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LOCALIZED APPROPRIABILITY:
PECUNIARY EXTERNALITIES IN KNOWLEDGE EXPLOITATION

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LOCALIZED APPROPRIABILITY: PECUNIARY EXTERNALITIES IN KNOWLEDGE EXPLOITATION[1]

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ABSTRACT. Pecuniary externalities are crucial in shaping the distinctive competences and the economic success of innovative firms. The analysis of conditions for localized appropriation associated to the intensive use of idiosyncratic factors by means of the introduction of biased technological change provides a new understanding about knowledge appropriability and stresses the key role of external factors in the exploitation of technological knowledge.

KEY WORDS: PECUNIARY EXTERNALITIES; LOCALIZED APPROPRIABILITY; DIRECTION OF TECHNOLOGICAL CHANGE.

JEL CLASSIFICATION: O31

1. INTRODUCTION

Recent advances in the economics of knowledge make possible important progress in understanding the key role of pecuniary externalities in knowledge exploitation. The analysis of the characteristics of localized knowledge appropriability embodied in idiosyncratic production factors plays a key role in shaping the intentional strategy of firms about the direction of technology. The firm is viewed as a learning agent able of creative reactions that induced by market forces and building upon learning processes, elaborates and implements intentionally strategies of both knowledge generation and exploitation. These strategies include the exploration of factor markets and the identification of the idiosyncratic production factors that is convenient to use intensively.

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The analysis of localized appropriability articulates the integration of the theory of the firm developed by Edith Penrose with the notion of localized technological change originally articulated by Joseph Stiglitz, Anthony Atkinson, and Paul David (1975) respectively in the context of the theory of production and the economics of innovation and technological change is most fertile (Antonelli, 1995). The appreciation of the localized context into which technological knowledge can be better appropriated and the direction of the technological change is selected in order to increase its exploitation provides important clues to understanding the dynamics of technological change and its implication for the implementation of firms' innovative strategies.

The rest of the paper is structured as it follows. Section 2 elaborates the notion of localized appropriability and highlights the role of pecuniary externalities. Section 3 develops the analysis in terms profitability of the introduction of technological knowledge that makes it possible an intensive use of idiosyncratic production factors both in terms of a reduction in production costs and an increase in the appropriability of the rents stemming from the generation of new technological knowledge. The conclusions summarize the main results and explore the implications for strategic decision-making.

2. KNOWLEDGE APPROPRABILITY AND PECUNIARY EXTERNALITIES

The path breaking contributions of Richard Nelson (1959) and Kenneth Arrow (1962a) who first analyzed knowledge as an economic good per se, have shaped the early economics of knowledge. This strand of analysis had lead to the identification of a number of key characteristics of technological knowledge such as non-divisibility, non-appropriability, non-rivalry in use, non-excludability.

Because of non-excludability 'inventors' cannot appropriate knowledge. Because of non-exhaustibility, reproduction costs are far lower than generation costs. The combined effect of non-excludability and non-exhaustibility makes it possible for imitators to benefit freely of the new knowledge. Incentives for the generation of the correct amount of knowledge are not sufficient and this leads to substantial market failure. The economic analysis of knowledge, as an economic good, makes it clear that actually knowledge is a public good.

The analysis of knowledge as a public good based upon its non-appropriability can be contrasted with the notion of localized appropriability. Localized appropriability, is the possibility for inventors to appropriate the stream of benefits stemming from the introduction of innovations, as the result of the downstream vertical integration of knowledge, purposely generated, in products and production processes that are highly idiosyncratic and as such make it possible to retain a long-lasting costs advantage. In order to achieve localized approapriability firms need to elaborate a clear strategy. This approach is the result of quite a long analytical process that is necessary to consider with care (Antonelli, 2005).

The Arrovian top-down approach to the economics of knowledge has been challenged by a different strand of analysis according to which technological knowledge is mainly viewed as the result of a bottom-up process of learning. In this approach to the economics of knowledge the distinction between tacit and codified knowledge plays a key role. The resource-based theory of the firm has provided the foundations to this approach and has highlighted the key role of learning routines in the generation of knowledge.

