The Effect of Innovation on Productivity: Evidence from Turkish Manufacturing Firms

Burcu Fazlıoğlu and Başak Dalgıç and Ahmet Burçin Yereli

TOBB Economics and Technology University, Hacettepe University, Hacettepe University

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THE EFFECT OF INNOVATION ON PRODUCTIVITY: EVIDENCE FROM TURKISH MANUFACTURING FIRMS

Burcu Fazlıoğlu[1] *Basak Dalgıç*[2] *Ahmet Burçin Yereli*[3]

Abstract:

This paper explores the effects of firms' innovation activities on their productivity changes systematically for Turkish manufacturing firms differentiating between different typologies of innovation. To do so, we utilize a recent and comprehensive firm level dataset over the period 2003-2014, mainly constructed on the four consecutive waves of the "Community Innovation Surveys". We employ endogenous switching methodology controlling for endogeneity and selection bias issues as well as analyzing counterfactual scenarios. The main finding of the study points to firm heterogeneity in terms of both propensity to innovate and their benefiting from innovation activities. Our results indicate that all types of innovation activity have positive effects on the productivity of firms with respect to non-innovating firms. Further, we find robust evidence for the differential impact of innovation on firm productivity across different innovation types.

Keywords: Internal and External R&D, Product and Process Innovation, Organizational and Marketing Innovation, Firm Productivity.

JEL Classifications: D22, L25, O30.

[1] Department of International Entrepreneurship, TOBB Economics and Technology University, Ankara, Turkey. E-mail: bfazlioglu@etu.edu.tr
[2] Department of Public Finance, Hacettepe University, Ankara, Turkey. E-mail: basakcakar@hacettepe.edu.tr
[3] Department of Public Finance, Hacettepe University, Ankara, Turkey. E-mail: aby@hacettepe.edu.tr

1. Introduction

Early studies claim that growth in many countries could be partly explained by growth in capital and labor. The remainder is attributed to the 'Solow residual', which is interpreted as a measure of productivity growth after the seminal work of Solow (1957). Since then, an extensive literature developed attempting to explain this residual with technical change (Griliches, 1996, 1998). However, it was still lack of fully explaining productivity growth, as the information on innovation was not employed. Driven by these facts complementary research emerged so as to explain the linkage between innovative activity and productivity. Although the regarding literature handled the issue at the aggregate or industry level, innovation making decision units are firms. Further, as innovation is the search for adoption and commercialization of new processes, products and organizational structures it comprises uncertainty. Accordingly, innovation itself and its effects on productivity can be heterogeneous among firms. Thus, to examine into innovation and productivity nexus, firms should be taken as the unit of observation.

Far from being a concern of advanced countries alone, benefits from innovative efforts in terms of the firm performance gains importance especially for developing regions of the world, as innovation activity is costly for such countries due to their scarce resources of technology and human capital. Motivated by these facts, this paper investigates the effects of firms' innovation activities on their productivity changes systematically for Turkish manufacturing firms differentiating between different typologies of innovation. To do so, we use a comprehensive dataset on the innovation activities of firms in Turkey and in so doing we aim to expand the limited literature on developing countries.

It can be suggested that innovation efforts can translate into productivity gains for firms such that innovations can both increase firms' efficiency and improve the products they offer, hence escalates demand and reduces costs of production (Hall, 2011). There exists contradictory evidence about gains from innovation in terms of firm performance where the empirical evidence on this relationship varies among types of firms, measurement of productivity as well as across different types of innovation. Some studies have shown that innovation positively effects firms' productivity (Crépon, Duguet and Mairesse 1998; Griffith et al., 2006; Hall et al., 2009; Chudnovsky et al. 2006; Masso and Vahter, 2008) whereas some others have shown that innovation negatively effects firms' productivity (Raffo et al., 2008; Duguet, 2006 Janz et al., 2004; Lööf and Heshmati, 2006; Van Leeuwen and Klomp, 2006). Although there is much less evidence the regarding negative effects of innovation on productivity compared to those with positive findings, this conflicting evidence indicates that there are still unidentified issues regarding innovation and productivity nexus. Literature further suffers from the lack of utilization of a multidimensional approach to evaluate the productivity gains from different types of innovations. Namely, extant empirical studies on the subject mostly focus on traditional proxies such as R&D and patents but do not capture different innovative activities (for surveys of the literature see Hall, Mairesse and Mohnen, 2010; Mairesse and Sassenou, 1991).

In this paper, it is conjectured that typologies of innovation play different roles on firm performance. Thus, adopting an input-output approach we dissect the effects of innovative inputs (internal R&D and embodied technical change, external R&D and disembodied technical change) as well as outputs of innovation (product, process and organizational). Further, as the importance of product innovation for productivity gains might differentiate by the degree of novelty we distinguish between different types of product innovation, where the product new to the market is considered as radical and the product new to the firm is perceived as only incremental. Our evidence is based on a recent and comprehensive firm level dataset for Turkish manufacturing firms over the period 2003-2012, mainly constructed on the four consecutive waves of the "Community Innovation Surveys" i.e. 2006, 2008, 2010 and 2012. In order to conduct our analyses on the innovation-productivity relationship for Turkish firms, we utilize an endogenous switching technic, providing us to exploit the richness of our dataset, controlling for endogeneity and selection bias issues as well as analyzing counterfactual scenarios. In this setup, we are particularly interested in characteristics of firms that innovate and the productivity differentials between firms that undertake innovative activities with respect to those that do not.

Our contribution to the regarding literature on innovation-productivity nexus is threefold. First of all, we present a comprehensive analysis of the association between productivity and innovation, dissecting between various innovation indicators as well as taking an input-output approach to different innovation modes. To the best of our knowledge this study is the first attempt to explore the effect of innovation on productivity for Turkish firms, using non-traditional proxies for innovation via analyzing differential impacts of different types of innovations. We employ innovation input vs. innovation output dichotomy, as well as investigating the role of internal and embodies versus external and disembodied sourcing of knowledge. Secondly, both economic intuition and stylized facts suggests that different modes of innovation are endogenous and there exists endogeneity between all modes of innovation and firms' future productivity performance. Apart from the most of the studies, to control for endogeneity that might occur between different typologies of innovation we estimate instruments for other innovation efforts that govern what else the firm is undertaking in terms of innovations. Our final contribution stems from our methodology of endogenous switching, allowing us to further examine counterfactual scenarios. Namely, this technique is telling in terms of innovating firms mean productivity gain (loss) from innovation but also non-innovating firms mean productivity gain (loss) from non-innovating where the latter is largely neglected in the literature.

The main findings of our study point to firm heterogeneity in terms of both propensity to innovate and their benefiting from innovation activities. Moreover, we find complementarity among various typologies of innovation. While the importance of factor changes for each typology, the larger the firms are, the more they engage in exporting, the more intangible assets they have, the more they outsource and act as an subcontractor, the more likely they engage in some kind of innovation activity. Our input-output approach highlights that innovative outputs turn out to be a more direct driver of productivity improvements than innovative inputs. On the input side, we confirm the importance of R&D in spurring productivity yet internal R&D has a stronger association with productivity improvements than outsourced R&D. In terms of innovation outputs, there exists a hierarchical structure of productivity gains running from process innovation than to organizational than to product/service than to marketing innovation.

