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The influence of human resource management practices on learning and innovation in developing countries: pharmaceutical firms in Mexico

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Abstract

A growing stream of literature attempts to understand the influence of human resource management practices on learning and innovation. Notwithstanding progress so far, development of a comprehensive theory on the issues involved is still at an early stage. This paper is a contribution in the context of developing countries. It examines the pertinence of exploring the intermediate processes linking management practices to innovation. More specifically, it looks at a number of practices underpinning learning by individuals involved in innovation. Such practices condition the working environments in which learning strategies adopted by firms take place. Analysis is supported by bivariate probit regression using survey data about pharmaceutical firms in Mexico. Results show that training, workers' involvement in decision making and, to a lesser extent, remuneration are practices conducive to learning and innovation.

Keywords: Learning and innovation; human resource management; Mexico
JEL codes: O31, O32, O54

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1. Introduction

Innovation is an interactive process of knowledge-creation, diffusion and use (Lundvall, 1992; Nelson, 1993). Knowledge is generally understood as the accumulated structure of ideas, theories, experiences and practices that provide individuals, organizations and society at large with understanding of or give meaning to them and their environment. Learning involves a passive dimension, in which specific responses emerge through engaging in activities unrelated to learning itself and where causality is not understood. It also involves an active dimension underpinning discovery of underlying reasons beyond events, formulation of mental maps and integration of new constructs into existing cognitive structures (Polanyi, 1966).

Firms are at the core of systems of innovation (Nelson and Winter, 1982). As such, they must develop competencies in product design and production, overall management and assessment of consumer needs and linkages to up- and down-stream suppliers and distributors (Lundvall, 1992). They must search, develop R&D routines and further engage in the learning processes for innovation (Dosi, Freeman *et al.*, 1994). Innovation rests on a given set, or endowment, of material resources, human skills and relevant knowledge but also on the way these are organized and co-ordinated in pursuit of firms' strategic goals (Barney, 1991; Leonard-Barton, 1992).[1] Those factors condition the multiple directions in which information and knowledge flows feed, back and forth, across production, marketing and sales. Notably, they condition the performance of R&D (Lundvall, 1988 and 1992). Furthermore, they influence the type and strength of interactions and learning activities that firms establish with other agents in the environment (Lundvall, 1992; Laursen and Salter, 2004). Learning about firms' internal organization and work practices is vital to understand the functioning of systems of innovation (Nelson, 1991; Coriat and Weinstein, 2002).

In this context, recent contributions to the literature on innovation and management of innovation, suggest that human resource management practices could explain diversity in learning and innovation performances between firms, sectors of economic activity or, even, countries (Lorenz and Wilkinson, 2003). However, consistent theoretical,

[1] There is the possibility for these same factors to become a handicap, as core rigidities, that firms need to overcome in order to confront new challenges or carry out new projects (Leonard-Barton, 1992).

empirical and comparative work on these matters is still at an early stage (Hemmert, 1998; Lorenz and Wilkinson, 2003). A major challenge remains the need to explain the mechanisms whereby human resource management practices influence innovation (Delery, 1998; Laursen and Foss, 2003). Existing literature hints at ways to address this issue. As asserted by Amabile (1996b and a), Mumford (2000) and James (2002), research could further explore factors underpinning creativity and the ways in which creative thinking spreads across groups, organizations and the wider environment in which firms operate. Alternatively, recent work by Lorenz and Valeyre (2005) and Arundel, Lorenz *et al.* (2007) on organizational and management practices and learning and innovation, suggest the pertinence to examine more careful the relationship between management practices and individuals' learning. In this regard, Zanko and Couchman (1998) assert that developing countries offer interesting opportunities for research.

This paper, therefore, expects to further understanding of the influence of human resource management practices on learning and innovation in the case of developing countries. To do so, it identifies some learning strategies followed by pharmaceutical firms in Mexico. Alternative decisions are between internal development and/or external acquisition of technology and knowledge. It, then, inquires about the human resource management practices that underpin the choice of specific learning strategies and how this is done. Section 2 discusses learning from alternative organizational and individual perspectives. This sets the framework to understand the importance of individuals' learning for the functioning of organizations. Section 3 consists of two parts. The first introduces lessons from recent studies on human resource management and innovation. The second examines specific practices conditioning individuals' learning, while characterizing management styles in a country such as Mexico. The discussion leads to a series of hypotheses to be tested during the empirical analysis. Section 4 describes the pharmaceutical industry in Mexico. Section 5 describes the data used in this paper. Section 6 discusses the research strategy used in this paper. Section 7 contains empirical results. Conclusions are presented in section 8.

2. Survey of the literature on learning and management

Organizational learning

Economics literature often depicts organizations as systems that process information in order to make the appropriate decision in light of uncertainty (Casson, 1990; Nonaka, 1994; Nonaka and Takeuchi, 1995). Neoclassical theories of the firm see knowledge creation as an input-output problem-solving activity, which merely requires adequate processing to yield unambiguous solutions. However, Nonaka (1994) points out that this approach not only underestimates the nature of the activity at stake but excludes the possibility of explaining the potential of firms to create new information and knowledge. Furthermore, to conceptualize organizations as mere information processing entities assumes uniformity in the learning processes across them, which is not the case.

Organizations have cognitive structures and memories. Over time, they develop specific types of behaviours and mental representations that perpetuate their social patterns. Nelson and Winter (1982) and Kay (2000) argue that organizational knowledge or competencies become embedded in organizational routines, which act as organizational memory. These mental representations, or routines, influence individuals' learning within the organization and transmit organizational heritage to new personnel. Organizations can know less than the aggregation of its members if there is little or poor communication between its members.

Kessler, Bierly *et al.*, (2000), Bierly and Chakrabarti (1996) and Zack (1999) point out that organizational learning always involves choices regarding internal and external learning, as firms often need to decide whether to develop their own knowledge or acquire and/or imitate that of others. The main reason to develop internal sources 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. The rationale underlying the notion of absorptive capacity is that the more objects, patterns and concepts stored in the organizational memory, the more readily is new information about these constructs acquired and the easier it is to use them in new settings. This is because learning often takes place through association with patterns, situations or events already

recorded in organizational memory. 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 are not limited to other organizations. They include external publications, universities, research institutes, government agencies, consultants and professional and personal networks. Moreover, Kim, (1998 and 2000) develop an international dimension to this argument, by pointing out that external knowledge acquisition and imitation can also function across and connect national systems of innovation.

Individuals' learning

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; Nonaka, 1994; Nonaka and Takeuchi, 1995). 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).

The literature on cognitive and behavioural sciences points out that individual learning involves a process of continuous creation, destruction and recreation of cognitive structures (Fiol and Lyles, 1985; Fiol, 1994; Ambrosini and Bowman, 2001). Individuals scan the environment for information, select, prioritize and adapt what they find, interpret their findings and apply them to their existing cognitive structures (Lane and Lubatkin, 1998). Fiol, (1994) points out that this process need not be conscious or intentional and does not necessarily immediately modify behaviour. Rather, it leads to new interpretations or meaning of available information. A comparison of different interpretations takes place until a new understanding of the issues at stake is achieved. All dimensions of learning feed on each other and result in a series of loops and

interactions that are difficult to explain by individuals within organizations but clearly take place.

Vinding (2006) suggests that the extent, level and quality of knowledge available in organizations' personnel are positively correlated with the size of the stock of knowledge feeding organizational learning. This, in turn allows for better judgement as to the search for and selection and analysis of even newer internal and external information. Education is one of the key inputs for building individuals' expertise, some of which can be codified into articles, books, drawings or other forms of storable figurative communication. Yet good education is not sufficient to build an advanced level of individual knowledge. Brusoni, (2002) and Loasby, (2002) assert that application of the principle of division of labour to knowledge results in specializations along disciplinary, functional or institutional lines, as well as emergence of scientific knowledge that has increased the productivity of knowledge and provided frameworks and focus for addressing a variety of issues. The more individuals advance in their areas of specialization the more the expertise they acquire and the larger their potential contribution to organizational knowledge. Cohen and Levinthal (1990) and Lundvall and Johnson (1994) expand the role of knowledge specialization by arguing that expertise involves not only substantive technical know-how but also entails where to find the necessary complementary knowledge, including knowing the source of relevant information.

