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Absorptive Capacity, R&D Spillovers and Product Variety: An Empirical Evidence for Tunisia

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Abstract

Economic and technological performance of a developing country like Tunisia depends on its R&D efforts as well as its absorptive capacity of foreign R&D. In spite of launching several ambitious R & D projects, many gaps characterizing absorptive capacity still persist. For better locating the origin of these gaps, this study examines the effect of both the national and foreign absorptive capacity on the competitive position of Tunisia based on the product variety.

Thus, the two main problems analyzed within this paper include: First, the analysis of aggregation process of absorptive capacity on a macroeconomic scale by distinguishing the various sources of R&D spillovers i.e. national or foreign, intra-industrial or inter-industrial. Second, the study empirically analyzes the effect of absorptive capacity on the product variety.

Keywords: Absorptive capacity, R&D spillovers, product variety.

1. Introduction

In comparison to the traditional role of innovation and R&D in economic growth models, recent work of Nelson and Winters (1982) and Dosi (1988) highlight the effect of R & D spillovers on economic growth. In fact, the literature related to economic growth traditionally neglected the role of exchange of technology transfer as a potential factor of economic growth

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under the effect of the non localized character of technology and inefficiency of the mechanisms of appropriability. On the contrary, when the conditions of appropriability are robust and the technological change becomes localized, the market of technological knowledge will be more restricted on an international scale.

The assumption of absorptive capacity also fall under this logic according to which each unit of knowledge can be created, used and exchanged only by specific means of competences acquired by a firm. These are assimilated through organizational trainings and the provision of complementary units of knowledge emanating from other firms, universities and institutions of research. In other words, the capacity of innovation seems to be strongly conditional on access to external technological information, the training opportunities, and the accumulation of internal and external tacit knowledge at each firm.

In spite of the diversity of work related to product variety particularly that of Dixit and Stiglitz (1977), Eathier (1982), Eaton and Kierzkowski (1984) Feenstra (1994), Feenstra and Markusen (1994), Jones (1995) and Funke and Ruhwedel (2003), few of these studies were devoted to the absorptive capacity of R&D spillovers at all levels of analysis i.e. at the firm, the industry and in particular at the country level.

Economic and technological performance of a developing country like Tunisia depends on its R&D efforts as well as its absorptive capacity of foreign R&D. In spite of launching several ambitious R & D projects, many gaps characterizing absorptive capacity still persist. For better locating the origin of these gaps, this study examines the effects of both national and foreign absorptive capacity on the competitive position of Tunisia based on the products variety.

Thus, this paper attempts to analyze: firstly, aggregation process of absorptive capacity on a macroeconomic scale by distinguishing the various sources of R&D spillovers. Secondly, empirically analyze the effect of absorptive capacity on product variety in Tunisia.

2. Aggregation Process of the Absorptive Capacity

This section describes the aggregation process of absorptive capacity at the firm level by assuming that output decreases with a marginal increase in absorptive capacity, as a country approaches its technological border. Criscuolo and Narula (2001) suggest that duplication of existing technologies is "paradigmatic", whereas, these technologies are "pre-paradigmatic" on the technological border i.e. difficult to reach. Indeed, as a country approaches the technological border, accessibility to existing technologies become increasingly difficult. In other words, several technologies are in competition but a few of them can be adopted. The cost of imitation increases as the prosecutor cancels the lag with the leader and the number of technologies potentially valid for imitation reduces. The equation for absorptive capacity can be formulated as follows:

$$\Phi i = \Phi(R_{i,} \beta); \text{ where } d\Phi/dRi > 0;\ d^2\Phi/dR_i^2 < 0;\ d\Phi/dRi\ d\beta i < 0;\ d\Phi i/d\beta < 0 \quad (1)$$

According to this formulation, absorptive capacity is a function of R&D (R_i) effort and the degree to which external knowledge corresponds to the need of the firms as well as the general complexity of knowledge indicated at the same time by the parameter β.

By extending this reasoning on a macroeconomic scale, similar assumptions can be postulated when we define absorptive capacity by introducing the parameter β as a measure of technological lag. In this case, the process of accumulation of knowledge sets out at a lower speed as the country approaches the technological border and the assimilation of external knowledge is more difficult, under the effect of the complexity of acquired knowledge. For this reason, when a country closes the technological lag with the leader, investment in R&D is essential along the structure of convergence (Criscuolo and Narula, 2001).

Thus, there is an additional factor to justify high cost of the imitation process: the proximity of the follower to the technological border weakens its aptitude to absorb external knowledge and thus its imitation of the advanced products for a given level of investment in R&D resolves the problems. This is why the firms often prefer access to various co-operative strategies such as the joint-ventures and alliances in R&D, if the market for new technologies does not exist (Narula, 1999).

This implies that absorptive capacity is not constant along the structure of convergence: rather it develops with the technological development. The countries having different distances with respect to the border will thus have different aptitudes to assimilate the technological spillovers.

By taking into account the results previously established, it is possible to describe the cumulative technological capacity as follows:

$$\dot{C} = r_i + \Phi^m{}_i \, I_m \sum_{i \neq j} R_j + \Phi_i^{m^*} I_m{}^* \sum m^*{}_k + \Phi_i^t t$$
$$0 \leq \Phi_i^h \leq 1 \text{ for } h = m, m^*, t \qquad (2)$$

$$0 \leq I_J \leq 1 \quad \text{for } j = m, m^*$$

The new variable m^* is posed as investment specific to the firm of the same industry but located in all the other countries. The variable t represents "general knowledge" in the sense that it is associated with the infrastructure of knowledge[1] inside the individual systems of innovation in all the countries on the one hand and the overall activities of the operative firms in other industries generating a pool of inter-industrial R&D spillovers.

The study introduces various parameters of spillovers and absorptive capacity associated with the varied sources of knowledge. It is supposed that under the assumption that many technological spillovers are localized: the spillovers generated by the activities of R&D of the national firms are more

[1] The infrastructure of knowledge is generally identified like an indivisible good accessible to multiple users and includes the institutions of public research, the universities, the organizations of protection of intellectual property etc

significant than those of the firms located in other countries ($Im > Im^*$). Moreover, the capacity to assimilate spillovers will be more significant if external knowledge is technologically similar to that developed inside the firm.

$$\Phi_m > \Phi_{m*} > \Phi_t$$

To carry out an aggregation, it is necessary to take into account the existence of diversity in the base knowledge between the national firms. If this base determines the external knowledge that the firm is able to absorb, then different aggregate versions of the accumulation of knowledge can be obtained on a national scale.

