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Innovation Strategies and Firm Performance; Simple or Complex Strategies?

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Abstract

This paper analyzes the effect of various Innovation Strategies (ISs) of firms on their future performance, captured by labor productivity. Using five waves of the Community Innovation Survey in Sweden, we have traced the innovative behavior of firms over a decade, i.e. from 2002 to 2012. We distinguished ISs to be either simple or complex (in various degrees) ones. A Simple IS is defined as when firms engage in only one of the Schumpeterian four types of innovations, i.e. process, product, marketing, or organizational, while a complex IS is when firms simultaneously engage in more than one types. The main findings indicate that those firms that choose and afford to have complex ISs are better off in terms of their future productivity in compare with those firms that choose not to innovative (base group) and also in compare with those firms that choose simple ISs. The results is mostly robust for those complex innovators that have a higher degree of complexity and also keep the balance between technological (product and process) and non-technological (organizational and marketing) innovations.

Key words: Innovation Strategy, simple, complex, firm performance, productivity, firm level, Community Innovation Survey, Panel

JEL-codes: D22, L20, O31, O32

1. Introduction

A right innovation strategy can help firms for a sustainable competitive advantage (Porter, 2008). According to Schumpeter, a firm has an option to choose an innovation strategy involving product, process, marketing or organizational innovation¹. These can be termed as “simple” innovation strategy, because firms decide to engage in only one type of innovation. Recent evidence, however, shows that a good portion of innovative firms chooses to engage in various types of innovation at the same time, i.e. “complex” innovation strategy (Karlsson and Tavassoli, forthcoming)². Recent evidence also shows that those firms pursuing complex innovation strategies are more persistent in doing innovation compared to those who pursue simple innovation strategies (Le Bas and Poussing, 2014). However, we know very little about the effect of such complex versus simple innovation strategies on performance of firms. This is partly because both theoretical and empirical studies have devoted minor attention to other innovation strategies than those related to technological innovation (Haned, Mothe and Nguyen-Thi, 2014; Oh, Cho and Kim, 2014). This is clearly a serious limitation, because the co-existence and co-evolution of different types of innovation (both technological and non-technological) is important for firm performance (Damanpour and Aravind, 2012; Le Bas and Poussing, 2014). For instance, it is argued that explaining the productivity gain (as a measure of performance) by only technological innovation is too restrictive, since productivity gains are not only related to sales, but also to production efficiency and factor saving (Polder et al, 2010).

Thus, expanding the scope of analysis of innovation strategies beyond the field of technological innovation is crucial. This will provide a much richer understanding of firms’ choices of innovation strategies as well as of the effects of different simple and complex innovation strategies on firm performance (Le Bas, Mothe & Nguyen-Thi, 2015). Although more demanding in terms of firm capabilities, we argue that more complex innovation strategies are able to provide “complementarities” between various types of innovation, hence leading to amplified productivity gain for firms³ (Damanpour & Evan; 1984; Gera & Gu, 2004).

¹ Schumpeter (1934) also described a fifth type of innovation – ‘new sources of supply’ –, which we exclude here, since we have no data on such innovations.

² Considering both simple and complex innovation strategies, this implies that, in total, firms can choose between sixteen different “innovation combinations”.

³ We will elaborate this argument more in detail in Section 2.

Understanding how firms' choices of innovation strategy affect firm performance is of course important from a management and owner perspective. Not least can we assume that in times with increased levels of competition and shortened product cycles the ability of firms to generate innovations may be more important for firms' competitive advantage and performance than ever (Artz, et al, 2010). Thus, innovation can be seen as a requisite objective for all firms that want to improve firm success and performance (Varis & Littunen, 2010). It is also important from a scholarly perspective at least for two reasons. First, most studies of the relationship between innovation strategies and firm performance has focused on simple innovation strategies involving product and/or process innovations⁴. The effects of complex innovation strategies have seldom been analyzed⁵. Second, incorporating the effect of simple vs. complex innovation entails the important concept of "complementarities" between innovation types, which was recently studied in terms of innovation inputs, e.g. internal and external R&D (Catozzella & Vivarelli, 2014), but not yet in terms of innovation output. Finally, an understanding of the relationship between innovation strategies and firm performance is important from the perspective of public innovation policies. Most such policies seem mainly to focus product and possibly process innovations. The need to support more complex innovation strategies by means of innovation policies is rarely considered.

We employed a panel of five waves of the Community Innovation Survey in Sweden (covers the period 2002 to 2012). We distinguished innovation strategies to be either simple or complex (low, medium, and high) ones. A simple innovation strategy is when firms decided to engage in only one of the Schumpeterian four types of innovations, i.e. process, product, marketing, and organizational, while a complex innovation strategy is when firms simultaneously engage in more than one types. The main findings indicate that those firms that choose and afford to have complex innovation strategies are better off in terms of their future productivity in compare with those firms that choose not to innovative (base group) and also in compare with those firms that choose simple innovation strategies. The results is mostly robust for those complex innovators that have a higher degree of complexity and also keep the balance between technological (product and process) and non-technological (organizational and marketing) innovations, i.e. "organic" firms.

⁴ For instance, Bogliacino and Pianta, (2011) analysed two types of innovation strategies: technological competitiveness (product innovation) and cost competitiveness (process innovation).

⁵ And even if in those studies that focused merely on simple innovation strategies, not all types of simple innovation is adequately investigated (for instance marketing innovation has been barely considered).

This paper is organized as follows: Section 2 provide a literature review on the relation between innovation strategies of firms and their performance, by distinguishing between simple and complex strategies. Section 3 describes our data. Section 4 provides a descriptive of variety of innovation strategies that firms (in our dataset) actually engage. Section 5 explains the empirical strategy of the paper. Section 6 reports and discusses the empirical results, and Section 7 concludes and provides suggestions for future research.

2. Innovation Strategies and Firm Performance

Researchers have recently increased their efforts to analyze empirically the economic effects of innovation and these efforts have increasingly targeted the effects at the firm level (Evangelista and Vezzani, 2010; Tavassoli, 2014). There are several motivations to why firm level analyzes are justified in this field. However, the most important motivation is an increased dissatisfaction with aggregated analyzes, which are unable to handle the complexity and randomness of innovation processes, the heterogeneity of firms' innovation behavior and the differing sources of firms' competitiveness (Dosi et al, 2012). We can also observe more and more attempts to go beyond the R&D-focused version of the innovation process. These studies make analyze the effects of innovation on firm performance using different measures of firms' innovation inputs, activities and outputs. Still most studies disregard that firms have wide options in terms of which innovation strategies to pursue and the effects on firm performance of different innovation strategies.

2.1 Innovation Strategies

Innovation is one of the key factors for the success, sustainable competitive advantage and survival of firms (Jimenez & Sanz-Valle, 2011) and consists in principle of a certain knowledge about how to do things better than the existing state of the art (Teece, 1986). Innovation can, from a firm perspective, be conceived as a complex process involving the development, transformation and application of new combinations of ideas, knowledge, technologies, capabilities and resources with the objective to develop a new idea or behavior with the potential to (i) increase the profitability of a firm, (ii) reduce its production and distribution costs, and/or (iii) increasing the willingness of customers to buy and pay for their products (Therrien, Doloreux & Chamberlain, 2011; Jiménez & Sanz-Valle, 2011). The capability to drive innovation processes depends on historical and current investments in several complementary factors including the knowledge and skills of the employees, R&D, management methods, firm culture, and internal & external networks (Feeny & Rogers, 2003).

The importance of managing different types of resources and network links in innovation processes has been stressed both in evolutionary economic theory and in the resource-based view of the firm (Nelson & Winter, 1982; Teece, 1988). It is a main assumption in the resources-based view of the firm that only firms with certain resources, network links, and characteristics will achieve competitive advantages through innovation and, therefore achieve superior performance (Camisón & Villar-López, 2014). Heterogeneity in the internal characteristics of firms contributes to explain their heterogeneity in terms of innovation strategies (Dosi et al, 2012).