Individuals' knowledge and learning skills can be substantially augmented by what Amabile (1997) calls "something extra", or creative thinking. Creativity is defined as the production of novel ideas in any domain and creative thinking refers to a cognitive style favourable to taking new perspectives on problems, an application of techniques (or 'heuristics') for the exploration of new cognitive pathways, and a working style conducive to persistent, energetic pursuit of one's work. Amabile, (1997) and Sternberg, O'Hara *et al.* (1997) allege that creativity requires being in the frontier of available knowledge, the combination of synthetic, analytical and practical abilities, independent thinking style, intense motivation and persistence in pursuing an idea, risk-taking personality and an environment conducive to exploration.

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; Nonaka, 1994; Nonaka and Takeuchi, 1995). 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 during their life and relates to the context in which these take place. The more diverse the experience the richer is the content of tacit knowledge. Nonaka (1994) and Nonaka and Takeuchi (1995) state that tacit knowledge involves cognitive structures, based on mental models that provide overall positive and normative perspective to actions and activities, as well as technical elements, based on know-how and practice under specific circumstances. Tacit knowledge is the "practical" is the 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 individual knowledge. Kim (1998) complements this view by pointing out that, in addition to motivation or, perhaps, a consequence of it, intensity of effort, or the amount of energy individuals use to solve problems, constitutes a major driver in the construction of meaning in organizations.

In sum, individuals are the beginning and a major source of organizational knowledge and learning. Through exploring issues, education and training, creative thinking, experiences and beliefs, expertise and relationships, intentions and freedoms and intensity of efforts, individuals contribute to learning and innovation in organizations. Building suitable working environments for all these processes to take place is therefore imperative for firms.

3. Management practices, learning and innovation

Innovation literature systematically explores the influence of human resource management practices on learning and innovation (Michie and Sheehan, 1999; Laursen and Mahnke, 2001; Doeringer, Lorenz *et al.*, 2003; Greenan, 2003; Laursen and Foss,

2003; Michie and Sheehan, 2003; Campos and Pina, 2004; Arundel, Lorenz *et al.*, 2007). Recent empirical work stems mostly from surveys of firms in developed countries. Enquiries include the impact of labour market deregulation and labour flexibility on innovation, together with the search for complementarities between human resource management practices underpinning innovation (Michie and Sheehan, 1999; Laursen and Foss, 2003; Michie and Sheehan, 2003). These studies suggest human resource management interventions are complementary and mutually reinforcing, to be used as part of coherent incentive systems (Michie and Sheehan, 1999, Laursen, 2003 #190). The more innovative the system of practices, the greater the likelihood a firm will both carry out and be productive in innovation. Consequently, "if firms adopt work practices in a complementary fashion, then empirical tests should consider the impacts of groups of practices rather than simply the effects of individual practices" (Ichniowski, Shaw *et al.*, 1997).

Based on the work by Laursen and Foss (2003), Chiesa, (1996), Datta, Guthrie *et al.* (2003) and Laursen and Mahnke (2001), the nature and corresponding influence of management practices may be contingent on firms' industry or sectoral affiliation, the characteristics, challenges and opportunities associated to the knowledge bases in which firms operate. Together with the peculiarities of innovation processes in a given industry, are likely to influence the linkages between management practices and innovation. Firms adopting different innovation strategies or operating in completely different sectors would benefit distinctly from adoption of even comparable management practices.

A relevant conclusion from the previous studies is the absence of a comprehensive theory to explain why and how management practices bear on innovation performance (Laursen and Foss, 2003). Therefore, research should shed light on the mechanisms through which human resource management practices influence organizational resources and, in turn, firms performance (Delery, 1998). This paper contends that one such mechanism is learning by individuals involved in innovation.

Management practices

This Section identifies some human resource management practices conditioning individuals' and, therefore, organizational learning. Relevant interventions include training, compensation or remuneration, workers' participation in decision-making processes, rotation programmes and management-worker communication through, for example, trade union organizations. Analysis of the characteristics of such practices in Mexico is the basis for the empirical analysis in this paper.

Training

Training supports development of technical skills but also managerial and interpersonal skills for planning, decision making, organizational development and the like (Sparkes and Miyake, 2000; Barton and Delbridge, 2001). In practice, training goes beyond formal knowledge acquisition to include reflection on learning and learning through problem-solving (Gray, Cundell *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-producer organizations (Casas, 2001; Okada, 2004). Studies on Mexico and other Latin American countries document the importance of training in addressing motivational problems affecting blue-collar workers facing extremely low levels of education and limited development opportunities (Colmenares, 1992; García, 2002). Frequent problems result, however, from poor formalization of training structures, mismatches between training and promotion, enhanced independence, authority and responsibility (Domínguez and Brown, 1998; 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; Carrillo and Ramirez, 1997; García, 2002; Islas, 2003). Training is the main factor linking firms with knowledge-producer institutions such as universities and public research centres in Mexico (Casas, 2001). One would expect positive, significant impact on learning and innovation from internal and external training.

Compensation

The type of incentives and how they are administered condition diverse motivational styles and, thereby, attitudes towards work (Badawy, 1988; Florida and Goodnight, 2005). The customary recommendation from the literature is to provide a mix of both

intrinsic rewards -such as greater autonomy, additional developmental opportunities and public recognition-and extrinsic ones –such as pay increases and promotions (Mumford, 2000; James, 2002). Countries such as Mexico are characterized by tight markets for skilled-labour and reliance on wage contention policies to keep inflation in check and underpin industrial competitiveness. In addition, studies in the case of the maquiladora industry have shown that high turn-over rates for people at different hierarchy levels in Mexico constitute a major obstacle to improved firm performance (Forest, 1994; Sargent and Matthews, 1997). It may hamper the success of training programs for example. Consequently, compensation mechanisms become instrumental to attract, motivate and retain personnel (Flynn, 1994; Stephens and Greer, 1995; Abramo, 1997; Dussel, 2003). As Forest (1994) argues, adequate individual rewards would motivate Mexican workers to excel in their jobs. In Mexico the concept of payment per-hour is seldom provided and even faces serious constraints under both local labour laws and customary union practices, hence setting monthly remunerations is the usual practice (Flynn, 1994; Sargent and Matthews, 1997; Samstad and Pipkin, 2005). Compensation packages usually include something more than nominal salaries. Non-pecuniary often 'status enhancing' perks are highly appreciated particularly at higher levels of responsibility and skills (Flynn, 1994; Stephens and Greer, 1995). One would expect progressive compensation levels to have positive effects on individuals' learning.

Empowerment

Notable among innovative human resource management practices is decentralisation of both decision-making and problem-solving rights (Zanko, Couchman *et al.*, 1998; Laursen and Foss, 2003). Whenever decision-making flows down together with relevant knowledge, tools and incentives, it opens up possibilities for individuals to influence and participate in the design and operation of work environments, to adapt or respond to emerging challenges and opportunities for innovation (Lipsey and Carlaw, 1998; Zanko, Couchman *et al.*, 1998; Mumford, 2000). In this context, available literature points out that, in general, labour relations in Mexico are highly hierarchical (Carrillo and Ramirez, 1997; García, 2002). Power flows top-down, based on paternalism, links of trust and loyalty between workers and immediate supervisors (Forest, 1994; Schuler, Jackson *et al.*, 1996; Muller and Rowell, 1997). Delegation of responsibility is limited to particular tasks, often without decision-making authority and resistance to follow-up and control (Martínez and Dorfman, 1998). Notwithstanding this, some studies

document successful empowerment experiences, particularly in contexts other than maquiladoras. Difficulties for Mexican workers to assume higher responsibilities and more importantly, to participate actively in organizational or technical change stem from their low qualifications and education attainments (Abramo, 1997). Stephens and Greer (1995) and 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, they show strong work ethics and openness to long journeys, assume extraordinary responsibilities and the like. The expectation, therefore, is that workers' involvement in decision-making would have a positive impact on learning.

Rotation assignments

Following traditional Japanese organizational practices, management literature identifies rotation assignments as suitable to promote knowledge diffusion within firms (Mumford, 2000; Laursen and Foss, 2003). By putting staff in contact with the broader organization, rotation practices are expected to support programme development and implementation, provide group interaction and minimize friction and conflict (Mumford, 2000; Laursen and Foss, 2003). They also enhance coordination across multiple tasks and understanding of problems faced by other colleagues (Laursen and Foss, 2003). In this context, however, empirical research in the context of Mexico and other Latin American countries suggests rotation assignments can have opposite effects on firms' performance. For example, a survey on metalwork and food industries in Latin America Abramo (1997), documented that, although widely diffused across industries in the region, the practice is seldom accompanied by wage increases, changes in the time supervisors established for experienced workers to complete similar tasks or, well designed training and retention programmes. Consequently, it intensifies job responsibilities, work-related diseases and job dissatisfaction (Abramo, 1997). García (2002) commented on similar problems in the case of a General Motors plant in Mexico City. He argued that rotation is frequently hindered by strict job descriptions and task specialization associated with assembly processes. Strict standardization of jobs, processes, inputs, behaviours and outputs reduce workers mobility and flexibility, thereby hindering learning processes (Jones, 1996). We expect our empirical analysis to shed light on this divergence in the literature.