Under the simplified assumptions that in a country, there are N national firms, p identical firms localized outside, and there is only one sector in the economy, one can derive an aggregated formulation from the equation. Thus, the equation of knowledge accumulation on the scale of a country, takes the following form:

$$\dot{C}_t = n\,\dot{c}_t = n\,r_t + \Phi_t^{m*} I_{m*}\, p\, m_t^* + \Phi_t^{t}\, t_t$$

$$\dot{C}_t = R_t + \Phi_t^{m*} M^* + \Phi_t^{t} t \quad (3)$$

With M * as a pool of R&D expenditure carried out elsewhere, R is the total pool of the national R&D expenditure and Φ is a decisional variable which determines the value of the parameter related to the absorptive capacity. The fraction of inter-industrial and total knowledge that n national firms are ready to assimilate is noted per t. In the second case where the firms have a different base of knowledge, the following equation is obtained:

$$\dot{C}_t = \sum^{n}_{i=1} \dot{c}(t)_t$$

$$\dot{C}_t = n\,r(t) + (n-1)\,m(t)\, I_m \sum^{n}_{i=1} \Phi_i^{m}(t) + pm^*(t) I_{M*} \sum^{n}_{i=i} \Phi_i^{m*}(t) + t(t) \sum^{t} i_{=1} \Phi_i^{t}(t) \quad (4)$$

Between these extreme cases, firms share a common part of the base knowledge and acquire different levels of absorptive capacity. However, formulation of this more realistic situation requires more complicated analyses.

During the preliminary phase of catching up, a primary condition for accumulation of knowledge is that investment in national R&D activities must satisfy a threshold level of technological competences. But during the phase of catching up, the assimilation of R&D spillovers acquires an increasingly significant role. The analysis of Cohen and Levindhal (1989) postulate that the absorptive capacity of a firm is a function of investment in R&D as well as complexity of external knowledge, an extension of this relation can be discussed.

At this level, it is considered that the national absorptive capacity is dependent on three principal factors: the national R&D expenditure (Rt), the distance compared to the technological border (Dt), and institutional context implementing the dissemination of knowledge on a national and international scale (Wt > 0).

$$\Phi^{i}_{t} = \Phi\ (R_t, D_t, Wt) \quad \text{for } i = M^*, T \qquad (5)$$

Moreover, the contribution of research efforts to the accumulation of absorptive capacity is positive, but with a decreasing rate ($d\Phi/dR>0$ and $d^2\Phi/dR^2 < 0$).

In the light of above mentioned formulations, along with the process of aggregation, certain systematic and institutional aspects must be considered. Although innovation and training are developed inside the firms, these are also encrusted in a network of bonds with other firms and institutions; it is these interactions that determine the dynamic process of training.

Thus, the diffusion of a pool of knowledge as well as the creation of new knowledge determines the national stock of effective technological knowledge and the accumulation of national absorptive capacity. The parameter W represents the various aspects of institutional whole which determine the dissemination of external knowledge and the capacity to acquire it. For example, the existence and efficiency of public and private institutions that suggest the best practices of information, the degree of commercial opening of the country, the incentives to firms for the exploitation of external knowledge and the availability of an educated and specialized labour force ready to evaluate and assimilate new technologies. The specific value of this parameter will depend on the social and cultural factors as well as policies at a particular stage of development. A rise in W (for example a change of the policy guideline towards a higher degree of the commercial opening) will increase the absorptive capacity and thus the assimilation of foreign knowledge ($d\Phi/dW > 0$).

Given the characteristics of knowledge assimilation that affect the learning environment of a firm (Cohen and Levindhal. 1989), the author proposes an indicator of the complexity of knowledge to know the technological shift (the distance from a country compared to the technological border). This shift can be measured in the following way:

$$D_t = C^* - C_t \qquad (6)$$

C^* represents the technological border, which is by simplicity constant in time and C_{t-1} is the stock of base knowledge, i.e. the technological level that a country could realize. At each point of time, a technological shift is the result of former investment in R&D and the efforts made in the absorption of foreign knowledge i.e. the absorptive capacity is based on the current and past efforts of R&D. The distance from the technological border is thus an indicator of efficiency of a country in exploiting the available knowledge and innovation for efficient production (technical efficiency). Moreover, the cumulative relation between absorptive capacity and technological development can be easily revealed: absorptive capacity supports the accumulation of technological knowledge and the technological advances deeply stimulate the development of absorptive capacity. However, the realization of this virtual circle depends on the existence of a minimal level of knowledge inside countries (Criscuola and Narula, 2001), i.e. a given country must have as a preliminary this minimal level to be able to assimilate foreign knowledge.

Moreover, as the threshold level base knowledge is reached, the capacity of a country to assimilate foreign knowledge increases in a stationary way, until the economic and technological characteristics become similar to those available in the industrial leader and a significant volume of external knowledge is imitated.

Consequently, once a country reaches the threshold level of knowledge accumulation, the creative destruction (known under the term "widening") becomes a dominating characteristic of the structure of innovation. The market of creative destruction is marked by the technological facility of entry and a fundamental role played by the contractors as well as new firms. The new contractors enter an industry with new ideas and innovations, launch new companies which question the established firms and continuously disturb the current methods of production, organization and distribution, which destroy the revenues associated with the preceding innovations. In other words, the structure of innovation of the "widening" type is connected to a base that is continuously reinforced by enormous technological opportunities[2], entry of new innovators and erosion of technological and competitive advantage of the existing firms (Aghion and Howitt, 1992).

However, as a country limits the shift with the leader, assimilation of R&D spillovers become more difficult under the effect of limited quantity of technological advances that can be imitated. On the contrary, if a country fails in the realization of this threshold level, it will be attenuated by the process of creative accumulation (often qualified by the term "deepening") of the most innovative countries.

Indeed, this process is characterized by the domination of already

[2] It was largely recognized (see Winter 1984 and Jovanovic 1982) that the weak conditions of opportunity limit the innovative entry and the innovative performance of the firms already existing successfully. However, better opportunities support entry with sufficient pool of technological and scientific knowledge.

existing firms and the presence of significant barriers to entry for the new innovators[3]. With their stocks of knowledge accumulated in a specific technological field, competences in R&D, production, distribution and significant financial resources, the already existing firms create significant barriers to entry for new contractors and small firms. In other words, the structure of innovation of the "deepening" type is connected to the domination of a restricted number of firms which are continuously innovating through accumulation of technological and innovative capacities (Malerba and Orsenigo, 1996).