The remainder of this paper is organized as follows. Section two gives brief information on background literature. Section three introduces the data and methodology and Section four presents the results of our empirical investigation. Section five concludes.

2. Background Literature

Since economic growth is taken as an endogenous phenomenon (Romer, 1990; Aghion and Howitt, 1992), Schumpeter's (1942) and Porter's (1985) perceptions of innovation have received much more attention. In fact, research on innovation as a driver of productivity growth through efficiency gains was initiated by seminal works of Griliches (1979), Pakes and Griliches (1980). These studies related innovative inputs to knowledge accumulation within the notion of production function. Following these seminal works Kline and Rosenberg (1986) emphasized the need for a better understanding of innovation itself due to its complex and uncertain nature. Schumpeter (1934) defines innovation as a result of entrepreneurial search for new products, new processes and new organizational structures. The effects of innovative activity are heterogeneous among firms such that while it may offer market power to some firms, it may only provide marginal gains to others. As different typologies of innovation bring about different impacts on firms, our understanding of different modes innovation has developed only recently by the availability of firm level innovation surveys. Such surveys are designed to directly measure different innovation efforts of firms. With the utilization of these surveys traditional measures of innovative activities such as R&D spending and patent counts are replaced by direct measures of innovative inputs and outputs of firms[4].

Modern innovation surveys mostly rely on The Oslo Manual (OECD, 1992, 1996, 2005) providing guidelines on the definition of various types of innovation[5]. Surveys designed according to the Oslo Manual characterize firms' innovation process by providing information on (i) indicators of innovation input, such as the sources of knowledge, a wider range of innovation expenditures such as the acquisition of patents and licenses, product design, personnel training, trial production, and market analysis as well as R&D spending (ii) indicators of innovation output, such as the introduction of new products and processes, organizational changes and marketing innovations, the percentage of sales due to products new to the firm or new to the market. According to the Manual, four types of innovation are distinguished; product, process, organizational and marketing.

As to product innovation, which is a new or significantly improved product or service, it can be said that they differ in their main features from the previous products of the firm (OECD 2005). If it is a product, this difference can be found in its technical specifications, materials, or components[6]. OECD (2005) further classify product innovations as either product innovations new to market or new to firm. Following the classification of innovations -radical innovation, a really new innovation, and an incremental innovation- made by Garcia

[4] Note that R&D spending is an input to innovation activity and does not provide information about the success of innovation. On the other hand, although patent counts measures invention success, and thus partially could be considered as a proxy for innovation output, they are very noisy in terms of their market value.

[5] For a history of the innovation surveys see among others Mytelka et al. (2004), Mairesse and Mohnen (2010).

[6] For instance the first portable MP3 player was already including some existing technology, but it was completely new due to the way it was combining those technologies. As regards service innovations, they can be distinctive in terms of user friendliness, or speed and efficiency in service, i.e., giving medical advises through a web page (Oslo Manual, 2005: p.47-51).

and Calantone (2002), innovations new to market can also be classified as really new innovations and “innovations new to market” can be classified as incremental innovations (Doran, 2012). Innovations new to market are important as it is the first introduction of a product into a firm’s market before firm’s competitors and, are not radical as it may have already been available in other markets (OECD 2005). On the other hand, innovation new to firm is only an incremental/imitative innovation as the product is already being sold onto the market by competitors (OECD 2005).

Process innovation is defined as the implementation of a new or significantly improved production process, distribution method, or support activity for goods or services (OECD 2005). As for process innovation, it is more about decreasing unit costs of production or delivery, increasing the quality. That is process innovation is rather concerned with the identification of more effective internal operations of production and distribution hence related with the cost effectiveness (Martinez-Ros and Labeaga 2009). Thus, it is inherently technological in nature.

Organizational innovation is defined as the introduction of (i) significantly changed organizational structures, (ii) advanced management techniques or (iii) new or substantially changed corporate strategic orientations (OECD, 2005). As for organizational innovations, they aim to reduce administrative or transaction costs, improve workplace satisfaction and hence labor productivity, gain access to non-tradables or reduce supply costs. Organisational innovation can be classifies as non-technological and incremental (Garcia and Calantone, 2002; Mol and Birkinshaw, 2009). Marketing innovation is defined as an innovation type which focuses on customer needs, engaging into new markets, or newly positioning a firm’s product on the market with the objective of increasing the firm’s sales (OECD 2005).

A very common distinction in the literature is made between product and process innovations following Schumpeter (1934) and originating from the Utterback and Abernathy’s (1975) ‘product-life cycle’ model. According to this model, when markets are immature, firms might offer many new products such that the rate of product innovation is high. After new products are introduced to the market and as the market matures, firms begin to compete on costs and economies of scale and hence process innovations become prominent (Klepper, 1996). This model also indicates a complementary relationship between these two types of innovations, which occurs over time. Freeman and Soete (1997) also note that product innovations may result in process innovations. For instance, Kraft (1990) shows that firms, which engage in product innovation, are more likely to introduce process innovations, but firms, which engage in process innovation, are not more likely to engage in product innovation. Yet another strand of empirical literature has proved a complementarity between those forms of innovations regardless of the time (Doran, 2012). Mohnen and Roller (2005) suggest the idea that one type of innovation may necessitate the introduction of another form of innovation. For instance, Martinez-Ros and Labeaga (2009) show that just as product innovations may be followed by product innovations, process innovations might also be followed by product innovations. Less attention has been paid on organizational (Lööf and Heshmati, 2006; Raffo et al., 2008) and marketing innovations (Gallini, 2002; Hall, 2003).

Linkage between firm specific factors and innovation across different innovation types are extensively studied in the literature. Industrial economics literature hypothesize that innovation efforts of the firm can primarily be explained by the characteristics of the industry in which it operates such as market opportunities, technological opportunities and appropriability conditions (Levin et al., 1985, 1987; Mansfield, 1986). On the other hand, at the firm level particular attention has been paid on the core competences of the firm (Vega-Jurado et al., 2008). These identify the internal characteristics of the firms that positively affect their innovation behavior and can be related to tangible or intangible assets of firm. The core competences of the firm include technological competences, generally measured by innovative inputs such as R&D intensity (Bhattacharya and Bloch, 2004; Crepon et al., 1998); human resource competences (Romer, 1990; Griliches, 1998; Hong et al., 2012) and organizational competences (Webster, 2004). Firms' age and size are also recognized as significant factors for firms' innovation behavior (Crepon et al., 1998). Less attention has been paid on whether internal characteristics of firms play differential roles on different innovation types.

Another literature has evolved assessing the impact of different innovation activities in favoring firm productivity[7]. It can be suggested that innovation efforts can translate into productivity gains for firms such that innovations can both increase firms' efficiency and improve the products they offer, hence escalates demand and reduces costs of production (Hall, 2011). Nevertheless, the empirical evidence on this relationship varies among types of firms, measurement of productivity as well as across different types of innovation. For instance, while some studies utilize levels of productivity such as value added per employee

[7] Crépon et al. (1998) offers a structural model of innovation and productivity –referred as the 'CDM' model- which is widely employed in the empirical literature.

(Crepon et al., 1998; Mairesse and Robin, 2009) or sales per employee (Griffith et al., 2006; Jefferson et al., 2006; Van Leeuwen and Klomp, 2006), others make use of total factor productivity growth (Chudnovsky et al., 2006; Lööf and Heshmati, 2006).