4. Pharmaceutical industry in Mexico

Mexico ranks among the top ten pharmaceutical markets in the world and second in Latin America. Local market dynamics are reflected in private retail sales of some US$8.7 billion. Annual growth rates have reached 6.0-8.0 per cent (IMS-Health). 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 (Katz, Burachik *et al.*, 1997; Guzmán, 2005). It has some relatively attractive facilities for new drug development and basic research, particularly in public research institutions. However, activities in those areas remain limited. The country's contribution to pharmaceutical innovation is more evident during clinical trials or during manufacturing, marketing and product life-cycle support of existing products (Jungmittag, Reger *et al.*, 2000; Guzmán and Viniegra, 2005; Santiago-Rodriguez, 2008). Innovations are incremental, in the shape of new formulations, improved processes and product quality enhancements (Secretaría de Salud, 2005).

Local industry investments average US$150 million annually in plant modernization, technological upgrading and clinical research (AMIIF, 2005). The industry is characterized by labour specialization requirements and higher salaries than others in the country. International organizations specialized in studies of work environment and job satisfaction systematically place pharmaceutical firms among the best places to work in Mexico (GPWI). This has been the case over the last five to six years.

Global multinationals dominate the local market. They are the more dynamic enterprises in terms of investment, technological and research performance (Katz, Burachik *et al.*, 1997; Guzmán and Viniegra, 2005). Multinationals manufacture and export finished products with quality and safety standards comparable to developed countries. Locally, they concentrate on the more lucrative private retail market. However, production scales may be much lower. By contrast, local firms focus on manufacturing of generic drugs and depend strongly on sales to the public health sector (Dussel, 1999). There is however, a clearly identified segment of very dynamic domestic firms including Probiomed®, Bioclon/Laboratorios Silanes™ and Laboratorios Sophia™. As generics manufacturers they have slowly developed the ability to perform basic research,

particularly, by incorporating modern biotechnology techniques. More importantly, their growth strategies rest on more systematic innovative efforts.

These considerations seem to corroborate Cimoli (2002)'s view of Mexico as an internationally competitive "modernized assembly factory". The fairly complex structure of the pharmaceutical industry in Mexico and that of other larger Latin American countries raises questions about the capacity of local markets and, particularly, domestic firms, to strengthen further their technological efforts (Katz *et al* 1997). To what extent does the structure and operation of the industry contribute to develop further the base of human resources for innovation in the country? The insufficiency or inadequacy of this factor remains a major shortcoming for local firms (Guzmán, 2005).

5. Data and variables definition

Data used in this paper come from the National Survey of Employment, Salaries, Technology and Training[2] (ENESTyC). This is a survey carried out by the National Institute for Statistics, Geography and Informatics, (INEGI) [3] on behalf of the Department of Labour, Mexico[4]. ENESTYC is representative at the national level and builds on a stratified sample of manufacturing establishments in Mexico. Stratification is based on size as measured by total employment. Firms with 100 or more employees are all included plus a random sample of those with less than 100 employees. There are no fixed time frames to run the survey, though six waves have been carried out so far: 1988, 1992, 1995, 1999, 2001 and 2005. We used data from the event 2005[5]. The module for the pharmaceutical industry (NASCI code 3254) includes 141 establishments, representative of 388 establishments in total. Our effective sample without missing values is 112 establishments. Table 1 provides descriptive statistics about the industry.

[2] *Encuesta Nacional de Empleo, Salarios, Tecnología y Capacitación.*
[3] *Instituto Nacional de Estadística, Geografía e Informática.*
[4] *Secretaría del Trabajo y Previsión Social.*
[5] The latest publicly available edition of the ENESTYC corresponds to the event 2001. With a previous authorization and commitment to observe all confidentiality requirements by INEGI, we processed preliminary data for the event 2005, with information for 2004.

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[3]	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[2]	31.7	18.8	0	74

Notes: 1. Standard Deviation. 2. Difference between the year in which a firm started operations in current business and year of collection of the survey, 2004; 3. Thousand Mexican pesos. For more detailed definitions of R&D variables and external knowledge sources, see Section 5.1 below.
Source: Authors, with information from ENESTYC, 2005, INEGI

The dependent variable

Construction of the dependent variable follows an already well established literature on internal *vs* external acquisition of technology. For instance Veugelers (1999) and (Cassiman and Veugelers, 2006) analyses on innovation strategies by Belgium manufacturing firms departs from traditional transaction cost theory for which choices of internal and external sources of technology are mutually exclusive (Williamson, 1975 and 1985). The authors challenge this notion by bringing in two ideas from the literature. On the one hand, development of technological capabilities in-house may give firms substantial bargaining and exchange powers in external technology markets. On the other, firms need to build adequate 'absorptive capacity' in order to screen the market and properly exploit newly acquired technologies (Cohen and Levinthal, 1990). This suggests the potential to treat internal and external innovation strategies as complementary or, at least, as non-mutually exclusive. Piga and Vivarelly (2004) and Catozzella and Vivarelli (2007) exemplify work along similar lines in the case of Italian manufacturing firms. Shiu-Wang and Ruei-Hung, (2008) offer evidence in the cases of Japan, the Republic of Korea and the Taiwan Province.

In a recent paper, Zúñiga, Guzmán *et al.* (2007) applied a framework similar to the one in (Cassiman and Veugelers, 2006) to study strategies underpinning technology acquisition by pharmaceutical firms in Mexico. In particular, they looked at in-house R&D and technology transfer behaviours of the industry between 1994 and 2000. The analysis built on data from a national manufacturing census and is, therefore, fairly similar to that used in this paper[6]. Some conclusions stemming from the study include:

[6] The first waves of the ENESTYC were embedded within the manufacturing census.

- Internal and external learning strategies are perceived as exogenous in the Mexican industry. Technology purchases have a marginal effect on corporate R&D investment decisions. In-house R&D has little influence on external acquisition of technology.

- The low probability of complementarities may be explained by two divergent technological objectives pursued by firms. Market exposure, through exports for example, drives R&D. By contrast, external procurement of technology responds to the search for increased productivity, capital intensity and company size. Nevertheless, the authors claim that international diversification, for instance through exports, may, in fact, underpin adoption of complementary learning strategies.

Difficulties to extract more concise conclusions about complementarity between learning strategies reflects, to a large extent, inherent limitations of the information available from official sources. Data only allow performance of indirect tests of complementarity. More definite conclusions should be based on more direct tests requiring finer gradations of dependent variables[7].

From the above, two options of learning strategies by pharmaceutical firms can be distinguished: internal and external. The former implies that firms carry out R&D in-house and develop their own technology. In the terminology used by Miravete and Pernias (2006), the indicators in this paper capture demand enhancing innovation: design of new products and/or cost-reducing process innovation: design of machinery and equipment for own use. These two activities shape firms' internal learning strategies. This definition in terms of novelty is a finer distinction as compared with

[7] Research on methodologies to test for complementarities among several aspects of innovation includes theoretical papers as in Athey and Stern (1998) and Lokshin, Carree *et al.* (2004). Empirical work is found in Greenan (2003); Laursen and Foss (2003); Piga and Vivarelli (2004); Mohnen and Roller (2005); Cassiman and Veugelers (2006); Miravete and Pernias (2006) and Cattozzella and Vivarelli (2007). At least two approaches are available to test for complementarity. The "direct" one is based on a productivity function of innovation (Athey and Stern, 1998). In this case, an indicator of performance is regressed on a number of explanatory variables. In general, such approaches have developed for models in which dependent variables are continuous. Alternative models for categorical variables, such as those in Miravete and Pernias (2006) or in Cattozzella and Vivarelli (2007), impose strong data and computing requirements that face considerable limitations for relatively small datasets. An alternative is to perform "indirect", and somehow weaker, tests for complementarity based on the notion of clustering (Athey and Stern, 1998). This eliminates the need to find proper performance indicators (Cattozzella and Vivarelli, 2007).