The traditional theory of the firm claims that innovation only can have a transitory effect on a firm's performance in a competitive market, since the information about the new combination will soon be diffused in the market and rapidly imitated by competitors. According to this perspective, all firms in the long run will converge to the steady-state equilibrium (Knight, 1921). However, there exist substantial empirical evidences indicating that there are firms in all kinds of industries that continue to exhibit performance superior to other competing firms in the same industry for considerable periods of time, irrespectively of the institutional setting (Kemp et al., 2003). The findings that some firms, over longer periods, exhibits superior performance than other firms in the same industry is consistent, among other at least with evolutionary school of economics according to which the behavior of any firm is based on a set of learned principles and routines (Nelson & Winter, 1982). Firms have routines for a number of sub-processes including (i) production, (ii) distribution, (iii) design and construction, (iv) management, administration and commercial activities, (v) innovation, and (vi) renewal of routines. Here, the quality of each firm's routines together with the importance of knowledge inside the firm, organizational structure and R&D affects its position vis-à-vis its competitors. Naturally, firms cannot preserve a superior position permanently based on existing routines. To keep or improve their position firms must develop new and upgrade their routines, i.e. introduce innovations. Of course, this also includes the routines for developing innovations. The continuous renewal of routines drives the changes in different industries as well as in the economic system as a whole.

When it comes to innovation strategy, the literature has been mainly concerned with technological competitiveness (product innovation) and cost competitiveness (process innovation) (Bogliacino and Pianta, 2011). Although useful classification, we think this is simplistic view of looking at innovation strategies of firms. Looking at Schumpeter's basic types of innovation, he distinguished between at least four types: product, process, marketing

or organizational innovation. The exact definition of these variables (in the way that we used them in our empirical analysis) is presented in Appendix 1. Therefore, a firm can choose any of these four types and also any combination of these four types. If firm choose focus and engage in only one these types of innovation, then a firm is pursuing the so-called to “simple” innovation strategy. On the other hand, if a firm choose to engage in more than one type of innovation, then a firm is pursuing the so-called “complex” innovation strategies (Le Bas and Poussing, 2014; Karlsson and Tavassoli, forthcoming). Such choice of simple versus complex innovation strategies has important consequence for the performance of the firm (measured as e.g. productivity level, sales, export). The next section will discuss such issue in detail.

2.2 The impact of various innovation strategies on firm performance

A clear link between innovation and performance was introduced by the literature on endogenous economic growth. Accordingly, the growth of an economy is governed by the level of technology. The level of technology is a function of the rate of industrial innovation, which depends on the share of GDP invested in R&D (Romer, 1990). Innovation is here treated as a non-rivalrous input in the production process. The incentives to innovate are a function of the institutional framework of the economy and the degree of competition in the economy, which determines to what extent innovators, can acquire rents from their innovation. The innovation process has its own externalities. The accumulation of technological progress increases the knowledge base and make sequential innovations possible (Stokey, 1995). All firms including rival firms benefit from knowledge flows and technology spillovers across economic agents (Griliches, 1992).

In empirical studies of firm performance effects of innovation, the most commonly used performance measures are single-dimension measures, such as productivity, employment, sales, exports and profits but also financial measures such as the returns on assets have been used (Bessler & Bittelmeyer, 2008). Productivity is probably the most important aspect of economies in general at all levels. At the macro level, productivity is critical for the general level and growth of economic welfare. At the firm level, productivity is crucial for the competitiveness of firms and thus for their survival and growth prospects. Highly productive firms tend to have a higher output growth and a lower risk of exit, while low productivity is an indicator of probable future exit (Foster, Haltiwanger & Krizan, 1998). Moreover, the relative productivity between firms tends to be correlated with wages and exports.

Earlier studies of the effect of innovation on firm productivity typically reported a positive relationship (Hashi & Stojčić, 2013). In these studies, R&D expenditures were mostly used as the main measure of innovation. Unfortunately, R&D expenditures suffer from many shortcomings when used as a measure of innovation activity, since they are an input measure and do not include other critical elements in innovation such as learning-by-doing and investments in physical and human capital. Studies based on R&D expenditures also give very little information about the innovation process per se as well as firms' choices of innovation strategies (Kemp et al., 2003). Later studies building upon a new generation of models analyzing the effect of innovation on firm productivity have shifted the research focus to the complexities of innovation processes and to the channels through which the innovation inputs stimulate a better firm performance (Crepon et al, 1998; Lööf & Heshmati, 2006; Bogliacino & Pianta, 2012). According to these models, the innovation process consists of four stages: (i) the decision to innovate, (ii) the decision on how much to spend on innovation, (iii) the relationship between expenditures on innovation and innovation output, and (iv) the relationship between innovation output and firm productivity⁶.

We would like to suggest an extension of this description of the innovation process also to include the decision on what innovation strategy to choose⁷. We see the innovation process as consisting of the following five stages: (i) the decision to innovate, (ii) the decision on which of the simple and complex innovation strategies (in total fifteen combinations) to choose⁸, (iii), the decision on how much to spend on the chosen strategy, (iv) the innovation performance (output)⁹, and (v) the relationship between innovation output and firm performance. Considering stage (i) to (iv), firms are assumed heterogeneous in terms of introducing innovation strategies, since different firms have different knowledge stocks and different innovative capabilities (Barbosa, Faria & Eiriz, 2013). For instance, firms with low innovative capabilities, such as new entrants, might be limited to implement simple innovation

⁶ In most of these studies, innovation input is defined as investments in R&D measured either as the total amount invested (Lööf & Heshmati, 2006) or the share of R&D expenditures to total sales turnover, i.e. innovation intensity (Chudnovsky, Lopez & Pupato, 2006). Some studies use a broader definition of innovation expenditures and include expenditures on machinery, organization, markets, etc. The explanatory variables used in these studies include (i) firm size, (ii) export intensity, (iii) human capital, (iv) cooperation with suppliers, customers, universities, research institutes, etc., (v) the existence of public support for R&D and innovation, (vi) previous experiences of R&D and innovation, including persistence in innovation, (vii) the quality of the institutional setting, (viii) country or region specific cultural values, and (ix) access to finance, including public subsidies for innovation activities.

⁷ An innovation strategy can be simple or complex, as explained earlier.

⁸ These innovation strategies are mutually exclusive and collectively exhaustive choices.

⁹ Here the output of such investment refers to "innovation output", which the successful realization (introduction) of the chosen innovation strategy.

strategies¹⁰ (Dasgupta & Stiglitz, 1980). On the other hand, the existing empirical evidences suggest that more complex innovation strategies are associated with a better firm performance (Gera & Gu, 2004). This leads firms to be heterogeneous in the final stage as well, i.e. being different from each other in term of performance. The below subsection will distinguish between the effect of simple versus complex innovation strategies on performance of firms.

2.2.1 The impact of “Simple” innovation strategies

As noted earlier, simple innovation strategy is when a firm decide to engage in only one type of Schumpeterian innovation types. Starting from product innovation, it is about introducing new products, which represents a new combination of characteristics in line with the preferences of potential customers or changing the characteristics of current products in a way that increases the potential customers’ willingness to pay for this bundle of characteristics. In this manner, a successful introduction of a product innovation contributes to productivity by increasing the sales value of the firm given that input costs do not increase more (Bogliacino and Pianta, 2011). Moreover, product innovation can also contribute to productivity by reducing the input costs by finding and using cheaper materials, components and systems.

Process innovations involve the introduction of new methods of production, including new ways of handling a good or a service commercially. Process innovations contribute to productivity by reducing production costs via a more efficient use of inputs and allowing for a larger production scale (Bogliacino and Pianta, 2011). Moreover, process innovation can also increase the customers’ valuation of the products by increasing the product quality and reducing delivery lead-times.

