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Abstract

This paper investigates the influence of human resource management on learning from internal and external sources of knowledge. Learning for innovation is a key ingredient of catching-up processes. The analysis builds on survey data about pharmaceutical firms in Mexico. Results show that the influence of human resource management is contingent on the knowledge flows and innovation goals pursued by the firm. Practices such as training--particularly from external partners; and remuneration for performance are conducive to learning for innovation.

Keywords: Learning; R&D; human resource management; pharmaceuticals; Mexico
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1. Introduction

Recent contributions to the literature suggests that differences in human resource management practices can explain diversity in innovation performances between firms, sectors of economic activity, even countries (Lorenz and Valeyre 2005; Lorenz and Wilkinson 2003; Michie and Sheehan 2003). Available studies indicate that such practices are complementary, to be used as part of coherent incentive systems (Laursen and Foss 2003). Consequently, empirical tests should consider the impacts of groups of practices rather than simply the effects of individual practices (Ichniowski et al. 1997). But why this is so? Consistent theoretical, empirical and comparative work on the linkages between human resource management and innovation is still at an early stage (Laursen and Foss 2003). Innovation scholars have thus joined the more ample debate of how and why human resource management influences a firm's performance more generally (Boseli et al. 2005; Combs et al. 2006).

The literature hints at some candidate factors linking human resource management to innovation. Arguably more careful exploration of the latent processes associated with the organization of people involved in innovation is needed.[1] Based on Cohen and Levinthal (1990) and Wright et al. (2001) this paper looks at how human resource management contributes to learning and the development of innovation capabilities within an organization.

Empirical work on human resource management and innovation stems mostly from surveys of firms in developed countries. By contrast, the case of developing countries remains largely uncharted; the omission is noteworthy. White (2002) argued that human resource management practices are a double edged sword for learning and innovation capacity building in developing countries. Such practices contribute to research and other technological capabilities at firm level; yet accumulated capacities can erode because of inadequate or poor management of people. Arundel et al. (2007) further contend that closer examinations of the relationship between human resource management, interactive learning and innovation should help to explain the conformation, functioning and development of national systems of innovation. This paper is one of the first systematic studies on human resource management and learning for innovation in a developing country context.

Laursen and Foss (2003) and Datta et al. (2005) documented that the nature and corresponding influence of human resource management is contingent on the firm's industry or sectoral affiliation; hence on the characteristics, challenges and opportunities associated to the innovation processes and knowledge bases in which a firm operates. Unfortunately detailed research about how those factors work remains scarce. This paper explores the case of the pharmaceutical industry. This is an industry that stands out at the global level for its socioeconomic, health and ethical implications; intensive R&D efforts characterize pharmaceuticals as a highly science-based industry. Pharmaceuticals are interesting from managerial perspective. Cockburn et al. (1999) asserted that changing technologies for drug discovery require changed practices to organize and motivate researchers; it demands strict

[1] This intermediate approach is familiar for research on the influence of human resource management on creativity and creative thinking (Amabile 1996; Sternberg et al. 1997).

professional and balanced personnel and administrative management. Likewise Chiesa (1996) showed that differences exist in managerial approaches supporting drug discovery on the one hand, and drug development on the other. Since the latter type of activities is the more common in developing countries, usual conclusions about how human resource management influences learning and innovation can differ relative to studies about firms in developed countries.

Laursen and Mahnke (2001) found positive relationships between firm types and knowledge strategies with combinations of human resource management practices in the context of innovation. Accordingly this paper identified some learning strategies followed by pharmaceutical firms in Mexico; it looked in particular, at those supporting learning from both internal and external sources of knowledge. The paper then enquired about which human resource management practices underpin the choice of joint learning strategies, and how this is done. This is one of the first studies in the field that incorporates external markets for knowledge as a relevant dimension for the analysis.

The paper proceeds as follows: Section 2 discusses the literature on organizational learning and innovation with emphasis on catching up processes; reference to the pharmaceutical industry illustrates some of the main points. Section 3 introduces some specific human resource management practices supporting learning for innovation. The discussion informs some hypotheses to guide the subsequent empirical analysis. Section 4 presents the data and the research strategy used in this paper. Section 5 contains empirical results. Some final discussion and conclusions are presented in section 6.

2. Literature review

Knowledge creation within organizations is a complex cumulative, multilayered process. It begins at individual level, since employees are the building blocks of any organization (Nelson and Winter 1982). Simon (1991) suggests that organizations only learn through their members and/or by employing new members who add knowledge previously unavailable. The cognitive potential of organizations is, to a considerable extent, determined by accumulated skills and knowledge of their individual members (Nelson and Winter 1982). Good education is a key input, yet not sufficient to build an advanced level of individual knowledge. The more individuals advance in their areas of specialization the more the expertise they acquire and the larger their potential contribution to organizational knowledge.

The importance of individual knowledge for organizational learning is further underscored by the fact that a significant part of the knowledge accumulated by individuals is tacit (Polanyi 1966). Tacit knowledge refers to meaning acquired through experience and is difficult to formalize or communicate. It emerges during the actions and activities that individuals undertake and relates to the context in which these take place. Tacit knowledge is the “practical” foundation of individual skills (Nelson and Winter 1982). Nonaka (1994) and Nonaka and Takeuchi (1995) add that individuals’ intentionality or willingness to practice the search for meaning in their environment in order to understand and improve it, is critical to the enhancement of individual knowledge. In their view, intention and freedom are major forces

motivating individuals to expand their knowledge. Building working environments suitable for all the aforementioned processes to take place is imperative for firms.

Zack (1999) and Kessler et al. (2000) point out that organizational learning involves choices regarding internal and external sources of knowledge; firms often need to decide whether to develop their own knowledge or acquire and/or imitate that of others. The main reason to develop knowledge internally is to generate absorptive capacity (Cohen and Levinthal 1990). Absorptive capacity refers to the ability to evaluate and use outside knowledge. It is based on the level of related knowledge already available in firms, including basic skills as well as recent technological and scientific developments in specific fields. Absorptive capacity arises out of previous knowledge accumulation and intensity of current learning efforts by firms and their members. External sources of knowledge, in turn, bring fresh thinking and provide a benchmark for internal efforts. Sources of external knowledge include other firms, but also external publications, universities, research institutes, government agencies, consultants and professional and personal networks. Kim (1997 and 1998) developed an international dimension to this argument by quoting that external knowledge acquisition and imitation can function across and connect national systems of innovation.

Empirical literature documents that dynamic latecomer firms have coupled local searches, through internal learning efforts, with diffusion and assimilation of external knowledge through, for instance, reverse engineering. Learning strategies differ in complexity, uncertainty and risk, let alone the type of resources and how these are mobilized by firms in search of specific goals. In order to catch-up learning strategies have to be incorporated strategically over a sufficient time horizon as benefits take time to materialize. Short-time benefits from knowledge sharing cannot sustain long-term expansion strategies without the creation of internal knowledge and absorptive capacity to support the acquisition of external knowledge (Cardinal and Hatfield 2000). Human resource management influences and plays a mediatory role in these processes; it influences the organization and mobilization of individuals and their corresponding knowledge (Barney 1991; Cohen and Levinthal 1990). Such systems assist in the creation, transfer and integration of knowledge flows that enrich a firms' human capital, as a stock (Wright et al. 2001); in ways that are valuable, rare and inimitable (Grant 1996). Firms can guide systems of innovation by searching among, eventually nurturing the knowledge residing outside their physical boundaries. The pharmaceutical industry is illustrative of the issues discused above.

Learning and catching-up in pharmaceuticals

Kim et al. (1989) identified three main channels for pharmaceutical firms in developing countries to develop new products: (1) by developing new raw materials through in-house R&D; firms can substitute parts of the manufacturing process of patented drugs; (2) by relying on multinationals as source of technology through licensing or technical assistance; and (3) by purchasing active ingredients and excipients in open markets. In any of the two later cases, domestic R&D efforts are needed to build up the capacities required to manufacture the final drug.

As firms gain in technological complexity and innovation capacity, internal learning plays increasingly relevant roles moderating the process of learning from external markets (Escribano et al. 2009; Hung and Ruei-Hung 2008). In a study about the differences in technological strategies and corresponding innovation behaviours of 37 pharmaceutical firms in Korea, Kim et al. (1989) categorized firms according to scale of operations and technological capabilities. Large firms with significant technological capabilities used external knowledge to complement domestic technological efforts. They exhibited the highest degree of innovativeness. By contrast, large firms with relatively lower capabilities relied on external knowledge to improve short-term profitability. Finally, smaller firms showed a dual behaviour: On the one hand, firms that had developed some fair technological capabilities relied, almost exclusively, on domestic research efforts; they enjoyed the highest rates of growth. On the other hand, small firms with low capabilities tended to imitate products with relatively limited technological complexity. Mobility of personnel constituted their preferred channel to capture external knowledge.

More recently Singh (2007) documented the progression in the innovative capacity of Indian drug manufacturers. Starting as bulk generic suppliers, Indian firms are gaining presence in drug discovery and clinical research. Notable for this process has been the formation of alliances with large US and European firms; efforts to capture and benefit from knowledge and experience of highly qualified Indian expatriates and significant export orientation (Meyers 2006; Reddy 1997).

