Innovation Capabilities and Firm Labor Productivity

C. Peeters and B. van Pottelsberghe de la Potterie

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Carine Peeters¹ and Bruno van Pottelsberghe de la Potterie²

Abstract —

This study relies on a Cobb-Douglas production function to assess the relationship between the development of innovation capabilities by firms and their labor productivity. Intra-organizational capabilities relate to firms’ corporate culture and work organization, generation of innovative ideas and selection of projects, and innovation funding sources. Inter-organizational capabilities relate to the use of external information from vertical partners, competitors, and consultants, and to R&D partnerships with scientific institutions. In addition to the traditional effect of a growth in the ratio of physical capital per employee, both types of innovation capabilities are found to significantly increase labor productivity.

Keywords — Innovation, organizational capabilities, performance, labor productivity.

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I. INTRODUCTION

The role of innovation for firms’ economic performance is largely recognized in the academic, business and political spheres. The interest of researchers in this issue probably goes back to the works of Schumpeter (1942) and Penrose (1959). According to them, the exploitation of monopolistic positions leads firms to short-term gains while innovation activities allow benefiting from a long-term growth. Another stream of literature recognizes that differences in firms’ resources and capabilities contribute to explain observed differences in performance. This is a central theme in evolutionary economics (Nelson and Winter, 1982), the resource-based view of the firm (e.g., Wernerfelt, 1984), and the theory of dynamic capabilities (e.g., Teece and Pisano, 1994; Teece et al., 1997). This paper seeks to bridge these two literature streams by investigating how the development by firms of capabilities associated with the innovation process impacts their labor productivity.

There are numerous empirical studies assessing the impact of innovation on firms’ performance. They differ in terms of both dependent variables (e.g., sales growth, profit margins, productivity) and explicative variables (e.g., R&D, patents, innovation output). Most of them find a positive impact (e.g., Griliches, 1986; Hall and Mairesse, 1995; Baldwin and Johnson, 1996; Crépon et al., 1998; Lööf and Heshmati, 2002). Studies that investigate firms’ capabilities and their potential impact on competitive advantage and other measures of performance are on the contrary mainly conceptual (e.g., Nelson and Winter, 1982; Teece et al., 1997; Patel and Pavitt, 2000). Henderson and Cockburn (2000) argue that measuring firms’ capabilities is a very difficult task, but that the potential insight one could get from that measurement is worth the attempt. Interesting examples of such contributions include Geroski et al. (1993) who show that the direct effect on firm profitability of producing an innovation is complemented by an indirect effect resulting from the development of internal capabilities; the study of Lorenzoni and Lipparini (1999) on the relational capability of firms as a distinctive organizational capability that leads to superior innovativeness and growth; and the empirical study of Kremp and Mairesse (2004) on the impact of knowledge management practices on labor productivity.

With the aim of contributing to this challenging area of research, this paper uses original survey data that provide a direct measurement of firms’ capabilities associated with the innovation process. Indicators of innovation capabilities built through factor analyses enable to evaluate the role of these capabilities for firms’ labor productivity. An empirical model based on a Cobb-Douglas production function shows that the development of particular innovation capabilities positively impacts labor productivity, beyond the well-known effect of an increase in the ratio of physical capital per employee.

The remaining of this paper is structured as follows. A synthetic review of the two main streams of literature on which this study builds is provided in section 2. Section 3 presents the empirical model, the survey data, and some basic statistics. Estimation results are discussed in section 4. Section 5 concludes.
II. LITERATURE BACKGROUND

Providing an extensive review of all studies that contributed to the current understanding of the relationship between firms’ capabilities, innovation, and economic performance goes beyond the scope of this paper. However, in order to ground the present research in a theoretical and empirical framework, the major conclusions of two streams of literature are synthesized here below. The first section focuses on studies that empirically assess the relationship between innovation and firm performance using innovation input or output indicators. The second section discusses several papers that have attempted to introduce concepts of capabilities as determinants of firms’ performance, with a particular attention to innovation capabilities. Both sections open the way to the research question of the present study.