Marketing innovations involve the opening of new markets according to Schumpeter’s classification but are in the modern management literature interpreted as improvements of the mix of target markets including market segmentation, and in methods to serve these markets (Johne, 1999). Innovations concerning the mix of markets include manipulation of the four famous marketing P’s, i.e. product, price, promotion and place (including distribution methods and channels). Primary goals here are to increase the total sales volume to make the

¹⁰ Naturally, one have to consider the possibility of reversed causality in the sense that firm performance can influence (i) the decision to innovate or not to innovate, (ii) the choice of innovation strategy, (iii) the decision on how much to spend on innovation and on the distribution over different innovation types, if a complex innovation strategy has been chosen, and (iv) the decision on how much to spend on innovation. Interestingly, innovation can be spurred by both a low and a high firm performance. In the first case the motivation is to improve firm performance and in the second to preserve a good firm performance. The existing empirical evidences suggest that more complex innovation strategies are associated with a better firm performance (Gera & Gu, 2004).

exploitation of economies of scale possible to compete effectively with price, to effectively segment markets to catch a larger share of the consumer surplus and offer product characteristics and associated services that increase the willingness of customers to pay for these products. However, firms have to make a strategic choice between trying to supply (i) products at the lowest cost, (ii) products that are special in some way (differentiation), or (iii) products focusing a distinct niche market, since firms cannot optimize their performance if they pursue different market strategies at the same time (Porter, 1985). Empirical evidence shows that marketing innovation is beneficial for developing and sustaining competitive advantages, at least based on lowering cost and differentiation (Naidoo, 2010). They can in particular contribute to labor productivity via increased sales values by: (i) improving the customers' perception of the firm's products, and also (ii) by opening up new markets and distribution channels for the firm's products. New markets and distribution channels implies larger sales volumes, which contributes to productivity via increased opportunities to take advantage of scale economies in production.

Finally, organizational innovations are innovations involving changes in the routines of firms aiming at improving the efficiency, productivity, profitability, flexibility and creativity of a firm using disembodied knowledge. Examples of such innovations are: (i) introduction of knowledge management systems that improves the skills in searching, adopting, sharing, coding, and diffusing knowledge among employees, (iii) introduction of new administrative and control systems and processes, and (iv) introduction of new internal structures with their associated incentive structures including decentralized decision-making and team work (e.g. self-managed teams). Organizational innovation can contribute to productivity via: (i) a more rational organization of production, (ii) increasing the firm's ability to effectively adopt an emerging core technology (Khanagha, Volberda, Sidhu, Oshri, 2013), (iii) increasing dynamic capabilities (Volberda, Van Den Bosch, Heij, 2013), and (iv) by improving the customers' perception of the firm's products, for example, by the channels that the services related to the products are organized.

2.2.2 The impact of "Complex" innovation strategies

There exists evidence that a more balanced rate of technical (product and process) and non-technological (marketing and organizational) innovations is more effective in helping firms to preserve and improve their performance than implementing them alone (Damanpour & Evan, 1984; Damanpour et al, 1989). This means going beyond a simple innovation strategies and incorporate a more complex strategy, where various types of innovation are to be pursued by

a given firm simultaneously. The innovation literature, however, does not reveal any definitive conclusion whether there is a single best innovation combinations that leads to a superior firm performance. Nevertheless, it seems different types of innovation are related to each other and need to be implemented in conjunction (Walker, 2004). Indeed recent evidence shows that firms often choose complex innovation strategies (Karlsson and Tavassoli, forthcoming). This may indicate that there exist various interrelationships and complementarities between the pure forms of innovation. It makes sense to expect such complementarities effect (within a complex innovation strategy), since the production of new knowledge requires the combination of diverse and yet complementary bits of knowledge in a complex setting (Antonelli, 2003). Catozzella and Vivarelli (2014) recognized such complementarities between innovation inputs strategies (i.e. internal and external R&D, acquisition of machinery, and technological acquisitions). We are arguing for the same complementarities effect between innovation outputs strategies. The logic behind complementarities effect comes from the notion of supermodularity, i.e. “activities are Edgeworth complements if doing (more of) any one of them increases the returns to doing (more of) the others” (Milgrom and Roberts, 1995: 181). But why firms may gain amplified performance (productivity) if they combine various types of innovation? The main idea here is that combining various types of leads to mutually reinforcing each of the innovation types and hence eventually lead to higher performance of firms. We have three reasons for such claim. First, the knowledge needed to one type of innovation can spillover to benefit the firm to engage in another types of innovation. This is particularly shown in the case of product to process innovation (and vice versa) (Flaig & Stadler, 1994)¹¹. Moreover, there are several studies pointing to the complementarities between organizational innovation and other types of innovation. For instance: (i) organizational innovations are beneficial for other types of innovation, especially (technological) process innovation, since they reduce the tension within the firm who is going to implement the process innovation (Hollen, Van Den Bosch, Volberda, 2013) and product innovation in the pharmaceuticals industry (Staropoli, 1998), (ii) organizational innovation is associated with process innovations in the logistics sector (Germain, 1999), and (iii) organization, market and product innovations are interrelated in public organizations (Walker, 2008). Second, based on the “recombinant growth”, the recombination of different types of knowledge or different types of innovations leads to the performance growth (Weitzman, 1998). Third, increasing the investments in any of innovation types increases the marginal

¹¹ This is particularly because product innovations that involve the launching of completely new products may demand associated process innovations.

profitability of the others (Milgrom & Roberts, 1990). Therefore, when two or more of the simple innovation strategies are adopted simultaneously, one can expect that their joint adoption leads to a higher firm performance than the sum of the firm performances from their individual adoptions (Mairesse & Mohnen, 2010)¹². This should be particularly true when there is a balance between technological (product and process) and non-technological (marketing and organizational) innovation, which can be found in so-called “organic” organizations (Damanpour et al, 1989). Such organic organization is also in line with the Dual-Core Model of innovation, where bottom-up technological innovation is combined with top-down non-technological innovation and produce a higher and amplified firm performance (Daft, 1989). These arguments give us reasons to expect that introduction of complex innovation strategies has significant positive effects on firm performance, especially when there is balance with technological and non-technological innovations.

To sum up, we expect that simple innovation strategies (all the four basic types of innovation) somehow contribute to the level of labor productivity within firms. However, when it comes to explaining the variation in the level (and growth) of labor productivity among firms, our hypothesis is that more complex innovation strategies are the main explanatory variables. The logic behind this hypothesis is based on complementarities between various types of innovation and hence the amplified effect of these innovation types on firms’ productivity when they are pursued together by firms.

HP1: Simple innovation strategies can increase the future productivity level of firms

HP2: Complex innovation strategies have more pronounced productivity effect than simple innovation strategies, especially when there is a balance between technological and non-technological innovations

3. Data

The innovation related data in this study comes from five waves of the Swedish Community Innovation Survey (CIS) in 2004, 2006, 2008, 2010, and 2012. The CIS 2004 covers the period 2002-2004 and CIS 2006 covers the period 2004-2006 and so on, hence using the five ways,

¹² The existence of complementarities between different simple innovation strategies have been tested in several studies using data from innovation surveys. Complementarities exist but they tend to vary between different sectors of the economy (Mairesse & Mohnen, 2010).

provide us with information about innovation activities of firms over a ten years period, i.e. from 2002 to 2012. In all five waves, there is information concerning product and process innovations as well as to innovation inputs (e.g. R&D investments). In the last three waves, there is also information concerning the marketing and organizational innovations. The survey consists of a representative sample of firms in industry and service sectors with 10 and more employees. Among them, the stratum with 10-249 employees has a stratified random sampling with optimal allocations and the stratum with 250 and more employees is fully covered. The response rates in the five waves vary between 63% and 86%, in which the later CIS waves having higher response rates compared with the earlier ones.