In addition to some firm characteristics and environmental factors, the literature stresses the contribution of human resources for successful catching-up in the pharmaceutical industry. Such contribution has been linked to the availability of human resources, well defined corporate goals and managerial preferences. Equally important have been the promotion of good engineering and research skills, an aggressive entrepreneurial orientation, dynamic organizational practices and engineering leadership.

In the case of pharmaceuticals in Mexico, Zúñiga et al. (2007) studied the joint use of in-house R&D and technology transfer over the period 1994-2000. The study concluded that internal and external learning strategies are exogenous in the local industry. In-house R&D has little influence on external acquisition of technology; at the same time, technology purchases only marginally affect corporate R&D investment decisions. The authors indicated that the observed low probability of complementarities could be explained by two divergent technological objectives of pharmaceutical firms. Market exposure, through exports for example, drives R&D. By contrast, external procurement of technology responds to searches for increased productivity, capital intensity and company size. Nevertheless international diversification, through exports, can lead to joint learning strategies.

This paper re-examines some of the conclusions by Zúñiga and colleagues). In order to do so, it incorporates additional information about the learning processes taking place inside the firm. Major differences include our finer definitions of the dependent variables; Zúñiga and colleagues looked only at whether firms performed R&D or not, or the participation of pharmaceutical firms in technology licensing. Moreover, the inclusion of variables on human

resource management practices sheds light on how such interventions influence adoption of combined learning activities.

3. Human resource management and learning

This section identifies some human resource management practices conditioning individuals' and, thereby, organizational learning. Relevant interventions include training, compensation for performance, worker's participation in decision-making, rotation assignments and staff hiring.

Training: Training supports development of technical skills but also managerial and interpersonal skills for planning, decision-making and organizational development. In addition to formal knowledge acquisition, training can include reflection on learning and learning through problem-solving (Gray et al. 2004). Training takes two main forms: on-the-job, frequently provided by staff attached to the organization and off-the-job, through formal external, classroom, education and linkages to external knowledge-producers (Okada 2004). Training helps to address motivational problems affecting blue-collar workers facing extremely low levels of education and limited development opportunities (García 2002). Frequent problems result from poor formalization of training structures, mismatches between training and promotion opportunities, enhanced independence, authority and responsibility (Samstad and Pipkin 2005). This is compounded by weak incentives for training, incompatibility with work schedules, inappropriate conditions for new skills to be put in place and high post-training turn-over (Abramo 1997). From the above, it is expected that:

H1: Training influences positively the likelihood that a firm adopts joint learning strategies.

Compensation: The type of compensation incentives and how they are administered to workers condition motivational styles and attitudes towards work (Florida and Goodnight 2005). The literature recommends the provision of a mix of intrinsic rewards-such as greater autonomy, additional developmental opportunities and public recognition; and extrinsic ones–such as pay increases and promotions (James 2002; Mumford 2000). Accordingly, in Mexico compensation packages usually include something more than nominal salaries. Non-pecuniary, 'status enhancing' perks are highly appreciated particularly at higher levels of responsibility and skills (Stephens and Greer 1995). Studies about the maquiladora industry in Mexico, characterized by high turn-over rates, indicate that compensation mechanisms are instrumental to attract, motivate and retain personnel (Dussel 2003; Stephens and Greer 1995). However in developing countries compensation for performance is often conditioned by tight markets for skilled-labour and wage contention policies, as means to keep inflation in check and underpin industrial competitiveness. The discussion above suggests that:

H2: In general, remuneration levels positively influence adoption of joint learning strategies.

Worker's empowerment: The provision of decision-making and problem-solving rights, together with relevant knowledge, tools and incentives, opens up possibilities to influence and participate in the design and operation of work environments, to adapt or respond to emerging challenges and opportunities for innovation (Mumford 2000). In this regard, literature points

out that, in general, labor relations in countries such as Mexico are highly hierarchical; power flows top-down, based on paternalism, links of trust and loyalty between workers and immediate supervisors (Carrillo and Ramírez 1997; García 2002). Delegation of responsibility is limited to particular tasks, often without decision-making authority and resistance to follow-up and control (Martínez and Dorfman 1998). However, difficulties for Mexican workers to assume higher responsibilities, to participate actively in organizational or technical change often stem from their low qualification and education attainment (Abramo 1997). Rao and Teegen (2001) argue that highly-skilled Mexican workers, notably those working for multinational affiliates or high-standard Mexican companies, are less inclined to traditional work styles. Particularly at managerial levels, Mexicans show strong work ethics and openness to long journeys and assume extraordinary responsibilities. The discussion so far suggests that:

H3: In general, workers' empowerment positively influences adoption of joint learning strategies by the firm.

Rotation assignments: According to literature on Japanese organizational practices rotation assignments promote knowledge diffusion within firms. Rotation supports programme development and implementation, provide group interaction and minimize friction and conflict; it also enhances coordination across multiple tasks and understanding of problems faced by other colleagues (Jones 1996; Mumford 2000). This notwithstanding, in the context of Mexico and other Latin American countries rotation can have opposite effects on firms' performance. For example, Abramo (1997) documented that, although widely diffused across industries in the region, rotation is seldom accompanied by wage increases, changes in the time supervisors established for more experienced workers to complete similar tasks or, well designed training and retention programmes. Rotation intensifies job responsibilities, work-related diseases and job dissatisfaction; potential benefits are frequently hindered by strict job descriptions and task specialization associated with assembly processes (García 2002). In light of this somewhat conflictive evidence:

H4: Rotation assignments can influence positively the likelihood that firms perform dual learning strategies.

Staff hiring: Strategic hiring, ways to introduce new members to the organization, in team building or in training programmes are all recognized as means for firms to accumulate technological and other types of capabilities. March (1991) identified turnover and staff replacement as mechanisms introducing variability in organizations and whereby, renewed opportunities for organizational learning. New comers reduce levels of socialization within the firm, relative to more experienced staff; in such a way firms can induce increased opportunities to exploration and knowledge accumulation. A mix of experience and skills, the intention to keep consistency with in-house innovation or production teams, with short- and long-term knowledge requirements constitute relevant criteria to hire new staff (Du and Ai 2008; Santamaría et al. 2009). Potential benefits from hiring new staff stem however, from the introduction of increased diversity in individual knowledge, rather than on an intrinsic superiority in the skills and knowledge of new employees. Staffing practices in Mexico are often constrained by whether firms seek for blue-collar or more skilled white-collar personnel. In the

first case the process is relatively simple given the traditionally low qualification of the local labour force. Things complicate when staffing positions requiring increasing skills, as the country lacks a critical mass of well trained and experienced people; finding the right candidate induces greater complications and larger costs (Forest 1994). The discussion so far leads to the expectation that:

H5: Staff hiring supports acquisition of external knowledge to complement internal learning efforts.

4. Data and research strategy

Data used in this paper were extracted from the *Encuesta Nacional de Empleo, Salarios, Tecnología y Capacitación* (ENESTyC).[2] This survey was carried out by the *Instituto Nacional de Estadística, Geografía e Informática* (INEGI) on behalf of the *Secretaría del Trabajo y Previsión Social* (STPS), Mexico. ENESTYC represents the entire Mexican manufacturing sector. The manufacturing establishment constitutes the unit of analysis. The survey builds on a stratified sample based on the establishment's size, as measured by total employment: Large 251+; medium: 101-250; small: 10-100 and micro: 0-5. Establishments with 100 or more employees are included together with a random sample of those with less than 100 employees. Confidence level is 95 percent, with an estimated non-response of 10 percent.

The latest available publication of ENESTYC corresponds to 2001. Nevertheless, based on an agreement to comply with pertinent confidentiality requirements by INEGI, personnel from the Institute processed, on our behalf, the preliminary data for the event 2005. The information corresponds to the year 2004. In ENESTYC the module for the pharmaceutical industry (NASCI code 3254)[3] includes 141 data points; however, the effective working sample, excluding missing values, is 112 data points. The remaining of this paper uses, indistinctly, the terms establishment and firm.

Dependent variables: ENESTYC contains information on pharmaceutical R&D performed in Mexico; this is represented as rd_inhouse. The dataset equally identifies the objectives of R&D. In line with Mexico's specialization in generic drugs, the novelty of the R&D outcomes takes the firm as reference; innovations can be new to the firm but not necessarily to the Mexican market or the world. This paper focuses on R&D supporting: improvement or design of new machinery and equipment for the firm's own use; this is interpreted as new process innovation. Alternatively, R&D underpins the design of new pharmaceutical products. This paper looks at firms that perform R&D for new product/process innovation, as denoted by rd_new_proc_prod.[4] The distinction of R&D in terms of both novelty and outcome is a step forward as compared with Zúñiga et al. (2007); they looked at R&D in generic form only.

[2] ENESTYC stands for National Survey on Employment, Wages, Technology and Training in the manufacturing industry, Mexico.
[3] NASCI stands for North American Industrial Classification System.
[4] In the interest of space and feasibility of the analysis, the study of the relationship between human resource management and the indicators on R&D for product and process innovations, respectively, is the matter of a separate paper.