In view of the arguments previously established regarding decreasing outputs with a marginal rise in the absorptive capacity, it is reasonable to postulate that when a country approaches the technological border (R & D becomes weaker), the assimilation of R&D spillovers will be possible only if there is a concomitant rise in the national R&D expenditure or if there is a facility that enables access to foreign sources of knowledge.

Moreover, the structures of innovative activities (creative destruction or creative accumulation) differ systematically between the various technological classes and it proves that the appropriateness of the absorptive capacity development are amplified within the framework of the structure of innovation of the widening type under the effect of free entry and thus the intensity of competition[4].

This idea consolidates the assumption according to which the factors

[3] According to Winter (1984), this structure of innovation is marked by high stability in the row of innovators under the effect of the effectiveness of the mechanisms of appropriability and the significant cumulativity in the base knowledge. In this case, when the innovators maintain their position as leaders, they are able to innovate continuously while being based on the former innovations (a high cumulativity) and to protect their innovations from imitation (an effective appropriability).

[4] The comparison between these two structures of innovation marks the presence of differentiated technological modes, and depends on the specific combination of technological opportunities, the appropriability of the innovations, the cumulativity of the technical advances and the properties of the base knowledge characterizing the innovative activities of the firms. Therefore, the concept of technological mode identifies many fundamental structural conditions which contribute to define necessary competences and the inciting and dynamic properties of the processes of innovation.

associated with technology play a fundamental role in the sectoral assignment and the organization of the innovative activities in general and the absorption of rival R&D in particular.

When a country is slightly outdistanced compared to the leader, the complexity of knowledge requires more intensified efforts on behalf of the national firms, a fuller volume of information on valid technology (to reduce the uncertainty connected to the process of assimilation) and base knowledge which extends beyond the field of national specialization.

The empirical results of Mancusi (2004) explicitly consolidate this reasoning by showing that absorptive capacity stimulates the sensitivity of a country to R&D spillovers: as the shift of a country compared to the technological leader is broad, this sensitivity is lower. However, the analysis is criticizable to the extent in which it is shown that in the presence of a high technological shift the national potential to increase this sensitivity is high.

This is why, in our model the relation between absorptive capacity and the national level of development is nonlinear. The equipment of a minimal level of primary knowledge is essential like a precondition to the improvement of absorptive capacity.

To appreciate the impact of the parameter relating absorptive capacity to the dynamics of knowledge accumulation, the author proposes to use the following functional form for the parameter related to the absorptive capacity:

$$\Phi^{i}_{t} = C_{t-1} \exp(-C_{t-1})\, \alpha\, (W\,R)^{\sigma}_{t} \quad ; \quad C_{t-1} > \check{C} \text{ and } i = M^{*}, T \qquad (7)$$

Where α is a parameter of scale and $0 < \sigma < 1$. For a given level of the flow of knowledge described by equation (4), a stock of knowledge at each point of time can be calculated by using a method of inventory. That makes it possible to lead to the following formulation:

$$C_t = (1-\emptyset)\, C_{t-1} + \dot{C}_t \quad ; \quad \dot{C} = R_t + \Phi_t^{m^*} M^* + \Phi_t^{t}\, T \qquad (8)$$

Where, Ø is the exogenic rate of obsolescence. The pre-exposed specification of absorptive capacity (by equation7) involves a functional form in S of the stock of knowledge.

The structure of evolution of this stock was previously and identically treated in the standard logistic function of technological diffusion models. This similarity is not randomly realized so far as the technology transfer and the assimilation of R&D spillovers play a crucial role in the model.

3. R&D Spillovers and Product Variety: Empirical Application in Case of Tunisia

In the economic literature, problems related to the factors of product variety are treated in the context of international trade theories and also within the framework of endogenous theories of growth. However, the bond between R&D spillovers and the product variety remain still insufficiently analyzed.

3.1 Formulation of the Assumptions

Several approaches based on international trade in differentiated products, suppose that a combination of the scale of output from the offer side, and the preference for variety from the demand side, involve a correlation between product variety and size of countries. Whereas, the models of dynamic growth stipulate; that variety and quality are the results of investment in human capital targeted for innovation and imitation. In this respect, the introduction of new products into the countries having high levels of product variety seems to be led by R&D. On the other hand, countries that are outdistanced by the border of the observable variety tend to carry out high growth rates of the variety. This idea will reinforce the assumption of the effect of R&D spillovers. A minimal threshold of investment in R&D is necessary to introduce at least products and processes of production that are available elsewhere instead of developing them.

According to the endogenous theories of growth, innovation depends largely on human capital in comparison to investment in physical capital. In particular, the rate of innovation can be reinforced by investment in R&D. The potential of imitation increases particularly with the level of qualification of the labour force. The skills can be justified either directly through education or by the effects of R&D spillovers.

At this level, the formal test operated by Addison (2002) refers to the assumption according to which changes in product variety based on international trade, must be guided by the initial conditions like the extent of efforts for innovation and the R&D spillovers. Recent economic studies have led to results according to which measurement of variety and quality of a product is positively correlated with the income per capita. However, the intensity of the correlation differs according to the groups of countries: for the consumer and intermediate goods, the weakest correlation between the product variety and the income per capita are often specific to North America and Western Europe. On the other hand, the articulation between variety and quality of the product and income per capita must be differentiated from both demand and supply sides.

On the level of demand, the first causal relation can pass from the income per capita to the variety and quality of products. Indeed, the reasoning directed from the demand side suggests that in economies with high income, consumers demand not only more consumption but also a broader variety and a more refined quality of the consumer goods. The experiment of the United States over the last twenty years, suggest that the consumers in countries with high income massively spend on products with richer variety. The subtle degrees of product differentiation of the products by country of origin are instrumental factors for the illustration of the relation between the income per capita and the variety in consumption.

An additional bond from the demand side between the variety, quality and the income per capita is based on the importance of rise in exports, which induce a rise in income per capita. This mechanism is mainly caused by the emergence along exports, of the products which are at the same time new and of better quality. Indeed, the richest economies export more in nominal terms than the poor countries by being exposed to the world market with a larger variety of goods.

The intra-industrial trade in horizontally differentiated products can lead to increase in efficiency through increased output and welfare materialized by the provision of a broader range of products for the consumers. In this case the costs of adjustment are lower than within the inter-industrial trade traditionally associated with comparative advantage, in which ascending specialization implies abandonment of contestable and comparatively underprivileged industries and the displacement of factors towards a limited number of industries directed towards exports. This exerts in its turn the effects of distribution for the compensation of the factors. In other words, horizontal differentiation, involves profits through the emergence of wider product varieties and potential economies of scale, without generating heavy costs of reallocation. Between these two extreme cases, the intra-industrial trade in vertically differentiated products creates specialization in the spectrum of quality, like the result of R&D expenditures and investment in human capital at the same time.