Zúñiga, Guzmán *et al.* (2007), as they only accounted for performance of R&D in a generic form.

Alternatively, the external strategy denotes that firms can obtain technology from external markets by means of: purchase of technology packages, acquisition of machinery and equipment, hiring consultant firms, accessing specialized literature. In addition, firms may carry out R&D in partnership with other agents (Cassiman and Veugelers, 2006). A firm is an active learner whenever it pursues at least one of them. Internal and external strategies can be deployed together.

Tables 1 and 2 summarize the characteristics and the learning strategies, respectively, of pharmaceutical firms in Mexico. Table 2 also describes the corresponding indicators available from ENESTYC. A large share of firms claimed to perform R&D in-house (62.5 per cent), while those active in external knowledge markets were similar (56.3 per cent). Distribution by specific sources of external knowledge is fairly diversified. Yet, specialized literature seems the most important: 33.0 per cent. Internal and external learning strategies are positively and significantly correlated: 0.51. A similar situation exists in the case of different external knowledge sources.

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
1. *INTERNAL: In-house R&D*	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 products	1 if firms declare the goal of R&D in house is to design new products	69 (61.6%)	0.98*	1		0.47*						
1.2 Design new machinery & equipment for own use	1 if firms declare the goal of R&D in house is to create new machinery & equipment for own use; 0 otherwise; this is process innovation	21 (18.8%)	0.37*	0.33*	1	0.33*						
2. *EXTERNAL: Knowledge acquisition from external markets*	1 if firms acquire technology through at least one of the following forms of contact with external agents. 0 otherwise:	63 (56.3%)	**0.51***			1						
2.1 Technology packages	1 if firms acquire packaged technology. 0 otherwise	30 (26.8%)	0.34*			0.53*	1					
2.2 Consultant	1 if firms hire consultants. 0 otherwise	28 (25.0%)	0.23			0.51*	0.68*	1				
2.3 Literature	1 if firms access specialized literature in their field; 0 otherwise	37 (33.0%)	0.43*			0.62*	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 features of the industry; 0 otherwise	9 (8.0%)	0.09			0.26*	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			0.35*	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*			0.52*	0.29*	0.22*	0.19	0.35	0.43	1

*Notes: * Different from zero at 1% level of significance*
Source: Authors based on data from ENESTYC, 2005, INEGI

Table 3 reveals a significant number of firms pursuing internal and external learning strategies (47.3 per cent). About 15.2 per cent choose internal only, while 8.9 per cent choose an external only strategy. Some 28.6 per cent of firms pursue neither of these strategies. Clustering among strategies implies that doing more of one increases the expected return on the other (Cattozzella and Vivarelli, 2007).

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

	External sources		
Internal sources	No	Yes	Total
No	32 (28.5)	10 (8.9)	42 (37.5)
Yes	17 (15.2)	53 (47.3)	70 (62.5)
Total	49 (43.8)	63 (56.3)	112 (100.0)
		Pearson $X^2(1) = 28.7371$***	

Notes: Categories are exclusive; sample includes only firms without missing values for all variables included in the analysis; *** significant at 1% level of confidence; percentage share of each cell relative to total firms in sample within parenthesis
Source: Authors, with information from ENESTYC, 2005

Explanatory variables

This paper explores an assumed intermediate link between human resource management and innovation, individual learning. Screening of ENESTYC, 2005 in search for practical definitions of the variables described in Section 3.1 began by identifying and classifying management practices into several groups according to the literature: training, remuneration, empowerment, rotation and the like (Jones, 1996; Mumford, 2000). We excluded variables with correlations equal or larger than ± 0.5 . Table 4 presents the main explanatory and control variables included in the analysis.

Control variables

Studies in alternative contexts -for instance, Lundvall and Valeyre (2007) in the case of Europe, OECD (1998) for the larger OECD area and Kaplinsky (1995) for developing countries- document the interrelation between modern management practices and specific organizational strategies adopted by firms. Such practices shape distinct environments in which learning by individuals, firms and even countries takes place (Arundel, Lorenz *et al.*, 2007). The variable *mod_pract1* indicates that the firm uses just-in-time and/or total quality management practices. The indicator made it possible to overcome high and positive correlations between the individual variables on just-in-time or total quality management and

indicators on empowerment or rotation[8]. Alternative definitions were also considered in subsequent stages. In the interest of space, they are described in Annex 1. Correlations for the whole set of variables appear in Table 5.

Table 4. Explanatory and control variables included in the analysis*

Variable	Number of firms without missing values =112		Description
	Learning strategy		
	Internal	External	
Explanatory human resource management practices			
Train04	67	60	1 if the firm provided training to its employees in 2004; 0 otherwise.
Ln_avg_rem**	4.85	4.80	Average remuneration per worker representing total remuneration (salaries and benefits) paid in 2004 divided by average total employment during the same year; variable normalized by applying a natural logarithm transformation[1]
Empower2	1=7 2=23	1=7 2=23	1 if the firm incorporates workers in decision making and it declares that the practice is important; 2 if the practice is not important; 0 if workers do not take part in decision making
Temprot	30	33	1 if the firm possesses precise regulations about temporary employee rotation assignments (Regulation may be set by collective contract or other internal negotiations); 0 otherwise
Control Variables			
Mod_pract1	50	49	1 if the firm reports the use of total quality management and/or just-in-time organizational practices irrespective of actual importance; 0 otherwise
Exptsize2	1=23 2=20	1=16 2=18	Firms classified by exporting behaviour and size. 1=large, 2=small and medium sized (SME)
Fdisize2	1=16 2=4	1=10 2=5	Firms classified by size and foreign ownership: 1=large, 2=SME

*Additional variables used in subsequent stages of the analysis are reported in Annex 1. **Refers to the minimum and maximum average wage in MX$1000. 1. The transformation may be undefined for firms declaring employment but failing to report information on salaries. In order to solve this problem, Mairesse and Mohnen (2004) advise that replacing shares equal to 0 by 0.01 and 1 by 0.99 does not hamper model estimates.

[8] Models including either just-in-time or total quality management were tested without significant changes in the results.

Table 5. Correlations between variables included in the analysis

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	**train04**	1																								
2	**tr_pubuniv**	0.14	1																							
3	**tr_priuniv**	0.19	0.52	1																						
4	**tr_firm**	0.46	0.26	0.23	1																					
5	**tr_tradeorg**	0.21	0.17	0.12	0.15	1																				
6	**tr_freelance**	0.35	0.20	0.24	0.28	0.14	1																			
7	**tr_sup_mach**	0.37	0.18	0.21	0.32	0.23	0.48	1																		
8	**tr_internal**	0.66	0.09	0.23	0.19	0.11	0.26	0.42	1																	
9	**external_tr**	0.60	0.24	0.31	0.76	0.34	0.37	0.40	0.30	1																
10	**wagecat**	0.08	0.08	0.21	0.10	-0.01	0.23	0.21	0.20	0.07	1															
11	**wages**	0.13	0.07	0.07	0.02	0.07	0.14	0.18	0.29	0.04	0.62	1														
12	**remun**	0.23	0.05	0.07	0.05	0.16	0.12	0.10	0.17	0.12	0.48	0.77	1													
13	**ln_avg_wage**	0.13	0.30	0.35	0.24	0.13	0.22	0.13	0.22	0.19	0.06	0.15	0.09	1												
14	**ln_avg_rem**	0.14	0.31	0.38	0.24	0.14	0.23	0.13	0.22	0.21	0.10	0.23	0.16	0.98	1											
15	**ln_hour_rem**	0.14	0.22	0.35	0.20	0.06	0.12	0.05	0.15	0.19	0.07	0.03	-0.07	0.73	0.74	1										
16	**ln_hour_wage**	0.13	0.20	0.33	0.20	0.05	0.11	0.05	0.15	0.18	0.04	-0.03	-0.12	0.75	0.73	0.99	1									
17	**empower2**	0.12	-0.12	-0.07	0.06	0.06	0.13	0.05	0.01	0.09	-0.07	-0.06	0.00	0.04	0.04	-0.03	-0.03	1								
18	**union1**	0.26	0.13	0.07	0.19	0.21	0.10	0.26	0.24	0.22	0.34	0.40	0.39	0.14	0.16	0.10	0.08	-0.16	1							
19	**pow_union**	0.20	0.00	-0.01	0.18	0.18	0.17	0.26	0.15	0.19	0.09	0.20	0.21	0.21	0.21	0.13	0.12	0.67	0.34	1						
20	**temp_rot_cc**	0.16	0.14	0.09	0.26	0.10	0.23	0.26	0.13	0.22	0.26	0.17	0.15	0.10	0.08	0.03	0.04	0.09	0.28	0.27	1					
21	**temp_rot_ir**	0.18	-0.12	-0.09	0.05	-0.15	0.19	0.00	0.13	-0.04	0.27	0.15	0.11	-0.16	-0.14	-0.07	-0.09	0.25	-0.16	0.00	-0.02	1				
22	**temprot**	0.25	-0.01	0.04	0.20	-0.12	0.29	-0.13	0.21	0.10	0.42	0.24	0.17	-0.06	-0.05	0.00	-0.01	0.26	0.00	0.15	0.52	-0.77	1			
23	**fdisize2**	0.13	0.09	0.09	0.02	0.00	0.08	-0.01	0.19	-0.02	0.08	0.24	0.21	0.38	0.40	0.35	0.34	0.15	0.15	0.23	-0.06	-0.05	-0.04	1		
24	**exptsize2**	0.12	0.20	0.19	0.01	0.11	0.20	0.19	0.18	0.05	-0.06	-0.12	0.09	0.42	0.45	-0.29	-0.27	0.07	-0.17	0.10	-0.11	-0.08	-0.12	0.44	1	
25	**mod_pract1**	0.25	0.02	0.01	0.10	0.11	0.17	0.21	0.14	0.12	-0.02	-0.03	0.04	0.15	0.14	-0.03	-0.01	0.49	-0.03	0.36	-0.07	0.12	0.10	0.18	0.14	1

