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# R&D specialization and manufacturing productivity growth: A cross-country study

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ABSTRACT

This study examines how R&D specialization within the manufacturing sector affects productivity growth, constructing various measures of R&D specialization using a concentration index and industrial classification. Based on 11 member countries of the Organization for Economic Co-operation and Development (OECD) for the period from 1981 to 2000, the results obtained based on the fixed-effect panel data model with cross-sectional dependence indicate that concentrating suitable R&D resources within a few industries tends to promote productivity growth. Moreover, this positive effect is relevant to concentrating on development-oriented industries or process innovation-oriented industries.



## 1. Introduction

The importance of innovation on sustaining growth is widely recognized among countries. By promoting technological competitiveness or active price competitiveness, innovation serves as the main driver of productivity, playing a critical factor in explaining the growth differentials of economies (Crepsi and Pianta, 2008). Most empirical studies examining the R&D-productivity nexus reach a consensus for a significantly positive relation using disaggregated and aggregated data, e.g., firm-level (Griffith et al., 2004; Hall, 2011a), industry-level (Ngai and Samaniego, 2011), and region-level (Castellani and Pieri, 2013) data. Thus, most countries, especially those in the Organization for Economic Co-operation and Development (OECD), have placed greater emphasis on R&D activity since the 1980s. At the Barcelona Summit in 2002, the European Council committed to increasing R&D investment to 3% of GDP by 2010.

R&D specialization denotes the distribution of the R&D share of sub-industries in the manufacturing sector, and it can be treated as one indicator of technological specializations. As the technological regime in each industry differs substantially, it affects the opportunities for innovation and thus leads to diverse R&D intensities across industries. Such a specialization is essentially dynamic and determines a country's innovation capability. During the 1980s–1990s, the phenomenon of more and more R&D investment being concentrated in few industries, especially in technology-intensive industries, has been duly noted (Brody, 2005; OECD, 2007)[1]. However, the high degree of RD specialization has

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[1] Brody (2005) calls attention to industries in which the R&D policies are focused in several selected countries. The main expenditure in the U.S. has been in military-related industries, whereas in Germany it has been the automotive industry. The Science, Technology and Industry Scoreboard (OECD, 2007) also shows differences in the allotment of R&D resources to different industries in OECD countries. In Germany, more than half of R&D resources are dedicated towards the medium-high technology industry, whereas Finland and Canada have a high level of R&D inequality with respect to their high-tech industries. The cases in Australia and Norway are significantly different, with resources being relatively equally allocated between high, medium-high, and medium-low technology industries.

been decreasing over time: the R&D Gini coefficient decreased from 0.78 in 1999 to 0.75 in 2005 for 40 large OECD and non-OECD countries (Hall, 2011b).

The difference in industrial allocation of R&D resources across countries is related to the size of an economy, the institutional structures, technological policies, and so on. For example, in an endogenous-growth model, O'Donoghue and Zweimuller (2004) show that incentives to innovate and monopoly distortions both depend on the proportion of industries that conduct R&D. Patents hence affect the allocation of R&D resources across industries. Generally, industries with a large market, more technological opportunities, and a higher degree of appropriability raise the private return of innovation, are they are deserved to devote more R&D resources (Klenow, 1996). Nevertheless, the specialization of R&D activities in specific industries relates to growth and innovation by achieving economies of scale associated with the learning process (Cantwell and Vertova, 2004), accumulating technological experience, and enhancing absorptive ability for new knowledge. However, if a country's R&D resources are specialized in 'incorrect' technologies from the dynamic perspective, it does not matter to growth (Urraca-Ruiz and Laguna-Molina, 2014). Alternatively, Garcia-Vega (2006) claims that R&D diversification helps firms receive more spillovers from other technological classes, thereby resulting in cross-industry knowledge sharing and promoting R&D productivity. The debatable opinions regarding the influence of technological specialization on aggregate growth suggest the need for empirical evidence.

Various strands of the literature have begun to investigate the role that technological specialization plays on economic performance from various dimensions, such as economic growth (Alginger and Falk, 2005; Jungmittag, 2004; Urraca-Ruiz and Laguna-Molina, 2014), convergence in levels of innovation capability, structure of production, and export patterns (Anderson and Ejermo, 2008; Archibugi and Pianta, 1992; Frantzen, 2008; Mahmood and Singh, 2003). Some studies have linked R&D to variation in cross-country productivity growth, though mainly focusing on differences in the source of R&D activity (Guellec and Van Pottelsberche de la Potterie, 2004; Park, 2004; Savvides and Zachariadis, 2005; Van Pottelsberghe de la Potterie and Lichtenberg, 2001). However, we still know little about the role played by the degree of R&D specialization on productivity growth.