Empirical studies on the relationship between innovation and firm performance

The first one to empirically address the role of innovation for economic growth is Solow (1957). Solow uses a Cobb-Douglas production function and concludes that the traditional inputs of the production function, i.e. labor and physical capital, only explain a fraction of economic growth. The remaining fraction would result from technological progress. This residual part is the so-called “Solow’s residual”. In the decades that followed, many authors worked at decomposing this residual and finding a way to express technological progress as an explicit explicative variable of economic growth, and not only as a residual. A major contribution in this literature stream came from Minasian (1969) who first proposed to proxy technological progress by and R&D indicator and introduce it directly into the production function. This approach has then been further applied and elaborated by authors like Griliches (1979, 1986), Hall and Mairesse (1995), and Del Monte and Papagani (2003).

Cohen and Levinthal (1989) argue that the key role played by R&D results from two effects. The first one is the development of innovations that R&D investments enable. The second one is the learning effect associated with the progressive development of a stock of knowledge at the origin of a firm’s absorptive capacity. This ability to recognize, assimilate and exploit external information and knowledge would be a crucial aspect of a firm’s capacity to innovate (Cohen and Levinthal, 1990). According to Griffith et al. (2003), many existing studies would actually underestimate the R&D social rate of return by neglecting this absorptive capacity dimension.

Another interesting contribution to the firm-level literature on the relationship between innovation and performance comes from Crépon et al. (1998). Conceptually, the authors present innovation as a process that starts with R&D and continues with the application of patents and the sale of new products. Empirically, they build a model that explains productivity by innovation output and innovation output by research investments. Their results demonstrate that it is in fact innovation output (patent applications and sales from new products) that drives firm productivity, and not innovation input (R&D investments).

Many other studies validate the positive effect of innovation on various indicators of firm performance (e.g., Damanpour et al., 1989; Geroski et al., 1993; Banbury and Mitchell, 1995; Roberts, 1999; Lööf and Heshmati, 2002). A review of 30 empirical studies by Walker (2004) shows indeed that in about 60% of cases the empirical tests validate the positive relationship between innovation and organizational performance. This percentage appears to be slightly higher for services
than for manufacturing sectors, in studies using samples smaller than the median of 141 firms, and in studies using effectiveness measures of performance like market share, as opposed to efficiency measures like return on assets.

**Capabilities, innovation, and firm performance**

In the evolutionary economics stream of literature, heterogeneity in firms’ managerial, organizational and technological capabilities is recognized and presented as a factor explaining differences in firms’ profitability, performance, and growth (Nelson and Winter, 1982). This “revolutionary” view of economics led to the development of the resource-based view of the firm (RBV) that posits that the possession of valuable, rare and costly to imitate resources with no close substitute provides firms a competitive advantage (e.g., Rumelt, 1984; Wernerfelt, 1984; Grant, 1991).

Capabilities can be viewed as bundles of routines (Dosi et al., 2000; Winter, 2003; Lewin and Massini, 2004), or more generally practices, that enable firms to combine their resources to efficiently achieve a particular activity (Grant, 1991). Because firms’ resources and capabilities are difficult to measure, this area of research remained to a large extent conceptual. But still, the few empirical studies that exist demonstrate a positive effect on firm performance (e.g., Knott and McKelvey, 1999; Lorenzoni and Lipparini, 1999; Galbreath, 2005).

Because innovation is recognized as a key factor of firm performance, many researchers have worked to discover what practices enable firms to successfully innovate (e.g., Pavitt, 1994; Dougherty, 1996; Hargadon and Sutton, 1997; Baer and Frese, 2003; Kratzer et al., 2004). An interesting contribution to this field of research comes from Rothwell (1992) who identifies a set of innovation success factors, such as: a good external and internal communication; treating innovation as a corporate-wide task; carefully planning and controlling innovation projects; maintaining a high quality of production; having a strong market orientation; providing good technical service to customers; the presence of champions and gatekeepers; the dynamism, commitment, and openness of the management team; attracting talented people; the visibility of support to innovation; having a long term strategy to which innovation plays a key role; insuring corporate flexibility, responsiveness, and acceptance of risk; and developing a culture of innovation.

Baldwin and Johnson (1996) also show that more innovative firms place “greater emphasis on management, human resources, marketing, financing, government programs and services, and production efficiencies”, and are more successful than less innovative firms. Another study by Kremp and Mairese (2004) finds that particular knowledge management policies translate into significantly better innovation performance and productivity. These policies are a culture that encourages information and knowledge sharing, employee retention policies, partnering for knowledge acquisition, and implementing written knowledge management rules.