In so doing the resource-based theory of the firm presents learning as the joint product of current activities and hence assimilates knowledge to learning. Edith Penrose (1959) identifies the firm, its organization and its routines, as the privileged actor in the learning process. The firm precedes the production function as its primary activity consists the generation of new technological knowledge. Each firm, as it is well known, learns and builds up new capabilities and eventually discovers new possible applications for production factors and competences that are found within its own boundaries. According to resource-based theory, in other words, innovative firms are successful when they try and make the most effective use of production factors that are not only locally abundant, but also internally -within its own boundaries- abundant (Foss, 1997 and 1998). The bottom-up approach to understanding the dynamics of knowledge stresses the role of internal learning processes, as the necessary and sufficient condition for the generation of new knowledge at large (Foss and Mahnke, 2000).

The economics of localized technological change makes it possible to implement the resource-based theory of the firm and hence contribute a bottom up approach to the economics of knowledge in three cardinal points: a) the qualification of the conditions for generation as shaped by the localization of the learning process; b) the emphasis upon the intentional decision making that stems from the creative reaction of innovative firm; c) the notion of localized appropriability. Let us analyzes then in turn.

2.1 LOCALIZED LEARNING

The analysis of learning has been much qualified and sharpened by the insight of Anthony Atkinson and Joseph Stiglitz (1969) who introduced the strong hypothesis that technological change can take place only in a limited technical space, defined in terms of factor intensity. Technological change is localized because it has limited externalities and affects only a limited span of the techniques, contained by a given isoquant, that are identified by the actual context of learning, in the proximity of equilibrium conditions where firms have been producing. In other words technological change can only take place where firms have been able to learn: the localization here is strictly defined in terms of factor intensity and with respect to the techniques in place at each point in time.

The localized approach paves the way to implementing a broader understanding of the determinants and conditions that qualify the generation of technological knowledge. The notion of localized technological knowledge in fact makes it possible to stress the role of knowledge as a joint-product of the economic and production activity. Agents learn how, when, where and what, also and mainly, out of their experience, accumulated in daily routines. The introduction of new technologies is heavily constrained by the amount of competence and experience accumulated by means of learning processes in specific technical and contextual procedures. Agents, in this approach, can generate new knowledge, only in limited domains and fields where they have accumulated sufficient levels of competence and experience. A strong complementarity must be assumed between learning, as a knowledge input, and other knowledge inputs such as R&D laboratories, within each firm (Antonelli, 2001).

Learning indeed is one of the basic sources of new technological knowledge. As such it exerts a strong and clear effect in terms of a definition of the cognitive space into which each firm can expand its current technological base. As a consequence the new technological knowledge generated by each firm is constrained within the proximity of its current activities. In other words, learning exerts a powerful localizing effect, which limits the spectrum of possible discoveries. At the same time however the generation of new knowledge can take a wide variety of possible directions impinging upon the specific form of learning that is actively implemented and the context into which it takes place (Antonelli, 1995, 1999, 2001).

2.2 CREATIVE REACTION AND DECISION MAKING

In the analyses of both Penrose and Atkinson-Stiglitz, technological change is localized and constrained by organizational routines, but it is the automatic result of learning without any intentional and explicit effort. In the economics of localized technological change, instead, the introduction of innovations is the result of an intentional decision-making.

Localized technological knowledge is the result of the intentional valorization of potential competence based upon learning. The generation of new knowledge is viewed as the result of an intentional conduct induced by a specific process that can be successfully implemented only when a number of key conditions apply.

The analysis of the specific context into which the decision-making about technological change takes place, provides the opportunity for understanding the specific conditions that make it possible to convert learning into knowledge and new technologies. Knowledge is no longer regarded as the automatic by-product of learning, but rather the result of an intentional process and explicit decision-making. The role of the Schumpeterian creative reaction, emphasized in the localized technological change approach, makes it possible to overcome this limitation (Schumpeter, 1947). The innovation process is activated when and if emerging mismatches between expected and actual conditions of both product and factor markets and performances induce firms to change their routines. Only then, tacit knowledge, accumulated by means of learning processes, is actually converted into technological knowledge and new technologies are finally introduced (Antonelli, 1995 and 1999).