For variables definitions, see Tables 3 and 4 and Annex 1

It is also necessary to control for capital origin and export behaviour of firms. These condition technological performances of the pharmaceutical industry in Mexico (Zúñiga, Guzmán *et al.*, 2007) and other Latin American countries (Katz, Burachik *et al.*, 1997; Dussel, 1999). From ENESTYC, these variables reveal positive correlations, in excess of 0.5, among themselves and with other indicators in the analysis, such as salaries. We normalized them with respect to the size of the firm. Hence, the paper incorporates the majority of variables used by Zúñiga, Guzmán *et al.* (2007).

6. Research strategy

The dependent variables in this paper are binary. When combined, they transform into a categorical variable on possible choices of learning strategy: internal only, external only and a combination of both internal and external strategies. A suitable econometric approach to deal with unordered categorical variables is multinomial logit analysis (Wooldridge, 2001; Greene, 2003). This implies estimation of a system of simultaneous binary equations of the form:

$$\text{Prob}(Y=j) = \ell^{Zi\delta j} / \sum_{k=1}^{4} \ell^{Zi\delta k} ;$$

$$j \in [\text{Noint-Noext}(0), \text{Internal}(1), \text{External}(2), \text{Internal\&External}(3)]$$

Zi, vector of characteristics –e.g. HRM practices; of firm i

We estimated a multinomial logit model featuring three alternative specifications[9]: First, model (I) with control variables only; then, model (II) including only explanatory variables and, finally, model (III) as the basic model including the full information set. Model (III) was statistically significant at the one percent confidence level. The computed log-likelihood ratio (-103.96) was greater than the critical value of the X^2 statistic at the one percent level of significance with 24 degrees of freedom. The value of the Cox and Snell R^2 was 0.435. Although the value of the Count R^2, 0.625, was rather modest, predicted probabilities fairly matched actual distribution of learning strategies in Table 3: internal only, 12.7 per cent, external only, 7.2 per cent, internal and external, 51.8 per cent; and any of the former strategies, 28.3 per cent. Larger deviations corresponded to the share of firms adopting an exclusively internal learning strategy or a combination of internal and external approaches. The values of both the Cox and Snell R^2 and the Count R^2 agreed with usually acceptable

[9] See Annex 2

values for qualitative dependent variable models in the context of innovation studies (Amara and Landry, 2005)

In spite of the appeal of these results, a major shortcoming of the approach stems from the suspected complementarity among learning strategies. This leads to violation of an implicit, but critical, assumption underpinning multinomial logit analysis: Independence of Irrelevance of Alternatives (IIA) (McFadden, 2000; Long and Freese, 2006). According to this assumption, all else being equal, the choice for a given alternative should be independent from the rest of the available choices. In the context of this paper, violation of IIA implies that adoption of an external only type of strategy may, for instance, be strongly influenced by the availability of internal only strategies and even more so, by combination of internal and external approaches. Although Zúñiga, Guzmán *et al.* (2007) suggest complementarity between learning strategies may not hold in the Mexican case, we have also expressed our reservations about such conclusion. Lack of proper data prevents performing more adequate tests for complementarities.

An alternative to overcome this shortcoming is to use bivariate probit analysis. As an extension of probit regression, it allows the running of two simultaneous equations with the expected correlation in their disturbance terms (Greene, 2003). In this study the dependent variables refer to in-house performance of R&D, *rdtype1e* and acquisition of technology through external sources, *ext*. The covariates are described in Sections 4.2 and 4.3.

y1* and y2* are latent variables, such that:

y1*= In-house R&D geared to obtain new product and/or processes
y2*= Acquisition of technology from external sources
M = Vector of management variables that influence the probability of choosing among learning strategies internal and external
X = Vector of industry characteristic variables that influence the probability of choosing among learning strategies
εi , νi = Vectors of disturbances
$y_1^* = \beta' M + u_1 X + \varepsilon i$, $F_{rdtype1e} = 1$, if $y_1^* > 0$, 0 otherwise
$y_2^* = \delta' M + u_2 X + \nu i$, $F_{ext} = 1$, if $y_2^* > 0$, 0 otherwise

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

Delery (1998) advises the use of multiple definitions of management practices to explore and take into account alternative ways in which such practices target staff in specific departments or activities. Therefore, the analysis has, first, identified a basic model featuring the variables of interest and, then, changed the information set 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 two goals: to explore the effect of alternative definitions of management practices and, check the robustness of the initial results.

7. Econometric results

Table 6 presents the results from the bivariate probit analysis. For comparison purposes it includes results from binary probit regressions for each specification, models (1) and (3). Models (1) and (2) include control variables only, while the full information set is depicted in models (3) and (4). The estimated coefficients from (1) and (3) are somewhat similar to those in the corresponding bivariate options. Nevertheless, the potential for unobserved characteristics leading to an overlap in the determinants of both *rdtype* and *ext* may result in undesirably biased results. This is confirmed by the values of ρ corresponding to models (2) and (4) respectively; they are positive and statistically significant at a 1 per cent confidence level. This supports adequacy of bivariate over binary specifications.

Table 6. Basic specification binary and bivariate probit models linking learning strategies to human resource management practices

	(1)		(2)		(3)		(4)	
	Binary		Bivariate		Binary		Bivariate	
Variables	**rdtype1e**	**ext**	**rdtype1e**	**ext**	**rdtype1e**	**ext**	**rdtype1e**	**ext**
train04					1.46***	0.74	1.40***	0.67
					(0.49)	(0.53)	(0.43)	(0.45)
ln_avg_rem					0.51**	0.32	0.47*	0.33
					(0.25)	(0.24)	(0.25)	(0.24)
empower2					0.48**	0.35*	0.49***	0.36*
					(0.19)	(0.18)	(0.18)	(0.19)
temprot					-0.48	0.3	-0.52*	0.31
					(0.29)	(0.28)	(0.30)	(0.29)
mod_pract1	0.41	0.83***	0.44*	0.85***	-0.16	0.43	-0.1	0.45
	(0.27)	(0.27)	(0.27)	(0.27)	(0.33)	(0.31)	(0.33)	(0.32)
fdisize2	-0.68***	-0.59***	-0.67***	-0.59***	-1.01***	-0.78***	-1.04***	-0.81***
	(0.25)	(0.21)	(0.25)	(0.20)	(0.27)	(0.24)	(0.28)	(0.23)
exptsize2	0.59***	0.25	0.57***	0.25	0.51**	0.21	0.55**	0.19
	(0.2)	(0.17)	(0.20)	(0.17)	(0.23)	(0.19)	(0.23)	(0.18)
Constant	-0.073	-0.34	-0.084	-0.34	-3.25***	-2.48**	-3.04***	-2.45**
	(0.23)	(0.24)	(0.23)	(0.24)	(1.2)	(1.14)	(1.15)	(1.11)
Observations					112			
Log Likelihood Full	-67.20	-69.25	-124.55		-57.48	-63.28	-111.04	
Wald test full model	(3)12.68***	(3)15.82***	(6)23.77***		(7)30.696***	(7)24.809***	(14)58.131***	
ρ			0.696 (0.102)				0.7015 (0.109)	
Wald Test for ρ=0			(1)19.05***				(1)16.50***	