The variable on external learning (external_mkt), in turn, denotes that firms obtain technology from external markets by means of: purchase of technology packages, acquisition of machinery and equipment, hiring consultant firms, accessing specialized literature, technology licensing, and/or through collaboration with other firms in order to learn about the general conditions of the industry. A firm can also do R&D in partnership with other agents. Based on Cassiman and Veugelers (2006) a firm is considered an active learner if it pursues at least one of the former seven activities. Table 2 below provides further details on the dependent variables.

Control variables: Arundel et al. (2007) in the case of Europe, OECD (1998) for the OECD countries and Kaplinsky (1995) for developing countries documented the interrelation between adoption of modern management practices and organizational strategies adopted by firms. Such strategies correspond with the type of management practices available for firms, and shape the environment in which learning takes place (Arundel et al. 2007). In the case of pharmaceutical firms, and in the context of Good Manufacturing Practices (GMPs),[5] total-quality-management (TQM) and just-in-time (JIT) practices assist in meeting the strict quality controls required by regulatory authorities. In this study the variable *modern_practice* controls for the use of JIT and/or TQM.

Capital origin and export behaviour condition strongly the technological performance of pharmaceutical firms in developing countries (Kim 1989; Zúñiga et al. 2007). Foreign ownership will determine the perceived importance of R&D for the firm's business strategy in the host country. In the case of countries such as Mexico, multinational affiliates generaly show a rather passive technological behavior; R&D remains concentrated at the parent company. In the case of exports, systematic R&D efforts assist firms in meeting some of the challenges derived from increased exposure to foreign markets. This paper incorporates these observations via the variables fdi and export_dummy, respectively. Finally, the paper captured scale effects associated with a firm's size, as defined in terms of total employment.

Variables on human resource management: ENESTYC contains data on human resource management practices adopted by pharmaceutical firms in Mexico. The practices include the provision of training, the use of rotation assignments and worker's participation in decision-making; additional questions indicate the regulation of practices such as staff hiring and rotation. In general, variables are measured in terms of adoption by the firm. A few variables in the dataset reflect intensity of human resource management practices. For example, indicators on worker's participation in decision-making and rotation show the importance of such practices from the perspective of the employer. Delery (1998) advised to explore the effects of distinct human resource management constructs on a firm's performance; accordingly, this paper incorporated distinct definitions for each variable included in the analysis.

Annex 1 presents detailed definitions and descriptive statistics for the control and explanatory variables used in this paper; the correlation analysis appears in Annex 2.

[5] GMPs define the best rules/practices to manufacture a drug as approved by health authorities in a given country (Seiter 2005).

Research strategy

The dependent variables in this paper are binary; they indicate the adoption of internal and external learning strategies, respectively. The expected interrelation among these two strategies suggests the presence of some unobservable characteristics of the firm that influence the selection of learning strategies. A suitable econometric approach for this study is bivariate probit analysis; as an extension of probit regression, the bivariate specification allows the running of two simultaneous equations with the expected correlation in the disturbance terms (Greene 2003). The resulting system of equations looks as follows:

y_{i^*} and y_{j^*} are latent variables, such that:
y_{i^*}= In-house R&D
y_{j^*}= Acquisition of external technology
M = Vector of management variables that influence the probability of choosing among learning strategies
X = Vector of firm characteristics (control variables) that influence the probability of choosing among learning strategies
εi , νi = Vectors of disturbances

$y_i^* = \beta' M + uiX + \varepsilon i$, $Y_{internal}$=1, if $y_i^* > 0$, 0 otherwise (1)

$y_j^* = \delta' M + ujX + \nu i$, $Y_{external}$=1, if $yj^* > 0$, 0 otherwise (2)

The approach assumes:

$$E(\varepsilon / m, x) = E(\nu / m, x) = 0 ,$$
$$Var(\varepsilon / m, x) = Var(\nu / m, x) = 1 ,$$
$$Cov(\varepsilon, \nu / m, x) = \rho$$

Modeling proceeded as follows: first, a basic model was identified, including the dependent variables, rd_inhouse and external_mkt. Then, the rd_new_proc_prod was introduced in order to account for the goals of R&D. The next step was to explore the effects associated with each of the different definitions of the human resource management variables; the information set was changed by shifting one group of practices at a time while keeping as close as possible to the structure of the basic model. This exercise served the additional goal of checking for the robustness of the results.

In order to corroborate the adequacy of the bivariate specification, estimates were contrasted with those from equivalent univariate probit equations. The value and statistical significance of the errors correlation term, ρ, for the bivariate models was also examined. A positive and significant test of ρ indicates that the learning strategies are interrelated; univariate models will capture only partial information and render biased results (Greene 2003). Estimates for models in section 5 confirmed that the bivariate specification was adequate. An additional set of models

explored the extent to which the dependent variables are explained by the variables on firm characteristics.[6]

5. Empirical results

Mexico ranks among the top ten pharmaceutical markets in the world and second in Latin America. It is an important manufacturing and export base for Latin America and, to a lesser extent, the United States, Europe and Asia. The country has real, albeit poorly exploited, abilities to imitate and generate innovative pharmaceutical products (Guzmán 2005). Mexico contributes to pharmaceutical innovation during manufacturing and product life-cycle support of existing drugs; innovations are incremental, in the shape of new formulations, improved processes and product quality enhancements (Secretaría de Salud 2005). The industry is characterized by strong labour specialization requirements and salaries higher than others in the country.

Multinational affiliates dominate the more lucrative private market in Mexico. Affiliates manufacture and export finished products with quality and safety standards comparable to developed countries; yet production scales are much lower. By contrast, local firms focus on manufacturing of generic drugs and depend strongly on sales to the public health sector. There is however a clearly identified segment of dynamic domestic firms whose business strategies rest on systematic innovative efforts. As generics manufacturers, they have developed some basic research capabilities, particularly, by incorporating modern biotechnology techniques. Table 1 presents some descriptive statistics about the pharmaceutical industry in Mexico.

[Table 1 here]

Learning behaviour

Table 2 reveals that a large share of pharmaceutical firms in Mexico performed R&D in-house during 2004 (62.5 percent); the number of firms active in external markets for knowledge was similar (60.7 percent). Distribution of firms by specific source of external knowledge is fairly diversified; yet, specialized literature seems the most frequent mechanism: 33.0 percent. Internal and external learning strategies are positively and significantly, albeit weekly correlated: 0.47.

[Table 2 here]

Table 3 reveals a significant number of firms pursuing internal and external learning strategies, 49.1 percent. About 13.4 percent choose internal only, while 11.6 percent choose an external only strategy. Some 25.9 percent of firms pursued neither of these strategies. Clustering among learning strategies implies that doing more of one increases the expected return on the other.

[6] In the interest of space results from univariate models and for those including the control variables only were omitted from presentation. Results are consistent with those presented in this paper.

As for the relationship between joint learning strategies and some specific human resource management interventions, some findings for pharmaceutical firms in Mexico are as follows: Firms show great propensity to provide training to employees, frequently in the form of both internal and external training. By contrast, pharmaceutical firms show a limited inclination to allow worker participation in decision-making. Even in those occasions when workers have a voice, the practice is reported as having little importance for the company. In the case of rotation assignments, firms in our sample reported heterogeneous behaviour; they distributed almost equivalently between those that do not use staff rotation; and those for which the practice is used and is reported as relevant. Finally, firms showed a strong propensity to regulate staff hiring practices.

[Table 3 here]

Econometric results

Table 4 presents the results from the bivariate probit analysis. Model (1) includes rd_inhouse as internal learning strategy; model (2) replaces rd_inhouse with rd_new_prod_proc. Identification of variables whose effects and statistical significance are exclusive for a specific kind of learning strategy is indicative of complementarity between such strategies (Piga and Vivarelli 2004; Cassiman and Veugelers 2006). This finding supports the notion that building adequate internal absorptive capacity is necessary to engage and, eventually, benefit from linkages with external knowledge producers.

Table 4 reveals that the use of a more detailed definition of R&D helps to better appreciate the effects of the explanatory variables on learning. Estimates for individual variables show the positive and statistically significant effects of training and remuneration for performance, particularly for internal learning activities.

Estimates in Table 4 support previous findings by Zúñiga et al. (2007) as well. Foreign ownership tends to negatively impact on both internal and external learning activities. By contrast, exposure to external competition, through exports, underpins R&D by pharmaceutical firms. Scale effects are also taken into account, as remuneration for performance is expressed in interaction with a variable on the size of the firm.

[Table 4 here]

Marginal effects: A complementary way to look at results in table 4 is by computing the marginal effects on specific outcomes associated with changes in a given explanatory variable (Long and Freese 2006). In line with the goals of this paper, a third column for each of the models (1) and (2) reports the probability that a firm pursues joint learning strategies. The estimates confirm that the provision of training and remunerations have positive effects on joint learning strategies underpinning new product and/or process innovations. As for rd_inhouse, it is confirmed that only the provision of training seems to matter for the learning efforts of a firm. The marginal effects associated with the variables on firm's characteristics corroborate the

conclusions that export behavior and foreign ownership influence learning by pharmaceutical firms in Mexico.