From the perspectives of both industrial and technological policies, the more fundamental issue is how to appropriately and effectively allocate R&D resources across industries. A nation's R&D may focus on either specific competitive-advantage or growth opportunities in emerging industries, but a question thus arises: Does diversity or specialization of R&D better promote productivity growth? This crucial question remains a debatable issue and has not been well examined. Klenow (1996) and O'Donoghue and Zweimuller (2004) point out that differences in technologies or rewards across industries are ignored in most economic growth models. This study aims to empirically investigate whether or not the sharing of R&D resources across industries is an influential factor in cross-country variation in productivity growth. In other words: Which strategy is more likely to lead to high productivity growth in a country—a concentration of R&D resources in a narrow range or spread across a wide range of industries?

Unlike previous studies where production or patent distribution has been used to measure technological specialization, we adopt two dimensions of R&D specialization to relate to productivity growth in eleven OECD countries for the period from 1981 to 2000. One uses the concentration and inequality indices to measure R&D spending across manufacturing industries. The other directly counts the R&D expenditure between two subgroups of industries. This measure based on R&D investment is a direct and more adequate gauge of technological specialization than patents, which are sometimes treated as weapons to block competitors rather than production inputs. Furthermore, R&D investment does not necessarily produce a patent, but it can act as a form of absorptive capacity for new knowledge to promote productivity (Griffith et al., 2004).

This study also considers group-wise heterogeneities as well as pair-wise country correlations over time. We employ the fixed-effect panel data model with cross-sectional dependence to implement empirical estimations. To consider the potential difference in productivity effects of R&D specialization due to the nature of R&D investment, we further divide R&D allocations into research-oriented or development-oriented types and then carry out various estimations.

The remainder of this paper is structured as follows. Section 2 briefly discusses the (dis)advantages of both R&D specialization and diversification and outlines the trends affecting cross-country productivity growth and the benefits from the distribution of R&D activities across industries or technological areas. Section 3 presents the empirical model and estimation procedure. Section 4 describes the data and descriptively provides the evolution of R&D specialization, total factor productivity (TFP), and their relationship. Section 5 reports and analyzes the estimation results. The final section summarizes concluding remarks and policy implications.

## 2. Technological specialization and productivity: Theory and literature

### 2.1. Allocation of R&D resources: Specialization vs. diversification

Why and how does technological specialization matter to aggregate economic performance? The theoretical arguments are diverse and debatable. The main supporting arguments are mainly two lines of thought. One is the Ricardian model that emphasizes the role of productivity difference. If one country concentrates its production in the sectors with faster increase in productivity, it is useful for economic growth (Laursen, 2000). Thus, specializing on good technologies offers higher possibilities for growth, because they improve aggregated productivity (Jungmittag, 2004). The other argument is the Kaldorian approach that claims that only some key sectors are able to induce demand-led growth (Dalum et al., 1999). Los and Verspagen (2006) develop an industry-level model of growth and trade, in which evolving specialization patterns are the endogenous result of innovation, international technology spillovers, and learning-by-doing. Innovation helps industries enlarge their share in the consumption market and reinforces the effects of specialization on aggregate productivity for industries on the technological frontier. This suggests a positive association between technological specialization and productivity.

The technological environment in which each industry is located is quite diverse in that technology-intensive and science-based industries generally exhibit high productivity growth. When countries observe different paths of growth correctly and specialize in those technologies, technological specialization offers higher opportunities in terms of market and knowledge exploitation (Fagerberg, 2000; Laursen, 2000; Montobbio and Rampa, 2005). In the case of limited R&D resources, allocating most resources to the targeted industries can also create the scale effect. Archibugi and Pianta (1992) also point out that countries with relatively limited R&D resources tend to invest in narrow industrial niches. Urraca-Ruiz and Laguna-Molina (2014) summarize the reasons why specialization in technologies with superior opportunities should induce growth, including: (1) generating higher value added, (2) preventing shifts in technology paths, (3) stimulating the productivity by the industries themselves and by spillover effects on other industries, and (4) representing a greater potential