Robust standard errors in parentheses. ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; degrees of freedom for X^2 test in parentheses before the actual value. For definitions of variables, see Table 4 and Appendix 1

Looking at results for the distinct learning strategies, one can see the relevance of the variables on human resource management, particularly for the performance of in-house R&D. Individual human resource management variables seem to capture the previous significance of the indicator of modern organizational practices. Identification of management practices whose effect and statistical significance are almost exclusive for a specific kind of strategy is in line with results from previous empirical studies, such as Piga and Vivarelli (2004) and Cassiman and Veugelers (2006). In the case of in-house R&D performance, it supports the notion that building adequate internal absorptive capacity is necessary to engage and, eventually, benefit from linkages with external knowledge producers (Cohen and Levinthal, 1989 and 1990). Organizational practices offer suitable mechanisms to do so.

Results for individual variables show the positive and statistically significant effect of training, together with workers' participation in decision-making processes. It would seem intriguing to find a low level of statistical significance in the variable on remuneration. Nevertheless, the literature hints as to how to read this finding. For instance, Terziovski and Morgan (2004) argue 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 support this conclusion, as it is coupled with poor research infrastructure. Unfortunately, since ENESTYC lacks information to explore this idea further, more detailed qualitative enquiries are required to provide more accurate conclusions.

The results in Table 6 support previous findings by Zúñiga, Guzmán *et al.* (2007). Foreign ownership tends to be negatively correlated with active learning behaviours. By contrast, exposure to international markets, through exports, underpins R&D investments by local industry. Scale effects are also taken into account, as exporting behaviour and capital origin are captured by the variables.

The adequacy of the bivariate specification is reflected in the predicted probabilities for specific outcomes. Table 7 shows probabilities for individual choices of learning strategies and conditional probabilities for joint approaches. Estimates are close to the actual distribution of choices in Table 3.

Table 7 Predicted probabilities for specific (combination of) choices for learning strategies[1]			
	External acquisition of technologies		
In-house R&D	No	Yes	Conditional on R&D
No	0.282 (0.226)	0.089 (0.079)	-----
Yes	0.149 (0.106)	0.479 (0.240)	0.735 (0.172)
Conditional on external	-----	0.808 (0.171)	

[1] Results in terms of percentages with respect to total firms in the sample; probabilities evaluated at variables mean values; robust standard errors in parentheses.

Marginal effects of management variables

A different way to look at results from basic model (4) is to compute marginal effects on specific outcomes associated with changes in a given explanatory variable. With the no-linearities involved in bivariate probit models, marginal effects depend on changes in the variable of interest as well as on levels assumed for all remaining variables in the equation. For binary variables, the only relevant change in probabilities is the movement from 0 to 1 and vice-versa. In the context of this study, that means going from non-adoption to adoption of a particular management practice. For continuous variables Christofides, Stengos *et al.* (1997) and Christofides, Hardin *et al.* (2000) suggest that changes can be evaluated in different magnitudes in relation to the mean, for instance, standard deviations or percentages. See also Long and Freese (2006). Remaining variables are computed at their mean value. Table 8 presents marginal effects for management variables in model (4).

Table 8 Marginal effects of variables in basic model (4) in Table 6.				
	Train04[a]	Ln_avg_rem	Empower2	Temprot[a]
In-house R&D	0.513*** (0.128)	0.170* (0.091)	0.177*** (0.066)	-0.189* (0.106)
Ext	0.262 (0.167)	0.130 (0.093)	0.140* (0.73)	0.120 (0.110)
Conditional				
RD given ext	0.426** (0.205)	0.83 (0.055)	0.085* (0.048)	-0.190*** (0.071)
Ext given R&D	-0.012 (0.192)	0.051 (0.790)	0.058 (0.066)	0.200** (0.087)

Robust standard errors in parentheses; ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; [a]Changes for discrete binary variables are from 0 to 1. For continuous variables changes are calculated at the mean value.

Table 8 confirms that provision of training and worker empowerment have positive effects on in-house R&D, as does training conditional on acquisition of external knowledge. This result is consistent with previous innovation studies in the context of developing countries which show that access to training from external knowledge providers may underpin improvements in firms' technological performances (Okada, 2004). That the empowerment variable reflects the importance of the practices for the organization, leads to the conclusion that by genuinely

opening to workers participation, firms can shape environments conducive to individuals and, thereby, organizational learning. The following sections explore some of these issues.

Exploring alternative definitions of management practices

Sections 7.2.1.-7.2.4. present results from alternative specifications of variables in model (4). The exercise included training, empowerment, remunerations and temporary rotation. Comparisons with model (4) should be considered with care, as shifting variables definitions means the models may not be directly comparable (Long and Freese, 2006). Nonetheless, the goal is to explore further the importance of management variables while shedding light on the robustness of previous results.

Alternative definitions of training

Table 9 presents alternative definitions of the training indicator. Following the studies by Laursen and Foss (2003) and Michie and Sheehan (1999and 2003) on management and innovation, model (5) distinguishes between internal and external provision of training. Casas (2001) points out that, in Mexico, training is probably one of the most important reasons for firms to interact with other agents in the environment. Innovation scholars extend the argument by noting that such interactions are contingent on the specific knowledge requirements of the firm (Cohen and Levinthal, 1990; Laursen and Salter, 2004). Models (6)-(11) identify different training providers: public or private universities, other firms, trade organizations, individual consultants and machinery suppliers. Models reported in Table 9 report positive and statistically significant values for ρ. This shows the adequacy of the bivariate probit models and confirms that the estimates from univariate decision specifications would be inefficient.

Table 9. Bivariate probit models featuring alternative definitions of training, by main provider

	(5)		(6)		(7)		(8)		(9)		(10)		(11)	
Variables	**rdtype1e**	**ext**	**rdtype1e**	**ext**	**rdtype1e**	**ext**	**rdtype1e**	**ext**	**rdtype1e**	**ext**	**rdtype1e**	**ext**	**rdtype1e**	**ext**
external_tr	0.77**	0.51												
	(0.31)	(0.31)												
tr_pubuniv			0.7	0.45										
			(0.49)	(0.43)										
tr_priuniv					0.46	-0.094								
					(0.36)	(0.33)								
tr_firm							0.35	-0.025						
							(0.29)	(0.28)						
tr_tradeorg									1.36***	0.51*				
									(0.38)	(0.3)				
tr_freelance											0.61**	0.54*		
											(0.29)	(0.29)		
tr_sup_mach													0.032	0.094
													(0.30)	(0.30)
tr_internal	0.57	0.083	0.85**	0.26	0.77**	0.27	0.74**	0.27	0.72**	0.20	0.73**	0.13	0.80**	0.20
	(0.35)	(0.35)	(0.35)	(0.35)	(0.35)	(0.35)	(0.35)	(0.34)	(0.35)	(0.33)	(0.34)	(0.35)	(0.37)	(0.38)
ln_avg_rem	0.34	0.26	0.37	0.27	0.35	0.35	0.37	0.33	0.37	0.29	0.35	0.26	0.43*	0.32
	(0.25)	(0.24)	(0.25)	(0.24)	(0.25)	(0.24)	(0.25)	(0.23)	(0.25)	(0.24)	(0.25)	(0.23)	(0.25)	(0.23)
empower2	0.49***	0.34*	0.57***	0.39**	0.52***	0.35*	0.50***	0.36**	0.53***	0.34*	0.51***	0.36*	0.51***	0.36**
	(0.18)	(0.19)	(0.19)	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)	(0.20)	(0.19)	(0.18)	(0.19)	(0.18)	(0.18)
temprot	-0.48*	0.37	-0.49*	0.34	-0.48	0.37	-0.50*	0.35	-0.31	0.44	-0.65**	0.22	-0.46	0.36
	(0.29)	(0.29)	(0.30)	(0.29)	(0.30)	(0.29)	(0.30)	(0.29)	(0.30)	(0.29)	(0.32)	(0.31)	(0.29)	(0.29)
mod_pract1	-0.052	0.51*	-0.031	0.5	-0.042	0.51*	-0.013	0.50*	-0.11	0.49	-0.035	0.50	-0.005	0.5
	(0.33)	(0.31)	(0.32)	(0.31)	(0.31)	(0.30)	(0.33)	(0.30)	(0.33)	(0.31)	(0.33)	(0.31)	(0.32)	(0.31)
fdisize2	-1.02***	-0.77***	-1.07***	-0.80***	-1.04***	-0.81***	-1.03***	-0.79***	-1.04***	-0.78***	-1.06***	-0.80***	-1.02***	-0.79***
	(0.26)	(0.24)	(0.27)	(0.23)	(0.27)	(0.23)	(0.26)	(0.23)	(0.30)	(0.24)	(0.25)	(0.24)	(0.26)	(0.23)
exptsize2	0.60***	0.21	0.52**	0.17	0.54**	0.19	0.56***	0.19	0.51**	0.19	0.53***	0.15	0.52**	0.18
	(0.21)	(0.18)	(0.21)	(0.18)	(0.21)	(0.18)	(0.20)	(0.18)	(0.23)	(0.18)	(0.20)	(0.18)	(0.21)	(0.18)
Constant	-2.28**	-2.04*	-2.14*	-1.89*	-1.99*	-2.21**	-2.20**	-2.11**	-2.23**	-2.01*	-2.07*	-1.84*	-2.37**	-2.08**
	(1.10)	(1.07)	(1.11)	(1.06)	(1.12)	(1.08)	(1.10)	(1.05)	(1.10)	(1.05)	(1.09)	(1.04)	(1.10)	(1.05)
Observations							112							
ρ	0.69		0.71		0.74		0.71		0.70		0.70		0.72	
Wald Test for ρ=0	(1)16.0***		(1)16.7***		(1)19.0***		(1)16.9***		(1)15.5***		(1)16.5***		(1)17.8***	