Empirical innovation research has mainly focused on the innovation and firm level productivity nexus from the input side measuring innovative inputs with traditional proxies such as R&D spending expenditure. Most studies on R&D expenditure find it to have a net positive effect on productivity (for surveys of the literature see Hall, Mairesse Mohnen, 2010; Mairesse and Sassenou, 1991). Besides, in terms of outputs of innovation, patents are the most widely studied in the regarding literature. Empirical studies demonstrate that patents have a significant impact on firms' performance (Balasubramanian and Sivadasan 2011; Bloom and Van Reenen 2002; Crépon, Duguet and Mairesse 1998).

It is only recently, that the focus has changed towards the output-orientated view discriminating between different types of innovation. In terms of product innovation, Mohnen and Hall (2013) suggest that product innovation benefits firms' productivity by creating a new source of demand potentially giving rise to scale effects or requiring less of inputs than the old products. On the other hand, the productivity may decline through the driving out old products from the market namely the cannibalizing effect of the new products. Further, when the product is launched to the market productivity might decrease initially and afterwards it may improve due to learning effects. Most of the studies have revealed a positive effect on productivity (Mairesse et al., 2005; Griffith et al., 2006; Raffo et al., 2008; Hall et al., 2009; Mairesse and Robin, 2009) whereas limited number of studies has shown a negative effect (Raffo et al., 2008; Duguet, 2006). The importance of product innovation for productivity gains might differentiate by the degree of novelty i.e. whether the product is new to the firm or new to the market. A product innovation new to the market has a larger potential in terms of creating productivity gains (Mohnen and Hall, 2013).

In terms of process innovation, it is suggested that process innovation is a priori expected to have more prominent positive effect on productivity as they are directly related with reductions in costs (Mohnen and Hall, 2013). In theoretical grounds, negative effects may arise be due to the fact that innovations might have disruptive effects on the firm in the short run owing to the inefficient production at the beginning stages of mass production (Roper et al.; 2008). It could also indicate that via process innovation although a typical firm gains some market power, if it is operating in the inelastic portion of its demand curve, its revenue productivity might fall when it becomes more cost efficient (Hall, 2011). Indeed, the empirical evidence is mixed. For instance, while some studies reveal a positive effect of process innovation on productivity (Mairesse et al., 2005; Griffith et al., 2006; Chudnovsky et al. 2006; Masso and Vahter, 2008) and some others reflect negative effects (Janz et al., 2004; Lööf and Heshmati, 2006; Van Leeuwen and Klomp, 2006). Most studies find a positive correlation between product innovation and productivity, but the impact of process innovation is ambiguous (Hall, 2011).

The literature still suffers from lack of studies on organizational and marketing innovations –i.e. non-technological innovations- in relation to firm performance. Effects of organizational innovations on firm performance increasing competitiveness have been proven by a number of studies indicating two different sets of results (Armbruster et al., 2008; Caroli and Van Reenen, 2001; Damanpour et al., 1989; Greenan, 2003; Piva and Vivarelli, 2002). Organizational innovations may precondition and facilitate product and process innovations as their success rely on the appropriability of such innovations to the organizational structures of the firms. Next, organizational innovations have an immediate positive effect on firm performance with regard to productivity, as they improve quality and flexibility of firm operations (e.g., Womack et al., 1990; Hammer and Champy, 1993; Goldman et al., 1995). On the other hand, it is well recognized that marketing includes strategic moves and they can be perceived as intangible assets affecting firm performance (Wernerfelt, 1984; Barney, 1991; Teece, Pisano and Shuen, 1997). Firms investing in marketing initiatives are more likely to satisfy their customers compared to their rivals and to adapt to changing market conditions (Baker and Sinkula 1999). Through marketing innovations implementation of new sales and distribution methodologies can lead to higher firm efficiency and performance.

3. Data and Methodology

We utilize a recent and comprehensive firm level dataset for Turkish manufacturing firms over the period 2003–2014. For the analyses three different sources of data that are collected by TURKSTAT are combined. The first one is Community Innovation Surveys that covers information on innovative activities of firms, the sources of information and costs for these activities. We use the 2006, 2008, 2010, 2012 waves of the Community Innovation Surveys (CIS) which includes information regarding the firms' innovation activities and allowing for the distinguishing between different modes of innovation. CIS are based on the Oslo Manual guidelines and they include typical list of questions characterizing characterize firms' innovation process. In CIS, a firm is defined to be an innovator if it has introduced over a new product or a new process, or has engaged in some behavioral and organizational dimensions of his innovative activities. The variables in CIS characterize the treatments within the framework of our empirical investigation and they correspond to three-year periods. For instance, the 2006 wave of the survey reveals information on whether the firm introduces new processes and/or new products during the period from 2004 to 2006. One of the advantages of CIS is that it includes information on both innovators and non-innovators. CIS data covers whole population of firms with more than 250 employees whereas it is a representative sample for firms with 10-250 employees. The second source of data is Structural Business Statistics (SBS) giving detailed information on firms' income, input costs, employment and investment expenditures. While SBS is a representative sample for firms less than 20 employees it is a census for more than 20 employees[8]. Lastly, we use Annual Trade Statistics (ATS) including information on export and import flows of firms. Combining CIS, SBS and ATS, we focus on Turkish manufacturing firms where our dataset includes a representative sample for firms with 20-250 employees and a whole population of firms with more than 250 employees. We pooled four CIS waves corresponding to 2006, 2008, 2010 and 2012 thus in total we have 8532 observations over 2004-2012.

Exploiting our rich dataset we adopt an input-output approach where we dissect the effects of innovative inputs as well as outputs of innovation. The list of the innovation indicators utilized in this study is summarized in Table 1. Specifically, we utilize the following variables for innovative activities of firms. As innovation inputs we dissect between firms that have embodied and disembodied innovative inputs. That is a firm is defined to have *embodied innovative inputs* if it has intramural R&D expenditures and/or invested in innovative machinery or equipment. A firm is defined to have *disembodied innovative inputs* if it has extramural R&D expenditures and/or acquired external knowledge from other enterprises or organizations such as patents, know-how, and other types of knowledge.

With regards to innovation outputs we dissect between four types of firms that is firms that make *product innovation*, firms that make *process innovation*, firms that make

[8] We applied a cleaning procedure largely inspired by Hall and Mairesse (1995) to SBS dataset. We threw out the abnormal observations (zero / negative) for the main variables such as output, intermediate inputs, labor cost etc. Then, we excluded observations where main variables and ratios (e.g. employee, value added per employee, capital per employee) display extraordinary jumps and drops over one year. Finally, we excluded firms in NACE sectors 16 (Manufacture of tobacco products), 23 (Manufacture of coke, refined petroleum products and nuclear fuel), 30 (Manufacture of office, accounting and computing machinery), 37 (Recycling) since they include small number of firms.

organizational innovation and firms that make *marketing innovation*. Formally these innovation outcomes are defined in surveys as follows: "A product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. A process innovation is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. An organizational innovation is the implementation of a new organizational method in the firm's business practices, workplace organization or external relations. A marketing innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing." (OECD 2005, annex B, pp.149-154). As the importance of product innovation for productivity gains might differentiate by the degree of novelty we further distinguish between different types of product innovation that is product/service new to the firm and product/service new to the market. A firm is defined to make a *product/service innovation new to the firm* if it has developed successfully a major new product line or service and/or if the firm upgraded an existing product line or service which were new only for the firm. A firm is defined to make a *product/service innovation new to the market* if it has developed successfully a major new product line or service and/or if the firm upgraded an existing product line or service which were new to both the firm and the market. In Table 2 we report descriptive statistics for the innovation indicators. First, firms in our dataset seem to prefer to engage in internal generation of knowledge rather than searching for external sources. In fact, on average 42 percent of firms has embodied innovative inputs whereas only 19 percent acquire disembodied inputs. Further, from the indicators of innovative output, we see that there does not exist much variation for firms in terms of producing different kinds of innovative outcomes.