The existing literature seems therefore to suggest that when R&D is successfully transformed into innovation output there is a positive effect on firm performance, and firm-specific capability factors would come into play into that process. The objective of this paper is to directly assess the impact of some specific organizational capabilities associated with the innovation process on firms’ labor productivity. The hypothesis is that by positively influencing the organization of work in a company these organizational capabilities would improve the efficacy of labor, and hence increase the value
created by employees. This paper adopts a comprehensive approach to the innovation process and does not focus exclusively on internal aspects of managing the innovation process. External aspects relating to firms’ interactions with their environment are also introduced in empirical analyses.

III. EMPIRICAL IMPLEMENTATION

The data set used in this study comes from an original survey launched in 2001 and aimed at evaluating the innovation capabilities of the largest firms in most sectors of the Belgian economy. Firms were asked to rate, on a Likert scale ranging from 1 to 5, their use of several routines and practices associated with the innovation process, from the generation of innovative ideas to the commercialization of new and improved products and processes. The choice of the particular survey items was based on a review of the existing literature on specific practices associated with innovation success (see above for a summary) and on two existing survey instruments. The first one is the Community Innovation Survey (CIS), an initiative started in 1993 by the OECD and Eurostat in order to track practices of EU companies regarding innovation. The second one is the French survey “Competences pour Innover” launched in 1997 by the SESSI (Industrial Statistics Service at the French Ministry of Industry). The survey was sent to 1301 firms and 148 questionnaires were filled and sent back. A comparison of the responding and non-responding samples shows no significant difference in terms of sector of activity, age, and region of operation. Only the category comprising the largest firms (over 500 employees) seems to be slightly overrepresented in the responding sample. This potential bias should be kept in mind for interpretation of the empirical results.

The indicators of innovation capabilities used in this study are built through factor analyses on the survey data. This technique is appropriate to cope with the potential problems arising from subjective survey questions since it summarizes different survey items related to a same subject area into one synthetic indicator (Anderson et al., 1983). The innovation capabilities indicators are the firms’ coordinates on the main factorial axes resulting from these factor analyses. They are grouped into 2 categories: (i) 6 intra-organizational capabilities refer to internal routines and practices that enable firms to develop new and improved products, (ii) 2 inter-organizational capabilities refer to firms’ interactions with their external environment in order to access new information and knowledge.

The six intra-organizational capabilities are the following:

- Developing a corporate culture that fosters innovative behaviors; that is sharing specific values that promote innovation, recognition and reward of people for innovation efforts, showing an open attitude towards innovative management practices, introducing innovation in global strategy and communicating innovation strategic goals to all employees, and promoting intrapreneurship.
- Organizing work for innovation; that is giving high importance to brainstorming sessions, team work, and face-to-face contacts, launching multidisciplinary teams organized around

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3 Focusing on large organizations to study the innovation capabilities of firms makes sense since they are found to be a major source of technology and innovation (e.g., Pavitt et al., 1987; Patel and Pavitt, 1991; Pavitt, 1994).

4 A detailed presentation of the survey instrument is provided in Peeters and van Potteslberghe (2003a).

5 For an extensive description of the construction of innovation capabilities indicators, see Peeters and van Pottelsberghe (2003b).
projects, rotating employees inside the organization, and facilitating exchange of information between marketing and technical departments.

- Using specific mechanisms to increase the generation of new ideas; that is launching regular market surveys and benchmarking exercises, using competitive intelligence processes, reading the patent literature, and accessing new skills through the recruitment process.
- Relying on an efficient project selection process; that is systematically storing innovative ideas, electronically codifying knowledge, formally estimating the probability of success of innovation projects, and systematically assessing the potential barriers.
- Protecting intellectual property; that is having an active IPR strategy, systematically integrating imitation risk, discussing IPR issues at top management meetings, evaluating the patentability of inventions, and scrutinizing competitors’ patent applications.
- Funding innovation projects. One factorial axis accounts for the use of a firm’s internal funds (allocation of own profits to innovation activities) and another accounts for the use of external funds (public subsidies, debt financing, and funds from private investors).