Alternative definitions of human resource management practices

The following sections present estimates from models with alternative specifications of the human resource management variables in model (2). The exercise serves to explore further the importance of human resource management variables while shedding light on the robustness of previous results.

Provision of training: Table 5 and 6 present models with alternative definitions of training. Based on Laursen and Foss (2003) and Michie and Sheehan (1999 and 2003), model (3) distinguished between internal and external provision of training. Model (4) includes an interaction term between the two types of training. Casas (2001) argued that, in Mexico, training is one of the most important reasons for firms to interact with other agents in the environment. The models in table 6 identified different training providers: public and private universities, other firms, institutions linked to local trade organizations, individual consultants and machinery suppliers.[7]

According to tables 5 and 6 the effects of training on learning strategies by pharmaceutical firms in Mexico change depending on the knowledge flows involved. This is consistent with Laursen and Salter (2004) who contend that managerial choice matters in shaping the propensity of firms to draw from universities, or in this case, other external training partners. Interestingly, external training contributes more significantly to in-house R&D for new product/process innovation than the internal kind. Estimates in table 6 show that the models for traditional knowledge producers rendered very poor results; by contrast, relationships with individual consultants and local trade organizations provided more meaningful information. In general, the effects on learning associated with remuneration for performance are more evident via the computation of marginal effects. For the remaining variables on human resource management, these provided no meaningful information for the analysis. No major changes were found in relation to the variables on firm's characteristics.

[Table 5 here]

[Table 6 here]

Worker's empowerment: Michie and Sheehan (1999 and 2003) and Laursen and Foss (2003) investigated the effect of labour relations on the probability of a firm being an innovator. The indicators included the existence of procedures to file grievances or frequency of strike actions; the evidence on the impact of these variables on innovation performance was inconclusive. Unionization is a relevant practice in Mexico; it has been mandatory under local labour

[7] Although not presented here, results from models with rd_inhouse showed the importance of internal training for in-house R&D. Estimates for variables on the firm's characteristics were consistent with those reported here.

regulations and heavily influential on worker-employer relationships. For instance, García (2002) argued that local managers often recognize unions as major obstacles to implementing organizational and technical change. Communication and negotiation between these parties are poor. In order to explore these issues, the analysis incorporated the presence of unions inside the firm, together with an interaction term between labour unions and worker's empowerment--Table 7.

Estimates from the models in table 7 indicate that simply allowing workers to participate does not influence learning activities—model (5); neither does it the presence of a labour union *per se*—model (6). However, interactions with local labour unions, as a way to channel worker's participation in decision-making, can facilitate learning for innovation—model (7).

Results for the remaining human resource management variables indicate that the provision of training is highly significant particularly for in-house R&D. Marginal changes in remunerations equally underpin joint learning strategies. Firm characteristics confirm the effects observed in tables 4 and 5.

[Table 7 here]

Compensation practices: Table 8 reports results for alternative indicators on remuneration for performance. Model (8) presents a more limited definition of compensation, in the form of salaries and excluding benefits. In Mexico the concept of payment per-hour is seldom provided, even faces serious constraints under both local labor laws and customary union practices; setting monthly remunerations is the usual practice (Samstad and Pipkin 2005). Nevertheless, since the practice of hourly remuneration is customary elsewhere in the world, models (9) and (10) include hypothetical variables on compensation per hour. In the first case, it is the full remuneration package, comprising salary plus benefits and, in the second, only salaries. The variables, normalized through a logarithmic transformation, capture scale effects associated with a firm's size.

Table 8 reveals that marginal changes in avgwage_size have positive, yet small impacts on the adoption of joint learning strategies. By contrast, none of the other measures of compensation provided meaningful information at standard levels of confidence. The remaining explanatory and control variables behaved in a fashion similar to that observed in tables 4 through 7.

[Table 8 here]

Rotation assignments: Four alternative definitions of rotation practices were investigated. In table, model (8) indicates that the firm uses rotation assignments regardless of their importance. Models (10) through (12) denote that the firm regulates temporary staff rotation either through collective contracts, any other form of internal regulation, or both. The models are statistically significant at customary confidence levels.

Table 9 reveals a lack of statistical significance of staff rotation practices in the context of joint learning strategies. By contrast, the provision of training and compensation for performance

continue to underpin learning strategies. In the latter case the effects are perceptible through computation of marginal effects. None of the remaining human resource management interventions rendered statistically significant information. As for the variables on a firm's characteristics, whereas exports support internal learning efforts, foreign ownership inhibits the use of both internal and external sources of knowledge. Modern organizational practices, in turn, influence participation in external markets for technology.

[Table 9 here]

Staff hiring: As a final exercise, table 10 presents the results for models with alternative definitions of staff hiring practices. Models (13) and (14) indicate that the firm regulates staff hiring through either collective contracts or any other form of internal regulation. The new variables on staff hiring failed to meaningfully explain the adoption of joint learning strategies by pharmaceutical firms in Mexico. As for the rest of explanatory and control variables, the estimated effects remained consistent with those observed in previous sections. When the firm hires new staff based on internal regulations, compensation for performance turned out statistically significant and positive for learning from external markets.

[Table 10 here]

6. Discussion and conclusions

This paper argued that understanding the factors linking human resource management to a firm's innovation performance calls for improved approaches to research. The analysis explored which and how human resource management practices support efforts to tap internal and external knowledge sources during the innovation process. The main contention is that such practices can either potentiate or constrain the learning opportunities, sanctions and rewards for individuals involved in innovation activities inside the firm.

Building on empirical evidence about pharmaceutical firms in Mexico, the paper found that a significant share of those firms implement combined learning strategies. In principle this finding is positive as successful catching-up frequently involves strategic use of internal and external knowledge sources. It is even more relevant if firms are, eventually, to contribute to further advancement of the technological complexity of the industry and overall economic environment.

This paper supports the conclusion by Zúñiga et al. (2007) on the complementarity of learning strategies in the pharmaceutical industry in Mexico; moreover one could agree that such complementarity is rather weak. Nevertheless a note of caution is pertinent here, as ENESTYC lacks information about customary innovation output indicators--patents, share of sales of innovative products and so on. These data limitations prevented the performance of more direct analyses of complementarity. Although Zúñiga and colleagues failed to recognize it, their study faced similar problems. Athey and Stern (1998) and Cassiman and Veugelers (2006) showed, theoretically and empirically, that in order to draw stronger conclusions about the nature of complementarity between learning strategies more direct tests are needed. Those tests include

some kind of innovation output function, together with finer gradations of the dependent variables. Hence, it is possible to investigate the impact of the chosen learning strategy on actual innovation performance. These perceived limitations do not invalidate our findings as our understanding of innovation was more as a learning and capability building process than as concrete outcomes in terms of product or process (Li et al. 2008).

This paper illustrated the complexity of doing research on human resource management practices and a firm's performance. Such practices are heterogeneous, a number of technological, market-related, institutional and idiosyncratic factors condition the way firms organize personnel. In our case, the focus on the pharmaceutical industry saved the need to control for industry and market differences, as in more traditional studies across industries. It also made it feasible to centre the attention on the stages of pharmaceutical innovation in which countries such as Mexico are able to participate. Arguably, both the nature of human resource management practices and their associated effects change depending on the particular stages of the innovation process in which firms, even countries, operate. A major drawback resulted however from the relatively limited size of the pharmaceutical industry in Mexico.

Heterogeneity in human resource management approaches also implies the need to look at a large number of variables, let alone the many possible interactions expected between them. This paper in particular documented the importance of two specific practices: the provision of training, particularly by external providers; and to a lesser extent, remuneration for performance. These findings are consistent with previous studies suggesting that in countries such as Mexico, training and adequate compensation can lead to improved performance of the labour force (Carrillo and Ramírez 1997; Dussel 2003). It is likely that whenever firms are characterized by limited R&D, technological progress necessarily requires interaction with other, more specialized and experienced agents in the system of innovation. Both external training and remunerations serve such goal.

In regards to the provision of training, and contrary to expectations from the literature, traditional knowledge producers failed to explain learning by pharmaceutical firms in Mexico. These results correspond with well documented mismatches between academic institutions and firms. In the particular case of Mexico, Ruíz (2004) argued about the distinct orientation of firms and public universities. Interactions between these agents are often hindered by bureaucratic burdens, limited flexibility and inability of universities to respond to a firm's training requirements, especially when training does not lead to obtaining academic degrees. In extreme cases, the mismatch reflects a low esteem, even reticence of public universities to design study programmes by contacting and gaining feedback from the productive sector (Ruíz 2004). Our analysis suggests that pharmaceutical firms tend to privilege interactions with organizations that are more closely related to the operation of the industry.

The literature suggests that adequate remuneration for performance should positively induce learning. In the case of pharmaceutical firms in Mexico, our evidence supported this idea only partially. The positive effects associated with remuneration were perceptible mostly via the computation of marginal effects. Is it that, in themselves, salaries in the industry are inadequate to promote learning for innovation? Is it because intangible issues, such as prestige and

recognition, are more relevant as mechanisms to underpin performance? For instance, Terziovski and Morgan (2006) argued that, in industries such as biotechnology, performance-linked rewards might not be as attractive and stimulating as compared to access to sophisticated scientific equipment and instruments enabling researchers to pursue their work and increase their intellectual capital. Traditionally low levels of R&D expenditures by the private sector in Mexico would support this conclusion, as research infrastructure is limited or rather poor. Unfortunately, lack of more detailed information in the ENESTYC dataset prevented further exploration of these ideas here.