Table 1: Definition of Innovation Variables

Embodied Innovative Inputs	=1 if firm has intramural R&D expenditures and/or invested in innovative machinery or equipment over the last 36 months, 0 otherwise.
Disembodied Innovative Inputs	=1 if firm has extramural R&D expenditures and/or acquired external knowledge from other enterprises or organizations such as patents, know-how, and other types of knowledge over the last 36 months, 0 otherwise.
Product/service Innovation	=1 if firm ‘developed successfully a major new product line or service over the last 36 months, and/or if the firm ‘upgraded an existing product line or service’ over the last 36 months’, 0 otherwise.
Process Innovation	=1 if firm has ‘acquired new production technology over the last 36 months’, 0 otherwise.
Organizational Innovation	=1 if firm has had ‘a completely new organizational structure’ or ‘had a major reallocation of responsibility and resources between departments’ over the last 36 months, 0 otherwise.
Marketing Innovation	=1 if the firm had positive spending on R&D including wages and salaries of R&D personnel, R&D materials, R&D education and R&D related training, 0 otherwise.
Product/service Innovation New-to-Firm	=1 if firm ‘developed successfully a major new product line or service over the last 36 months which were new only for the firm, and/or if the firm ‘upgraded an existing product line or service’ over the last 36 months’ which were new only for the firm, 0 otherwise.
Product/service Innovation New-to-Market	=1 if firm ‘developed successfully a major new product line or service over the last 36 months which were new to both the firm and the market, and/or if the firm ‘upgraded an existing product line or service’ over the last 36 months’ which were new to both the firm and the market, 0 otherwise.

Table 2: Descriptive Statistics of Innovation variables

	Percentage of Firms	Number of Firms
Embodied Innovative Inputs	41.54	3805
Disembodied Innovative Inputs	19.53	1789
Product/service Innovation	36.27	3322
Process Innovation	39.08	3579
Organizational Innovation	40.85	3741
Marketing Innovation	40.75	3732
Product/service Innovation New-to-Firm	22.02	2017
Product/service Innovation New-to-Market	25.23	2311

As we aim to investigate the effects of innovation on productivity of firms our main variable of interest is total factor productivity (TFP), which is measured by Levinshon and Petrin’s (2003) semi-parametric approach. Griliches and Mairesse (1995) criticize the ordinary least squares (OLS) estimation of production functions as firms’ input demands might be correlated with unobserved productivity shocks. That is profit-maximizing firms adjust their input demands each time they face these shocks. Thus, treating inputs as exogenous variables might create simultaneity bias in the OLS estimation of production functions while the unobserved shocks will be captured in the error term. Another problem that may arise by OLS estimation of the production functions is selection bias as capital stock responds to productivity shocks in lagged periods. Firms with larger amounts of capital stock would expect higher future returns for any given productivity level and, hence, they will continue to operate even if they observe low levels of productivity for the next period (Olley and Pakes, 1996). However, firms with smaller amounts of capital stock may have to exit the market in such conditions. While several theoretical models predict that the growth and exit patterns of firms are motivated to a large extent by productivity differences (conditional on the existence in the data), if firms prior to their exit know the productivity level, a correlation between productivity and capital stock would exist. Thus a negative correlation between the disturbance term and capital stock is expected in OLS estimations, i.e. the resulting capital coefficients an underestimate of the true coefficient.

To overcome these biases, Olley and Pakes (1996) and Levinsohn and Petrin (2003) suggest semi-parametric production function estimators. In order to eliminate the relationship between productivity shocks and variable inputs, Olley and Pakes (1996) proxy productivity shocks with investment decision of the firms. On the other hand, Levinsohn and Petrin (2003) suggest that investment can not be monotonically increasing in productivity in data sets with a large number zero observations in investment. Besides, deleting these zero observations might create loss in terms of efficiency, and hence Levinsohn and Petrin (2003) propose using material inputs as a proxy into the estimation as material inputs are generally reported positively in firm-level data sets. Since our data set shows a similar pat- tern (a large number of zero observations in investment series) we prefer to use Levinsohn and Petrin's(2003) methodology in estimating our TFP measure. We estimate our TFP using the standard Levinsohn and Petrin (2003) methodology at the 2-digit sectoral level where TFP is measured as the residual of labor and capital over value added under Cobb-Douglas technology, employing the firms' usage of intermediate inputs as a proxy variable for unobserved productivity shocks.

In order to conduct our analyses on the innovation-productivity relationship for Turkish firms, we utilize an endogenous switching technic, providing us to exploit the richness of our dataset as well as to control for endogeneity and selection bias issues. In this methodology, the factors enhancing firms' probability to innovate are analyzed firstly, and then, the productivity gains from process and/or product innovation are investigated. This model is widely used in many different areas (see among others Lee, 1978; Adamchik and Bedi, 2000; Ohnemus, 2007). While one way of avoiding selection bias arose by firms' innovation decision is to employ Heckman's (1979) selection model, we choose to use an endogenous switching model. In our case, the switching model is appropriate where some nexus between innovation and firm level productivity alters across discrete regimes of innovation. The high productivity performance of a firm impacts on her innovation decision and vice versa. Accordingly, given this endogenous relationship between firms' productivity and innovation activity, the unobserved behavior must be also taken into account, with the estimation of an auxiliary regression (Dutoit, 2007). In this setup, we are particularly interested in characteristics of firms that innovate and, the productivity differentials between firms that undertake innovative activities with respect to those that do not dissecting different modes of innovation.

In the endogenous switching model specification to assess innovation decision and its implications in terms of productivity can be modeled in a two-stage framework (Lokshin and

Sajaia, 2004). In the first stage, we use a selection model for innovation decision I_i is a latent variable for the decision to innovate both in terms of innovation inputs and outputs.

$I_i = 1\ if\ \alpha Z_i + \alpha E_{ij}^* + \eta_i > 0$ (1a)

$I_i = 0\ if\ \alpha Z_i + \alpha E_{ij}^* + \eta_i \leq 0$ (1b)

where η_i is the random disturbance term.

Z_i is a vector including a set of firm specific variables regarding the decision to innovate. These variables are capital intensity (measured as the ratio of the capital stock to the number of employees), logarithm of number of employment, export status, foreign ownership dummy (takes value 1 if firms' share of foreign capital is larger than zero), region dummies (identifying 12 Turkish regions distributed according to the NUTS2 classification) and 4 digit sector dummies as well as public support dummies. Public support dummies indicate whether a firm has received any public support over the last 36 months in one of three forms, i.e. subsidies from central government, subsidies from local/regional government agencies and subsidies from European Union (EU).