The two inter-organizational capabilities are the following:

- Looking for external information useful for a firm’s innovation process. A first indicator reflects the use of information from business organizations (customers, suppliers, competitors, and consultants), and a second indicator reflects the use of information from scientific institutions (universities, research institutes, and public labs).
- Building R&D collaborations with external organizations. A first indicator accounts for R&D collaborations with scientific institutions. A second indicator positively relates to R&D collaborations with a firm’s competitors and negatively relates to R&D collaborations with vertical partners.

Among the possible indicators of firm performance this study focuses on labor productivity. According to Grupp and Maital (2001), productivity is indeed a key performance benchmark because it relates to the profitability of a firm, its ability to lower costs, and its competitiveness.

The empirical model relies on a Cobb-Douglas production function with two factors of production: labor force and physical capital.

\[ Y = L^\alpha K^\beta. \]  

(1)

Where \( Y \) is the value added, \( L \) the labor force (number of employees), \( K \) the physical capital, and \( \alpha \) and \( \beta \) the elasticities of output with respect to labor force and physical capital respectively.

Under the hypothesis of constant returns to scale (\( \alpha+\beta=1 \)), the labor productivity equation can be written as follows:

\[ \frac{Y}{L} = \left( \frac{K}{L} \right)^{1-\alpha}. \]  

(2)

Taking the logarithm of this equation gives:

\[ \log \left( \frac{Y}{L} \right) = (1-\alpha) \log \left( \frac{K}{L} \right). \]  

(3)
The proposition that this study intends to test is that the development of innovation capabilities by firms positively influences their labor productivity. In other words, a higher ratio of value added per employee would not only be driven by an increase in the ratio of physical capital per employee, as the Cobb-Douglas production suggests, but also by the development of certain capabilities associated with the innovation process.

In order to test this hypothesis, the indicators of innovation capabilities are introduced into the production function. Given that both small and large firms have advantages and disadvantages for innovation (Rothwell and Dodgson, 1994) and that the relevance of specific management practices depends on the firm sector of activity (Ittner and Larcker, 1997), it is controlled for the firm size and sector technological opportunity. The estimated equation has the following form.

\[
y_i = a + b(k_i - l_i) + c l_i + T_i + f C_i + e_i.
\]

Where \(y_i\) is the logarithm of value added per employee in 2000; \((k_i - l_i)\) is the logarithm of physical capital per employee with the physical capital being approximated by the amount of fixed assets in 2000; \(T_i\) is the logarithm of the number of employees in 2000; \(C_i\) stands for the indicators of innovation capability\(^8\); \(i\) indexes the 148 firms (\(i = 1, \ldots, n\)); \(e_i\) represents the error terms that are assumed to be independent and normally distributed with a zero mean and unknown standard deviation \(\sigma\); and \(a, b, c, d_i, d, f\) are the unknown parameters.

Before going to the estimation results the remaining of that section provides some basic statistics on the survey data and variables used in this study. The sample of 148 firms is approximately equally distributed between firms of less than 200 employees (31%), between 200 and 499 employees (36%), and 500 employees or more (33%). In terms of sector of activity, 10% of companies in the sample belong to a high-tech sector, 26% to a medium high-tech sector, 20% to a medium low-tech sector, 16% to a low-tech sector, and 28% to the services industry. While 58% of firms in the sample have not applied for any patent in 2000, 80% of them affirm to have a percentage of sales coming from new products superior to 0. This is higher than what is usually found with CIS (Community Innovation Survey) in Europe where somewhat less than one out of two firms appears to be a technological innovator. This divergence probably results from the target of the present survey towards large firms, which CIS finds to have a higher propensity to innovate than small firms.

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\(^6\) Data on the number of employees, value added, and fixed assets come from BelFirst, a database comprising annual reports of companies operating in Belgium.

\(^7\) The categorization is based on the OECD classification of manufacturing firms into 4 classes: high-tech= aeronautic construction, desks and computing machines, pharmaceuticals products, radio, TV and telecommunication machines; medium high-tech= professional equipment, motorcar vehicles, electric machines, chemical industries, other transport equipment, non-electric machines; medium low-tech= rubber and plastic materials, naval construction, other industrial sectors, non-iron metals, non-metallic mineral products, metallic works, petroleum and coal, steel industry; low-tech= paper, printing and editing, textile industry, clothing and leather, food, drinks and tobacco, wood and furniture. A category for all service companies is added: commerce, hotels and restaurants, transports, posts and telecommunications, insurances, financial services, real estate activities, computer activities.