Robust standard errors in parentheses; ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; degrees of freedom for X^2 test in parentheses before the actual value; for definitions of variables, see Table 4 and Appendix 1

The differentiation of training in categories confirms the expectations about its importance for performance of internal learning strategies. However, the more interesting results arise from the distinction between different external training providers. Linkages with formal education institutions perform rather poorly. Firms should, therefore, rely strongly on their own domestic efforts. These results are in line with well documented difficulties to match interests between academic institutions and firms in countries such as Mexico. By contrast, relationships with local trade organizations and individual consultants seem to generate more positive results. Workers' empowerment continues to play a major role in support of internal learning strategies. It also tends to gain in importance whenever linkages with external training suppliers lack statistical significance. No major changes were found with regard to temporary rotation assignments.

Alternative definitions of workers' empowerment

Innovation scholars frequently test for the effect of labour relations on the probability of a firm being an innovator (Ichniowski, Shaw *et al.*, 1997; Michie and Sheehan, 1999and 2003). In practice, indicators include the existence of formal procedures to file grievances or frequency of strike actions. Evidence on the real impact of these practices, however, remains rather inconclusive. Unionization is a relevant practice in Mexico. It has been mandatory under local regulations and heavily influential on worker-employer relationships. In this regard, Abramo (1997) and García (2002) argue that local managers often recognize unions as major obstacles to implementing organizational and technical change. Communications and negotiations between these parties are poor. From the information available through ENESTYC, we constructed a dummy variable indicating the presence of such organizations inside firms. In addition, we investigated the impact of an interaction term between labour unions and workers' participation in the decision-making processes. Results appear in Table 9.

Positive and statistically significant tests on ρ different from zero suggest the adequacy of the bivariate probit specification and interrelation between learning strategies. Interestingly, results in model (12) suggest that the presence of labour unions *per se* does not influence learning activities. On the contrary, building sound interactions with local labour unions as a way to provide workers with opportunities to participate in decision-making may facilitate

learning and innovation. Training remains highly significant for in-house performance of R&D.

Table 10. Bivariate probit models with alternative indicators of workers empowerment

	(12)		(13)	
Variables	**rdtype1e**	**ext**	**rdtype1e**	**ext**
train04	1.21***	0.65	1.21***	0.52
	(0.43)	(0.43)	(0.40)	(0.42)
ln_avg_rem	0.43*	0.32	0.37	0.26
	(0.24)	(0.23)	(0.24)	(0.23)
union1	0.071	-0.16		
	(0.30)	(0.30)		
pow_union			0.75**	0.58*
			(0.35)	(0.33)
temprot	-0.32	0.43	-0.4	0.39
	(0.28)	(0.28)	(0.28)	(0.28)
mod_pract1	0.31	0.72**	0.13	0.61**
	(0.28)	(0.28)	(0.29)	(0.29)
fdisize2	-0.92***	-0.73***	-1.04***	-0.81***
	(0.29)	(0.21)	(0.27)	(0.22)
exptsize2	0.50**	0.18	0.56**	0.20
	(0.23)	(0.18)	(0.23)	(0.18)
Constant	-2.85***	-2.32**	-2.50**	-2.05*
	(1.09)	(1.09)	(1.12	(1.09)
Observations		112		
ρ	0.72 (0.10)		0.71 (0.11)	
Wald Test for ρ=0	(1)17.8***		(1)16.7***	

Robust standard errors in parentheses; ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; degrees of freedom for X^2 test in parentheses before the actual value; for definitions of variables, see Table 4 and Appendix 1

Alternative definitions of compensation practices

Table 11 reports results for alternative indicators on remuneration practices. Model (14) presents a more limited definition of compensation, as salaries but no benefits. Models (15) and (16) feature hypothetical variables on remuneration on a hourly basis. In the first case, it is the full remuneration package, comprising salary plus benefits and, in the second, only salaries. The existence of formal rules to set job descriptions, through collective contracts or other internal procedures, is reflected in model (17). In model (18), the new variable takes into account regulations applied to job descriptions and actual salary levels. Model (19) combines regulations for both salary levels and benefits paid by firms.

Table 11. Bivariate probit models featuring alternative definitions of compensation mechanisms for employees

	(14)		(15)		(16)		(17)		(18)		(19)	
Variables	rdtype1e	ext	rdtype1e	ext	rdtype1e	ext	rdtype1e	ext	rdtype1e	ext	rdtype1e	ext
train04	1.41***	0.68	1.35***	0.62	1.36***	0.64	1.41***	0.71	1.41***	0.7	1.48***	0.73
	(0.43)	(0.45)	(0.44)	(0.45)	(0.43)	(0.45)	(0.42)	(0.43)	(0.43)	(0.44)	(0.47)	(0.45)
ln_avg_wage	0.45*	0.28										
	(0.24)	(0.23)										
ln_hour_rem			0.30*	0.27								
			(0.18)	(0.17)								
ln_hour_wage					0.29*	0.24						
					(0.17)	(0.16)						
wagecat							0.13	0.31				
							(0.30)	(0.28)				
wages									-0.07	-0.05		
									(0.32)	(0.30)		
remun											-0.27	-0.15
											(0.37)	(0.34)
empower2	0.48***	0.36*	0.49***	0.36*	0.48***	0.36*	0.49**	0.39**	0.46**	0.35*	0.46**	0.35*
	(0.18)	(0.18)	(0.19)	(0.19)	(0.18)	(0.19)	(0.19)	(0.20)	(0.19)	(0.19)	(0.19)	(0.18)
temprot	-0.51*	0.31	-0.54*	0.30	-0.54*	0.30	-0.60*	0.14	-0.51*	0.31	-0.49*	0.31
	(0.30)	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)	(0.33)	(0.31)	(0.30)	(0.29)	(0.29)	(0.29)
mod_pract1	-0.10	0.44	0.00	0.53	0.00	0.51	-0.05	0.46	-0.04	0.46	-0.04	0.46
	(0.33	(0.32)	(0.33)	(0.32)	(0.33)	(0.32)	(0.32)	(0.32)	(0.32)	(0.32)	(0.32)	(0.32)
fdisize2	-1.03***	-0.80***	-1.05***	-0.84***	-1.04***	-0.82***	-0.92***	-0.74***	-0.91***	-0.72***	-0.89***	-0.71***
	(0.27)	(0.22)	(0.29)	(0.23)	(0.29)	(0.23)	(0.27)	(0.22)	(0.26	(0.22)	(0.26)	(0.21)
exptsize2	0.55**	0.2	0.62***	0.23	0.62***	0.24	0.67***	0.27	0.67***	0.28	0.66***	0.28
	(0.22)	(0.18)	(0.22)	(0.17)	(0.22)	(0.17)	(0.23)	(0.17)	(0.22)	(0.17)	(0.22)	(0.17)
Constant	-2.82***	-2.16**	-1.22***	-1.22***	-1.13***	-1.13***	-1.03***	-1.12***	-0.95**	-0.97**	-0.84**	-0.91**
	(1.05	(1.02)	(0.42)	(0.42)	(0.41)	(0.41)	(0.37)	(0.38)	(0.39)	(0.39)	(0.41)	(0.39)
Observations	112											
ρ	0.70*** (0.11)		0.71*** (0.11)		0.71*** (0.11)		0.73*** (0.10)		0.72*** (0.10)		0.72*** (0.10)	
Wald Test for ρ=0	(1)16.56		(1)16.72		(1)16.76		(1)18.31		(1)18.04		(1)17.87	