Additional questions remain for future analysis. In principle, we need to better understand the role of rotation assignments in the pharmaceutical industry in Mexico. However widely diffused among firms, the practice was seldom perceived as important by the firm. In a way, this lends some support to the comments by Abramo (1997) and García (2002) in section 3. Similar conclusions can be drawn in the case of staff hiring, the different definitions failed to provide meaningful information about the influence of the practice on the adoption of joint learning strategies.

Worker's participation in decision-making turned out to be infrequent or seldom important for pharmaceutical firms in Mexico. Consequently, the effects of such practice on learning were difficult to perceive econometrically. The finding should be taken with a grain of salt however, as it may simply reflect the nature of the operation of the pharmaceutical industry. Changes in the characteristics of pharmaceutical products are constrained by eventual needs to modify the manufacturing process; hence the risk that such process will require recertification and obtaining of a new marketing authorization. FDA (2004) stressed that strong standardization and regulation of drug manufacturing is a major factor constraining innovation opportunities in drug manufacturing. Similar logic may limit the scope of decision-making in the case of development of generic drugs.

A brief note on estimates for the control variables is obliged, as firm's characteristics accounted strongly for the explanatory power of the models in this paper. Foreign ownership systematically and negatively impacted on learning. This finding reflects the position that Mexico occupies in the business strategies of global pharmaceutical firms. Apart from the adaptation of products to the local market, systematic R&D performance falls short from the objectives of multinational affiliates.

By contrast, as suggested by Arora et al. (2001), competition in external markets for pharmaceutical products was found to positively influence learning. From a policy perspective this suggests the pertinence of promoting exports as a way to encourage innovation by local firms. The literature shows that successful catching up in South East Asia frequently involved strong orientation towards export markets.

Last but not least, adoption of modern organizational practices was found to be positive and statistically significant particularly for external learning strategies. In our view this reflects Mexico's well reputed position as a modern manufacturing centre (Cimoli 2002).

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Table 1: Summary statistics for the pharmaceutical industry in Mexico, 2004

Num. of establishments 112	Mean	SD[1]	Min	Max
Employment	438.3	498.7	1.1	3391.5
Total sales[2]	626557.6	1152467	2394	6958020
Domestic sales	553691.3	966085.1	0.0	6334508
Share of exports	0.07	0.15	0.0	1.0
Share of foreign capital	0.31	0.46	0.0	1.0
Years in operation[3]	31.7	18.8	0	74

Notes: 1. Standard Deviation. 2. Thousand Mexican pesos; 3. Difference between the year in which a firm started operations in current business and year of collection of the survey, 2004
Source: Author

Table 2. Definition and correlations among the variables shaping the learning strategies of pharmaceutical firms in Mexico

	Variable construction	**Firms without missing values (N=112)**	**1**	**1.1**	**1.2**	**2**	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**	**2.6**	**2.7**
1. rd_inhouse	1 if firms carry out R&D for new product and/or process in-house; 0 otherwise	70 (62.5%)	1										
1.1 Design new machinery & equipment	1 if firms declare the goal of R&D in-house is to create new machinery & equipment for own use; 0 otherwise	21 (18.8%)	0.37*	1		0.47*							
1.2 Design new products	1 if firms declare the goal of R&D in-house is to design new products	69 (61.6%)	0.98*	0.33*	1	0.34*							
2. *external_mkt*	1 if firms acquire technology through at least one of the following forms of contact with external agents. 0 otherwise:	68 (60.7%)	0.47*			1							
2.1 Technology packages	1 if firms acquire packaged technology. 0 otherwise	30 (26.8%)	0.34*			0.49*	1						
2.2 Consultant	1 if firms hire consultants. 0 otherwise	28 (25.0%)	0.23			0.46*	0.68*	1					
2.3 Literature	1 if firms access specialized literature in their field; 0 otherwise	37 (33.0%)	0.43*			0.57*	0.35*	0.43*	1				
2.4 Knowledge acquisition	1 if firms carry out, in collaboration with other firms in the industry, activities geared to learn about the business environment and other conditions of the industry; 0 otherwise	9 (8.0%)	0.09			0.24	0.12	0.21	0.07	1			
2.5 Machinery acquisition	1 if firms acquire machinery and equipment; 0 otherwise	15 (13.4%)	0.20			0.32*	0.30*	0.38*	0.17	0.37*	1		
2.6 External R&D	1 if firms carry out R&D in collaboration with external agents; 0 otherwise	29 (25.9%)	0.37*			0.48*	0.29*	0.22	0.19	0.35*	0.43*	1	
2.7 Licensing	1 if firms license technology; 0 otherwise	21 (18.8%)	0.14			0.39*	0.17	0.30*	0.10	0.11	0.28*	0.19	1

Notes: *Different from zero at 1% level of significance; variables in bold fonts were created by the authors
Source: Author

Table 3 Frequency of choice of learning strategy by pharmaceutical firms in Mexico

	External sources		
Internal sources	No	Yes	Total
No	29 (25.9)	13 (11.6)	42 (37.5)
Yes	15 (13.4)	55 (49.1)	70 (62.5)
Total	44 (39.3)	68 (60.7)	112 (100.0)
	N=112 Pearson $X^2(1) = 24.9554$***		

Notes: Categories are exclusive; ***significant at 1 percent level of confidence; percentage share of each cell relative to the sample total in parentheses
Source: Author

Table 4: Bivariate models linking human resource management practices to learning strategies

	(1)			(2)		
Variables	rd_inhouse	external_mkt	MgEffect	rd_new_prod_proc	external_mkt	MgEffect
train04	1.33***	0.47	0.33***	1.19**	0.48	0,34***
	(0.39)	(0.40)	(0.12)	(0.46)	(0.39)	(0,11)
rem_size	0.06	0.09*	0.03*	0.11**	0.09*	0,04**
	(0.06)	(0.05)	(0.02)	(0.06)	(0.05)	(0,02)
rule_hiring	0.05	0.39	0.12	-0.25	0.37	0,03
	(0.30)	(0.26)	(0.10)	(0.30)	(0.27)	(0,10)
imp_empowerment	-0.18	0.14	0.03	-0.12	0.15	0,01
	(0.24)	(0.23)	(0.09)	(0.24)	(0.24)	(0,09)
use_rotation_import	0.013	0.23	0.07	0.21	0.24	0,10
	(0.19)	(0.19)	(0.07)	(0.19)	(0.20)	(0,07)
modern_practice	0.27	0.71**	0.25*	0.20	0.73**	0,21*
	(0.38)	(0.36)	(0.13)	(0.34)	(0.36)	(0,13)
export_dummy	0.72**	0.50	0.22**	1.02***	0.51	0,31***
	(0.35)	(0.31)	(0.11)	(0.35)	(0.31)	(0,10)
fdi	-1.02**	-1.29***	-0.47***	-1.51***	-1.31***	-0,53***
	(0.41)	(0.34)	(0.10)	(0.44)	(0.34)	(0,09)
Constant	-1.02**	-1.51***		-1.63***	-1.53***	
	(0.44)	(0.51)		(0.55)	(0.50)	
Observations			112			
Log Likelihood Full	-103.7			-112.6		
Wald test full model	[16]60.6***			[16]61.5***		
ρ	0.85 (0.09)			0.65 (0.12)		
Wald Test for ρ=0	[1]19.44***			[1]15.03***		

Notes: Robust standard errors in parentheses. ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; degrees of freedom for X^2 test in square brackets; Mg. Effect. Marginal effects.
Source: Author.

Table 5: Bivariate probit models with alternative definitions of training

	(3)			(4)		
Variables	rd_new_prod_proc	external_mkt	Mg.Effect	rd_new_prod_proc	external_mkt	Mg.Effect
training_internal	0.34	0.052	0,08			
	(0.35)	(0.35)	(0,13)			
external_training	0.78**	0.38	0,24**			
	(0.33)	(0.32)	(0,12)			
internal_external_tr				0.38***	0.16	0.11***
				(0.13)	(0.12)	(0.04)
rem_size	0.07	0.08	0,03	0.07	0.08	0.03
	(0.06)	(0.06)	(0,02)	(0.06)	(0.05)	(0.02)
rule_hiring	-0.20	0.40	0,05	-0.21	0.39	0.05
	(0.29)	(0.27)	(0,10)	(0.29)	(0.27)	(0.10)
imp_empowerment	-0.10	0.16	0,02	-0.11	0.16	0.02
	(0.24)	(0.24)	(0,09)	(0.24)	(0.24)	(0.09)
use_rotation_import	0.20	0.23	0,09	0.20	0.23	0.09
	(0.19)	(0.20)	(0,07)	(0.19)	(0.20)	(0.07)
modern_practice	0.23	0.76**	0,22*	0.23	0.75**	0.22*
	(0.35)	(0.36)	(0,13)	(0.35)	(0.36)	(0.13)
export_dummy	1.02***	0.50	0,31***	1.02***	0.49	0.30***
	(0.33)	(0.31)	(0,10)	(0.33)	(0.31)	(0.10)
Fdi	-1.41***	-1.25***	-0,51***	-1.42***	-1.26***	-0.51***
	(0.42)	(0.35)	(0,10)	(0.41)	(0.34)	(0.09)
Constant	-1.22***	-1.35***		-1.23***	-1.38***	
	(0.44)	(0.45)		(0.43)	(0.44)	
Observations			112			
Log Likelihood Full	-112.0			-112.1		
Wald test full model	[18]72.36***			[16]72.01***		
ρ	0.65(0.12)			0.65(0.12)		
Wald Test for ρ=0	(1)14.6272***			(1)14.6349***		

Notes: Robust standard errors in parentheses; ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; degrees of freedom for X^2 test in square brackets; Mg.Effect: Marginal effects.
Source: Author.