\(^8\) A different equation is estimated for each indicator of innovation capability.
Table 1 provides the average value added per employee of firms in the sample according to their size, sector of activity, and innovativeness. The categorization into more and less innovative firms is based on the number of patent applications and share of innovative sales in total sales in 2000. Firms that score above the sample median are considered as more innovative and firms that score below the sample median are considered as less innovative.

Table 1: Average labor productivity per category of firms

<table>
<thead>
<tr>
<th>Category</th>
<th>VA/employee in 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sample</td>
<td>72.79</td>
</tr>
<tr>
<td>1-199 employees</td>
<td>72.02</td>
</tr>
<tr>
<td>200-499 employees</td>
<td>74.17</td>
</tr>
<tr>
<td>500- employees</td>
<td>71.94</td>
</tr>
<tr>
<td>High-tech</td>
<td>93.92**</td>
</tr>
<tr>
<td>Medium high-tech</td>
<td>67.78</td>
</tr>
<tr>
<td>Medium low-tech</td>
<td>85.22</td>
</tr>
<tr>
<td>Low-tech</td>
<td>65.96</td>
</tr>
<tr>
<td>Services</td>
<td>67.40</td>
</tr>
<tr>
<td>Patent applications:</td>
<td></td>
</tr>
<tr>
<td>&gt; 0</td>
<td>90.61**</td>
</tr>
<tr>
<td>= 0</td>
<td>63.61**</td>
</tr>
<tr>
<td>Innovative sales:</td>
<td></td>
</tr>
<tr>
<td>&gt; 10% of total sales</td>
<td>81.36</td>
</tr>
<tr>
<td>≤ 10% of total sales</td>
<td>70.20</td>
</tr>
</tbody>
</table>

** = significant difference with respect to population average at the 5% probability threshold. Source: own survey, Belgium, 2001, and BelFirst database.

No significant difference in average labor productivity is found according to the size class, and only firms in a high-tech sector display a significantly higher value added per employee than the average. More innovative firms show higher average value added per employee than less innovative firms but the difference with respect to the sample average is statistically significant only in terms of patent applications.

In order to get a first insight into the relationship between innovation capabilities of firms and labor productivity, Table 2 displays their coefficients of correlation. Student tests are run to assess their statistical significance. Most coefficients are positive and significant at the 5% probability level. This suggests that firms that develop certain intra- and inter-organizational capabilities associated with the innovation process enjoy higher labor productivity than other firms. It should also be noted that most indicators of innovation capabilities are significantly correlated among each others. They seem therefore to form a coherent set of capabilities on which the innovation process relies rather than independent substitutable practices.
Table 2: Coefficients of correlation between innovation capabilities and labor productivity

<table>
<thead>
<tr>
<th>Intra-organizational capabilities</th>
<th>VA/employee in 2000 (in log)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate culture</td>
<td>0.21**</td>
</tr>
<tr>
<td>Work organization</td>
<td>0.28**</td>
</tr>
<tr>
<td>New ideas generation</td>
<td>0.29**</td>
</tr>
<tr>
<td>Project selection process</td>
<td>0.26**</td>
</tr>
<tr>
<td>IP protection</td>
<td>0.20**</td>
</tr>
<tr>
<td>Innovation funding:</td>
<td></td>
</tr>
<tr>
<td>- External funds</td>
<td>0.21**</td>
</tr>
<tr>
<td>- Internal funds</td>
<td>0.05</td>
</tr>
<tr>
<td>Inter-organizational capabilities</td>
<td></td>
</tr>
<tr>
<td>External information from:</td>
<td></td>
</tr>
<tr>
<td>- Vertical partners, competitors, consultants</td>
<td>0.25**</td>
</tr>
<tr>
<td>- Scientific institutions</td>
<td>0.20**</td>
</tr>
<tr>
<td>R&amp;D collaborations with:</td>
<td></td>
</tr>
<tr>
<td>- Scientific institutions</td>
<td>0.32**</td>
</tr>
<tr>
<td>- Competitors &gt;&lt; vertical partners</td>
<td>-0.02</td>
</tr>
</tbody>
</table>

** = significant at the 5% probability threshold (Student test). Source: own survey, Belgium, 2001, and BelFirst database.