In the theory of international trade, the association of inter-industrial trade to painful adjustments and the intra-industrial trade with less expensive adjustments generated new theoretical developments in favor of the differentiation of products and the agglomeration of economies[5]. The inter-industrial trade is not only founded any more on comparative advantage, but also on the savings in agglomeration. On the contrary, the reasoning carried out from the offer side shows that the stationary state of the relation between product variety and income per capita refers at a temporal horizon of long term to shelter the transitory shocks emanating especially from the side of demand. These results highlight the significant effect of a variety of intermediate goods and capital goods as well as the non significant effect of a variety of consumer goods for the explanation of variations in income per

[5] It is the case of the United States in which the geographical agglomeration of the areas allows a high degree of industrial specialization (Krugman, 1993).

capita.

The theoretical developments so far discussed, led us to two fundamental assumptions:

Assumption 1

Product variety is reinforced by the national technological spillovers in comparison with the foreign R&D spillovers that they are intra-industrial or inter-industrial under the impact of absorptive capacity;

Assumption 2

Product variety is favorably conditioned by the demand side factors. Indeed, under the impact of intensity of competition and technological shift, Tunisia depends mainly on the diversity of consumer's preferences for the development of new product varieties.

In fact, the formulation of first assumption is based on the idea that the propagation of R&D spillovers depend particularly on technological congruence and complexity of knowledge which characterizes the source and destination of R&D spillovers. Indeed, and in the light of the determinants of absorptive capacity, we can consider that the coefficient related to the national technological spillovers will be statistically significant and positive, contrary to the foreign R&D spillovers in the explanation of product variety. At this level, innovation is based on the interaction of the resources allocated to R&D and training on the one hand, and the flow of external knowledge on the other hand. This is equivalent to saying that the current level of output which a country is ready to generate for a given level of stock of physical capital and labor will have to depend at the same time on the domestic efforts as regards the R&D and the activities of training, and also on the volume of knowledge available elsewhere. This idea shows an interactive relation between the efforts of domestic R&D and the pool of R&D spillovers. These results consolidate and emphasize the importance of absorptive capacity in the transmission of R&D spillovers.

With regard to the second assumption, a significant aspect of the explanatory variables of product variety will be analyzed: i.e. the factors from the demand side and the offer side. The empirical validation of this assumption fits in line with literature that insists on the results of the endogenous growth theories based on innovation (Romer, 1990). Indeed, these theories allotted to the R&D an increasingly crucial importance in the stimulation of economic and technological performances at the same time.

3.2 Pairing Between Technological Performance and Competitive Position Based on Product Variety: Sectoral Approach

This section analyzes the problem of pairing between technological performance and the competitive position of Tunisia in the following manufacturing sectors: electrical machinery and apparatus; food products, beverages and tobacco; chemicals products; textiles, textile products, leathers and footwear; metallurgical products, fabricated metal products, mining careers and oil. The author relies on vertical differentiation of products that are of lower or higher type as an indicator of competitive position based on the prices.

Moreover, it is also considered that the product variety is a major vector of a structural competitiveness model generating a built in competitive advantage and a nonreversible competitive position. This is why the study is based on the product variety as an additional indicator of competitive position.

Table 1 shows that the sectors of electrical machinery and apparatus; food products, beverages and tobacco; and chemical products, monopolize a number of patents substantially higher than the sectors of textiles, textile products, leather and footwear, mining career, oil, metallurgical products and fabricated metal products over the period 1987-2007: on average, 9 patents are deposited annually in the sectors of electrical machinery and apparatus; food products, beverages and tobacco; and chemical products against only an

Table 1
Tests of Comparisons of Averages and Variances of the Number of Patents Deposited Between Groups of Manufacturing Sectors During the Period 1987-2007

Group of Sectors	Sector	Sum.	Number of Observations	Average	Difference in Averages(t statistics)	F
Technologically Less Powerful Sectors (TLP)	Textiles Products, Leathers And Footwear	20	63	2.365	-6.508 * (-8.781)	0.138
	Metallurgical Products And Fabricated Metals Products	64				
	Mining, Careers And Oil	65				
Technologically More Powerful Sectors (TMP)	Food Products, Beverages And Tobacco	181	63	8.873		
	Electrical Machinery And Apparatus	179				
	Chemicals Products	192				
Test of Comparison of Variances (ratio = sd TLP/sd(TMP)) H0:ratio = 1	Ha:ratio < 1 ha:ratio! =1 ha:ratio > 1 Pr(F < F) = 0.0000 2*Pr(F < F) = 0.0000 Pr(F > F) = 1.0000					

(*) Significant difference in averages to the threshold of 1%

average of 2 patents deposited annually in the other sectors during the same period. In other words textile, textile products, leather and footwear; mining careers, oil and metallurgical products and fabricated metal products are technologically less powerful (TLP) than the other three manufacturing sectors.

To better appreciate this idea, the paper also analyzes the test of comparison of averages and of variances between the two groups of sectors i.e. the technologically less powerful sectors and those that are technologically more powerful (TMP). TMP results show that one cannot reject the assumption that the average number of patents deposited in the technologically less powerful sectors is lower than that of the technologically more powerful sectors.

Moreover, results of the test of comparison of variances enabled us to conclude that the variance of the number of patents deposited in the TMP sectors is higher than in that of the TLP sectors. Therefore, on the basis of number of patents deposited, the group of TLP sectors is more homogeneous. Thus, the analysis related to the patents deposited by the residents; show that the TMP sectors are mainly food products, beverages and tobacco; chemical products and electrical machinery and apparatus. The TLP sectors are textiles, textile products, leather and footwear; mining, careers and oil and metallurgical products and fabricated metal products.

With an aim of examining pairing between the technological performance and the competitive position based on the product variety, the difference in averages of the variety between the group of TLP sectors and the TMP sectors is analyzed during the period 1987-2007. It amounts to testing the null assumption of equality of the averages of product variety in the two groups of the above mentioned sectors. The alternative assumptions relate to the inequality of the averages of the products variety of the two groups of sectors of the sample. The results of this test are given in table 2.