There are 21,104 observations in total, after appending all five waves of CIS¹³. Constructing the panel dataset for CIS is not common yet in the literature, while it is frequently called for (Mairesse and Mohnen, 2010). In principle, it is possible to construct both balanced and unbalanced panel dataset using Swedish CIS waves. Nevertheless, we choose unbalanced one for two reasons: first, it simply gives us considerably more observations (16,166 observations in unbalanced versus 2,870 observations in balanced panel). Second, using balanced panel increases the risk of having a biased dataset toward larger firms, because larger firms tend to participate in all CIS waves more than smaller firms¹⁴. Therefore, unbalanced panel is preferable here and it is used in this study¹⁵. The unbalanced dataset consists of 16,166 observations, corresponding to 4,958 firms participated in at least two consecutive waves (2,488 firms participated in two waves, 1,534 firms in three waves, and 936 firms in four waves). Then we merged the innovation-related data in our unbalanced CIS panel with other firm-characteristics data (e.g. productivity, size, physical capital) coming from registered firm-level data maintained by Statistic Sweden (SCB). Such merging of CIS data with external data (registered data in our case) is argued to be remarkably beneficial to improve the dataset (Mairesse and Mohnen, 2010). We use both balanced and unbalance panel datasets in investigating the various choices of innovation strategies that firms made (Section 4), while we only report unbalanced panel dataset in analyzing the determinants of the various choices, basically since we gain more observations (Section 5). The variable description is presented

¹³ This is obtained after the usual data cleaning, i.e. dropping observations with zero turnover or zero employees.

¹⁴ The average size of firms in the balanced panel dataset is 375 employees while in unbalanced one is 170.

¹⁵ There is one year overlap between each consecutive CIS waves. Unfortunately this is an inherent issue with any panel of CIS data and we cannot explicitly correct for it. However, as Mairesse and Mohnen (2010) noted, this issue should mainly concern those studies that are dealing with the “innovation persistency”, because the overlap years may lead to overestimation of innovation persistency of firms.

in the Appendix 1. The Vector Inflation Factor (VIF) among regressors has the mean value of 3.86 and the maximum value for VIF score was about 5. This implies that multicollinearity is not severe and may not bias the subsequent regression analyses results in Section 5.

4. Variety of Innovation Strategies

There are four types of Schumpeterian innovation and a firms in a given point in time can choose to have any of these four types, any combination of these four types, or non them at all. Therefore, a firm can have any of sixteen possible “innovation combinations” at a given point in time. Based on our discussion in Section 2, we grouped these sixteen innovation combination to fall into one of the following four categories of innovation strategies: (i) Simple innovation strategy, when firm chooses to engage in introducing only one of the Schumpeterian types of innovation: only product, or only process, or only marketing, or only organizational innovations. (ii) Complex Low, when firm chooses to engage in introducing two types of Schumpeterian innovation simultaneously. (iii) Complex Medium, when firm chooses to engage in introducing three types of Schumpeterian innovation simultaneously. And finally, (iv) Complex High, when firm chooses to engage in introducing all four types of Schumpeterian innovation simultaneously. Table 1 reports the frequency and percentage of each innovation strategies as well as average firm turnover in each innovation strategies.

[Table 1 about here]

Table 1 show that firms choose between wide varieties of innovation strategy. Some firms choose to engage in simple innovation strategy, while others choose to be a complex innovator with various degrees, by combining various types of innovation at the same time. Overall, it is evident that firms choose from “all possible” sixteen combinations and they do not exclude even one possible innovation combination, let alone the four innovation strategies. There are several worthy points to highlight. First, more than half of the innovators (57%) in our sample are complex innovators with various degrees, i.e. introduce more than one type of innovation at a given point in time. This is striking as previous empirical studies rarely investigated the complex innovators (Crepon et al, 1998; Lööf and Heshmati, 2006; Griffith et al, 2006, Mairesse and Robin, 2009). Second, looking at these complex innovators, 33% (14+4+2+3+4+6) are engaging in low complex innovation strategies, 24% (3+3+3+7+8+9) in medium complex, and 8% in high complex innovation strategies. Third, looking more in detail at the innovations combinations which compose the four types of innovation strategies, the

most popular ones are: (i) only product, (ii) only process, (iii) only marketing, (iv) only organizational, (v) both product and process, and finally (vi) all four types of innovation. These six most popular innovation combinations account for 65% of all choosing innovation combinations. The next question is which of these innovation strategies (and also the ingredient innovation combinations) are more associated with higher performance of firms.

5. Empirical Strategy

The basic model in our empirical analysis is a standard Cobb–Douglas production function augmented with various innovation strategies of firms. The standard Cobb–Douglas production function is given as follows:

$$Q_{it} = AK_{it}^{\beta_1} L_{it}^{\beta_2} \quad (1)$$

Where Q_{it} is the value-added (as a performance measure) of firm i in the time point of t , K_{it} is the physical capital input, L_{it} is the ordinary labor input, and A is the knowledge input. By dividing Q_{it} with ordinary labor we may express (1) as a labour productivity function:

$$q_{it} \equiv \frac{Q_{it}}{L_{it}} = AK_{it}^{\beta_1} L_{it}^{\beta_2-1} \quad (2)$$

Let us now turn to our assumption about knowledge input, A . Pioneered by Romer's model of endogenous growth (Romer, 1990), several recent empirical studies attempt to operationalize A as the innovation output of firms. Most of these studies used product innovation alone or in the best case product and process innovation as the two separate innovation output (Griffith et al, 2006; Mairesse and Robin, 2009; Polder et al, 2010). All of these studies concerned with simple innovation strategies. We extend this stream of literature by incorporating various complex innovations strategies as well. Therefore, we operationalize A as follows:

$$A = IS^j \quad j=0, 1, 2, 3, 4 \quad (3)$$

Hence $A = IS^j$ is a categorical variable with five mutually exclusive and collectively exhaustive alternatives. We will consider $j=0$ (being non-innovative) as the reference (base) category and hence the interpretation of each remaining alternative categories need to be stated in refer to this base category. $j=1$ when firm chooses to engage in simple innovation strategy (i.e. introducing only one of Schumpeterian types of innovation: only product, or only process, or only marketing, or only organizational innovations). $j=2$ when firm chooses to engage in

complex-low innovation strategy, i.e. introducing two types of Schumpeterian innovation simultaneously. $j=3$ when firm chooses to engage in complex-medium innovation strategy, i.e. introducing three types of Schumpeterian innovation simultaneously. And finally $j=4$ when firm chooses to engage in complex-high innovation strategy, i.e. introducing all four types of Schumpeterian innovation simultaneously¹⁶. Combining (2), and (3), and transform it to be a linear function, the full model can be expressed follows:

$$\text{Ln } q_{it} = \beta_1 \text{Ln } K_{it} + (\beta_2 - 1) \text{Ln } L_{it} + \alpha_j IS_{it}^j + M_i + T_t + u_i + \varepsilon_{it} \quad (4)$$

Where, q_{it} is the labor productivity of firm i in year t , which is measured as value added per employee. K_{it} is the physical capital input measured as the value of machines, inventory, building, and land. L_{it} is the labour input, which is captured in two ways: first it is measured as the total number of employees, which controls for the size of the firm. Second it is measured as the portion of higher educated employees (three plus years of university education) in the firm, which controls for the level of human capital. M_i is industry-specific component that captures the heterogeneity between industries by indicating whether firm i belong to a manufacturing sector not. T_t is time-specific component that takes into account macroeconomic effects and business cycles that may affect the export decision and intensity. u_i is a firm-specific effect, which captures unobserved time-invariant firm heterogeneity (such as managerial ability or organizational culture) that may affect the productivity of firms. ε_{it} is an idiosyncratic error term. All time-variant explanatory variables are lagged one period in time (2 years) in order to reduce the simultaneous bias.

There are four technical points that should be discussed. First, as noted by previous studies¹⁷, IS^j can be possibly endogenous in Equation (4). This is because it seems likely that characteristics of firms unobservable to us (and thus omitted) can make them both increase their innovation output (reflected in IS^j) and their productivity. This means that the α_j parameters in (4) would be biased upward. In order to deal with such issue, we follow the suggestion of previous studies and use the predicted probabilities of IS^j rather than the actual value of IS^j . The predicted probabilities of IS^j are obtained from modelling the determinant

¹⁶ It is worthy to note that what we are using here is a similar approach to multiple inequality restrictions testing framework for detecting complementarities (Mohnen & Röller, 2005), where in our case five discrete-choice and non-overlapping categories form our innovation strategy variables.

