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Abstract:

The binomial logit model is applied to data of the Technology Development Foundation and of the State Institute of Statistics in order to identify determinants of the decision of Turkish manufacturing firms to innovate or not. Our findings are: (i) Determinants of innovation identified in innovation studies, such as firm size, market structure, and profitability exert a positive impact on that probability. Moreover, the relationship between the decision to innovate and each of the first two factors separately is an « inverted-U » one ; Determinants of innovation especially relevant to developing countries, such as competition on international markets, international technology transfers, skill level of the workforce, extent of vertical integration, and price level all have a positive influence. (*JEL* O12, O14, O31, O32)

I. Introduction

Since the eighties, a large number of firm-level studies have been carried out on different aspects of the process of technological change in developing countries (DCs). These studies have provided important insights into the *nature* and *determinants* of technological change in these economies as well as into its *impact* on economic development. The findings of these case studies confirm the importance of the acquisition of technological capabilities by firms for the industrialization of these countries. They also show that the nature and the causes of technological activities in the developing countries are quite different from those observed in the industrialized ones.

Following the results of these case studies, *econometric* investigations making use of firm-level data have been carried out for several countries in order to identify the sources of innovation activities (see Pamukcu, 2000, for a comprehensive and critical review of the literature). This line of research has provided interesting findings on the impact of a number of factors (firm characteristics, market structure, openness to external trade, purchase of foreign technology, degree of protection from foreign competition, etc.) on innovation activities, with obvious implications for technology policy. Although case studies of technological activities in Turkish firms are available, such as those by Ansal (1990,1994), Duruiz and Yenturk (1992), and Cetindamar (1999), no quantitative analysis using firm-level data has been carried out in order to gain insight into their innovation activities. The main objective of this paper is to fill the gap in this field. Our results have also implications for other DCs which, like Turkey, have started to liberalize their economies in the eighties.

Several studies, surveyed in Rodrik (1995), reveal that *static effects* of trade liberalization on growth in developing countries, originating mainly from intersectoral resource transfers, are rather limited and that only *dynamic effects* of these reforms might have a sustained positive effect on the development process. These dynamic effects are to be materialized through sustained productivity growth in firms, of which technological

change is one of the main determinants. This justifies the emphasis on the analysis of technological activities of firms in developing countries.

As far as Turkey is concerned, after having pursued an import-substitution industrialization strategy during the sixties and the seventies, she switched to a much more outward-oriented strategy in the eighties which entails export-promoting measures and import liberalization. Moreover, a Customs Union Agreement signed with the European Union (EU) and that came into effect in 1996, had led her to eliminate progressively in the eighties and in the first half of the nineties all barriers to imports from the EU, with whom she realizes more than 50 % of her external trade. Therefore, it is reasonable to expect that she will be very much in need of the dynamic effects of trade liberalization for sustained economic growth.

In section II, we present and discuss the database used in our paper. Section III is devoted to the discussion of the determinants of innovation included in the estimation, and of the empirical results. Section IV offers a summary of main findings, their implications for the Turkish economy and suggestions for future research.

II. Data and Estimation Method

The innovation survey was conducted by The Technology Development Foundation of Turkey in 1994 and covers 1297 Turkish manufacturing establishments with at least 10 workers (see TDFT, 1995, for more details) . It provides us with information, *inter alia*, on whether a firm introduced an innovation during the period 1989-1993, or not. The innovating firms are those which answered « yes » to at least one of the following four questions : did you perform in the last five years an innovation of the following type : (i) product improvement ; (ii) new product for the market ; (iii) process improvement ; (iv) use of new processes for production. It turned out that, according to this definition, 64 % of the surveyed establishments innovated during the period 1989-1993.

Consequently, the dependent variable of the model is a dichotomous qualitative variable, taking on the value of 1 when a firm innovates and the value of 0 when it does not. That is the reason why we have used the *binomial logit model*, in which the probability that a firm will innovate is estimated as a function of a certain number of explanatory variables. We disposed of more than thirty variables that might explain that probability.