The appreciation of the role of intentional decision-making in the generation of new knowledge, and specifically the identification of the creative reaction that pushes firms to actually generate new knowledge, provides the second major point of departure from the notion of knowledge as the automatic and spontaneous outcome of learning, put forward by Edith Penrose. Firms are reluctant to change their routines, their production processes, the networks of suppliers and their marketing activities as much as their goals and their understanding of the product and factor markets. Firms can overcome their intrinsic inertia and resistance to change only when a powerful failure mechanism is at work. Firms are pushed to take advantage of the tacit knowledge acquired by means of learning processes by emerging mismatches between their own beliefs, based upon perceptions, and related plans and the actual conditions of the markets for products and production factors[2]. Only when such a mismatch takes place and the quasi-irreversibility of decisions implemented impedes simple adjustments, firms are pushed, by emerging losses and performances below expected levels to react creatively by means of the introduction of innovations. To do so, the intentional and explicit generation of new technological and organizational knowledge becomes necessary.

Recent advances in cognitive economics confirm the role of intentional creativity in the generation of new knowledge and the specific behavioral context into which discoveries take place (Rizzello, 2003). As Nooteboom (2003: 225) properly articulates " discovery is guided by motive, opportunity and means. One needs an accumulation of unsatisfactory performance to generate motive; to overcome one's own inertia or that of others in organization. In markets, one also needs an opportunity of demand and/or technology. And one needs insights into what source and how to incorporate them in present competence"[3].

The transformation of the competence based upon learning processes into new, actual technological knowledge requires specific and dedicated efforts. The generation of new technological knowledge can be considered the specific activity of the firm and its distinctive function within the economic system: the firm is indeed the locus of technological discovery. Yet discovery and creativity are not an automatic, incremental, past dependent and hence deterministic activity guided by the sheer accumulation of internal competence based upon tacit learning, but rather the result of a complex path dependent process where at each point in

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[2] See North (1997:226) "Competition forces organizations continually to invest in new skills and knowledge to survive. The kind of skills and knowledge individuals and their organizations acquire will shape evolving perceptions about opportunities and, hence, choices that will incrementally alter institutions….While idle curiosity is an innate source of acquiring knowledge among human beings, the rate of accumulating knowledge is clearly tied to the payoffs. Secure monopolies, be they organizations in the polity or in the economy, simply do not have to improve to survive. But firms, political parties, or even institutions of higher learning, faced with rival organizations, must strive to improve their efficiency. When competition is muted (for whatever reasons), organizations will have less incentives to invest in new knowledge and, in consequence, will not induce rapid institutional change."

[3] See Greve (1998) who examines how performance feedback affects the probability of risky organizational. His empirical analysis in the radio broadcasting industry shows the consequences of shortfalls of performances on the probability of strategic change and their strong sensitivity to social and historical aspiration levels. Ocasio (1998) provides a theoretical reconciliation of theories of failure-induced change and threat-rigidity. The theory explicitly links the cognitive psychology that underlies risk-seeking behavior and threat-rigidity with the social groupings and cultural rules that structure thinking and decision making in organizations.

time firms make explicit and intentional efforts to generate new technological knowledge. Such efforts are most likely to be successful when a number of contextual and external conditions apply.

2.3 LOCALIZED APPROPRIABILITY

The appreciation of the intentional, contextual and resource consuming activity necessary to actually generate new technological knowledge leads to dig deeper into the analysis of the factors affecting the direction or characteristics of the new knowledge generated by firms. The conditions for knowledge appropriation and exploitation exert a powerful feedback upon the generation of new technological knowledge.

Along these lines it seems now more and more clear that not only the generation of knowledge is the result of intentional activities that build upon internal learning processes and yet are constrained by an array of external and localized complementary conditions. Knowledge exploitation, as well, is heavily constrained and shaped by the specific context of utilization. The localized conditions of knowledge usage affect sharply its appropriability: the notion of localized appropriability has important consequences (March, 1991; Antonelli, 2003).