E_{ij}^* is an instrument for other types of innovation activities. The need for such an instrument stems from the facts that an endogeneity issue may arise between different innovation indicators due to the complementary relationship among different forms of innovation (Doran, 2012). Thus, we need to control what else the firm is doing in other areas of innovation activities. For instance, firms, which engage in product innovation, might be more likely to introduce process innovations and vice versa. Firms investing in some kind of R&D (intramural or extramural) are more likely to produce innovation outcomes where vice versa is also possible. Therefore by means of a multivariate probit model we investigate whether our innovation variables are related or unrelated (Greene, 2003) and estimate instruments for other innovation activities. We run the multivariate probit model including five equations for observed "*other innovation activity*" of firms. For example, other innovation activity variable for product/service innovation takes value 1 if the firm is making R&D expenditure and/or engaging in a process innovation and/or engaging in organizational innovation and/or engaging in marketing innovation. Taking embodied and disembodied inputs of innovation as aggregate R&D investment; we have five types of innovating firms. Five other innovation activity instruments are estimated for firms that make R&D investment or not, engaged in product innovation or not, firms that engaged in process innovation or not, firms that have engaged in organizational innovation or not and firms that have engaged in marketing innovation or not. Note that, we do not distinguish between product/service innovation new to the firm and product/service innovation new to the market and use the other innovation activity instrument of product/service innovation for both types. Predicted values from these regressions are our other innovation activity instruments. The multivariate probit specification takes the following form (Galia Legros, 2004).:

$$E_{ij} = \delta_j + \beta_j Controls_{ij} + \eta_{ij} \; ; \qquad (2)$$

$$i = 1, \ldots, n \; ;$$

$$j = 1, \ldots, 5 \; ;$$

$$E[\eta_{i1}] = E[\eta_{i2}] = E[\eta_{i3}] = E[\eta_{i4}] = E[\eta_{i5}] \; ;$$

$$Var[\eta_{i1}] = Var[\eta_{i2}] = Var[\eta_{i3}] = Var[\eta_{i4}] = Var[\eta_{i5}] = 1 \; ;$$

$$Cov[\eta_{ij}] = p \;\; \forall j.$$

In the above setting, vector of controls $Controls_{ij}$ is restricted to firm size dummies (small, medium and large firms), 4-digit sector dummies and export status dummy. Other innovation activity instruments are inserted into our endogenous switching model where firms face two regimes (1) to innovate, and (2) not to innovate defined as follows:

$$Regime\ 1: \quad Y_{1i} = \beta_1 X_{1i} + \alpha E_{ij}^{*} + \varepsilon_{1i} \; if \; I_i = 1 \quad (3a)$$

$$Regime\ 2: \quad Y_{2i} = \beta_2 X_{2i} + \alpha E_{ij}^{*} + \varepsilon_{2i} \; if \; I_i = 0 \quad (3b)$$

where, Y_{1i} is the total factor productivity in logarithms for innovating firms in regime one and Y_{2i} is the total factor productivity in logarithms for non-innovating firms in regime two. X_{1i} and X_{2i} are vectors of independent variables for regimes one and two. These are capital intensity, logarithm of number of employment, export status, foreign ownership dummy, region dummies and sector dummies. ε_{1i} and ε_{2i} are the random disturbance terms. We run the endogenous switching model for the eight different I_i treatment effects (embodied innovative inputs, disembodied innovative inputs, product/service innovation, process innovation, organizational innovation, marketing innovation as well as product/service innovation new to the firm and product/service innovation new to the market) separately.

Equations (1a), (1b), (3a), and (3b) are estimated with simultaneous maximum likelihood estimation correcting for potential selection bias (Lokshin and Sajaia, 2004; Dutoit, 2007)[9].

The endogenous switching regression model can be used to analyze firms' relative performance from engaging in some kind of innovating activity or not engaging. This analysis can be realized through comparing the conditional expectations derived from endogenous switching regression model and they can be used to compare observed outcomes with counterfactual hypothetical cases. The conditional expectations for total factor productivity in the are presented in Table 3 and defined as follows: $E(Y_{1i}|I_i = 1)$[10] represents the conditional expectation of innovating firms' productivity from innovating (observed); $E(Y_{2i}|I_i = 1)$[11] represents the conditional expectation of innovating firms' productivity if they did not innovate (counterfactual); $E(Y_{1i}|I_i = 0)$[12] represents the conditional expectation of non-innovating firms' productivity if they innovated (counterfactual); $E(Y_{2i}|I_i = 0)$[13] represents the conditional expectation of non- innovating firms' productivity from not innovating (observed). Following Heckman et al. (2001), the effect of the treatment (i.e., innovation) on the treated (i.e., firms that innovated, "TT", is calculated as the difference between (a) and (c). TT represents innovating firms mean productivity gain (loss) from innovation. Likewise, the effect of the treatment (i.e., innovation) on the untreated (i.e., firms that did not innovate), "TU", is calculated as the difference between (d) and (b). TU represents non-innovating firms mean productivity gain (loss) from non-innovating. "BH_1" denotes the base heterogeneity for the firms that decide to innovate and is calculated as the difference between (a) and (d). "BH_2" denotes the base heterogeneity for the firms that do not innovate and is calculated as the difference between (c) and (b). Transitional heterogeneity denoted by "TH" is calculated as the difference between TT and TU. It assesses whether the effect of engaging in innovation on productivity is higher for firms that actually innovated or for firms that did not innovate than in the counterfactual case had they innovate. To test the significance levels for differences in Equations (4a)–(4d) t-tests are applied.

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[9] The error terms in equations (1a) or (1b), (3a), and (3b) are assumed to have a trivariate normal distribution

[10] $E(Y_{1i}|I_i = 1) = \beta_1 X_{1i} + \sigma_{1\eta}\lambda_{1i}$, where $\sigma_{1\eta}$ represents covariance of η_i and ε_{1i} and $\lambda_{1i} = \frac{\phi(\alpha Z_i)}{\Phi(\alpha Z_i)}$ such that $\phi(.)$ is the standard normal density function and $\Phi(.)$ is the standard normal cumulative density function.

[11] $E(Y_{2i}|I_i = 0) = \beta_2 X_{2i} + \sigma_{2\eta}\lambda_{2i}$, where $\sigma_{2\eta}$ represents covariance of η_i and ε_{2i} and $\lambda_{2i} = \frac{-\phi(\alpha Z_i)}{1-\Phi(\alpha Z_i)}$ such that $\phi(.)$ is the standard normal density function and $\Phi(.)$ is the standard normal cumulative density function.

[12] $E(Y_{2i}|I_i = 1) = \beta_1 X_{2i} + \sigma_{2\eta}\lambda_{1i}$.