¹⁷ Griffith et al (2006), Mairesse and Robin (2009), and Polder et al (2010) are example of these studies, albeit using different measures for innovation output.

of IS^j . This means the estimation in this paper is actually attributed to a two-step procedure: (i) in the first step, we estimated the determinants of all innovation strategies with an extensive set of explanatory variables, employing a Multinomial Logit model. (ii) We obtain the predicted probabilities of each innovation strategies from the first step and then will use these predicted probabilities in the second step of the procedure in order to estimate the Equation (4). In other words, we are adopting the instrumental variable approach¹⁸ to deal with the potential endogeneity of innovation strategy in the Equation (4). The model specification choice of variables, and results of the estimation of first step is reported in Appendix 2¹⁹. We mainly focus on presenting and discussing the second step of the procedure in this paper (in Section 6), which is the estimation of Equation (4).

Second, we used panel estimators in order to further account for the endogeneity, by controlling for some unobserved time-invariant heterogeneity in the model, i.e. an omitted variable bias in the relation between innovation and productivity. There are two common choices of panel estimator, i.e. Fixed Effect (FE) and Random Effect (RE). The Hausman test speaks in favor of FE estimator. However, as discussed by Baltagi (2008), one should not automatically interpret a rejection of the null hypothesis in a Hausman test as a rejection of the RE-model, since there are quite strong assumptions underlying this test. We indeed prefer not to use FE because of two reasons. First, all of our innovation strategy variables have considerably lower within variation compared to their overall and between variations. They are predicted values bounded between 0 and 1 and they change slowly within firms. In addition, considering that FE operates through within transformation, it is expected that FE does not work well in our case (Wixe, 2014). Second, it is not recommended to use FE if the dataset is characterized by the “small T, large N”, which is particularly the case in our dataset (Nickell, 1981). This is because the demeaning process, which subtracts the individual’s mean value of each explanatory variable, creates a correlation between regressor and error. Therefore, we have reported RE results. However, the main drawback of RE estimator is that it does not allow for correlation between the regressors and the time-invariant firm-specific term (u_i in Equation 4), which is a strict assumption. In order to (partly) remedy this, we also

¹⁸ In particular Two Stage Least Squares (2SLS)

¹⁹ Perhaps a worthy not here is that some previous studies employed multivariate probit model when it comes to modelling of the determinants of various innovation strategies. The main motivation for such estimation strategy was to accommodate the possible interrelation between various types of innovation (e.g. product process, and organizational innovation). We are not worry about such potential interrelation in our study, since we have five innovation strategies that are collectively exhaustive and mutually exclusive choices. That means in each period, a given firm can pick only one of these five choices, and hence the issue of interrelatedness should not be an issue in our study.

employed Hausman-Taylor estimator (RE-HT), allowing for correlation between all of innovation strategies variable with time-invariant firm-specific term (Hausman and Taylor, 1981). This way, we are further accounting for possible endogeneity of innovation strategies in Equation 4. In addition, we also employed First Difference (FD) estimator in order to further control the robustness of our results in regard to endogeneity by eliminating the time-invariant elements.. The advantageous of FD over RE-HT is that it requires only predetermined variable to account for endogeneity. Moreover, the dependent variable is productivity growth (unlike other models with productivity level), hence provide further insight on performance measure of firms. All results are reported and discussed in Section 6.

Third, as noted earlier, we follow Cobb–Douglas production function as our modelling framework. This model is inherently parsimonious when it comes to adding control variables, such as ownership structure of firm or amount of import and export. Nevertheless, an extensive set of control variables are indeed controlled for in our two-step procedure, when they already entered the first step in form of explanatory variables. Since, in the second step, we are using the predicted value of IS^j in Equation (4), adding explanatory variables (who actually formed the predicted values) would lead to serious multicollinearity issues in the estimation of the Equation (4). Such an estimation strategy of having a parsimonious model in the second step, while having extensive explanatory variables in the first step is also performed in previous similar studies (Griffith et al, 2006; Mairesse and Robin, 2009; Polder et al, 2010).

And finally, forth, the five innovation strategies might be correlated with each other and that can make it difficult to isolate the effect of each innovations strategy from each other on productivity. Nevertheless, we do not think this is an issue in our analysis for four reasons: (i) the five innovation strategies are mutually-exclusive choices, hence, data-wise, firms can choose only one of the these innovation strategies at the given time, (ii) there is a low correlation between RHS variables, which is reflected in VIF score (discussed in Section 3), (iii) the assumption of Independence for Irrelevant Alternative (IIA) is not violated in our data, and finally (iv) we performed a robustness check in the 1st stage of estimation by using multivariate probit estimation, which allows for the interrelation between all innovation strategies with each other ²⁰.

²⁰ In particular, using the multivariate probit estimation (instead of multinomial logit) in the first stage of estimation and then using predicted value in the second stage did not change the main results.

6. Result

Table 2 reports the estimation of Equation (4), where we estimate the effect of various innovation strategies (IS) on firm performances, measured as labor productivity (value added per employee) using a panel of firms from 2002 to 2012 (employing five waves of CIS in Sweden). As noted in Section 5, four estimators are employed: Model (1) pools the data uses ordinary least square (OLS), Model (2) employs panel estimator of generalized least Square (GLS) by using Random Effect (RE) in order to account for time-invariant firm-level heterogeneity, Model (3) employs Hausman-Taylor estimator (HTRE), in order to relax an assumption of Model (2), by allowing for correlation between the innovation strategy variables and the time-invariant firm-specific term, and finally Model (4) employs First Difference (FD) estimator in order to further control the robustness of our results in regard to endogeneity by eliminating the time-invariant elements.

[Table 2 about here]

There are four innovation strategies as explanatory variables for productivity of firms in Table 2. The peculiar innovation strategy of deciding not to innovative ($j=0$) is the base (reference) group and hence the interpretation of the estimated parameters of all reported four strategies should be done in refer to this base group. The predicted values are used for the four innovation strategies in Table 2 (instead of observed values)²¹. Looking at Simple IS, Model (1) shows that having those firms that choose simple innovation strategies (choosing only one of four Schumpeterian types of innovation) are better off in terms of their future productivity two years later in compare with those firms that choose not to innovate at all (base category). However, the significant effect of such strategy is vanished as soon as: we control for unobserved heterogeneity (in Model (2) to Model (4)), allow for correlation between the regressors and the time-invariant firm-specific term (Model (3)), and when it comes to productivity growth (Model (4)). Therefore, we cannot be confident to reject the null of our Hypothesis 1.

Looking at Complex IS-Low, the results shows that those firms that choose complex innovation strategies with low complexity (only two types of Schumpeterian innovations) are better off in terms of their future productivity two years later in compare with those firms that

²¹ These predicted values come from the first stage of the estimation procedure discussed in Appendix 2.

choose not to innovate at all. However, such effect is again vanished as soon as: we allow for correlation between the regressors and the time-invariant term (Model (3)), and when it comes to productivity growth (Model (4)).

An interesting and somewhat surprising result, is associated with those firms that choose complex innovation strategies with medium complexity (Complex IS-Medium). This strategy seems to have negative effect on productivity level (but no effect on growth). Looking more closely to these firms to see who they are (in Table 1), one can detect at least two problems with them. First, these firms choose three types of Schumpeterian innovations, and inherently they are not organic firms, i.e. they do not have balance between choosing technological (product and process) and non-technological (organizational and marketing) innovations. And as discussed in Section 2.2.2, we may not expect the higher productivity effect here. Second, while the difference between the complexity degree of Complex-Medium and Complex-High is only marginal, the average turnover (as proxy for size and financial capability) of firms who chose Complex-Medium is considerably lower than those firms who chose Complex-High strategy. For instance, those firms that choose the combination of product, marketing, and organizational innovations (PROD MAR ORG), have in average 3 times less turnover than those firms who chose complex high innovation strategies (855 MSEK versus 2430 MSEK). This could imply that it is not necessarily the complex-medium strategy that leads to lower productivity, but it was a wrong decision of firms to choose a relatively complex and “costly” innovation strategy, while they cannot afford it. Such wrong decision has reflected itself in lower productivity level of these firms.