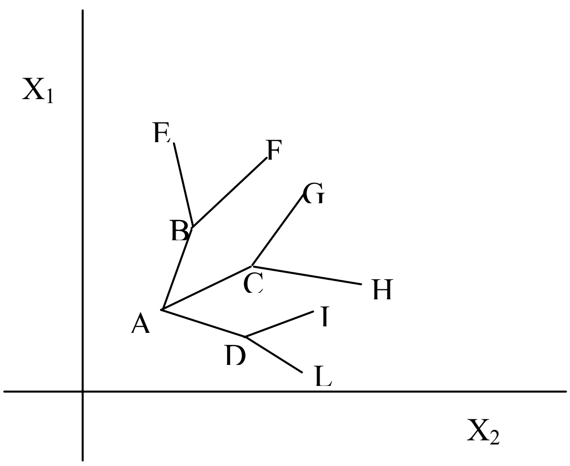
Learning firms need to select strategically the direction of their innovation activities. Although learning localizes the cognitive base in a limited spectrum, or ray, from the original focal point of activity, there are still many possible directions along which the generation of new technological knowledge can be aligned. A variety of possible discoveries can be the outcome of the intentional valorization of learning processes and the consequent accumulation of tacit knowledge. New technological knowledge does impinge upon the basic ground provided by learning by doing the current products, learning by using the current technologies and capital goods, learning by interacting with the actual variety of suppliers, competitors and customers. Yet the tacit knowledge and the competence acquired can be implemented and valorized in a variety of possible directions.

The choice among an actual array of possible discoveries becomes a crucial issue. The intentional choice of the direction of the possible discoveries marks the second strong departure from the deterministic notion of the firm as an agent moving along a predefined trajectory based upon past learning. As a matter of fact at each point in time the firm has in front a variety of possible directions towards which the creative activities can be ordered. Each needs to be assessed and the relative profitability needs to be valued both from the viewpoint of the costs of introduction and the revenue stemming from its application.

As Figure 1 shows at each point in time the learning firm has the opportunity to move in a Lancastrian (Lancaster, 1971) space of knowledge characteristics and related technological characteristics, branching out from the original point A to a variety of points B, C, D. Each of the new points exhibits an improvement and a change and it is the result of the generation of new technological knowledge and of the introduction of new technologies. In the subsequent unit of time, t_2 , the learning firm has the again opportunity to further branch out from the new points B, C, D towards the points E and F if it had reached point B at time t_1 , the points G and H, if it had reached point C at time t_1 , and points I and L if it had reached point D at time t_1 . The resource based theory of the firm, so far, is able to explain retrospectively why and how the learning firm has moved from any of such points to the next and indeed, each of the points generated sequentially, is related to the previous vintages by clear elements of complementarity and cumulability along a trajectory. The direction of the selected trajectory however can be identified only ex-post. From an ex-ante perspective the resource-based theory of the firm does not supply any strong analytical support to elaborate possible hypothesis about the direction of the future steps.

INSERT FIGURE 1 ABOUT HERE

FIGURE 1. THE DIRECTION OF THE GENERATION OF KNOWLEDGE



Here an important step forward can be made if the factors that constraint the selection of the direction of the sequential steps and act as focusing mechanisms are identified and analyzed within a single framework. The characteristics of knowledge and idiosyncratic production factors provide important help to identify the role of such focusing mechanisms.

The notion of pecuniary externalities plays a key role in this context. Pecuniary externalities apply when the prices for production factors differ from equilibrium levels and reflect the effects of external forces. According to Scitovsky (1954) pecuniary external economies consist of 'interdependence among producers through the market mechanism" (p.146).[4] There are pecuniary externalities when the market price of a production factor, for each specific quantity, is below its marginal productivity in equilibrium.

Pecuniary externalities stem from the effects of the dynamics of growth. The growth in demand and the increase in the division of labor with consequent entry of new firms in upstream and lateral industries in specific geographical and regional clusters have the ultimate effect of lowering the market price for the products that are an input of the production process in downstream industries (Kaldor, 1981).

With a given technology and assuming standard substitution among inputs, producers have a clear incentive to increase the intensity of utilization of production inputs characterized by pecuniary externality. Hence the input intensity of such factors will be higher in some specific locations than in others. In a dynamic context where technology is endogeneous, innovators have a strong incentive to direct the introduction of new technologies so as to increase the intensity of production factors that are available at prices that are below their marginal productivity. In a dynamic context, consequently, the input intensity of the production factors that happen to be characterized by pecuniary externalities will be much stronger than in a static context. Technological change works as a meta-substitution process.