Table 6: Bivariate probit models for learning strategies underpinning new product and/or process innovation; by type of external training provider

Variables	Internal	external	Internal	external	Internal	external	Internal	external	Internal	external	Internal	external	Internal	external
training_internal	0.49	0.17	0.43	-0.02	0.53	0.15	0.57	0.16	0.51	0.18	0.57	0.12	0.51	0.10
	(0.35)	(0.34)	(0.35)	(0.35)	(0.35)	(0.34)	(0.36)	(0.34)	(0.35)	(0.35)	(0.37)	(0.38)	(0.35)	(0.32)
training_firm	0.30	-0.02												
	(0.28)	(0.29)												
training_freelance			0.58**	0.66**										
			(0.28)	(0.29)										
training_priuniv					0.39	0.08								
					(0.34)	(0.37)								
training_pubuniv							0.74	0.56						
							(0.46)	(0.42)						
training_pubcent									0.26	-0.17				
									(0.36)	(0.37)				
training_sup_mach											-0.03	0.06		
											(0.29)	(0.31)		
training_tradeorg													1.51***	0.58*
													(0.45)	(0.32)
rem_size	0.09	0.09	0.11*	0.10*	0.09	0.09	0.11*	0.09*	0.10*	0.10*	0.10*	0.09*	0.08	0.08
	(0.06)	(0.06)	(0.06	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)	(0.05)
rule_hiring	-0.19	0.38	-0.34	0.27	-0.24	0.39	-0.26	0.36	-0.22	0.40	-0.21	0.40	0.090	0.55*
	(0.28)	(0.27)	(0.29)	(0.27)	(0.28)	(0.27)	(0.28)	(0.27)	(0.28)	(0.27)	(0.28)	(0.27)	(0.31)	(0.29)
imp_empowerment	-0.11	0.16	-0.12	0.14	-0.12	0.16	-0.13	0.14	-0.10	0.17	-0.10	0.16	-0.14	0.16
	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)	(0.25)	(0.25)	(0.24)	(0.24)	(0.24)	(0.24)	(0.25)	(0.24)
use_rotation_import	0.21	0.24	0.18	0.20	0.22	0.24	0.28	0.28	0.22	0.25	0.22	0.24	0.16	0.20
	(0.19)	(0.20)	(0.19)	(0.20)	(0.19)	(0.20)	(0.21)	(0.20)	(0.19)	(0.20)	(0.19)	(0.20)	(0.20)	(0.20)
modern_practice	0.29	0.76**	0.31	0.84**	0.30	0.77**	0.29	0.78**	0.27	0.77**	0.29	0.77**	0.24	0.76**
	(0.34)	(0.35)	(0.34)	(0.36)	(0.33)	(0.36)	(0.34)	(0.35)	(0.33)	(0.36)	(0.34)	(0.36)	(0.36)	(0.36)
export_dummy	0.95***	0.49	0.87**	0.36	0.91***	0.48	0.89**	0.42	0.94***	0.50	0.94***	0.49	0.92**	0.46
	(0.34)	(0.31)	(0.34)	(0.32)	(0.34)	(0.33)	(0.35)	(0.32)	(0.34)	(0.32)	(0.35)	(0.32)	(0.38)	(0.31)
Fdi	-1.42***	-1.28***	-1.45***	-1.32***	-1.42***	-1.28***	-1.49***	-1.32***	-1.38***	-1.31***	-1.42***	-1.28***	-1.46***	-1.24***
	(0.42)	(0.35)	(0.41)	(0.36)	(0.43)	(0.35)	(0.45)	(0.36)	(0.43)	(0.36)	(0.45)	(0.36)	(0.47)	(0.35)
Constant	-1.11**	-1.25***	-1.08**	-1.34***	-0.94**	-1.24***	-1.11**	-1.31***	-0.99**	-1.29***	-1.04**	-1.26***	-1.11**	-1.28***
	(0.43)	(0.44)	(0.44)	(0.45)	(0.44)	(0.45)	(0.44)	(0.45)	(0.43)	(0.45)	(0.43)	(0.44)	(0.43)	(0.44)
Log Likelihood Full		-115		-113		-115		-115		-116		-116		-108
X2		[16]53.2***		[16]59.6***		[16]52.9***		[16]52.1***		[16]52.6***		[16]51.5***		[16]59.3***
ρ		0.66		0.64		0.67		0.66		0.17		0.67		0.65
Wald test, ρ=0		[1]15.99***		[1]14.61***		[1]16.58***		[1]15.47***		[1]16.69***		[1]16.14***		[1]13.94***

Notes: Observations: 112; Internal: rd_new_proc_prod; External: external_mkt; ***,**,* significant at the 1%, 5% and 10% confidence level; robust standard errors in parentheses; degrees of freedom for X^2 test within squared brackets.
Source: Author.

Table 7: Bivariate probit models with alternative definitions of worker's empowerment

	(5)			(6)			(7)		
Variables	rd_new_prod_proc	external_mkt	Mg.Effects	rd_new_prod_proc	external_mkt	Mg.Effects	rd_new_prod_proc	external_mkt	Mg.Effects
train04	1.20***	0.49	0.35***	1.14**	0.52	0.34***	1.13**	0.41	0.33***
	(0.46)	(0.40)	(0.11)	(0.48)	(0.39)	(0.12)	(0.44)	(0.40)	(0.11)
rem_size	0.10*	0.09*	0.04**	0.11*	0.10*	0.04**	0.10*	0.09*	0.04**
	(0.06)	(0.05)	(0.02)	(0.06)	(0.05)	(0.02)	(0.06)	(0.05)	(0.02)
rule_hiring	-0.20	0.40	0.05	-0.23	0.35	0.03	-0.18	0.42	0.06
	(0.29)	(0.27)	(0.10)	(0.28)	(0.27)	(0.10)	(0.29)	(0.27)	(0.10)
use_empower	0.33	0.50	0.18						
	(0.36)	(0.37)	(0.13)						
lab_union				0.13	-0.09	0.01			
				(0.32)	(0.33)	(0.11)			
pow_union							0.70*	0.75*	0.29**
							(0.39)	(0.39)	(0.11)
use_rotation_import	0.07	0.15	0.05	0.16	0.29*	0.10*	0.00	0.13	0.03
	(0.20)	(0.20)	(0.08)	(0.17)	(0.18)	(0.06)	(0.19)	(0.20)	(0.07)
modern_practice	0.10	0.67*	0.18	0.19	0.76**	0.22*	0.14	0.75**	0.21*
	(0.34)	(0.36)	(0.13)	(0.33)	(0.35)	(0.12)	(0.34)	(0.36)	(0.12)
export_dummy	1.02***	0.52	0.31***	1.01***	0.51	0.31***	1.06***	0.53	0.32***
	(0.35)	(0.31)	(0.10)	(0.35)	(0.31)	(0.10)	(0.35)	(0.32)	(0.10)
fdi	-1.53***	-1.34***	-0.54***	-1.52***	-1.29***	-0.53***	-1.65***	-1.43***	-0.57***
	(0.43)	(0.34)	(0.09)	(0.42)	(0.35)	(0.09)	(0.40)	(0.37)	(0.08)
Constant	-1.58***	-1.54***		-1.64***	-1.52***		-1.50***	-1.45***	
	(0.54)	(0.50)		(0.52)	(0.53)		(0.53)	(0.50)	
Obervs.					112				
Log Likelihood	-112.1			-112.9			-110.8		
Full Wald test full model	(16)61.6***			(16)63.1***			(16)66.7***		
ρ	0.63			0.64			0.62		
Wald Test for ρ=0	(1)14.3790***			(1)14.8605***			(1)13.4196***		

Notes: Robust standard errors in parentheses; ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; degrees of freedom for X^2 test in square brackets; Mg.Effect: Marginal effects.
Source: Author

Table 8: Bivariate probit models with alternative definitions of compensation for performance