Finally, the effect of innovation strategy on productivity is the most robust one for those firms that choose complex-high innovation strategy (those that engaged in all four types of Schumpeterian innovations simultaneously). In all four models, the effect is positive and significant. This is due to complementarities effect of all Schumpeterian four types of innovation and the consequent amplified effect on productivity. We will discuss it further at the end of this section. This is indeed what we expected from our Hypothesis 2.

As noted earlier, the four innovation strategies can be broke down to their ingredient “innovation combinations”. This will provide a more “behind the scene” insight beyond the simple vs. complex innovation strategies that we have perused so far. There are fifteen innovation combinations: four of them belong to simple innovation strategies, six belong to complex-low, four belong to complex-medium, and finally one belongs to complex-high

innovation strategies (as depicted in Table 1). Then we have run the same regressions as Equation (4), but instead of the four innovation strategies, we used fifteen innovation combinations. The result of such breakdown of innovation strategies into their ingredient innovation combinations are reported in Table 3.

[Table 3 about here]

Looking at the ingredient of simple innovation strategies, product innovation positively and significantly affects the future productivity level of firms in Model (5) and Mode (6). However, the significance disappears in the last two models when we allowed a correlation between the innovation strategy variables and the time-invariant firm-specific term. Marketing innovation appears to be significant in only model (7), hence does not give us a signal of robust behavior. To sum up, we did not find a robust behavior in any of single innovation strategies, although product innovation seems in relative terms to be the most stable innovation strategy that positively and significantly can affect the future productivity of firms.

When it comes to the ingredients of the Complex IS-Low, there are two combinations (ingredients) that show robust results in all models. First, when a firm introduces product and process innovation simultaneously (PROD PROC). The reason is because of the twofold gains that these firms are enjoying: With new (or improved) products firms open new markets (taking competitive advantages), and with cost-reducing process innovations they can also increase the level of demand for their products. This intensifies the performance of complex innovators (Le Bas and Poussing, 2014). Second, (ii) when a firm introduces product and organizational innovation simultaneously (PROD ORG). Explaining this innovation combinations is also twofold (similar to previous one). Here firms combine product innovation with organizational innovation. With new (or improved) products firms open new markets, while at the same time, through organizational innovation, firms enable smoother innovation process by better routines, better knowledge sharing and problem solving procedure. These two mentioned Innovation Combinations (as two ingredients of Complex-Low innovation strategies) are also interesting in sense that they shows “moderating” role of process and organizational innovations for firms’ performance. While a large literature points to the effect of product innovation on performance, we only can see such effect when product innovation is combined with process and/or organizational innovation.

In line with finding of Table 2, the result of Complex-Medium innovation strategies shows some negative effects, but no ingredients of such strategy is really robust in Table 3. Finally, the only ingredient of Complex-High innovation strategies (i.e. simultaneously engaging in all Schumpeterian types of innovations) is robust in all models, as expected based on Table 2. This specific strategy can be seen as we combine “PROD PROC” and “PROD ORG” combinations and add marketing innovations. We already provided explanations about “PROD PROC” and “PROD ORG” above. Concerning the marketing innovation, it can intensify the market penetration of firms through better and innovative pricing, positioning, and promoting, hence provide further amplified effect of such complex innovation strategy on productivity. This specific complex innovation strategy can be seen as analogical to “Dual-Core Model of innovation”, where bottom-up technological innovation is combined with top-down non-technological innovation and produce a higher and amplified firm performance (Daft, 1989). This strategy can be also seen as analogical to “organic organizations”, where there is a balance between technological and non-technological innovations (Damanpour et al, 1989). To sum up, this shows that those firms that choose and afford to have the complex innovation strategies are better off in terms of their future productivity in compare with those firms that choose not to innovative (base group) and those firms that choose simple innovation strategies.

7. Conclusion

Firms may gain a sustainable competitive advantage, if they choose the right innovation strategy (Porter, 2008). However, what is the right innovation strategy that enhances a superior firm performance? Although not a new question, nevertheless, the literature has provided very limited insights so far both from theoretical and empirical perspectives on this topic (Le Bas & Poussing, 2014). Most prior studies have focused on technological innovations (product and process). However, we know already from Schumpeter that there exists also non-technological innovation (organizational and marketing). Moreover, any combination of these four Schumpeterian types of innovation can form complex innovation strategies, which we still have limited evidence about their effect on firm performances.

The purpose of this paper was to analyze the effect of various innovation strategies of firms on their future performance, measured by labor productivity. We employed five waves of the Community Innovation Survey (CIS) in Sweden, which enabled us to trace the innovative

behavior of a representative sample of Swedish firms over a decade, i.e. between 2002 and 2012. We distinguish between five innovation strategies, which compose of sixteen innovation combinations. Such innovation combinations, in turn, are formed by various combination of four basic Schumpeterian types of innovations, i.e. process, product, marketing, and organizational innovation. The main findings indicate that those firms that choose and afford to have a complex innovation strategy perform better in terms of their future productivity in compare with both those firms that choose not to innovative (base group) and those firms that choose simple innovation strategies. These firms are “organic” firms that have a good balance between technological (product and process) and non-technological (marketing and organizational) innovations (Damanpour et al, 1984) and enjoy from Dual-Core Model of innovation”, where bottom-up technological innovation is combined with top-down non-technological innovation and produce a higher and amplified firm performance (Daft, 1989). Moreover, looking more detail at of ingredient innovation combinations these innovation strategies, it turns out that there is a moderating role of process and organizational innovations on the effect of product innovation on productivity. Finally, the results may trigger the attention of innovation policy toward more complex strategies, rather than commonly pursued simple ones.

This study is the first step that incorporates a wide range of simple as well as complex innovation strategies in a common empirical setting. Now we have initial insight that complex innovation strategies perform superior. One area of further research is qualitative investigations of these specific strategies in order to shed light on the process of transformation of these complex strategies into the future performance of firm. Moreover, exactly which complex innovation strategies affect future productivity significantly can be country-specific. Future research is needed in other countries to improve the understanding. At the end, it should be noted that it was beyond the scope of this paper to discuss how different types of innovation “inter-related to each other”. Our purpose was to analyze the effects of different innovation strategies on the performance of firms and if there are systemic differences in this respect between the different innovation strategies. An area of future study would be to focus on interrelation between and within simple and various complex strategies.

Table 1-Innovation strategies: various combination of Schumpeterian innovation types

#	Innovation Strategy	Innovation Combinations	Frequency	Percentage (Total)	Percentage (Innovative)	Average Firm Turnover (MSEK)
1	Simple	NON-INNO	9718	46%	-	254
2	Simple	PROD	1512	7%	13%	466
3	Simple	PROC	1799	9%	16%	527
4	Simple	MAR	826	4%	7%	521
5	Simple	ORG	746	4%	7%	466
6	Complex-Low	PROD PROC	1580	7%	14%	1040
7	Complex-Low	PROD MAR	453	2%	4%	374
8	Complex-Low	PROD ORG	220	1%	2%	671
9	Complex-Low	PROC MAR	305	1%	3%	566
10	Complex-Low	PROC ORG	508	2%	4%	782
11	Complex-Low	MAR ORG	630	3%	6%	520
12	Complex-Medium	PROD PROC MAR	381	2%	3%	1030
13	Complex-Medium	PROD PROC ORG	347	2%	3%	1430
14	Complex-Medium	PROD MAR ORG	351	2%	3%	855
15	Complex-Medium	PROC MAR ORG	774	4%	7%	1010
16	Complex-High	PROD PROC MAR ORG	955	5%	8%	2430
Total			21104	100%	100%	-

Notes for Table 1: The table demonstrates four innovation strategies of firm (Simple, Complex-Low, Complex-Medium, and Complex-High). These four strategies are broken down to their ingredients, which are 16 possible innovation combinations that firms make. These 16 innovation combinations, in turn, are made by various combinations of the basic Schumpeterian four types of innovations (product, process, marketing, and organizational innovations). For instance, NON-INNO: non-innovative, PROD: doing only product innovation in year t , PROC: doing only process innovation in year t , MAR: doing only marketing innovation in year t , ORG: only organizational innovation in year t , PROD PROC: doing product and process innovations in year t , and so on. The “frequency” refers to number of observation corresponding to each innovation combination in the unbalanced panel dataset. Time period covers 2002 to 2012.