Pecuniary externalities become a factor of specialization and in a dynamic context, where technological change is endogeneous, they are a factor that shapes the direction of technological change.

Pecuniary externalities provide a novel and fruitful tool to understand the relationship between the generation of technological knowledge and its exploitation. So far it has found little application, as the literature has

[4] As Scitovsky notes: "This latter type of interdependence may be called pecuniary external economies to distinguish it from technological external economies of direct interdependence" (p.146)

explored more systematically the consequences of knowledge non-appropriability in terms of 'direct interdependence' non-mediated by the market mechanism.

As a matter of fact the notion of pecuniary externalities provides the foundations to elaborate a new understanding of localized appropriability and hence a new view upon the levels of incentives towards the generation of new technological knowledge provided by the market place in the context of the theory of resource based theory of the firm enriched by the economics of localized technological change.

The identification of the sources of pecuniary externalities consisting in local endowments of idiosyncratic production factors provides in fact the opportunity to increase substantially both the absolute effects of the technological change that a firm can generate and its appropriability. The intentional direction of the generation of technological knowledge and its direct embodiment by means of the eventual introduction of technological changes in the down stream production process towards the systematic exploitation of pecuniary externalities stemming from the local endowments of idiosyncratic production factors makes it possible for the firm at the same time to increase the gains in terms of efficiency for a given level of resources invested in the generation of new technological knowledge and new technologies and to better appropriate them.

The new understanding of the role of localized knowledge appropriability leads to a new appreciation of the idiosyncratic character of local resources and its productive and competitive effects and provides a new basket of analytical opportunities to grasp the key role of the specific and localized conditions that affect the actual chances of firms to exploit the technological knowledge they can generate.

The productivity of new technological knowledge, when applied to the actual production process, and the appropriability of the economic value stemming from its use, are much influenced by the relative price of the production factors being used. Firms that are able to identify idiosyncratic and production factors upon which they exert a specific control that enables low and exclusive acquisition costs can direct the introduction of new technologies so as to increase their role in their production process, and make an intensive use, and thus to extract much higher rents from their knowledge generation activities for much a longer period of time.

The identification and valorization of idiosyncratic resources becomes a clear and strong focusing device along which firms can align their research activities. The generation of new technological knowledge can be directed towards the exploitation of such idiosyncratic production factors so as to reduce production costs and create barriers to entry and to imitation. Such barriers to entry and imitation based upon the intensive use of idiosyncratic production factors prevent the dissipation of the economic rents stemming from their introduction and hence increase appropriability.

The appreciation of the role of localized knowledge appropriability and hence of biased technological change towards the intensive use of idiosyncratic production factors becomes a powerful tool to understand the criteria by means of which firm select the direction of the generation of new technological knowledge. A full-fledged economics of the distinctive competence of the firm that includes the context, into which the firm is based, can be elaborated impinging upon these elements.

3. LOCALIZED KNOWLEDGE APPROPRIABILITY AND THE IDIOSYNCRATIC DIRECTION OF TECHNOLOGICAL KNOWLEDGE

Following a well established tradition of analysis in the analysis of technological change at the system level (Kennedy, 1964; Samuelson, 1965; Acemoglou, 1998) it is well known that the intensive use of more abundant and hence cheaper production factors makes it possible to increase total factor productivity more effectively. Yet little attempt has been made, so far, to integrate this line of analysis, about the direction of technological change, with the theory of the firm and specifically with the analysis of technology strategy at the firm level.

The integration of these two levels of analysis makes it possible to grasp the role of the conditions of usage of knowledge as an incentive towards the selection of knowledge generation strategies at the firm and regional level. The direction of technological change has a strong effect on the results in terms of performance both at the level of the economic system and at the level of the firm. This is especially true in a globalized economy where firms, based in local, heterogeneous factor markets compete on global homogeneous product markets (Antonelli, 2005).

The search for new, more effective, uses of locally abundant production factors is a powerful alignment mechanism for the research strategies of a variety of learning agents that are co-localized and have access to the same pools of collective knowledge. As it is well known, the production that makes the most intensive use of locally abundant and hence cheaper production factors is most efficient, and it engenders systematic cost asymmetries when competitors have not access to the same factor markets.