The test statistics show that one cannot reject the assumption that the product variety in the TMP sectors is higher than that of the TLP sectors. These results reveal that the competitive position based on the product

Table 2
Test of Comparison of Averages of the Products Variety Between the Groups of Manufacturing Sectors During the Period 1987-2007

Group of Sectors	Number of Observations	Average of the Products Variety	Difference in Averages (t-statistics)
TLP sectors	63	0.124	-0.084 ** (-2.277)
TMP sectors	63	0.208	
Total	126		

(**) Significant difference in averages to the threshold of 5%

variety of Tunisia is more favored in the sectors which are mainly with strong absorption of technology and high-average technology, in comparison with the sectors which completely weaken absorption of technology like the sectors of mining, careers, and oil; metallurgical products, metal works, textiles, clothing, leather and shoes etc.

These results emphasize an essential dimension of the innovation activities: i.e. the assumption of absorptive capacity of external R&D. In others words, the exhaustion of traditional sources of competitiveness based on prices, the product variety constitutes for Tunisia a potential vector of reinforcement of its competitiveness on an international scale. For this reason, the factors that condition the extent of the product variety in Tunisia will be empirically analyzed next.

4. Specification of the Model

The present economic literature does not make it possible to easily assess factors conditioning the product variety. To do so, specification of the model must take into account certain assumptions that can be summarized as follows: initially, integrate the assumption of Jones (1995) and Aghion and Howitt (1998) are integrated according to which the product variety increases with increased investment in R&D. This assumption is confirmed by Jones

(1999) for countries having population growth will carry out higher product variety. An additional variable related to the pool of R&D spillovers is added to the series of explanatory variables to account for the assumption of Romer (1990). Lastly, an additional variable related to the growth of productivity is built-in in the model as a variable of control.

The integration of R&D spillovers as a factor subjacent with the product variety can lead to two significant components: the effect of competition and the effect of R&D spillovers. The effect of competition can be appreciated through an increase of the foreign firms due to the rise of the stock of foreign knowledge that reduces any possibility of product variety. As for the effect of the R&D spillovers, it is observed in the event of existence of complementarities between the foreign and national R&D. In other words, the effect of R&D spillovers on the product variety is ex-ante unknown.

The study introduces a model that makes it possible to take into account previously discussed assumptions. To emphasize the role of demand side factors that determine product variety, a variable related to the diversity of consumer's preferences is introduced into the model. This variable is measured by the growth of population which can cause the emergence of a broader range of goods.

However, product variety is not solely conceived from the demand side, it can be also justified by factors conceived from the offer side as was recommended by the endogenous growth theory. This is why it is preferred to highlight besides national technological innovation, the assumption that R&D spillovers exert a significant effect on product variety (Romer, 1990).

The effect of technological flows of knowledge in general and the R&D spillovers in particular on product variety was earlier proposed by Addison (2002) while integrating in the model other additional variables beside the above mentioned variables. These variables are the density of population in particular in the agglomerations characterized by similar activities, the average growth of the telephone lines by 1000 inhabitants, and the import of capital goods. With regard to the importance of the means of telecommunication, Easterly and Rebelo (1993) find that increase in the capacity of communication stimulates the total productivity of the factors by facilitating the propagation of rival knowledge and the coordination of productive units. As for the effects of the importation of capital goods, Keller (1997, 2002) discovers that new knowledge can be piled up with these imports and supports the growth of productivity through the competition they create.

The choice operated by Addison (2002) of the variables related to flows of knowledge reveal that the manner of propagation of R&D spillovers is important. However, it is necessary to distinguish the effects of various sources of R&D spillovers including national or foreign, intra-industrial exits of the same industry or inter-industrial transfers from other industries having different characteristics. This decomposition of the R&D spillovers makes it possible to emphasize the assumption of absorptive capacity of R&D spillovers which is dependent on the complexity of knowledge, R&D specific to the firms and human capital and industry specific characteristics. In addition, we suppose an instantaneous effect of the national technological spillovers on the development of product diversification. As for the foreign R&D, it is supposed that a temporal shift is possible to allow the assimilation of foreign R&D spillovers that are of intra-industrial or inter-industrial nature.

In addition, a matrix of weight in the measurement of R&D spillovers is integrated in the model. With this intention, an interactive term is incorporated between the analytical business enterprise research and development (ANBERD) and the share of sectoral imports in the total imports. This methodology makes it possible to take into account the direction and the intensity of foreign R&D spillovers which are intra-industrial or inter-industrial.

Lastly, and because the period considered in the analysis (1987-2007) is marked by social stability in Tunisia, the variable related to conflicts inside a country taken into account in the empirical analysis of Addison (2002) had to be omitted. In the light of the proposals discussed above, a model is formulated as follows:

$$PV_{it} = a_1PV_{it-1} + a_2INV_{it} + a_3EXTECH_{it} + a_4RINTRA_{it} + a_5RINTER_{it} + a_6POP_t + a_7RER_t + a_8INC_t + \mu_i + e_{it} \quad (9)$$

Where PV is the product variety in sector i, INV is the national technological innovation in sector i, EXTECH are the national technological spillovers, RINTRA are the intra-industrial R&D spillovers resulting from abroad, RINTER are the inter-industrial R&D spillovers resulting from abroad, POP is the growth rate of population, RER is the real effective exchange rate, INC is the foreign income per capita, μ is the specific effect of a sector, e is error term, i and t are the sectoral and temporal indexes.

According to Arellano and Bond (1991) to deal with a possible skew of omitted variables related to the specific effects, it is necessary to differentiate the equation in level (equation 9). The resulting equation of first difference takes the following general form:

$$PV_{it} - PV_{it-1} = a_1 (PV_{it-1} - PV_{it-2}) + a_2 (INV_{it} - INV_{it-1}) + a_3 (EXTECH_{it} - EXTECH_{it-1}) + a_4 (RINTRA_{it} - RINTRA_{it-1}) + a_5 (RINTER_{it} - RINTER_{it-1}) + a_6 (POP_t - POP_{t-1}) + a_7 (RER_t - RER_{t-1}) + a_8 (INC_t - INC_{t-1}) + e_{it} - e_{it-1} \quad (10)$$

This equation of first differences makes it possible to eliminate the sector specific effect and consequently the skew of invariant variables omitted in time.

The analysis in this study is based on the manufacturing sector including: electrical machinery and apparatus; food products, beverages and tobacco; chemical products; textile products, leather and footwear; metallurgical products, fabricated metal products, mining careers and oil.

The choice of these sectors rests mainly on the obviously observable dynamics of product diversification which characterizes such sectors in comparison with the other nonmanufacturing sectors or with the services sector. Moreover, structural considerations are implemented for the selection of these sectors. Indeed, these sectors integrate the production of intermediate goods, capital goods and consumer goods. Therefore, it is possible to examine particularly the differentiated impact of the explanatory variables conceived at the same time from the demand side and offer side on the one hand, and to avoid any skew of selection on the other hand.