IV. EMPIRICAL RESULTS

The model (see equation 4 in section III) is estimated by Ordinary Least Squares and the estimations are corrected for potential heteroscedasticity using the White procedure. Since many innovation capabilities indicators are significantly correlated, in order to avoid multicollinearity problems a different equation is estimated for each indicator. Table 3 provides the estimation results.

Column 2 displays the estimation results of the labor productivity equation without taking into account any innovation capability indicator. As expected, increasing the ratio of physical capital per employee is found to increase labor productivity. Actually, the estimated coefficient associated with this variable turns out to be positive and significant.

In columns 3 to 10, indicators of innovation capabilities are introduced in the model one at a time. The coefficient associated with the ratio of physical capital per employee remains positive and significant in all equations. Most estimated coefficients related to the innovation capabilities are also significantly different from 0 and improve the quality of fit of the model.

The estimation results of equations 2 to 4 reveal that developing a corporate culture that fosters innovative behaviors, organizing work in a way that supports innovation efforts, and using certain mechanisms to improve the ability to generate new ideas, are three objectives that, when sufficiently emphasized by firms, improve labor productivity. Examples of concrete routines and practices that enable firms to achieve these objectives include the diffusion of corporate values that encourage innovation at all levels of an organization, the recognition and reward of employees for learning and innovation efforts, the organization of work around projects undertaken by multidisciplinary teams,
the rotation of employees inside the company to enhance a broader understanding of the company’s various activities, the recruitment of people with different professional backgrounds, and the use of market surveys, benchmarking exercises, and competitive intelligence processes to assess the evolution of the market and technological environment on a continuous basis.

Table 3: Estimation results – Innovation capabilities and value added per employee in 2000

<table>
<thead>
<tr>
<th>Equ.</th>
<th>Capital / employee in 2000</th>
<th>Number of employees in 2000</th>
<th>High-tech sector</th>
<th>Medium high-tech sector</th>
<th>Medium low-tech sector</th>
<th>Low-tech sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eq. 1</td>
<td>0.177*** (0.053)</td>
<td>0.037 (0.036)</td>
<td>0.208 (0.207)</td>
<td>0.006 (0.127)</td>
<td>-0.006 (0.166)</td>
<td>-0.155 (0.154)</td>
</tr>
<tr>
<td>Eq. 2</td>
<td>0.170*** (0.051)</td>
<td>0.032 (0.036)</td>
<td>0.214 (0.190)</td>
<td>-0.035 (0.133)</td>
<td>0.011 (0.162)</td>
<td>-0.141 (0.152)</td>
</tr>
<tr>
<td>Eq. 3</td>
<td>0.160*** (0.051)</td>
<td>0.012 (0.034)</td>
<td>0.207 (0.199)</td>
<td>-0.043 (0.123)</td>
<td>0.035 (0.164)</td>
<td>-0.123 (0.151)</td>
</tr>
<tr>
<td>Eq. 4</td>
<td>0.163*** (0.054)</td>
<td>-0.014 (0.041)</td>
<td>0.129 (0.189)</td>
<td>-0.043 (0.113)</td>
<td>0.041 (0.175)</td>
<td>-0.161 (0.150)</td>
</tr>
<tr>
<td>Eq. 5</td>
<td>0.162*** (0.054)</td>
<td>0.019 (0.041)</td>
<td>0.181 (0.210)</td>
<td>-0.061 (0.139)</td>
<td>0.017 (0.161)</td>
<td>-0.148 (0.153)</td>
</tr>
<tr>
<td>Eq. 6</td>
<td>0.168*** (0.054)</td>
<td>0.024 (0.036)</td>
<td>0.132 (0.223)</td>
<td>-0.060 (0.141)</td>
<td>-0.040 (0.173)</td>
<td>-0.196 (0.162)</td>
</tr>
<tr>
<td>Eq. 7</td>
<td>0.168*** (0.052)</td>
<td>0.039 (0.036)</td>
<td>0.112 (0.207)</td>
<td>-0.093 (0.141)</td>
<td>-0.025 (0.163)</td>
<td>-0.181 (0.162)</td>
</tr>
<tr>
<td>Eq. 8</td>
<td>0.170*** (0.047)</td>
<td>-0.004 (0.036)</td>
<td>0.275 (0.207)</td>
<td>-0.035 (0.143)</td>
<td>0.012 (0.150)</td>
<td>-0.145 (0.134)</td>
</tr>
<tr>
<td>Eq. 9</td>
<td>0.146*** (0.052)</td>
<td>-0.001 (0.037)</td>
<td>0.042 (0.211)</td>
<td>-0.147 (0.122)</td>
<td>-0.075 (0.203)</td>
<td>-0.222 (0.149)</td>
</tr>
</tbody>
</table>