Table 2- The effect of various Innovation Strategies (IS) on firm performance

VARIABLES	(1) OLS	(2) GLS (RE)	(3) HTRE	(4) FD
<i>Innovation Strategies (IS)</i>				
SIMPLE IS	0.444** (0.175)	0.131 (0.112)	0.130 (0.182)	0.005 (0.009)
COMPLEX IS_LOW	0.343*** (0.130)	0.295*** (0.087)	0.179 (0.134)	0.006 (0.011)
COMPLEX IS_MEDIUM	-0.550*** (0.148)	-0.243* (0.137)	-0.328** (0.153)	0.013 (0.015)
COMPLEX IS_HIGH	1.141*** (0.209)	0.412** (0.192)	0.335* (0.202)	0.038** (0.019)
<i>Control variables</i>				
SIZE	-0.036*** (0.006)	-0.05*** (0.009)	-0.043*** (0.021)	-0.096*** (0.021)
PHYSICAL CAPITAL	0.057*** (0.004)	0.035*** (0.005)	0.02*** (0.011)	0.012*** (0.004)
HUMAN CAPITAL	0.465*** (0.049)	0.461*** (0.057)	0.061*** (0.098)	0.026* (0.136)
MANUFACTURING	-0.257*** (0.014)	-0.202*** (0.017)	-0.037*** (0.013)	-0.196*** (0.02)
TIME DUMMIES	YES	YES	YES	YES
Nr of firms	4,201	4,201	4,201	4,201
Observations	8,298	8,298	8,298	8,298

Notes for Table 2: The table reports the estimated parameters with standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variable is labor productivity (value added per employee) in all models. Non-innovative is the base category (innovation strategy). For other four innovation strategies, the predicted values are used in the regressions (as instruments) in order to reduce the possible endogeneity. Model 1 uses Ordinary Least Square (OLS), Model 2 uses Generalized Least Square (GLS) with random effect (RE), model 3 is Hausman-Taylor Random Effect estimator (HTRE), and model 4 uses First-Difference (FD) estimator. In Model 3, the possible endogeneity of all four innovation strategies are further taken into account (i.e. they are explicitly allowed to be correlated with firm-level random effect). The standard errors in Model 1 to 3 are bootstrapped and in model 4 are clustered over firms. The table uses unbalanced panel data of firms in CIS 2004, 2006, 2008, 2010, 2012. The main result of using balanced panel is similar to the above table. Innovation strategies are predicted values from a 1st stage estimation. Such 1st stage is discussed and reported in Appendix 2. All explanatory variables are lagged one period in time (2 years).

Table 3- The effect of various Innovation Combinations (ingredients of Innovation Strategies) on firm performance

VARIABLES	(5) OLS	(6) GLS (RE)	(7) HTRE	(8) FD
<i>Simple IS</i>				
PROD	0.767*** (0.178)	0.384** (0.171)	0.069 (0.138)	0.001 (0.015)
PROC	-0.318 (0.219)	-0.195* (0.117)	-0.121 (0.140)	0.005 (0.013)
MAR	-1.198* (0.657)	0.136 (0.546)	1.307** (0.552)	0.003 (0.019)
ORG	0.547 (0.636)	0.026 (0.382)	-0.469 (0.445)	0.010 (0.017)
<i>Complex IS_Low</i>				
PROD PROC	0.285*** (0.076)	0.238*** (0.070)	0.180** (0.074)	0.025* (0.015)
PROD MAR	-0.345 (0.389)	-0.364* (0.209)	-0.561** (0.267)	-0.040* (0.023)
PROD ORG	1.097* (0.608)	1.228** (0.539)	0.999** (0.463)	0.058* (0.034)
PROC MAR	1.966*** (0.676)	1.074* (0.575)	0.340 (0.574)	0.026 (0.035)
PROC ORG	-0.859* (0.441)	-0.077 (0.311)	0.257 (0.318)	0.017 (0.018)
MAR ORG	2.238*** (0.738)	1.036** (0.484)	0.415 (0.569)	-0.013 (0.021)
<i>Complex IS_Medium</i>				
PROD PROC MAR	-1.223*** (0.393)	-0.667* (0.341)	-0.394 (0.305)	0.013 (0.025)
PROD PROC ORG	0.938** (0.384)	-0.053 (0.284)	-0.422* (0.236)	0.014 (0.029)
PROD MAR ORG	0.103 (0.603)	-0.089 (0.483)	0.091 (0.459)	-0.065** (0.027)
PROC MAR ORG	-0.697** (0.319)	-0.362* (0.200)	-0.045 (0.247)	0.049** (0.024)
<i>Complex IS_High</i>				
PROD PROC MAR ORG	0.534** (0.239)	0.523** (0.222)	0.447*** (0.165)	0.034* (0.020)
<i>Control Variables</i>				
SIZE	-0.038*** (0.008)	-0.02*** (0.010)	-0.06*** (0.009)	-0.096*** (0.021)
PHYSICAL CAPITAL	0.060*** (0.003)	0.036*** (0.004)	0.031*** (0.003)	0.012*** (0.004)
HUMAN CAPITAL	0.466*** (0.050)	0.443*** (0.069)	0.415*** (0.048)	0.029* (0.136)
MANUFACTURING	-0.284***	-0.201***	-0.166***	-0.15***

	(0.025)	(0.023)	(0.025)	(0.035)
TIME DUMMIES	YES	YES	YES	YES
Number of Firms	4,201	4,201	4,201	4,201
Observations	8,298	8,298	8,298	8,298

Notes for Table 3: The table reports the estimated parameters with standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The dependent variable is labor productivity (value added per employee) in all models. Non-innovative is the base category. For other fifteen innovation strategies, the predicted values are used in the regressions (as instruments) in order to reduce the possible endogeneity. Model 5 uses Ordinary Least Square (OLS), Model 6 uses Generalized Least Square (GLS) with random effect (RE), model 7 is Hausman-Taylor Random Effect estimator (HTRE), and model 8 uses First-Difference estimator. In Model 7, the possible endogeneity of all fifteen innovation strategies are further taken into account (i.e. they are explicitly allowed to be correlated with firm-level random effect). The standard errors in Model 5 to 7 are bootstrapped and in model 8 are clustered over firms. The table uses unbalanced panel data of firms in CIS 2004, 2006, 2008, 2010, 2012. All explanatory variables are lagged one period in time (2 years). Table 3 is the result of a 2-step procedure, the same way as in Table 2. The result of the 1st step is available upon request.