[13] $E(Y_{1i}|I_i = 0) = \beta_2 X_{1i} + \sigma_{1\eta}\lambda_{2i}$.

$$TT = E(Y_{1i}|I_i = 1) - E(Y_{2i}|I_i = 1) \quad (4a)$$

$$TU = E(Y_{1i}|I_i = 0) - E(Y_{2i}|I_i = 0) \quad (4b)$$

$$BH_1 = E(Y_{1i}|I_i = 1) - E(Y_{1i}|I_i = 0) \quad (4c)$$

$$BH_2 = E(Y_{2i}|I_i = 1) - E(Y_{2i}|I_i = 0) \quad (4d)$$

Table 3: Conditional Expectations, Treatment, and Heterogeneity Effects

	Decision Stage		
Subsamples	To Innovate	Not to Innovate	Treatment Effects
Firms that innovated	(a) $E(Y_{1i}\|I_i = 1)$	(c) $E(Y_{2i}\|I_i = 1)$	TT
Firms that did not innovate	(d) $E(Y_{1i}\|I_i = 0)$	(b) $E(Y_{2i}\|I_i = 0)$	TU
Heterogeneity Effects	BH_1	BH_2	TH

Notes: (a) and (b) represent the actual expectations observed in the sample; (c) and (d) represent counterfactual expected outcomes.

$I_i = 1$ if firms engaged in innovative activity; $I_i = 0$ if firms do not innovate;

Y_{1i} : productivity of firms if they innovated;

Y_{2i} : productivity of the firms if they did not innovate;

TT: the effect of the treatment (i.e., innovation) on the treated (i.e., firms that innovated);

TU: the effect of the treatment (i.e., innovation) on the untreated (i.e., firms that did not innovate);

BH_i : the effect of base heterogeneity for firms that decide to innovate (i = 1), and do not decide to innovate (i = 2);

TH = (TT - TU), i.e., transitional heterogeneity.

4. Results

In the first step of our estimations we investigate factors enhancing firms' likelihood of engaging in innovative activities. We find an endogenous relationship between productivity and all types of innovative activities where we reject the null hypothesis of likelihood ratio (LR) test of independent equations[14]. Table 4 presents the results of the endogenous switching regression model estimated by full information maximum likelihood methodology for innovation indicators. Each column represents results for a different innovation indicator. The coefficient of innovation effort indicator is found to be positively significant for all innovative inputs. This suggests that for example, internal R&D is dependent on other efforts i.e. various innovation outputs. As expected, complementarity relationship is more pronounced for

[14] The likelihood ratio test shows that we can reject the null hypothesis (with p-value 0.000) indicating the equations measuring each type of innovation indicator and productivity are independent.

embodied innovation inputs with respect to disembodied innovation inputs. Among innovation outputs, product/service and process innovations are linked to other type of innovation efforts. This complementarity is more evident for product/service innovation than process innovations. Among different types of product/service innovations, innovations new to the market that are more radical are supported by other types of innovations more than incremental innovations.

Both indicators of internationalization namely foreign affiliation and export status positively and significantly increase the likelihood of investing on innovative inputs. Although export status positively and significantly impacts on all innovative outputs, foreign affiliation increases the probability of innovative outputs except product innovation and its forms. This rather surprising finding for product innovation might be due to the fact that foreign counterparts of the multinational firms in Turkey might be undertaking product innovation. As standard in the literature, we confirm that the larger the firms are, the more intangible assets they have, the more they outsource and act as an subcontractor, the more likely they engage in some kind of innovation activity.

Note that, subsidies from national resources have positive effects for all types of innovative activities whilst the subsidies from EU sources are found to be significant only for product (especially for incremental innovations) and marketing innovation outputs. On the one hand, this may indicate the inefficiencies in distribution or supervision of the EU subsidies for Turkey. On the other hand, since EU fund are already distributed to better performing firms receiving grants may not provide greater propensity to innovate with respect to firms without grants.

Table 5: ESM Innovation selection estimation: Innovation Outputs

	Internal R&D	External R&D	Product / Service	Process	Organizational	Marketing	New to Firm	New to Market
Other Effort	2.061***	1.665***	0.703*	0.586**	0.0346	0.270	0.478*	0.608**
	(0.212)	(0.229)	(0.419)	(0.250)	(0.199)	(0.199)	(0.255)	(0.242)
Employee	6.29e-05**	5.91e-05**	0.000225***	0.000226***	0.000204***	9.18e-05***	8.83e-05**	0.000157***
	(2.92e-05)	(2.40e-05)	(2.90e-05)	(3.41e-05)	(2.80e-05)	(2.41e-05)	(2.22e-05)	(2.46e-05)
Capital Intensity	1.53e-09	9.95e-09	6.72e-09	2.49e-09	1.58e-08	6.57e-08*	5.38e-10	9.85e-09
	(1.21e-08)	(1.20e-08)	(1.31e-08)	(1.17e-08)	(1.56e-08)	(3.49e-08)	(1.23e-08)	(2.23e-08)
Foreign Affiliation	0.167***	0.192***	0.0502	0.0995*	0.243***	0.125**	0.0276	0.0842
	(0.0549)	(0.0543)	(0.0528)	(0.0527)	(0.0508)	(0.0507)	(0.0533)	(0.0527)
Intangible Assets	0.140***	0.198***	0.137***	0.146***	0.165***	0.147***	0.0986***	0.140***
	(0.0347)	(0.0384)	(0.0338)	(0.0336)	(0.0322)	(0.0323)	(0.0357)	(0.0352)
Export Status	0.316***	0.231***	0.253***	0.226***	0.137***	0.200***	0.154***	0.333***
	(0.0364)	(0.0427)	(0.0421)	(0.0396)	(0.0406)	(0.0405)	(0.0450)	(0.0448)
Subcontracting	0.100***	0.113***	0.0534***	0.110***	0.171***	0.101***	0.0338**	0.101***
	(0.0360)	(0.0386)	(0.0149)	(0.0346)	(0.0331)	(0.0331)	(0.0161)	(0.0358)
Outsourcing	0.179***	0.122***	0.149***	0.142***	0.131***	0.0656***	0.199***	0.111**
	(0.0455)	(0.0460)	(0.0437)	(0.0436)	(0.0419)	(0.0124)	(0.0441)	(0.0441)
Subsidies from Government	1.643***	0.871***	1.219***	1.331***	0.599***	0.626***	0.634***	0.865***
	(0.0653)	(0.0465)	(0.0507)	(0.0528)	(0.0466)	(0.0461)	(0.0452)	(0.0456)
Subsidies from Region	1.749***	1.005***	1.099***	1.214***	0.956***	1.012***	1.003***	0.480***
	(0.0944)	(0.0615)	(0.0676)	(0.0704)	(0.0658)	(0.0665)	(0.0600)	(0.0605)
Subsidies from EU	0.110	0.243	0.486**	-0.000360	-0.00528	0.286*	0.321**	0.0105
	(0.219)	(0.152)	(0.198)	(0.186)	(0.168)	(0.163)	(0.147)	(0.150)
Wald Chi2	37.76(0.000)	39.57(0.000)	28.47(0.000)	30.09(0.000)	38.59 (0.000)	39.01(0.000)	34.31 (0.000)	31.06(0.000)
Log Likelihood	-1402.56	-917.84	-1319.52	-875.70	-1433.33	-944.58	-927.54	-1397.09
Observations	8352	8352	8352	8352	8352	8352	8352	8352

Notes: Reported are the estimated regression coefficients and the robust standard errors (in parentheses) from estimations. Asterisks denote significance levels (***: p < 1%; **: p<5%; *: p<10%). All regressions include region and sector dummies as controls.