Intra-organizational capabilities

| Corporate culture | 0.046** (0.021) |
| Work organization | 0.082*** (0.022) |
| New ideas generation | 0.090*** (0.031) |
| Project selection process | 0.077** (0.036) |
| IP protection | 0.040 (0.028) |

Innovation funding:

- External funds | 0.077** (0.033) |
- Internal funds | 0.024 (0.055) |

Inter-organizational capabilities

External information from:
- Vertical partners, competitors and consultants | 0.116*** (0.041) |
- Scientific institutions | 0.007 (0.058) |

R&D collaborations with:
- Scientific institutions | 0.256*** (0.081) |
- Competitors >= vertical partners | -0.072 (0.138) |

Constant | 3.458*** (0.245) |
R-squared | 0.198 | 0.230 | 0.246 | 0.263 | 0.236 | 0.216 | 0.222 | 0.266 | 0.236 |

Ordinary Least Squares; White correction for heteroscedasticity; levels of signification: * = 10%, ** = 5%, *** = 1%; standard errors into parentheses; 130 firms. Source: own survey, Belgium, 2001, and BelFirst database.
Another capability that positively influences labor productivity, though to a lower extent, is the ability to select the most promising innovation projects by keeping track of all new ideas and knowledge developed within the company, and systematically assessing the potential barriers and probability of success of the various innovation projects.

Being able to finance innovation projects positively impacts labor productivity. Leveraging external funds from banks, private investors, and public subsidies is particularly beneficial in that respect. Different factors may explain this result. First, firms that are better able to find adequate funding for their innovation projects are likely to innovate more, what in turn may positively affect their performance. Second, firms that use external funds to finance part of their innovation efforts have relatively more internal resources available to invest in other activities likely to improve the value created by their employees. However, the causal relationship between external innovation funding and labor productivity is ambiguous. It may indeed well be that external funds are available only to the best performing companies, whose labor productivity is likely to be higher.

The coefficient associated with the attention paid to protecting a firm’s intellectual property is not significantly different from 0. This lack of significant effect on the value added per employee is not so surprising. Actually, protecting intellectual property is an important dimension of a firm’s innovation process if it wants to appropriate the rents generated by its inventions and be able to reimburse the development costs it has supported. However, this variable is likely to act more as an incentive for a firm to invest in innovative activities, rather than as a way to improve labor productivity.

Equations 8 and 9 refer to the role that other organizations can play for a firm’s innovation process, either as a source of useful information, or as partners in R&D collaborations. It turns out that the ability of a firm to tap into the knowledge stock constituted by its external environment is a significant determinant of its labor productivity. The significant contribution of information provided by a firm’s customers, suppliers, competitors, and consultants usually results from informal interactions with these organizations. On the contrary, the positive effect on labor productivity of accessing and exploiting scientific knowledge from universities, research institutes and public labs generally requires more formal R&D partnerships.

The above results suggest that the corporate culture, work organization, ideas generation tools, and project selection process, are all internal mechanisms through which a firm can not only increase its ability to innovate, but more generally improve its production process and achieve higher labor productivity levels. Another mechanism through which a firm can increase the value created by its employees is by exploiting the external stock of knowledge that resides in its customers, suppliers, and competitors, in consulting companies, and in scientific institutions. This useful knowledge for a firm’s innovation process can either be accessed by informally interacting with these organizations or by entering into formal partnerships. It seems therefore that, in addition to increasing the ratio of physical capital per employee, developing certain innovation capabilities also enables firms to achieve higher labor productivity.

The present findings validate some results obtained by previous studies. Actually, equation 2 confirms the conclusions of Barney (1986), Hansen and Wernerfelt (1989), and Baer and Frese (2003) who argue that organizational culture and climate can be a source of superior performance for firms. It also validates the findings of Ichniowski et al. (1997) that innovative human resources practices like
incentive pay, teams, flexible job assignments, employment security, and training lead to higher levels of productivity than a more traditional approach to human resources management.