First, we removed the outliers that could bias the estimation results. A « cleaning » procedure, similar to the one adopted by Hall and Mairesse (1995), has been applied to our sample of 1297 firms : (a) firstly, firms not having answered for three consecutive years over the period 1989-1993 to the annual manufacturing surveys conducted by the State Institute of Statistics have been removed from the sample, leaving us with 1246 firms ; (b) secondly, let us denote by $x_{0.50}$ the median and by IDR (the interdecile range), i.e. $(x_{0.90} - x_{0.10})$. For each potential explanatory variable, the interval $[x_{0.50} \pm 3\,IDR]$ has been constructed. A firm with at least one explanatory variable outside that interval has been removed from the sample, leaving us with observations on 1108 firms. These two stages have thus eliminated 14.6 % of the initial sample of 1297 firms. Observations on the remaining 1108 firms have been used for econometric estimation. Secondly, we have computed the average values of the variables over the period 1989-1993. Finally, we have used the forward stepwise regression procedure in order to decide which variables should be retained in the final regression. For details on this procedure in the framework of the logit model, we refer to Cramer (1991). All regressions have been performed with LIMDEP, see Greene (1998).

In Table 1 we summarize the variables that we have used (first those identified as having important explanatory power in general, and secondly, those especially relevant to DCs), the proxy by which they have been measured, and their *marginal effects*, evaluated at the mean of the variables (to be called the "average" firm in the sequel), measured in percentage points. For the computation of the marginal effects from the

parameter estimates, we refer to Greene (2000).

III. Discussion of Results

A. Firm Size

Several reasons might explain a positive impact of the size on the innovation decision of firms is to be expected. First, as far as innovation activities are separated from production activities, they can be considered as « fixed costs » for firms. Therefore, large firms are in a favorable position compared to small- and medium-sized enterprises (SMEs) because they have more internal resources at their disposal and, when needed, they can obtain more easily funds on the capital market in order to finance their innovation expenditures. Second, since large firms often produce several different products, they may benefit more readily than SMEs from the results of their innovation activities if these activities entail economies of scope. Finally, large firms can pay higher wages and therefore hire more easily qualified personnel.

TABLE 1: ESTIMATION RESULTS

VARIABLE	PROXY	MARGINAL EFFECT (percentage points)
Firm size (1)	Number of employees (logarithm)	0,28***
Firm size (2)	Number of employees (square of logarithm)	-0,03**
Market structure (1)	Four-firm level concentration ratio (%)	0,86***
Market structure (2)	Four firm level concentration ratio (squared)	-0,0071*
Profit rate	Share of capital in value added (%)	0,16***
Competition on international markets	Exports (dummy variable)	20,47***
Technology transfer (I)	Share of capital imports in investment expenditures (%)	0,77***
Technology transfer (II)	R&D expenditures of American and Japanese firms (100 millions of dollars)	0,14*
Skill level of the workforce	Average wages and salary levels (logarithm)	0,07**
Extent of vertical integration	Firms using subcontracted inputs (dummy variable)	6,90**
Price level	Wholesale price index (logarithm)	0,09*

*** (** or *): : significant at 1 (5 or 10) % level.

The firm size is measured by the logarithm of the annual average of number of employees. We have introduced the square of the logarithm in order to find an answer to the question whether the relationship is a linear one or an « inverted U ».

It turns out that a one percent increase in the size of the "average" firm increases its probability of innovation by 0.28-0.03=0.25 points. The marginal effect of the square of the logarithm of the number of employees is negative, indicating that the relationship between size and innovation decision is an « inverted-U » one.

B. Market Structure

Since the debate initiated by Arrow (1962) on the respective influences of a competitive market and a monopoly on innovation, the question to which extent different market structures induce or discourage innovation has been much debated, with inconclusive results. As far as oligopolistic markets are concerned, they may induce innovation by pushing firms to differentiate their products. In addition, as most oligopolistic markets are characterized by a small number of large firms, this fact may advance innovation activities by increasing the appropriability of the research results and/or by providing to these firms all the advantages related to large size. Of course, an oligopolistic market may have a negative effect on innovation if there is collusion between the different members. Therefore, only an empirical analysis is able shed light on this issue. Three indicators of market structure were available, and all relate to the degree of concentration of production at a sectoral level : we used the share of the four largest firms in production as well as its square.

For our "average" firm, the probability to engage in innovation increases with the degree of concentration of the production : a one point increase in this variable increases the probability of innovation by 0.86 points. The marginal effect of the square of this variable is negative and statistically different from zero, meaning that the relationship between market structure and innovation is not linear.