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Appendix 1-Variable description

Variables	Type*	Definitions
q_{it}	C	Productivity of firm i year t , measures as value added per employee (log)
$PROD_{it}$	0/1	1 if firm i introduces only product innovation into the market in year t , 0 otherwise. A product innovation is the market introduction of a new or significantly improved good or service with respect to its capabilities, user friendliness, components or sub-systems. Product innovations (new or improved) must be new to the enterprise, but they do not need to be new to the market.
$PROC_{it}$	0/1	1 if firm i introduces only process innovation in year t , 0 otherwise. A process innovation is the implementation of a new or significantly improved production process, distribution method, or support activity for goods or services, such as maintenance systems or operations for purchasing, accounting, or computing (exclude purely organizational innovation). Process innovations must be new to the enterprise, but they do not need to be new to your market.
MAR_{it}	0/1	1 if firm i introduces only marketing innovation in year t , 0 otherwise. A marketing innovation is the implementation of a new marketing concept or strategy that differs significantly from the enterprise's existing marketing methods and which has not been used before. It requires significant changes in product design or packaging, product placement, product promotion or pricing. It exclude seasonal, regular and other routine changes in marketing methods.
ORG_{it}	0/1	1 if firm i introduces only organizational innovation in year t , 0 otherwise. An organizational innovation is a new organizational method in the enterprise's business practices (including knowledge management), workplace organization and decision making, or external relations that has not been previously used by the enterprise. It must be the result of strategic decisions taken by management. It exclude mergers or acquisitions, even if for the first time.
L_{it}	C	Number of employees in firm i year t (log)
K_{it}	C	Physical capital of firm i in year t , measured as the sum of investments in Buildings and Machines at year's end for (log)
$MANUF_i$	0/1	1 if firm belongs to manufacturing sector, 0 otherwise captured by forty two sector dummies
<i>Time Dummies</i>	0/1	Time-specific component captured by five time dummies

* 0/1 corresponds to dichotomous variable, C corresponds to continuous variable

Appendix 2- The first step of innovation strategies estimation

We employed Multinomial Logit model in order to investigate the determinants of various innovation strategies that firms choose²². The probability that firm i chooses innovation strategy j is given by:

$$P_{ij} = \text{Prob}(Y_i = j | \mathbf{X}_i) = \frac{\exp(\mathbf{X}_i' \beta_j)}{1 + \sum_{k=1}^J \exp(\mathbf{X}_i' \beta_k)} \quad j = 0, 1, 2, 3, 4$$

Where $\mathbf{X}_i$ is the vector of explanatory variables which are alternative-invariant regressors, β_j are a set of four parameters per each explanatory variable, capturing the effect of each explanatory variables on the probabilities of choosing each choices (innovation strategies), and j is innovation strategies: $j=0$ is when firms choose not to innovate at all and considered as based model, $j=1$ when firm chooses to engage in simple innovation strategy (i.e. introducing only one of Schumpeterian types of innovation: only product, or only process, or only marketing, or only organizational innovations). $j=2$ when firm chooses to engage in complex-low innovation strategy, i.e. introducing two types of Schumpeterian innovation simultaneously). $j=3$ when firm chooses to engage in complex-medium innovation strategy, i.e. introducing three types of Schumpeterian innovation simultaneously. And $j=4$ when firm chooses to engage in complex-high innovation strategy, i.e. introducing all four types of Schumpeterian innovation simultaneously. Explanatory variables are the usual ones commonly used in innovation literature. They are described underneath the Table A2.

Table A2: Determinants of various Innovation Strategies (IS)

VARIABLES	(1) SIMPLE	(2) COMPLEX_LOW	(3) COMPLEX_MEDIUM	(4) COMPLEX_HIGH
$RDIN_{it-1}$	0.442*** (0.093)	0.493*** (0.097)	0.432*** (0.119)	0.573*** (0.160)
$RDEX_{it-1}$	0.115 (0.104)	0.150 (0.103)	0.322*** (0.119)	0.177 (0.144)
$CONT.RD_{it-1}$	0.272** (0.111)	0.434*** (0.111)	0.594*** (0.132)	0.603*** (0.158)
$MACH_{it-1}$	0.258*** (0.082)	0.469*** (0.084)	0.622*** (0.106)	0.358*** (0.136)
$EXKN_{it-1}$	0.126 (0.089)	0.252*** (0.092)	0.268** (0.109)	0.426*** (0.132)
$TRAINING_{it-1}$	0.183** (0.092)	0.031 (0.094)	0.162 (0.109)	0.150 (0.134)
$MARK_{it-1}$	0.143 (0.096)	0.417*** (0.100)	0.562*** (0.112)	0.862*** (0.132)
COS_{it-1}	0.283** (0.112)	0.255** (0.116)	0.268** (0.131)	0.581*** (0.152)
$COCL_{it-1}$	-0.169 (0.131)	0.105 (0.134)	0.294* (0.153)	-0.225 (0.179)
$COCOM_{it-1}$	0.150 (0.146)	-0.118 (0.151)	-0.041 (0.164)	-0.174 (0.192)
$COUNIV_{it-1}$	-0.161 (0.102)	-0.011 (0.103)	-0.047 (0.109)	0.127 (0.119)
$COINST_{it-1}$	0.012 (0.120)	-0.040 (0.120)	-0.130 (0.138)	-0.288* (0.154)
$SIZE_{it-1}$	0.124*** (0.028)	0.247*** (0.030)	0.383*** (0.034)	0.450*** (0.046)
$PHYCAP_{it-1}$	0.005 (0.007)	-0.010 (0.008)	-0.011 (0.009)	-0.007 (0.012)
$HUMCAP_{it-1}$	0.556*** (0.176)	0.699*** (0.197)	0.991*** (0.233)	1.746*** (0.309)
$IMPORT_{it-1}$	0.551*** (0.198)	0.663*** (0.203)	0.633** (0.252)	1.126*** (0.304)
$EXPORT_{it-1}$	0.429*** (0.143)	0.502*** (0.139)	0.461*** (0.177)	0.641*** (0.211)
$UNINAT_i$	0.161** (0.080)	0.263*** (0.089)	0.283** (0.125)	0.065 (0.177)
$DOM MNE_i$	0.144 (0.098)	0.178 (0.108)	0.214 (0.139)	0.231 (0.184)
$FOR MNE_i$	0.067 (0.102)	-0.014 (0.114)	-0.080 (0.146)	-0.198 (0.192)
$MANUF_i$	0.127* (0.073)	0.301*** (0.082)	0.260*** (0.101)	0.800*** (0.151)

²² We have a situation where firm i can choose between any of five various innovation strategies j , which are collectively exhaustive and mutually exclusive choices ($\sum_{j=0}^J P_{ij} = 1$). We only have alternative-invariant (case-specific) regressors and we do not have any alternative-specific regressors. In this situation, a good model to employ is Multinomial Logit.

Notes for Table A2: The table reports Relative Risk Ratio (RRR) with clustered standard errors in parentheses. ***, ** and * indicate significance on a 1%, 5% and 10% level. Multinomial Logit model is used for estimating the five innovation strategies of all firms with being non-innovative as the base model (strategy). $RRR > 1$ means one unit increase in the corresponding regressor is associated with higher probability that firms chooses the corresponding innovation strategy in compare with the base model (being a non-innovative firm) by RRR times. Conversely, $RRR < 1$ implies a negative effect. Observations are pooled over $t=2004, 2006, 2008, 2010, 2012$. All time-variant explanatory variables are lagged one period in time (2 years). Explanatory variables are as follows: RDIN: internal R&D, RDEX: external R&D, CONT.RD: having continuous R&D, MACH: investment in machineries, EXKN: Acquisition of external knowledge, Training: investment in employee training, MARK: investment in market introduction of the product, COS: collaboration with suppliers, COCL: collaboration with clients, COCOM: collaboration with competitors, COUNIV: collaboration with universities, SIZE: number of employees, PHYSCAP: physical capital, HUMCAP: human capital, IMPORT: import intensity, EXPORT: export intensity, UNINAT: Uninational enterprise, DOM MNE: domestic MNE, FOR MNE: foreign MNE, MANUF: manufacturing sector. Concerning the choice of explanatory variables, RDIN, RDEX, CONT.RD, MACH, EXKN, and MARK are usual innovation inputs that capture various source of knowledge input to innovation process. COS, COCL, COCOM, and COUNIV are collaboration variables that are based on open innovation literature. PHYSCAP and HUMCAP capture physical and human capital of firms, whom both are expected to have positive effects on innovation. IMPORT and EXPORT capture international linkages of firm, which are motivated by learning-by-importing and learning-by-exporting literature. UNINAT, DOM MNE, and FOR MNE capture the ownership structure of firm, which are expected to have positive effect as opposed to base category (non-affiliated firm). Finally, MANUF captures the structural heterogeneity between manufacturing and service firms. Both Hausman tests and suest-based Hausman tests of IIA assumption point that IIA assumption is not violated in the estimation. Time dummies are included in the regression model. The estimation is based on unbalanced panel data with 9,061 observations.