The strategic impact of leveraging a firm’s network of partners deduced from equations 8 and 9 further emphasizes the conclusion of Belderos et al. (2004) who demonstrate, on a sample of Dutch innovating firms, a positive relationship between cooperative R&D and firm performance that depends on the type of partner. It also corroborates the positive effect on a firm’s innovativeness and performance of being open to its external environment, and hence developing a network competence (Lorenzoni and Lipparini, 1999; Ritter and Gemünden, 2003; Laursen and Salter, 2004).

V. CONCLUDING REMARKS

The objective of this study was to assess the contribution to labor productivity of the development by firms of certain capabilities associated with the innovation process. Two main streams of literature underlie this research question. On the one hand, an important empirical literature dating back to Solow (1957) shows the positive effect of innovation on firm performance. However, little is known about the process by which this effect occurs. On the other hand, many authors following the evolutionary economics approach proposed by Nelson and Winter (1982) argue that heterogeneity in firms’ performance is driven by heterogeneity in resources and capabilities. This last field of research has however remained largely conceptual and very few quantitative data are available to validate existing theories.

Relying on an original set of survey data directly aimed at assessing firms’ innovation capabilities, this study addresses these two shortcomings of existing literature and brings together two streams of research that are often let aside. Indicators of innovation capabilities introduced in a Cobb-Douglas production function reveal that the development of certain capabilities associated with the innovation process increases labor productivity, beyond the traditional effect of an increase in the ratio of physical capital per employee. This conclusion corroborates the work of Baldwin and Johnson (1996) who argue that more and less innovative firms differ in the business strategies they implement; among other in terms of marketing, human resources, and finance, and that these differences translate into higher performance for more innovative firms.

The capabilities that this study finds to significantly influence labor productivity are the development of a corporate culture of innovation, the adequate organization of work to sustain innovative efforts, the ability to generate new ideas, the selection of the most promising innovation projects, and the use of external information and knowledge accessed by either informally interacting with customers, suppliers, competitors, and consultants, or by formally collaborating with scientific institutions like universities, research institutes and public labs. Furthermore, a related study using the same dataset shows that the positive effect of these capabilities on labor productivity enable firms to depart from constant returns to scale and achieve economies of scale (Peeters and van Pottelsberghhe, 2005). Better intra- and inter-organizational capabilities would actually not only improve the innovation process, but also result into more productive work from the part of employees. Organizational capabilities associated with the innovation process can therefore be viewed as critical strategic tools for firms seeking to build competitive advantage and long-term performance.
Although this work contributes to a better understanding of the relationship between firms’ capabilities, innovation, and labor productivity, two main limitations should be acknowledged. First, the significant correlation between most innovation capabilities indicators prevents their simultaneous introduction into the production function in order to assess their relative importance in a comprehensive framework. This problem could be overcome by combining these indicators into one broad indicator representing a general capability of firms to innovate. However, this would reduce the insight provided by this work in terms of relationships between different capabilities associated with the innovation process and labor productivity. This dilemma is not new as Hansen and Wernerfelt (1989) also faced this problem of collinearity among organizational factors in explaining firm profitability. They chose to select the two least correlated factors as explicative variables to introduce in their model. This would have been a solution for the present study as well, but would also have resulted in a loss of insight.

The second limitation comes from the lack of time dimension in the data. This prevents from investigating the relation between the development of innovation capabilities and firms’ innovation output, and the effect of that development on firms’ performance. Certain capabilities are indeed likely to be necessary to innovate. But it is also likely that through their innovation activities firms develop certain capabilities that enable them to further innovate. This process of capabilities development would in turn positively impact firms’ performance. This view of innovation as a learning process is discussed by authors like Cohen and Levinthal (1989) and Malerba (1992). Geroski et al. (1993) provide a major contribution to this area of research by suggesting that the direct effect of innovation on firms’ profitability is less important than the indirect effect resulting from the development of distinctive capabilities.

The next step in this research project includes testing the effect of firms’ innovation capabilities on other indicators of performance, such as profitability and market power. This would broaden the strategic implications of developing certain capabilities associated with the innovation process for firms seeking to over perform competitors.

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