C. Profit Rate

Innovation activities are not carried out for their own sake but only if firms can increase their profits in this way. So, it will be interesting to verify the extent to which such a relationship exists between these two variables. A positive effect of profits on innovation is to be expected since a higher profit rate may increase the internal resources of firms (cash flow) and increase the firms' probability to engage in innovation. However, as pointed out in Kumar and Saqib (1996), and Braga and Willmore (1991), a low profit rate may be seen by firms as a threat that might eventually make them lose their market share, triggering therefore innovation activities. In this last case, a negative relationship between profit rate and innovation decision is expected.

The profit rate has been computed as the share of capital in value-added.

For our "average" firm, a one percent increase in this variable increases by almost 0.16 points the probability to innovate. Hence, the positive effect of higher profits on financing capacities of firms (cash flow) dominates any impact in the opposite direction that would accrue from low profits. We are inclined to think that this effect reflects mainly the financing constraints existing in the Turkish economy.

D. Competition on International Markets

Competition on the world market will push firms to innovate in order to gain market shares or not to lose the existing ones. The dynamic effects of trade liberalization, to which we made reference in the introduction, are likely to be caused - if they exist at all - by these pressures. The outcome of this factor is then positive, unless, of course, firms try to base their competitiveness on low labor costs, which, in the long term, is incompatible with a progressive innovation strategy. Apart from competitive pressures, production for foreign markets *per se* may have positive externalities on innovation activities of firms, increasing the probability of exporters to innovate, as shown by Westphal et al. (1984) and Pack (1992) respectively for South Korea and Taiwan.

The effect of competition on foreign markets on innovation is measured by a dummy variable taking on the value of 1 when a firm exports, and of 0 when it does not.

The positive sign of the marginal effect indicates that export-promoting measures of the eighties had a positive effect on innovation activities of Turkish manufacturing firms.

E. Technology Transfer

Technology transfer is classified according to whether the technology acquired is « embodied » (in capital or labor force) or not. For more details on this classification, see Fransman (1985).

Acquisition of embodied technology. Capital good imports may trigger innovation activities in importing firms in response to the need to adapt these goods to the local circumstances (complementary effect). On the other hand, the fact that new technology can be acquired readily from abroad may simply suppress any need to develop it, discouraging potential local innovative efforts (substitution effect). This negative effect will be more likely if an « import-dependence » culture has been created in firms by previous imports of capital. Econometric studies in other DCs do not give a unique answer to the question which effect is the dominating one, so that only an empirical analysis will reveal which one is dominant in Turkey. The relationship between technology imports, embodied or not, and innovation activities is a complex one, depending in particular on the development stage of a country, as emphasized in Evenson and Westphal (1995).

In order to account for this phenomenon, we used in the regressions the share of expenditures on imported capital goods in total investment expenditures.

A one percentage point increase in the share of capital imports in investment expenditures increases the probability of innovation of the 'average' firm by 0.77 points (note that this positive relation is linear, since the marginal effect of the square of this variable turned out not be significantly different from zero). This result indicates that the adaptation of imported technology to local conditions dominates the substitution effect of these imports.

Acquisition of non-embodied technology. For international technology spillovers, the main channels are : (a) analysis of patents granted abroad; (b) agreements between foreign and local firms concerning the training of the workforce ; (c) consulting the international scientific and technical literature ; (d) return of the expatriate workforce, if any.

In order to test for the existence of such spillovers, we used data on patents provided in Evenson and Johnson (1998) and constructed monetary flows of R&D expenditures accruing from American and Japanese firms' R&D expenditures to firms in Turkish manufacturing industries.

International technology spillovers exert a positive effect on innovation decisions of local firms : a 100 millions dollars increase in American and Japanese firms' R&D expenditures has a marginal effect of 0.14 points. Equivalently, this means that a one percent increase of these expenditures increases this probability by 2 points.

F. *Skill Level of the Labor Force*

Absorbing existing technologies is crucial for the industrialization of DCs and is a prerequisite for catching up with industrialized countries. Skilled workforce (i.e. engineers, technicians, skilled workers) is assumed to play an important role in the following stages of the technology transfer process : (a) exploration of the world market in search of technologies ; (b) entering negotiations with sellers of technology in order to acquire the relevant technical information (embodied or not) at a reasonable price ; (c) assimilating, adapting and modifying the newly acquired technology in order to make it work at international best practice level. Therefore, the availability of a stock of skilled workforce may be an important advantage in absorbing and modifying technology acquired from abroad. Whether this will be the case depends on the objectives of firms

and on the incentives accruing from the economic and institutional environment. For this issue we refer to Stewart (1977).

