World Economic Forum, 2013). Table 1 presents the indicators selected from these technology-related pillars for the countries under analysis in the paper. The data represent the position of the corresponding country from a total of 148 composing the global competitiveness ranking.

As illustrated in Table 1, the main constraints suffered by technological laggards (Greece, Italy, Portugal and Spain) are not the lack of skilled human capital or a limited access to the latest technologies available. Though slightly behind in both indicators, their situation is not considerably worse than that of the technological leaders (Denmark, Finland, Germany and Sweden). Indeed, as our empirical analysis will show, laggard countries are able to increase the resources dedicated to R&D activities when subject to a negative shock to their economies. On the other hand, the structural nature of the constraints suffered by these countries is reflected on:

- Their lack of capacity to innovate and retain talented human capital.
- The inability of their firms to absorb technologies.

1.2. Contribution

Given the intuition provided in the previous section, we build our model on two main features of the European economic system:

- From a formal standpoint, Table 1 together with the literature surveyed imply that:
  - The integration of physical and human capital is required to generate persistent economic growth.
  - The development of the NIS is essential to determine the capacity of a country to assimilate technology and innovate.

- From an empirical standpoint, the following behavior is observed across the European countries analyzed:
  - Technological leaders do not modify the intensity of their R&D when subject to shocks to their real economy.
  - Technological laggards react to shocks to their real economy by modifying the intensity of their R&D. However, these responses lack a persistent effect on their NISs.

Our model accounts for the formal features described above and explains the empirically observed behavior of the countries being analyzed. In particular, we illustrate how, even within a frictionless common market environment where technological innovations become immediately available to all countries, differences in TDLs constrain the incentives and the capacity of the laggards to innovate. Thus, as suggested by the literature on technological catch-up and absorptive capacities, differences in TDLs alone suffice to constrain the convergence process of the laggards (Hanusch & Pyka, 2009; López, Molero, & Santos-Arteaga, 2011; Castellacci & Natera, 2016).

However, the current paper goes beyond the fact that technological underdevelopment depreciates the skilled composition of the labor force and generates unemployment. As stated by the theoretical literature on brain drain and economic development (Bosetti, Cattaneo, & Verdolini, 2015; Docquier & Rapoport, 2012), migration processes reallocate skilled workers among the technologically developed countries allowing for a temporary

Table 1
Several innovation-related indicators composing the global competitiveness index*.

Country	Availability of scientists and engineers	Availability of latest technologies	Firm-level technology absorption	Capacity for innovation	Country capacity to retain talent
Denmark	36	29	20	13	43
Finland	1	1	7	2	2
Germany	17	13	16	3	9
Sweden	10	2	1	7	10
Greece	5	67	88	117	86
Italy	29	69	112	31	117
Portugal	16	15	29	42	111
Spain	11	33	49	57	108

**Note*: Data retrieved from the *The Global Competitiveness Report 2013-2014: Full Data Edition.* Refer to World Economic Forum (2013) for additional information regarding these variables. The indicators have been taken from the 7th (Labor market efficiency), 9th (Technological readiness) and 12th (Innovation) pillars.

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