	(8)			(9)			(10)		
Variables	rd_new_prod_proc	external_mkt	Mg.Effects	rd_new_prod_proc	external_mkt	Mg.Effects	rd_new_prod_proc	external_mkt	Mg.Effects
train04	1.20***	0.49	0.35***	1.14***	0.42	0.33***	1.15***	0.45	0.33***
	(0.46)	(0.39)	(0.11)	(0.44)	(0.38)	(0.11)	(0.43)	(0.38)	(0.11)
avgwage_size	0.12*	0.09*	0.04**						
	(0.06)	(0.06)	(0.02)						
remhour_size				0.15	0.17*	0.07*			
				(0.10)	(0.10)	(0.04)			
wagehour_size							0.14	0.16	0.06
							(0.11)	(0.10)	(0.04)
rule_hiring	-0.25	0.38	0.03	-0.16	0.45*	0.07	-0.15	0.45*	0.07
	(0.30)	(0.27)	(0.10)	(0.29)	(0.26)	(0.10)	(0.29)	(0.26)	(0.10)
imp_empowerment	-0.12	0.15	0.01	-0.031	0.22	0.04	-0.029	0.22	0.04
	(0.24)	(0.24)	(0.09)	(0.23)	(0.24)	(0.09)	(0.23)	(0.24)	(0.09)
use_rotation_import	0.21	0.23	0.09	0.14	0.19	0.07	0.14	0.19	0.07
	(0.19)	(0.20)	(0.07)	(0.18)	(0.20)	(0.07)	(0.18)	(0.20)	(0.07)
modern_practice	0.20	0.72**	0.21*	0.21	0.75**	0.22*	0.20	0.73**	0.21
	(0.34)	(0.36)	(0.13)	(0.35)	(0.37)	(0.13)	(0.35)	(0.37)	(0.13)
export_dummy	1.01***	0.50	0.31***	1.04***	0.49	0.31***	1.04***	0.49	0.31***
	(0.35)	(0.31)	(0.10)	(0.36)	(0.32)	(0.11)	(0.36)	(0.32)	(0.11)
Fdi	-1.51***	-1.30***	-0.53***	-1.41***	-1.29***	-0.51***	-1.38***	-1.25***	-0.50***
	(0.43)	(0.34)	(0.09)	(0.42)	(0.35)	(0.10)	(0.41)	(0.35)	(0.10)
Constant	-1.60***	-1.49***		-1.17***	-1.20***		-1.11***	-1.13***	
	(0.54)	(0.50)		(0.42)	(0.42)		(0.41)	(0.41)	
Observations				112					
Log Likelihood Full	-113			-113			-113		
Wald test full model	(16)61.2***			(16)58.1***			(16)56.5***		
ρ	0.65			0.65			0.65		
Wald Test for ρ=0	(1)15.1403***			(1)15.0337***			(1)15.3094***		

Notes: Robust standard errors in parentheses; ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; degrees of freedom for X^2 test in square brackets; Mg.Effect: Marginal effects.
Source: Author

Table 9: Bivariate models with alternative definitions of rotation assignments

	(11)			(12)			(13)			(14)		
Variables	rd_new_prod_proc	External_mkt	Mg.Effects	rd_new_prod_proc	External_mkt	Mg.Effects	rd_new_prod_proc	External_mkt	Mg.Effects	rd_new_prod_proc	External_mkt	Mg.Effects
train04	1.17**	0.46	0.34***	1.21***	0.36	0.34***	1.18***	0.48	0.34***	1.28***	0.34	0.35***
	(0.46)	(0.39)	(0.11)	(0.44)	(0.37)	(0.12)	(0.44)	(0.38)	(0.11)	(0.41)	(0.39)	(0.11)
rem_size	0.11**	0.09*	0.04**	0.10*	0.09	0.04**	0.10*	0.08	0.04**	0.09*	0.10*	0.04**
	(0.06)	(0.05)	(0.02)	(0.06)	(0.05)	(0.02)	(0.06)	(0.05)	(0.02)	(0.06)	(0.05)	(0.02)
rule_hiring	-0.23	0.40	0.04	-0.18	0.35	0.04	-0.20	0.41	0.05	-0.027	0.20	0.04
	(0.29)	(0.27)	(0.10)	(0.29)	(0.27)	(0.10)	(0.34)	(0.30)	(0.11)	(0.33)	(0.31)	(0.11)
use_rotation	0.37	0.36	0.02									
	(0.34)	(0.36)	(0.09)									
temp_rot_cc				-0.15	0.63*	0.06						
				(0.34)	(0.38)	(0.09)						
temp_rot_ir							0.005	0.01	0.07			
							(0.33)	(0.34)	(0.08)			
rule_temprotation										-0.34	0.42	0.06
										(0.32)	(0.33)	(0.09)
imp_empowerment	-0.10	0.18	0.15	0.03	0.23	0.07	0.002	0.29	0.00	0.07	0.20	0.03
	(0.24)	(0.24)	(0.13)	(0.22)	(0.23)	(0.13)	(0.22)	(0.21)	(0.12)	(0.23)	(0.23)	(0.11)
modern_practice	0.20	0.75**	0.22*	0.30	1.02***	0.30**	0.33	0.86***	0.26**	0.31	0.95***	0.28**
	(0.34)	(0.36)	(0.13)	(0.35)	(0.35)	(0.12)	(0.33)	(0.33)	(0.11)	(0.34)	(0.33)	(0.11)
export_dummy	1.02***	0.50	0.31***	1.00***	0.50	0.30***	0.99***	0.48	0.30***	1.04***	0.50	0.31***
	(0.36)	(0.31)	(0.10)	(0.36)	(0.32)	(0.11)	(0.35)	(0.31)	(0.10)	(0.35)	(0.30)	(0.10)
fdi	-1.50***	-1.29***	-0.53***	-1.45***	-1.33***	-0.53***	-1.45***	-1.24***	-0.51***	-1.48***	-1.30***	-0.52***
	(0.43)	(0.34)	(0.09)	(0.43)	(0.34)	(0.09)	(0.42)	(0.34)	(0.09)	(0.42)	(0.33)	(0.09)
Constant	-1.62***	-1.51***		-1.57***	-1.50***		-1.56***	-1.47***		-1.53***	-1.54***	
	(0.54)	(0.50)		(0.52)	(0.50)		(0.55)	(0.49)		(0.51)	(0.49)	
Observations												
Log Likelihood Full	-112.7			-111.4			-113.5			-111.2		
Wald test full model	(16)62.4***			(16)65.7***			(16)61.6***			(16)76.4***		
ρ	0.64			0.69			0.65			0.70		
Wald Test for ρ=0	(1)15.0830***			(1)16.4549***			(1)15.7068***			(1)17.0065***		

Notes: Robust standard errors in parentheses; ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; degrees of freedom for X^2 test in square brackets; Mg.Effect: Marginal effects.
Source: Author

Table 10: Bivariate probit models with alternative definitions of staff hiring

	(15)			(16)		
Variables	rd_new_prod_proc	external_mkt	Mg.Effects	rd_new_prod_proc	external_mkt	Mg.Effects
train04	1.16***	0.54	0,34***	1.25***	0.43	0,35***
	(0.44)	(0.39)	(0,10)	(0.43)	(0.40)	(0,11)
rem_size	0.10*	0.10*	0,04**	0.11*	0.11**	0,04**
	(0.06)	(0.05)	(0,02)	(0.06)	(0.05)	(0,02)
hire_permwork_cc	0.05	0.05	0,02			
	(0.34)	(0.32)	(0,11)			
hire_permwork_ir				-0.32	0.33	0,00
				(0.30)	(0.31)	(0,11)
imp_empowerment	-0.08	0.09	0,00	-0.15	0.15	0,01
	(0.23)	(0.25)	(0,09)	(0.24)	(0.25)	(0,09)
use_rotation_import	0.18	0.26	0,10	0.21	0.24	0,10
	(0.18)	(0.20)	(0,07)	(0.19)	(0.20)	(0,07)
modern_practice	0.17	0.76**	0,21*	0.21	0.75**	0,22*
	(0.33)	(0.35)	(0,12)	(0.34)	(0.35)	(0,12)
export_dummy	0.99***	0.51	0,30***	1.05***	0.48	0,31***
	(0.35)	(0.31)	(0,10)	(0.35)	(0.31)	(0,10)
fdi	-1.44***	-1.32***	-0,52***	-1.56***	-1.30***	-0,54***
	(0.43)	(0.34)	(0,09)	(0.43)	(0.35)	(0,09)
Constant	-1.65***	-1.51***		-1.64***	-1.53***	
	(0.53)	(0.50)		(0.53)	(0.49)	
Observations		112				
Log Likelihood Full		-114.7			-112.9	
Wald test full model		(16)61.0***			(16)60.3***	
ρ		0.61			0.65	
Wald Test for ρ=0		(1)13.6820***			(1)15.1764***	

Notes: Robust standard errors in parentheses; ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; degrees of freedom for X^2 test in square brackets; Mg.Effect: Marginal effects.
Source: Author

Annex 1: Variables included in the analysis, by adoption of joint learning strategies[1]