The logarithm of the average wage and salary levels which, according to Lall (1983), « *(are) a measure of general employee skills, assuming efficient labor markets* (p. 381) », have been

selected as explanatory variable.

This variable has a statistically significant positive effect on the innovation decision : a one percent increase in salary levels of the "average" firm increases the probability of innovation by 0.07 points. Since the average salary and wage level is correlated with *general* employee skills, its positive impact on innovation may be interpreted as revealing (a) the importance of technology absorption for innovation in Turkey and (b) the important role of people situated at the lower levels of the hierarchy (for example, qualified workers) for this absorption.

G. *Extent of Vertical Integration*

Empirical studies, such as Katz (1982, 1987) and Pack (1981), reveal that firms in DCs produce in-house a considerable part of inputs they subsequently use in production. Two factors are mainly responsible for this situation : (a) the small size of the domestic market for intermediate and capital goods which impedes the division of labor between sectors and which results in a small number of firms on these markets (a situation exacerbated by the fact that scale economies are in general most important for the production of these goods) ; (b) domestic producers established on these markets may encounter other problems that maintain the demand at a low level : delays in delivering commands, an inadequate price/quality ratio, etc. These deficiencies may be caused, in turn, by insufficient education of the workforce.

In-house production of a large part of the inputs is likely to exert a negative effect on the innovation activities of firms : indeed, the use of the workforce in the production of goods that are very different from a technical point of view, will preclude its use for innovation activities, for which a critical effort level must be reached before becoming productive. Hence, we expect a positive effect of lower vertical integration on the innovation decision.

In order to test for the existence of a positive impact of lower vertical integration on firms' innovation decisions, a dummy variable, taking on the value of 1 when the firm uses subcontracted input, and of 0 when it does not, has been added to regressions.

The positive sign of the marginal effect indicates that a lower degree of vertical integration has a positive effect on the innovation decision.

H. *Price Level*

A negative effect of a high and persistent inflation rate, such as the one observed in Turkey (60 % on average in the eighties and nineties, with a maximum of 140 % in 1994) on innovation activities is to be expected since it will increase uncertainty relating to the benefits of these activities. The inclusion of this phenomenon in our model can be rationalized on other grounds : the inflation rate is likely to be highly correlated with pressures emanating from demand and, thus, may be used to measure the impact of this variable on innovation activities. Another possible rationalization is that cash-flow, hence internal resources of firms, may be positively related to this variable, and thus can have a positive effect on innovation decision.

Wholesale price indices at a sectoral level have been used in the regressions in order to test for the existence of this effect.

A one percent increase in sectoral prices increases the probability of innovation by almost 0,08 points. As mentioned above, we consider this positive effect to accrue mainly from demand pressures. We must resort to this interpretation until a more direct indicator of the « demand-pull » factors influencing innovation can be used. Note that this might reflect, in part, the positive effect of cash flows on the innovation decision.

IV. Conclusions

In this paper we have presented the first results of the first micro-econometric analysis on determinants of innovation decisions in the Turkish manufacturing sector. We have used data of the innovation survey conducted by The Technology Development Foundation of Turkey in 1994. In that survey firms were asked whether they performed innovations or not. Consequently, our dependent variable is a binary (dummy) variable that takes on the value of 1 when a firm reported that it had innovated during the period 1989-1993, and that takes on the value of 0 when the firm reported that it was not engaged in innovation activities. We have used the binomial logit model in order to try assessing the impact of determinants on the probability that a firm is engaged in innovation activities. We have used a forward stepwise regression procedure in order to decide which variables are to be included in the final regression equation. The marginal effects of the determinants on the "average" firm have been presented in Table 1.

The following lessons might be drawn from our first empirical findings. The relationship between the decision to innovate and firm size seems to be an « inverted-U » one. The relationship between *market structure* and innovation decisions seems to be an « inverted-U » one as well. This calls for a closer examination in the near future. The impact of a one percent increase in the *profit rate* increases the probability by 0.16 points. It is likely that this effect reflects the positive impact of the availability of internal resources on innovation. *Competition on international markets* has a positive impact on the probability of innovation, a finding in concordance with empirical and theoretical literature on DCs. The positive effect accruing from *international technology transfers* reveals that Turkish firms are not isolated from worldwide technological developments. Our results reveal the importance of the *skill level of the workforce* for innovation. A lower degree of *vertical integration* increases the probability of innovation of firms that offer subcontracts whereas the *price level* exerts a positive effect as well.

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