Here the working of pecuniary externalities is clear. When the local endowments provide the supply of production factors at price that are below average level that cannot be easily accessed by other firms, the local incumbents have the opportunity to direct their innovations so as to create barriers to entry. Rivals may be able to imitate the new products that embody the new knowledge, but cannot compete on the same cost levels because they have not access to the same pecuniary externalities. Pecuniary externalities become a source of barriers to entry based upon production costs. Barriers to entry, built upon pecuniary externalities, substitute for barriers to imitation.

The analysis of market dynamics provides the basic elements to fully understand the mechanism at work, from the demand side. Since 'The theory of economic development' by Joseph Schumpeter (1934) it is well known that innovators can take advantage of a monopoly power that is, however, necessarily transient. Extra profits associated with the introduction of successful innovations stimulate the imitative entry of newcomers. Increased competition drives price-cost margins to minimum levels. Industrial dynamics however is more and more characterized by monopolistic competition cum barriers to entry among firms that are heterogeneous both with respect to their local factor markets and to their own competence and skills, organized by means of internal factor markets.

In such a market place the competitive advantage of innovators is based much more on the mix of idiosyncratic production factors that have contributed to shape the direction of technological change, rather than on the exclusive command of proprietary technological knowledge. Even if new competitors can imitate the new idiosyncratic and localized technology, their production process will be less effective than that of innovators because of the differences in the costs of production factors. In this context, the more specific is the technology introduced by innovators, i.e. the more it reflects the use of idiosyncratic production factors that are specific to innovators, and the less likely is the possibility that newcomers, even when and if they succeed in grasping the new technological knowledge and imitate the new technology, will be able to match the production costs of innovators and hence reduce their competitive advantage.

Innovators relying on the pecuniary externalities provided by idiosyncratic production factors can command a cost advantage upon which long lasting barriers to entry and to mobility can be built. Each innovator becomes the local monopolist in a well-defined market niche. The size of the niche depends upon the specification of the products with respect to the preferences of consumers and upon the cross price elasticity with respect to other similar products. The latter in turn are built around the idiosyncratic competences of other competitors. Innovators will fix strategic prices in the niche according to the ease of mobility and entry of the competitors in the broader basket of niches competing for the demand of similar customers and the levels of cross price elasticity, that is the mobility of customers across the different niches.

Let us consider a firm able to generate a given amount of technological knowledge that is the result of the intentional valorization of its internal learning processes. The firm can direct such technological knowledge towards the introduction of idiosyncratic technological change that shapes the production function in such a way that the output elasticity of idiosyncratic production factors (I) is much higher than the output elasticity of generic production factors (G). This is convenient when, for the innovating firm, locally abundant production factors are available at a price (r) that is lower than the price of the other production factors (p): i.e. when $r<p$. Conversely the introduction of generic technological change has no effect on the ratio of output elasticities. In other words the generation of (more) generic knowledge leads to the introduction of a (more) neutral technological change with no modifications in the output elasticity of the production factors G and I.

To make this point clear let us consider a standard production function prior to the introduction of the new technology:

(1) $Y(t) = (I^E G^F)$,
where I and G are respectively the idiosyncratic and generic inputs; E and F measure their output elasticities.

After the introduction of respectively generic-intensive and idiosyncratic-intensive technological changes, the new alternative production functions can be specified as it follows:

(2) $Y(t+1)_g = A (I^u G^v)$,
(3) $Y(t+1)_l = A (I^s G^t)$,
(4) $C = rI + pG$,

where at time t+1 after the introduction of the new technology, Y_l is the production process that uses an idiosyncratic-intensive technology and Y_g is the production process that uses a generic-intensive technology; u, v, s, and t measure the different output elasticities. Hence from the comparison between equation (1) and in equation (2) we see that $u<E$; $s>E$.

Let us now consider the effects of the alternative directions of technological knowledge in terms of knowledge exploitation. When factors are not equally abundant in each local factor market ($r<p$), it is clear that the unit costs (CY_l) of the goods manufactured by means of an intensive use of locally abundant and idiosyncratic factors are lower than the costs (CY_G) of the goods manufactured with generic-intensive technologies that rely upon inputs that are available to every firm at the same price:

(5) $CY_l < CY_g$.