Recourse to data based on the indicators of international trade through the analysis of product variety due to overlapping of the imports and exports (measurement of products variety by overlap index and quality index); require incorporation of the real effective exchange rate in the model. It is possible to suggest that the depreciation of real effective exchange rate will involve a rise of exports i.e. foreign demand of the domestic product varieties and vice versa. In other words, it is expected that the depreciation of real exchange rate will stimulate product variety, with an intensified width as the products are accessible and marketed externally. So the real effective exchange rate constitutes an additional variable conceived from the side of demand of the product variety.

In addition, the approximation of R&D spillovers is preferred while making interaction between analytical business enterprise research and development (ANBERD) of the countries of our sample and flow of imports Thus, the intra-industrial and inter-industrial R&D spillovers are formulated respectively in the following way:

$$RINTRA_{it} = m_{it}DIRDE_{it}RINTRA_{it} = m_{it}DIRDE_{it}$$
$$RINTER_{it} = m_{jt}\sum DIRDE_{jt}RINTER_{it} = m_{jt}\sum DIRDE_{jtI \neq J}$$

Where $RINTRA_{it}$ are the foreign intra-industrial R&D spillovers intended for sector i at time t, $RINTER_{it}$ are the foreign inter-industrial R&D spillovers intended for sector i at time t, DIRDE are the analytical business enterprise research and development, m_{it} is the share of imports in total imports specific to sector i, m_{jt} is the share of imports in total imports specific to sectors j, i and j are sectoral indexes and t is the temporal index.

With an aim of harmonizing data related to product variety and those related to the R&D spillovers that are intra-industrial or inter-industrial, the author resorts to the standard international classification of industry (ISIC), revision 3, available in the data base of OECD.

Concerning the efforts of domestic R&D, considering the unavailability of data for sectoral R&D expenditures, the author resorted to the approach of output for the measurement of efforts of technological innovation and the domestic technological spillovers. This is why; the national effort of innovation activities (INV) is approximated by the number of patents deposited by the residents inside a given sector and the national technological spillovers (EXTECH) by the number of patents deposited by the residents in other sectors.

5. Empirical Results

The model described by equation (10) takes the form of a model in dynamic panel in which a delay of the variable related to the product variety appears as an explanatory variable. The study resorted to the generalized method of moments (GMM) in dynamic panel which allows controlling the individual and temporal specific effects and mitigating skews of endogeneity of the variables.

GMM estimator in a system of Blundel and Bond (1998) combines equation 10 in first differences (equation 10) with the equation in level (equation 9) in which the variables are instrumented by their first differences. GMM estimator in system allows overcoming the limits characterizing the estimator of differences of which in particular: the delayed values of the explanatory variables are weak instruments of the equation in first differences. Differentiation of the equation in level eliminates the inter-individual variations and takes into account only the intra-individual variations. Thus, the equation in first difference (equation 10) is estimated simultaneously with the equation in level (equation 9) by the GMM. In the equation in level, the variables are instrumented by their first differences.

Two tests are associated to the GMM estimator in dynamic panel: the test of suridentification of Sargan/Hansen which makes it possible to test the validity of the variables delayed as instruments and the test of autocorrelation of Arellano and Bond where the null assumption is the absence of second order autocorrelation of the errors of equation in differences.

For estimating equations 9 and 10 by the GMM in system we used the lagged values of one year of the variables related to the intra-industrial R&D spillovers ($RINTRA_t$) and inter-industrial ($RINTER_t$) spillover as instruments.

Empirical results show that the test of Hansen (p-value = 1.00) does not make it possible to reject the assumption of validity of lagged variables in level and differences as instruments. Moreover, the test of Sargan (p-value= 0.344) also shows that we cannot reject the null assumption of validity of the instruments. Moreover, the test of autocorrelation of second order of Arellano and Bond (p-value = 0.339) shows the absence of autocorrelation of second order.

Results reveal positive repercussions of the efforts of national innovation resulting from other sectors on product variety in a given sector: an increase in the pool of national technological spillovers of 10 percent generates 3.594 percentage of additional product variety. In other words, the product variety is strongly conditioned by absorptive capacity of the national technological spillovers.

In contrast, the technological innovation realized inside the sector exerts non significant effect on product variety. However, the positive and significant effects of national technological spillovers on product variety are opposed by the negative repercussions of the inter-industrial R&D spillovers resulting from abroad.

The negative and largely significant repercussions of the foreign R&D resulting from other sectors on product variety are mainly explained by the low absorptive capacity of the inter-industrial foreign R&D which characterizes the national economy. This inefficiency in the process of adjustment of R&D undertaken elsewhere in favor of the national manufacturing sectors translates into incapacity to fight against competition in the world market. This idea is reinforced by the absence of significant effects of the intra-industrial R&D spillovers on product variety of Tunisia. These results reveal the low absorptive capacity of foreign R&D spillovers.

Table 3
Results of the of GMM Estimates with Dependent Variable: Products Variety

PVt	Coefficient (t-Student)
PV_{t-1}	0.1707 (0.99)
INV	0.2187 (0.29)
EXTECH	0.3594 *** (2.94)
$RINTRA_t$	0.0002 (0.21)
$RINTER_t$	-0.0003 *** (-4.27)
INC	0.0002 ** (2.26)
RER	10.7950 (-0.72)
POP	8.1542 * (1.68)
Constant	-44.0423 *** (-2.68)
Test of validity of the instruments of Hansen	chi2(118) = 0.00 p-value = 1.000
Test of validity of the instruments of Sargan	chi2(118) = 123.61 p-value = 0.344
Test of autocorrelation of Arellano-Bond	
Arellano-Bond test for AR(1) in first differences:	Z = -1.93 p-value = 0.053
Arellano-Bond test for AR(2) in first differences:	Z = 0.96 p-value = 0.339

Number of Observations: 120 Number of Sectors: 6
(***) Significant at a threshold of 1% (**) Significant at a threshold of 5% (*) Significant at a threshold of 10%

In this context, Tunisia is forced to reduce technological gaps which are increasingly widened in each sector in question so that it can absorb and transform the foreign R&D spillovers into profits as regards variety of the products. The absence of positive effects of the inter-industrial R&D spillovers also shows the importance of technological congruence between the source and the destination for the propagation and the assimilation of the R&D spillovers.

Moreover, results of the estimates show that the income per capita of the principal trade partners of Tunisia as well as population growth exert positive and significant effect on products variety. In other words, the competitive position based on the product variety of Tunisia seems more reinforced by the factors explained from the demand side than those conceived from the offer side. This idea also translated the crucial role assigned to the diversity of preferences to stimulate product variety. However, the real effective exchange rate does not exert any significant effect on product variety.