Next, we explore the relationship between innovation and productivity for firms engaging in innovative activities and not. As we discussed earlier, we employ ESM to identify the correlation between firms' decision to innovate and TFP, specifically whether there is endogeneity between innovation and productivity. In fact, we do find an endogenous relationship between all innovation types and productivity. Conceptualizing this now we turn our attention gauging the impact of innovation on TFP.

Table 6 presents the expected total factor productivity under actual conditions and counterfactual scenarios for innovative inputs where Panel A shows the results for embodied inputs and Panel B represents the results for disembodied inputs. Cells (a) and (b) signify the expected total factor productivity that can be observed from the sample. The expected total factor productivity of firms that invested on internal R&D is about 8.004, whereas it is about 7.951 for the group of firms that did not invest. Such a comparison might misguide the researcher to evaluate that the firms that invested on embodied inputs is 0.66 percentage points on average more productive than the firms that did not invest. Cells (c) and (d) denote the expected total factor productivity in the counterfactual scenarios. In case (c), firms who actually invested on embodied inputs would have TFP around 7.963 if they did not invest. In case (d) had firms who did not invest invested, their TFP level would be 8.085. The last column of Table 6 presents the treatment effects of innovation on TFP. TT shows that innovating firms' mean productivity gain from innovation is 0.041 percentage points. That is firms that actually invested on embodied inputs would be less productive if they did not invest. Further, TU show that firms that did not invest would be 0.134 percentage points more productive if they had invested.

A negative transitional heterogeneity effect (0.093) demonstrates important sources of heterogeneity in a sense that the positive effect of innovation is significantly smaller for the firms that actually did innovate relative to those that did not innovate. This might indicate two different but not mutually exclusive explanations. First, there may be a self-selection effect in terms of innovation that is already more productive firms might self-select into innovation. Or, higher post-innovation effects might be emerging for non-innovating firms, which may possess an absolute disadvantage in productivity. In fact, descriptive evidence reveals higher productivity levels for innovating firms than innovators except marketing innovation. Table 6 further presents the expected total factor productivity under actual conditions and counterfactual scenarios for disembodied innovative inputs in panel B. Similar to the results from embodied innovative inputs, TT shows that innovating firms' mean productivity gain from innovation is 0.039 percentage points. That is firms that actually invested in disembodied inputs would be less productive if they did not invest. Moreover, TU reveals that firms that did not invest in disembodied inputs would be 0.117 percentage points more productive if they had they innovated. These results imply that positive effect on the productivity levels of firms investing in disembodied innovative inputs; however, the transitional heterogeneity effect is still negative and, the effect is significantly smaller for the firms that actually did invest in external R&D relative to those that did not.

The results from ESM estimations of internal and external R&D, confirm the importance of R&D in acceleration of productivity for Turkish manufacturing firms. At the same time, however, treatment effects on productivity for internal R&D is higher than those of outsourced R&D suggesting a more central role for internally developed research. Outsourced R&D may not boost productivity as much as internal R&D due to the issues related to absorptive capacity of firms in internalizing external knowledge or coordination failures with the external providers of R&D or problems related with acquiring know-how. Further, embodied R&D investments specifically through acquisition of new machineries has direct effects on productivity or capacity utilization. This result also emphasizes that inherently firm specific is knowledge is more valuable.

Table 6: ESM Treatment Effects for Innovative Inputs

PANEL A: Embodied R&D			
	Decision Stage		
Subsamples	To Invest	Not to Invest	Treatment Effects
Firms that invested	(a) 8.004	(c) 7.963	TT= 0.041***
Firms that did not invest	(d) 8.085	(b) 7.951	TU= 0.134***
Heterogeneity Effects	BH1= -0.081**	BH2= 0.012***	TH= -0.093***
PANEL B: Disembodied R&D			
	Decision Stage		
Subsamples	To Invest	Not to Invest	Treatment Effects
Firms that invested	(a) 7.948	(c) 7.909	TT= 0.039***
Firms that did not invest	(d) 8.02	(b) 7.903	TU= 0.117***
Heterogeneity Effects	BH1= -0.072***	BH2= 0.006***	TH= -0.078***

Table 7 gives the expected total factor productivity under actual conditions and counterfactual scenarios for innovative outputs. Panel A presents the regarding results for product/service innovation. The expected total factor productivity of firms that innovated (product/service) is about 8.055 while these firms' TFP would be around 7.994 if they did not innovate. However, the treatment effect is found to be insignificant indicating product/service innovation does not have an effect on productivity levels of innovating firms. On the other hand, the expected total factor productivity by firms that did not innovate (product/service) is about 7.973 while these firms' TFP would be around 8.114 had they innovated. Hence, firms that did not innovate would be 0.141 percentage points more productive if they had innovated. The transitional heterogeneity effect is negative implying a significantly smaller impact of product innovation on productivity for the firms that actually did innovate relative to those that did not innovate.

Panel B shows the regarding results for process innovation. The expected total factor productivity of firms that innovated (process) is about 7.850 while these firms' TFP would be around 7.768 if they did not innovate. Treatment effects thus indicates that firms mean productivity gain from innovation is 0.082 percentage points. The expected total factor productivity by firms that did not innovate is about 7.821 whereas these firms' TFP would be around 8.007 had they innovated. Treatment effects thus indicates that firms mean productivity loss from not innovating is 0.186 percentage points. The transitional heterogeneity effect is negative implying a significantly larger impact of process innovation on productivity for the firms that that did not innovate compared with firms who actually did innovate. In Panel C and Panel D, we see the results for organizational and marketing innovation respectively. We observe positively significant treatment effects indicating "firms that actually innovated would be less productive if they did not innovate" as well as "firms that did not innovate would be more productive if they had innovated". The transitional heterogeneity effect is negative for both types of innovations.

Our findings reveal a clear ranking of productivity gains from different typologies of innovation outputs. The regarding hierarchy of treatment effects runs from process innovation than to organizational than to product/service than to marketing innovation. As regards to product/service innovation, while innovating firms does not gain from product/service innovation, non-innovating firms mean productivity loss from non-innovating is smaller than process innovation. This comparatively weak result for product/service innovation with respect to other innovation outputs (except marketing) is consistent with the theoretical view outlining time delays in transforming innovations into productivity improvements owing to learning effects. In terms of process innovation, we observe highest productivity gains. This results may arise since they are technological innovations introduced primarily with the aim of reducing production costs and improving efficiency. Among non-technological innovations which are incremental in nature, organizational innovation has a more pronounced effect with respect to marketing; as effects of this typology of innovation is more akin to those of process innovation. Indeed, organizational innovation are by definition inclined to reduce administrative, transaction and supply costs aiming to increase productivity whereas marketing innovation focuses on customer needs aiming to increase the firms' sales which would have indirect effects on productivity. Finally, innovative outputs turn out to be a more direct driver of productivity than innovative inputs as innovative inputs may take time to affect productivity.