Generally it is clear that for any given disequality between the unit costs of generic and idiosyncratic inputs such that $r<p$, the productivity of a given amount of new technological knowledge will be larger, the larger is the bias in the new technology as measured by the ratio of s/t. For a given $r<p$, the larger is s/t and the higher is the total factor productivity stemming from a given amount of technological knowledge.

Composition effects as defined by the relative abundance of inputs in local factor markets are major external factors in shaping the direction of technological change. When the most productive factor is cheaper and hence its use is more intensive, and the least productive factor is more expensive and hence its use is less intensive, production costs are lowest. The growth of total factor productivity derived from the introduction of a given technology is higher; the higher is the output elasticity of the productive factor, which locally is most abundant.

Composition effects act as sorting devices. For a given supply of new and rival technologies, with similar shift effects, composition effects act as powerful selection devices and the rates of success in the introduction of new technologies will be influenced by the local conditions in the factor markets. Labor-intensive technologies will be far more successful in labor abundant countries and capital-intensive technologies will be adopted faster in capital abundant countries. The introduction of new technologies that are characterized by high levels of output elasticity of labor, but small shift effects, might be delayed forever in capital-intensive countries. This analysis is most important when the global economy is considered: in the global economy in fact firms based in highly heterogeneous local factor markets compete in quite homogeneous product markets. Different agents, rooted in different regions, with different endowments and hence different conditions in their local factor markets may react with similar levels of creativity to similar changes in their current conditions, introducing new technologies with marked differences in terms of factor intensity not only because of the effects of internal localized learning and the conditions of access to the local pools of collective knowledge, but also because of the selection mechanism stemming from powerful composition effects. Here composition effects, stemming from the pecuniary externalities associated to the costs of well identified and idiosyncratic inputs, act as a focusing mechanism that explains both the direction of the introduction of new technologies and their selective adoption and diffusion (Antonelli, 2003).

Finally, we consider the price at which the goods that have been manufactured with the new technologies can be sold. The products manufactured with a more idiosyncratic-intensive technology, that make a more intensive use of the locally abundant factors, including those internal to the firm, that not available at the same conditions to competitors, enjoy systematic cost asymmetries with respect to imitators and hence can take advantage of substantial barriers to entry and to mobility. In product markets characterized by monopolistic competition, incumbents protected by barriers to entry and to mobility can fix high prices for they products, far higher than those of competitors. This is not the case when technological change is generic-intensive: every firm can use production factors that are not idiosyncratic. Hence new competitors can imitate the new technology and their entry drives the prices to competitive levels. Clearly the prices of products manufactured with a higher intensity of idiosyncratic inputs (P_I) are higher than the prices of the products manufactured with a low intensity of idiosyncratic inputs (P_G). Search processes might also be directed towards those knowledge outcomes that are much easier to protect through IPRs.

Equations (2) and (3) can be combined into the traditional frontier of possible production:

(6) $Y_G = e\ (Y_I)$

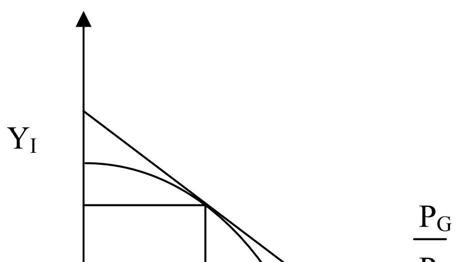
The solution to the optimization problem is easily found with an isorevenue that defines the possible revenues that can be earned with the alternative production functions considered. The slope of the isorevenue measures the ratio of the prices of the products manufactured with a new generic-intensive technology (P_G) to the prices of the products manufactured with a new idiosyncratic-intensive technology (P_I). The equilibrium is found where:

(7) $d Y_g / d Y_I = P_I / P_G$

Clearly there are stronger incentives to select the mix with more biased technologies, than generic ones. A simple geometric exposition can help to grasp the point. As it is shown in Table 2, the shape of frontier of production possibilities which considers the trade-off between the levels of output Y_I which can be attained with the introduction of a new technology that makes intensive use of locally abundant and idiosyncratic production factors and the levels of output Y_G that can be attained with the introduction of a new technology which use generic production factors, is clearly asymmetric. The idiosyncratic-intensive technology is more efficient than the generic-intensive one. Moreover the slope of the isorevenue, much smaller than 1, reflects the positive effects for idiosyncratic-intensive innovators of the price asymmetry with respect to imitators, which have not access to the same idiosyncratic production factors. Idiosyncratic-intensive innovators can charge higher prices and retain larger price-cost margins than generic-intensive innovators. The combination of both effects is reflected by the optimization that clearly favors the introduction of technologies based upon the more intensive use of locally abundant and idiosyncratic production factors.