Variable	Freq.	Mean	S.D.	Description
train04	0=0; 1=55	1	--	1 if the firm provided training to its employees in 2004; 0 otherwise.
tr_internal	0=8; 1=47	0.85	--	1 if training is provided by colleagues in-house; 0 otherwise
external_tr	0=6; 1=49	0.89	--	1 if the firm provides training through external providers (public universities, private universities, other firms, consultants or the industry's trade organization); 0 otherwise.
Internal_external_tr	1=6; 2=8; 3=41	2.64	0.68	1 if the firm provides internal training; 2 if the firm provides external training; 3 if the firm provides both internal and external training; 0 otherwise.
training_pubuniv	0= ;1=			1 if external training was provided by a public university; 0 otherwise
training_priuniv	0= ;1=			1 if external training was provided by a private university; 0 otherwise
training_firm	0= ;1=			1 if external training was provided by another firm; 0 otherwise
training_tradeorg	0= ;1=			1 if external training was provided by a training centre linked to a trade organization; 0 otherwise
training_freelance	0= ;1=			1 if external training was provided by an individual consultant; 0 otherwise
training_sup_mach	0= ;1=			1 if external training was provided by a supplier of machinery & equipment; 0 otherwise
imp_empowerment	0=29; 1=20; 2=6	0.58	0.68	1 if the firm incorporates workers in decision-making but the practice is not important; 2 if the practice is important; 0 if workers do not take part in decision-making
union	0=; 1=			1 If the firm reports a labour union in-house; 0 otherwise
use_empower	0=29; 1=26	0.47	0.50	1 if the firm incorporates workers in decision-making; 0 otherwise
pow_union	0=36; 1=19	0.34	0.48	1 If the firm incorporates workers in decision-making and there is a labour union in-house; 0 otherwise.
rem_size	--	6.98	2.81	Average remuneration per worker representing total remuneration (salaries and benefits) paid in 2004 by average total employment during the same year. Variable normalized by applying a natural logarithm transformation[2] and expressed in terms of a firm's size.
avgwage_size	--	6.51	2.67	Average salaries per worker paid in 2004 by average total employment during the same year. Variable normalized by applying a natural logarithm transformation[2] and expressed in terms of a firm's size.
remhour_size	--	1.97	1.58	Average remuneration per hour paid in 2004. Variable normalized by applying a natural logarithm transformation[2] and expressed in terms of a firm's size.
wagehour_size	--	1.50	1.51	Average salaries per hour paid in 2004. Variable normalized by applying a natural logarithm transformation[2] and expressed in terms of a firm's size.
use_rotation	0=26; 1=29	0.53	--	1 if the firm uses employee rotation assignments; 0 otherwise
use_rotation_import	0=26; 1=5; 2=24	0.96	0.96	1 if the firm uses employee rotation but the practice is not important; 2 if the practice is important; 0 if workers do not take part in rotation assignments
rule_temprotation	0=27; 1=28	0.51	--	1 if the firm governs temporary employee rotation assignments (Regulation is through collective contract or other internal negotiations); 0 otherwise
temp_rot_cc	0=44; 1=11	0.20	--	1 if the firm reports that it governs rotation assignments for employees through collective contracts. 0 otherwise.
temp_rot_ir	0=34; 1=21	0.38	--	1 if the firm reports an internal regulation, other than collective contracts, to govern temporary rotation assignments for employees. 0 otherwise
rule_hiring	0=25; 1=30	0.54	--	1 if the firm governs staff hiring for permanent positions through collective contract or other internal procedures. 0 otherwise
hire_permwork_cc	0=42; 1=13	0.24	--	1 if the firm governs staff hiring for permanent positions through collective contracts. 0 otherwise
hire_permwork_ir	0=34; 1=21	0.38	--	1 if the firm governs staff hiring for permanent position through internal regulations. 0 otherwise
modern_practice	0=12; 1=43	0.78	--	1 if the firm reports the use of TQM and/or JIT practices; 0 otherwise
export_dummy	0=23; 1=32	0.58	--	Firms classified by exporting behaviour
fdi	0=42; 1=13	0.24	--	Firms classified by foreign ownership: 0= Domestic, 1=foreign
size_firm	1=66; 2=46	1.44	0.50	Size of the firm as defined by total employment; 1=small and medium sized (SME), 2=large

Notes: Variables in bold are those created by the authors based on the information from ENESTYC, 2005; 1. Firms in sample, 112. Difference denotes the number of firms adopting a single learning strategy; 2. The logarithmic transformation was calculated only for firms reporting employment and alaries. S.D. Standard deviation
Source: Author

Annex 2: Correlation analysis of explanatory and control variables included in the analysis

		1	2	3	4	5	6	7	8	9	10	11	12
1	train04	1											
2	training_internal	**0.66**	1										
3	external_training	**0.60**	**0.30**	1									
4	avgwage_size	0.12	**0.27**	**0.27**	1								
5	remhour_size	0.14	0.21	0.22	**0.82**	1							
6	wagehour_size	0.13	0.19	0.21	**0.79**	**0.99**	1						
7	imp_empowerment	0.16	0.09	0.11	0.13	0.02	0.02	1					
8	use_empower	0.15	0.05	0.11	0.05	-0.03	-0.03	**0.91**	1				
9	pow_union	0.20	0.15	0.19	0.12	0.09	0.09	**0.72**	**0.75**	1			
10	use_rotation	0.20	0.08	0.16	-0.02	0.00	0.02	**0.54**	**0.63**	**0.55**	1		
11	use_rotation_import	0.18	0.06	0.13	-0.01	0.02	0.04	**0.56**	**0.66**	**0.57**	**0.96**	1	
12	temp_rot_cc	0.16	0.13	0.22	0.18	0.08	0.08	0.14	0.12	**0.27**	0.18	0.16	1
13	temp_rot_ir	0.18	0.13	-0.04	-0.18	-0.14	-0.14	0.15	0.22	0.00	**0.29**	**0.29**	-0.02
14	rule_temprotation	**0.25**	0.21	0.10	-0.01	-0.02	-0.03	**0.24**	**0.27**	0.15	**0.37**	**0.36**	**0.52**
15	rule_hiring	0.16	0.15	0.09	0.13	0.02	0.01	0.00	0.04	0.03	0.10	0.14	0.17
16	hire_permwork_cc	0.04	0.17	0.10	0.17	0.06	0.08	0.04	0.05	0.20	0.05	0.10	0.33
17	hire_permwork_ir	0.18	0.08	0.04	-0.10	-0.15	-0.16	-0.07	-0.02	-0.13	0.06	0.07	-0.02
18	modern_practice	**0.25**	0.14	0.12	-0.01	-0.06	-0.04	**0.44**	**0.51**	**0.36**	**0.53**	**0.53**	-0.07
19	export_dummy	0.14	**0.26**	0.12	**0.41**	**0.38**	**0.38**	0.09	0.09	0.12	0.02	0.05	-0.03
20	fdi	0.17	**0.26**	0.08	**0.48**	**0.42**	**0.40**	0.19	0.19	**0.28**	0.16	0.17	0.14
21	training_firm	**0.46**	0.19	**0.76**	**0.25**	0.21	0.21	0.11	0.09	0.18	0.14	0.13	**0.26**
22	training_freelance	**0.35**	**0.26**	**0.37**	0.13	0.07	0.08	0.14	0.15	0.17	0.20	0.19	0.23
23	training_priuniv	0.19	0.23	**0.31**	**0.38**	**0.40**	**0.38**	0.05	-0.02	-0.01	0.03	0.08	0.09
24	training_pubcent	0.16	0.24	**0.26**	0.14	0.12	0.11	0.06	0.09	0.12	0.06	0.06	0.16
25	training_pubuniv	0.14	0.09	0.24	0.15	0.20	0.19	-0.07	-0.11	0.00	-0.07	-0.03	0.14
26	training_sup_mach	**0.37**	**0.42**	**0.40**	0.11	0.06	0.06	0.16	0.11	0.26	0.15	0.20	0.26
27	training_tradeorg	0.21	0.11	**0.34**	0.13	0.08	0.07	0.11	0.09	0.18	0.16	0.13	0.10

	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
13	1														
14	**0.77**	1													
15	**0.46**	**0.48**	1												
16	0.06	0.19	**0.55**	1											
17	**0.51**	**0.38**	**0.73**	-0.03	1										
18	0.12	0.10	0.13	0.09	0.08	1									
19	-0.09	-0.06	0.06	0.01	-0.01	0.15	1								
20	-0.09	0.05	0.02	0.07	-0.13	0.19	**0.55**	1							
21	0.05	0.20	0.09	0.13	0.01	0.10	0.11	0.11	1						
22	0.19	0.29	**0.27**	0.09	0.19	0.17	**0.25**	0.14	**0.28**	1					
23	-0.09	0.04	0.09	0.14	-0.05	0.01	**0.33**	0.19	0.23	0.24	1				
24	-0.01	0.07	0.14	0.11	0.20	0.07	0.04	-0.05	0.15	**0.26**	0.10	1			
25	-0.12	-0.01	0.07	0.04	0.05	0.02	0.23	0.11	**0.26**	0.20	**0.52**	0.22	1		
26	0.00	0.13	0.08	0.10	0.04	0.21	0.19	0.02	**0.32**	**0.48**	0.21	**0.29**	0.18	1	
27	-0.15	-0.12	-0.23	-0.06	-0.19	0.11	0.10	0.04	0.15	0.14	0.12	0.17	0.17	0.23	1

Notes: Characters in bold indicate statistical significance at the 1 percent level
Source: Author

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