Besides, our empirical results reveal the importance of contribution of the evolutionary theories which allot to absorptive capacity a driving role in the realization of both technological and economic performance. The analysis shows in particular the place absorptive capacity of national technological spillovers occupy to stimulate product variety. In opposition, the absence of significant and positive effect of the foreign R&D spillovers that are intra-industrial or inter-industrial on product variety reflect their low absorptive capacity.

The study later on examines the importance of absorptive capacity of the foreign R&D spillovers in the determination of competitive position based on product variety. For this reason, the presence of a higher temporal shift is allowed by tolerating a higher number of lags as instruments for the variables related to the foreign R&D spillovers. The lagged values of foreign R&D spillovers ($RINTRA_t$ and $RINTER_t$) of at least a year are particularly used as instruments. Results of GMM estimates are given in table 4.

The tests of suridentification of Hansen (p-value = 1.00) and Sargan (p-value= 0.129) show the validity of lagged variables as instruments.

Table 4
Results of GMM Estimates by Method GMM in System

PVt	Coefficient (t-Student)	Coefficient (t-Student)
PVt_{-1}	0.1527 (0.83)	0.1646 (0.93)
INV	0.2163 (0.31)	0.1873 (0.27)
EXTECH	0.3637 *** (3.02)	0.3929 *** (3.14)
$RINTRA_t$	0.0000	0.0017 **
$RINTRA_{t-1}$	(0.01)	(2.21)
$RINTER_t$	-0.0003 ***	-0.0001 **
$RINTER_{t-1}$	(-4.22)	(-2.08)
INC	0.0002 ** (2.34)	0.0000 (0.62)
RER	-13.5590 (-0.87)	7.6030 (0.45)
POP	8.2926 * (1.71)	5.8981 (1.17)
Constant	-46.2823 *** (-2.79)	-25.9954 * (-1.91)
Test of validity of the instruments of Hansen	chi2(82) = 0.00 (p-value = 1.000)	chi2(82) = 0.00 (p-value = 1.000)
Test of validity of the instruments of Sargan	chi2(82) = 96.63 (p-value = 0.129)	chi2(82) = 97.16 (p-value= 0.121)
Arellano-Bond test for AR(1) in first differences	Z = -1.94(p-value = 0.053)	Z = -1.94 (p-value= 0.053)
Arellano-Bond test for AR(2) in first differences	Z = 0.97 (p-value = 0.333)	Z = 0.97 (p-value = 0.383)

(***) Significant with the threshold of 1%
(**) Significant with the threshold of 5%
(*) Significant with the threshold of 10 %

Dependent variable: product variety
Number of observations: 120
Number of sectors: 6

Moreover, the test of Arellano-Bond indicates that one cannot reject the null assumption and thus the absence of second order autocorrelation of the errors (p-value = 0.333). Results of the estimates show that the presence of a number of lags of at least a year of the variables related to the foreign R&D spillovers as instruments do not affect their absorptive capacity. Indeed, results show that the foreign intra-industrial R&D spillovers do not have an effect significantly different from zero on product variety and those of inter-industrial type exert a significant and negative effect on product variety.

Moreover, considering the low absorptive capacity of foreign R&D spillovers on the one hand, and the technological gaps widened with respect to the developed countries on the other hand, the factors explained from the demand side in particular the foreign income and the growth of population, consolidate Tunisia's competitive position of product variety.

For better apprehending the role played by absorptive capacity as a determinant of products variety, we chose to resort to the foreign R&D spillovers lagged by one year ($RINTRA_{t-1}$ and $RINTER_{t-1}$) instead of instantaneous spillovers ($RINTRA_t$ and $RINTER_t$) while preserving the same number of lags as instrument (at least a year).

At this level, results of the estimates indicate the presence of a positive and significant effect of the foreign and intra-industrial R&D spillovers lagged by one year on product variety: an increase of 10 percent in the foreign and intra-industrial R&D spillovers lagged by one year increase the product variety by 0.017 percent. On the contrary, the foreign and inter-industrial R&D spillovers lagged by one year continue to exert a negative and significant effect on product variety.

These last results translate the problems encountered during the transmission of the foreign R&D spillovers in general and those of inter-industrial type in particular. The foreign R&D resulting from the same sector can be materialized by profits as regards product variety only when it is lagged by one year.

In the light of these results, the factors of product variety explained from the offer side reveal the importance of absorptive capacity of the national technological spillovers to reinforce its international competitiveness.

6. Conclusion

Empirical results show that the product variety of Tunisia is substantially higher in more powerful technological sectors. Therefore, besides the traditional sources of competitiveness based on prices, the product variety constitutes for Tunisia a potential vector of reinforcement of its competitiveness on an international scale. This result illustrates also the importance of absorptive capacity in the determination of international competitiveness of a country insofar as the product variety is higher in the sectors with strong absorption of R&D.

In the light of these results, the paper takes a more thorough empirical analysis which aims at locating the sources of R&D spillovers. The analysis is related to the factors that are likely to stimulate the extent of product variety. It concludes that national technological spillovers as a factor from the offer side and growth of population and foreign income per capita as factors from the demand side are relevant to product variety.

However, the positive and significant effects of the national technological spillovers are opposed by the negative and significant effects of the inter-industrial R&D spillovers and no significant effects of the intra-industrial R&D spillovers resulting from abroad. This implies the low absorptive capacity of foreign R&D spillovers. In this respect, these R&D spillovers can be materialized by profits as regards product variety only when they are lagged by one year and are resulting from the same industry.