Firms able to select their technological innovations so as to introduce a bias in favor of the creation and subsequent intensive use of idiosyncratic production factors have a larger mark-up because of three factors: a) lower production costs, b) higher product prices, c) barriers to entry and imitation lasting for a longer stretch of time.

TABLE 2. OUTPUT AND REVENUE MAXIMIZING INCENTIVES TO MAKE INTENSIVE USE OF IDIOSYNCRATIC INNOVATIONS



In sum, the generation of technological knowledge and the eventual technological change is directed by: a) b) the costs-reducing use of locally abundant production factors; c) the profit-increasing use of local idiosyncratic production factors. According to the value and weights of these parameters the characteristics of new knowledge and the direction of technological change (See Table 1) can be assessed ex ante.

The embodiment of technological knowledge into a selective and directed technological change that takes into account the local conditions of both product and factor markets makes it possible to appropriate the stream of benefit associated with its generation.

4. CONCLUSIONS

The integration of the resource based theory of the firm with the traditions of analysis based upon the notion of localized technological knowledge yields important dynamic results when the analysis focuses the determinants of the selective generation of new technological knowledge, as the result of the identification and exploitation of the sources of external knowledge and the introduction of biased technological change that favors the intensive use of production factors that are idiosyncratic to each firm. The new analysis about the distinction between learning and knowledge and the new understanding about the key role of pecuniary externalities in localized knowledge appropriability emphasizes the strategic role of the direction of technological knowledge and provides an economic foundation for the notion of distinctive competence of the firm, much used in management and strategic analysis (Teece, 1998, 2000).

Learning is a necessary, but not sufficient condition for the generation of new knowledge. External factors play a key role both in the intentional generation and exploitation of technological and organizational knowledge. The combined effect of internal learning, external knowledge and the conditions for exploitation associated to the intensive use of idiosyncratic factors by means of the introduction of biased technological change cum intentional decision-making provides key inputs to understanding the path dependent and idiosyncratic features of the knowledge generated by the firm as the basis for building its distinctive competences.

The generation of new knowledge is not the automatic and spontaneous product of internal learning processes. Internal learning is a necessary, but not sufficient condition for the generation of new knowledge. Intentional and selective strategies are necessary in order to generate new knowledge. Technological knowledge intentionally generated by firms has a strong idiosyncratic character that is influenced both by the characteristics of internal learning processes and by the characteristics of local factor and product markets.

In order to increase knowledge appropriability firms have a clear incentive towards the generation of technological knowledge that makes possible the introduction of an intentional direction of technological change. The downstream vertical integration into specific production processes qualified by the intensive use of locally and possibly internal production factors, that are highly idiosyncratic and hence cheaper for a limited number of users, favors the productivity of new directed technologies and reduces the risks of imitation by rivals who have not access to the same factor markets. Such production factors are idiosyncratic to the innovating firm by locational factors or directly as the result of their intentional creation by each firm.

Pecuniary externalities make it possible for firms to better appropriate technological knowledge embodied in processes and products. The strong positive effects in terms of reduced production costs and increased knowledge appropriability stemming from the intensive use of idiosyncratic – either locally available or internally created- production factors provide a clear incentive to select the direction of knowledge generation. The opportunities for localized knowledge appropriation provided by pecuniary externalities become a powerful mechanism to direct not only the introduction of new technologies but also the generation of new technological knowledge. A direct feedback emerges between knowledge exploitation and generation strategies.

The identification of the sources of the idiosyncratic production factors that is more convenient to use intensively becomes a powerful guideline to direct the technology strategy of innovative firms. The result is the creation and exploitation of a broader distinctive competence of the firm that includes its geographical and industrial localization and is able to make a strategic and dynamic use of it.

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