Table 7: ESM Treatment Effects for Innovation Outputs

PANEL A: Product/Service Innovation			
	Decision Stage		
Subsamples	To Innovate	Not to Innovate	Treatment Effects
Firms that made innovation	(a) 8.055	(c) 7.994	TT= 0.061
Firms that did not make	(d) 8.114	(b) 7.973	TU= 0.141***
Heterogeneity Effects	BH1= -0.059***	BH2= 0.021***	TH= -0.080***
PANEL B: Process Innovation			
	Decision Stage		
Subsamples	To Innovate	Not to Innovate	Treatment Effects
Firms that made innovation	(a) 7.850	(c) 7.768	TT= 0.082***
Firms that did not make	(d) 8.007	(b) 7.821	TU= 0.186***
Heterogeneity Effects	BH1= -0.157***	BH2= -0.053***	TH= -0.104***
PANEL C: Organizational Innovation			
	Decision Stage		
Subsamples	To Innovate	Not to Innovate	Treatment Effects
Firms that made innovation	(a) 8.020	(c) 7.952	TT= 0.068***
Firms that did not make	(d) 8.046	(b) 7.908	TU= 0.138***
Heterogeneity Effects	BH1= -0.026***	BH2= 0.044***	TH= -0.070***
PANEL D: Marketing Innovation			
	Decision Stage		
Subsamples	To Innovate	Not to Innovate	Treatment Effects
Firms that made innovation	(a) 7.761	(c) 7.706	TT= 0.055***
Firms that did not make	(d) 8.100	(b) 7.985	TU= 0.115***
Heterogeneity Effects	BH1= -0.339***	BH2= -0.279***	TH= -0.060***

As the importance of product innovation for productivity gains might differ by the degree of novelty, we disentangle product/service innovation into whether the product/service is new to the firm or new to the market and estimate regarding treatment effects. In Table 8 we demonstrate the expected total factor productivity under actual conditions and counterfactual scenarios for different types of product/service innovation where Panel A shows the results for product/service new to the firm and Panel B represents the results for product/service new to the market. First of all, from Panel A we notice that firms that made product/service innovation new to the market would be 0.068 percentage points less productive if they did not innovate and non-innovating firms mean productivity loss is 0.154 percentage points. However, although product/service innovation new to the market has a larger potential in terms of creating productivity gains, strikingly its treatment effects are insignificant for firms that actually innovated. Moreover, non-innovating firms mean productivity loss is smaller for product/service innovations new to the market than product/service innovations new to the firm. This result may stem from the fact that product/service innovations new to the market are radical innovations such that it might be more difficult for the firm to internalize and translate them into productivity improvements.

Table 8: ESM Treatment Effects for Different Types of Product/Service Innovation

PANEL A: New to the Firm			
	Decision Stage		
Subsamples	To Innovate	Not to Innovate	Treatment Effects
Firms that made innovation	(a) 8.057	(c) 7.989	TT= 0.068***
Firms that did not make	(d) 8.085	(b) 7.931	TU= 0.154***
Heterogeneity Effects	BH1= -0.028***	BH2= 0.058***	TH= -0.086***
PANEL B: New to the market			
	Decision Stage		
Subsamples	To Innovate	Not to Innovate	Treatment Effects
Firms that made innovation	(a) 8.054	(c) 8.022	TT= 0.032
Firms that did not make	(d) 8.075	(b) 7.940	TU= 0.135**
Heterogeneity Effects	BH1= -0.021***	BH2= 0.082***	TH= -0.103***

5. Concluding Remarks

Promoting innovation is one of the main concerns of public policy authorities so as to stimulate productivity of production units of an economy and hence economic growth. Just as the main production units are firms the effect of innovation on firm productivity is an important issue for economists and policy makers as it has implications for industrial policy. In this paper we attempt to provide a better understanding of the effects of firms' innovation activities on their productivity changes systematically for Turkish manufacturing firms differentiating between different typologies of innovation. Adopting an input-output approach we dissect the effects of innovative inputs (internal R&D and embodied technical change, external R&D and disembodied technical change) as well as outputs of innovation (product, process and organizational). We employ endogenous switching methodology, allowing us control for endogeneity and selection bias issues as well as analyzing counterfactual scenarios. Within this two-step procedure setup, firstly we analyze factors enhancing firms' propensity to innovate and next we estimate returns from various typologies of innovation.

The overall picture from the analysis confirms firm heterogeneity in terms of both propensity to innovate and their benefiting from innovation activities. Our findings reinforce the view that there exists a complementary relationship between different forms of innovation. Namely, engaging in one type of innovative activity triggers other forms. Specifically, such complementarity is more evident for embodied innovative inputs with respect to disembodied innovative inputs. Among innovation outputs, product/service and process innovations are linked to other type of innovation efforts. This complementarity is more evident for product/service innovation than process innovations. Further among types of product/service innovations distributed according to their novelty, other types of innovations support radical innovations more than incremental innovations. Therefore, a good deal among innovation activities could contribute more to firm productivity.

Consistent with the traditional patterns in the empirical literature on innovation we confirm that the larger the firms are, the more they engage in exporting, the more intangible assets they have, the more they outsource and act as an subcontractor, the more likely they engage in some kind of innovation activity. Yet, the role of each factor differs for each type of innovation. Public supports are found to have positive effects for all types of innovative activities pointing out a clear avenue for policy intervention in terms of subsidies. The subsidies from national sources are found to be more effective than EU sources. The reason behind this finding might be the obstacles arising in distribution or supervision of the EU subsidies or since EU funds are gained by better performing firms, receiving grants may not provide greater propensity to innovate with respect to firms without grants.

Adapting an input-output approach gains special importance in terms of the results from the second step of our endogenous switching analysis. Regarding results reveal that innovative outputs turn out to be a more direct driver of productivity improvements than innovative inputs as innovative inputs may be exposed to time-delays in affecting productivity. On the input side, we confirm the importance of R&D in spurring productivity yet internal R&D has a stronger association with productivity improvements than outsourced R&D. Having more direct effects on productivity or capacity utilization embodied R&D investments inherently builds up firm specific knowledge. On the other hand, outsourced R&D may incur problems related with absorptive capacity of firms in internalizing external knowledge or coordination failures. Accordingly as internally developed is found to be more valuable for firms, for policy intervention purposes resources should be allocated to subsidize and support internal R&D investments of firms instead of promoting external R&D.

On the output side, there is significant heterogeneity pronounced in contribution to productivity coming from different typologies. Indeed, there exists a hierarchical structure of productivity gains running from process innovation than to organizational than to product/service than to marketing innovation. We find a lacking effect of product/service innovation on productivity with respect to process or organizational innovations. This can be interpreted as signal of time delays in terms of translating innovations into productivity gains due to learning effects. Higher productivity gains arising from process and organizational innovations stem from the fact that these innovations are introduced with the aim of reducing costs. Another piece of evidence we provide is that productivity gains differ by the degree of novelty of product/service innovation. Incremental innovations are found to be more pronounced in fostering productivity gains than radical innovations, as radical innovations might be more difficult for the firm to internalize and translate into productivity improvements.

Note that, our counterfactual scenarios add further insights to innovation-productivity nexus. Throughout the analysis we show not only the fact that firms that actually innovated would be less productive if they did not innovate but also firms that did not innovate would be more productive had they innovated. The second finding is puzzling in the sense that engaging in innovation would improve non-innovating firms productivity, but some firms are reluctant to do so. A reasonable explanation of their non-innovating behavior could clue the uncertain nature innovation activity and firm heterogeneity in terms of barriers to innovate. Such heterogeneity in firm behavior indicates heterogeneity in market failures emphasizing the importance of detailed firm-oriented policy design instead of aggregate interventions at sectoral or country level.

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