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Appendix 1

Tests of Comparisons of Averages and Variances of the Number of Patents Deposited Between Groups of Manufacturing Sectors During The Period 1987-2007

0: technologically less powerful sectors
1: technologically more powerful sectors
Two-sample t test with equal variances

Group	Obs	Mean	Std.Err	Std.Dev	[95% Conf. Interval]	
0	63	2.365079	.2582996	2.05019	1.848746	2.881413
1	63	8.873016	.6946847	5.513889	7.484361	10.26167
Combined	126	5.619048	.4700364	5.276146	4.688787	6.549308
Diff	-6.507937	.7411515	7.9748830	-5.040990		

diff = mean (0) - mean(1) t = -8.7808
Ho: diff = 0 degrees of freedom = 124
Ha: diff < 0 Ha: diff! = 0 Ha: diff > 0
Pr(T < t) = 0.0000 Pr (|T| > |t|) = 0.0000 Pr(T > t) = 1.0000

Variance ratio test

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
0	63	2.365079	.2582996	2.05019	1.848746	2.881413
1	63	8.873016	.6946847	5.513889	7.484361	10.26167
combined	126	5.619048	.4700364	5.276146	4.688787	6.549308

ratio = sd(0) / sd(1) f = 0.1383
Ho: ratio = 1 degrees of freedom = 62, 62
Ha: ratio < 1 Ha: ratio != 1 Ha: ratio > 1
Pr(F < f) = 0.0000 2*Pr(F < f) = 0.0000 Pr(F > f) = 1.0000

Appendix 2

Test of Comparison of Averages of the Products Variety Between the Groups of Manufacturing Sectors During the Period 1987-2007

0: technologically less powerful sectors
1: technologically more powerful sectors
Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
0	63	.1239048	.0210683	.1672247	.0817898	.1660197

1	63	.2076857	.0301653	.2394294	.1473862	.2679852
Combined	126	.1657952	.0187025	.2099356	.1287806	.2028099
Diff	-.083781	.0367943	-.1566071	-.0109548		

diff = mean(0) - mean(1) t = -2.2770
Ho: diff = 0 degrees of freedom = 124
Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.0122 Pr(|T| > |t|) = 0.0245 Pr(T > t) = 0.9878

Variance ratio test

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
0	63	.1239048	.0210683	.1672247	.0817898	.1660197
1	63	.2076857	.0301653	.2394294	.1473862	.2679852
Combined	126	.1657952	.0187025	.2099356	.1287806	.2028099

ratio = sd(0) / sd(1) f = 0.4878
Ho: ratio = 1 degrees of freedom = 62, 62
Ha: ratio < 1 Ha: ratio! = 1 Ha: ratio > 1
Pr(F < f) = 0.0027 2*Pr(F < f) = 0.0053 Pr(F > f) = 0.9973

Tests of Spécification and Résultats of Estimates
Dépendant Variable: Products Variety

Dynamic Panel-Data Estimation, One-Step System GMM

PV	Coef.	Robust. Std.Err.	z	P>|z|	[95% Conf. Interval]	
PV						
L1	.1706813	.1723773	0.99	0.322	-.1671721	.5085346
INV	.218668	.7419089	0.29	0.768	-1.235447	1.672783
EXTECH	.3593948	.122161	2.94	0.003	.1199636	.5988259
RINTRA	.0001623	.0007758	0.21	0.834	-.0013583	.0016829
RINTER	-.0002625	.0000615	-4.27	0.000	-.0003831	-.0001419
RER	-10.79488	14.94032	-0.72	0.470	-40.07737	18.48761
INC	.0001842	.0000815	2.26	0.024	.0000245	.000344
POP	8.15422	4.856641	1.68	0.093	-1.364622	17.67306
Cons	-44.04225	16.43696	-2.68	0.007	-76.2581	-11.8264

Arellano-Bond test for AR(1) in first differences: z = -1.93 Pr > z = 0.053
Arellano-Bond test for AR(2) in first differences: z = 0.96 Pr > z = 0.339
Sargan test of overid. restrictions: chi2(118) = 123.61 Prob > chi2 = 0.344
Hansen test of overid. restrictions: chi2(118) = 0.00 Prob > chi2 = 1.000
Group variable: i Number of obs = 120

Time variable: t — Number of groups = 6
Number of instruments = 127 — Obs per group: min = 20
Wald chi2 (7) = 440.78 — avg = 20.00
Prob > chi2 = 0.000 — max = 20

Dynamic Panel-Data Estimation, One-Step System GMM

PV	Coef.	Robust Std. Err.	z	P|z|	[95% Conf. Interval]	
PV						
L1.	.1526909	.1831849	0.83	0.405	-.20643449	.5117266
INV	.2162747	.7067774	0.31	0.760	-1.168984	1.601533
EXTECH	.3637182	.1204866	3.02	0.003	.1275688	.5998677
RINTRA	.00011	.0007984	0.01	0.989	-.0015539	.0015759
RINTER	-.0002882	.0000684	-4.22	0.000	-.0004221	-.0001542
RER	-13.5587	15.60939	-0.87	0.385	-44.15281	17.03487
INC	.0002056	.0000877	2.34	0.019	.0000337	.0003776
POP	8.292571	4.844697	1.71	0.087	-1.202861	17.788
cons	-46.28226	16.61317	-2.79	0.005	-78.84347	-13.72106

Arellano-Bond test for AR(1) in first differences: z = -1.94 Pr > z = 0.053
Arellano-Bond test for AR(2) in first differences: z = 0.97 Pr > z = 0.333
Sargan test of overid. restrictions: chi2(82) = 96.63 Prob > chi2 = 0.129
Hansen test of overid. restrictions: chi2(82) = 0.00 Prob > chi2 = 1.000
Group variable: i — Number of obs = 120
Time variable: t — Number of groups = 6
Number of instruments = 91 — Obs per group: min = 20
Wald chi2 (7) = 2921.10 — avg = 20.00
Prob > chi2 = 0.000 — max = 20

Dynamic panel-data estimation, one-step system GMM

PV	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf. Interval]	
PV						
L1.	.1646413	.1778953	0.93	0.355	-.1840271	.5133097
INV	.1873374	.7028184	0.27	0.790	-1.190161	1.564836
EXTECH	.3928634	.1252406	3.14	0.002	.1473963	.6383304
RINTRA						
L1.	.0017025	.0007706	2.21	0.027	.0001923	.0032128
RINTER						
L1.	-.0001186	.000057	-2.08	0.037	-.0002303	-7.00e06

RER	7.603025	16.97558	0.45	0.654	-25.66849	40.87454
INC	.0000398	.0000646	0.62	0.538	-.0000868	.0001664
POP	5.898083	5.055086	1.17	0.243	-4.009704	15.80587
Cons	-25.99538	13.59094	-1.91	0.056	-52.63314	.6423824

Arellano-Bond test for AR(1) in first differences: z = -1.94 Pr > z = 0.053
Arellano-Bond test for AR(2) in first differences: z = 0.87 Pr > z = 0.383
Sargan test of overid. restrictions: chi2(82) = 97.16 Prob > chi2 = 0.121
Hansen test of overid. restrictions: chi2(82) = 0.00 Prob > chi2 = 1.000

Group variable: i	Number of obs = 120
Time variable : t	Number of groups = 6
Number of instruments = 91	Obs per group: min = 20
Wald chi2(7) = 842.68	avg = 20.00
Prob > chi2 = 0.000	max = 20