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# Capabilities and investment in R&D: An analysis on European data

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ABSTRACT

In this paper we test the effect of technological capabilities (accumulated knowledge and organization/production routines) on the R&D intensity for a panel of European industries. Our proxy for capabilities is the distance from the technological frontier. Estimation is carried out with System Generalized Methods of Moments and is robust to various specifications. Our identification strategy is limited to the average (reduced form) effect.

We find a strong effect of capabilities on the amount invested in R&D, after controlling for demand pull, technology push, size, and cash constraints. The latter ones are the main variables used in the literature on the determinants of innovative expenditure, of which R&D is one of the components. The elasticity of the distance from the technological frontier is 10%, of similar magnitude (but opposite sign) with regard to the effect of internal resources.

When we allow for heterogeneous impact, clustering the industries according to their technological level, we see that the effect of capabilities is robust, but concentrated in Medium and Low Tech sectors. Moreover, the effect is stronger in the upswings of the business cycle and is concentrated in peripheral countries. These latter stylized facts may suggest that the divergence induced by lack of capabilities is somehow nonlinear and increases when a critical mass is missing.



## 1. Introduction

The aim of this paper is to provide an empirical assessment of the main tenet of theorists of technological change in the Schumpeterian tradition, namely that capabilities – defined as accumulated knowledge and organization/production routines – are the key to explain the behavior of economic agents regarding the introduction of new processes or products (Cimoli et al., 2008; Dosi, 1988; Nelson and Winter, 1982).

Although the derived (sizable) empirical literature gives an account of a number of stylized facts that are consistent with this hypothesis – i.e. heterogeneity, persistence of productivity differences etc. (Bottazzi et al., 2010; Dosi et al., 2012) – an empirical test of the main proposition has not been offered, to the best of our knowledge. Most likely, the reason is technical and related, on the one hand, with the measurement of both technical change and capabilities, and on the other hand with the definition of structural models that incorporate the latter.

We proceed in the following way. First of all, we limit ourselves to R&D. Although capturing only one of the

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possible forms of innovative expenditure, it is less prone to measurement errors: other type of expenditures, e.g. adoption of new processes, may be poorly reported because of secrecy strategies by firms, and may be confused with simple capital deepening by survey respondents.

Secondly, we use industry level data, which are less subject to measurement errors due to spillover effect (see Sections 2.3 and 3.1 for a discussion), are not subject to sample selection, and allow covering a much larger time span.

Thirdly, we put forth a measure of capability. Since the evidence on technical change suggests that the efforts of the firms are *localized*, i.e. they are oriented around their current position in some (undefined) technology space, we explicitly map industries in a relevant *economic* metric, namely Total Factor Productivity (TFP). In fact we define the technological leader sector-by-sector in our sample and we compute (log) distance from the technological frontier. Larger distances are associated with lower capabilities.

Fourthly, we estimate only reduced form effects, to avoid embarking on theoretical discussions over behavioral representation of economic agents. Since our interest is mainly empirical, we prefer to concentrate on the issue of identification, rather than on structural estimation. In the robustness checks, we discuss issues of possible misspecification and heterogeneity for our diagnostic tests.

The main result of this paper is that we estimate a reduced form elasticity of 10%. Reducing the distance from the frontier by 10% increases the investment in R&D by 1%. When we allow for heterogeneous impact, the strongest effect appears in Medium Tech sectors, and the impact is significant only for Medium and Low Tech. When we allow for differences across the business cycle, we see that the effect is concentrated in the upswing. Finally, when we allow for heterogeneous impacts across areas, we see that the strongest impact occurs in peripheral countries. Taken together, these three pieces of evidence suggests the presence of some sort of non-linearity and that catching up occurs only if a certain critical mass is reached, although this evidence require further assessment.

This paper proceeds as follows. Section 2 discusses the related literature; Section 3 presents the data and econometric approach; Section 4 the results and Section 5 the concluding remarks. Additional material is included in Appendix.

## 2. Related literature

### 2.1. Related literature on capabilities

A major tenet of the evolutionary theorizing in economics is the persistence heterogeneity within the population of firms. This heterogeneity is due not only to initial conditions, but mostly to the nature of the technological change as a localized search based on trial and errors (Dosi, 1988). In this perspective, the tendency of companies to organize their innovative plan as variations of technological artifacts that proved to be effective and through problem solving routine based on previous experience (i.e. along a specific technological trajectory) generates cumulativeness and path dependency. Dosi and Grazzi (2006, 2010) provide robust empirical evidence of the heterogeneity of firms with regard to production routines and the nature of their problem solving knowledge (i.e. in terms of capabilities). Exercises in the measurement of capabilities and in the assessment of their drivers (e.g. cooperation, networking, strategic management and learning) have been conducted at various level of aggregation (Archibugi and Coco, 2005; Iammarino et al., 2008, 2012; Teece et al., 1997; Vanhaverbeke et al., 2002; Von Tunzelmann, 2009a; Von Tunzelmann and Wang, 2007; Zollo and Winter, 2002).

At the same time, there has been both theoretical and empirical effort to try to measure the association between capabilities and development/industrialization (e.g. Lall, 1992; Von Tunzelmann, 2009b). The nexus between technological capabilities and the patterns of innovation is shared by the Structuralist tradition (Bielschowsky, 2009), which has a major focus on South America.[1] Relatedly, some scholars try to explain how this heterogeneity in terms of capabilities maps into patterns of performances (Bottazzi et al., 2001, 2010; Dosi et al., 2012).

In sum, this nexus between capabilities and performance is explored mainly at the aggregate level and in reduced form, i.e. without identifying the channels though which this effect is displayed. Moreover, a lack of emphasis over the causality issue can be detected, since it is obvious that performance feeds back into the stock of capability.

For the engine of growth to work, or in other words, for the capability to accumulate, it is important to translate capabilities into innovation in order to pursue performance, as discussed by Bogliacino and Pianta (2013), in the framework of a structural model.

Moreover, the relationship between capability and innovation shed light on the divergence or convergence of companies, sectors, regions and countries and this raises a key policy issue.

### 2.2. Determinants of innovative expenditure

In the definition of our empirical specification we made a careful revision of the literature to investigate the control variables that are usually used in R&D regression. Most of the literature on the determinants of innovative activity has focused on three determinants: size, demand pull, and technology push.

The role of size as a contributor to innovative effort has been labeled Schumpeterian Hypothesis (Cohen and Levin, 1989), although the reference is disputed, since in reality two versions of Schumpeter coexist, and size plays a diametrically opposite role in his two masterpieces (Schumpeter Mark I and Mark II, Breschi et al., 2000). The recent literature based on Innovation Surveys suggests that size is indeed an important correlate of innovative activity (Crépon et al., 1998; Mairesse, 2010), but it can be criticized on the ground that it is simply a poor and general proxy of other omitted variables (Bottazzi et al., 2010; Dosi, 1988).

Demand pull hypothesis has been postulated by Schmookler (1966). Studying the technological revolution

[1] Discussion and evidence is presented in Cimoli et al. (2008, 2011) and Cimoli and Porcile (2009).