Robust standard errors in parentheses; ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; degrees of freedom for X^2 test in parentheses before the actual value; for definitions of variables, see Table 4 and Appendix 1

Tests on the value of ρ indicate that coefficients from bivariate probits are more consistent than alternative binary specifications. None of the alternative measures of remuneration turns out to be significant at standard levels of confidence. However, the remaining variables behave in the expected fashion. Training and workers empowerment are the two variables with the strongest significance for and positive influence on internal learning strategies.

8. Alternative definitions of rotation assignments

Table 12. Bivariate models featuring alternative definitions of temporary rotation assignments

	(20)		(21)	
Variables	**rdtype1e**	**ext**	**rdtype1e**	**ext**
train04	1.25***	0.73*	1.23***	0.75*
	(0.43)	(0.43)	(0.42)	(0.45)
ln_avg_rem	0.51**	0.3	0.45*	0.34
	(0.25)	(0.24)	(0.25)	(0.24)
empower2	0.43**	0.39**	0.43**	0.39**
	(0.19)	(0.18)	(0.18)	(0.19)
temp_rot_cc	-0.33	0.28		
	(0.35)	(0.36)		
temp_rot_ir			-0.25	0.18
			(0.29)	(0.31)
mod_pract1	-0.14	0.47	-0.07	0.42
	(0.33)	(0.32)	(0.32)	(0.31)
fdisize2	-0.97***	-0.81***	-1.00***	-0.78***
	(0.28)	(0.24)	(0.27)	(0.23)
exptsize2	0.48**	0.19	0.52**	0.17
	(0.23)	(0.18)	(0.23)	(0.18)
Constant	-3.20***	-2.32**	-2.97***	-2.47**
	(1.15	(1.11)	(1.15	(1.11)
Observations	112			
ρ	0.66*** (0.20)		0.65*** (0.12)	
Wald Test for ρ=0	14.93		14.62	

Robust standard errors in parentheses; ***, **, * denote significance at the 1%, 5% and 10% levels, respectively; degrees of freedom for X^2 test in parentheses before the actual value; for definitions of variables, see Table 4 and Appendix 1

Two alternative definitions were tested in the case of rotation practices. Models (20) and (21) further distinguish if the firm regulates such practice either through collective contracts or any other form of internal regulation. The results in Table 12 reveal the lack of statistical significance of the practice in the context of learning strategies. By contrast, training and empowerment remain important underpinnings of learning strategies. Compensation becomes relevant for an exclusively internal learning strategy whenever temporary rotation practices are regulated by collective contracts. Considering that manufacturing firms tend to adopt job rotation more or less frequently, one would need to continue exploring further what they gain

from such practice. The positive, significant value of ρ, suggest the adequacy of the bivariate approach, as compared to binary specifications.

9. Conclusions

Recent research efforts explore the influence human resource management practices have on innovation performance at firm level. Most studies strive to trace the direct links between these two factors. While many lessons have been learned, significant gaps remain in understanding the likely mechanisms whereby management interventions influence innovation. Against this background, this paper argues that one such mechanisms relates to the learning processes undertaken by those involved in innovation. Individuals constitute the building blocks upon which learning and innovation processes unfold inside organizations. Accordingly, the paper explores the role of some management practices in shaping working environments conducive to learning and innovation. Empirical evidence refers to the pharmaceutical industry in Mexico.

The analysis illustrates some of the main challenges involved in conducting research on human resource management practices and firms' performance. Such practices are heterogeneous, a number of technological, market-related, institutional and, even, idiosyncratic factors condition the approaches available to firms to organize personnel. This implies the need to look at a large number of variables, as well as the many possible interactions expected between them. In this regard, focusing on the pharmaceutical industry in Mexico saves the need to control for industry and market differences, as in more traditional studies across industries or countries. It also makes it feasible to focus attention on the manufacturing dimension of pharmaceutical innovation, thereby reducing some of the heterogeneity of the processes involved. More importantly, it captures the dimension of innovation in which countries such as Mexico are usually more able to participate. A major drawback however, results from the relatively limited size of the industry in Mexico.

The paper identifies learning strategies available to firms to acquire technology either through in-house R&D efforts or by linking to external knowledge sources. Technology acquisition by either means is interpreted broadly as learning. In line with recent scholarly work on decisions about learning strategies and absorptive capacity by firms, we found a significant share of firms in the industry implementing a mix of internal and external learning strategies. This

supports the notion that firms need to develop and nurture sufficient technological bases in-house in order to access and benefit from external knowledge sources. This is even more relevant if firms are, eventually, to contribute to further advancement of the technological complexity of their industry and overall economic environment. Unfortunately, data limitations prevented us from performing proper analyses of the impact of the chosen learning strategy on actual innovation performance indicators. ENESTYC lacks information about customary output indicators, such as patents, share of sales of innovative products and the like.

Nevertheless, the analysis provides some evidence as to the influence management practices supportive of individual learning have on the choice of specific learning strategies at firm level. In particular, it documents the importance of two specific practices: building external linkages to knowledge-producer organizations, at least for the provision of training and the pertinence of including workers in decision-making processes. These findings are consistent with previous studies suggesting that, in countries such as Mexico, training and capacity to influence the working environment may lead to improved performance of the labour force. Moreover, it is likely that whenever firms are characterized by limited R&D, progress in research and technological complexity necessarily requires interaction with other, more specialized and experienced agents in the system of innovation. Contrary to expectations from the literature, traditional knowledge producers, such as universities, may experience difficulties in meeting the knowledge requirement of firms in the Mexican pharmaceutical industry. This presents interesting questions for future research.

The literature suggests that adequate levels of remuneration should induce more active individual learning processes. In the case of the Mexican pharmaceutical industry, our evidence suggests that this influence may not be as strong as compared to other management practices. Is it because, in themselves, salaries in the industry are inadequate to promote learning and innovation? According to the literature on management of R&D for example, is it because less tangible issues, such as prestige and recognition, gain relevance as mechanisms to underpin individuals' performance and commitment to work? Finding evidence about this conclusion requires different management constructs and approaches to research as compared to the one we are able to perform in this paper. Additional questions remain for future analysis. In principle, we need to increase our understanding of the role of temporary rotation practices for internal-only learning strategies. The practice tends to be widespread among

manufacturing firms in Mexico but is seldom perceived as important for the operation of firms. There is, indeed, much room for research about these topics in the future.

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Annex 1

	Mean	S.D.	Min	Max	Description
tr_pubuniv	0.143	0.351	0	1	1 if external training was provided by a public university. 0 otherwise
tr_priuniv	0.223	0.418	0	1	1 if external training was provided by a private university. 0 otherwise
tr_firm	0.634	0.484	0	1	1 if external training was provided by another firm. 0 otherwise
tr_tradeorg	0.259	0.440	0	1	1 if external training was provided through a training centre of a trade organization. 0 otherwise
tr_freelance	0.500	0.502	0	1	1 if external training was provided by an individual consultant. 0 otherwise
tr_sup_mach	0.527	0.502	0	1	1 if external training was provided by a supplier of machinery & equipment. 0 otherwise
tr_internal	0.786	0.412	0	1	1 if training is provided by colleagues in-house; 0 otherwise
external_tr	0.750	0.435	0	1	1 if the firm provides training through external providers (specialized public job training centres, public universities, private universities, other firms, consultants or the industry's trade organization); 0 otherwise.
wagecat	0.527	0.502	0	1	1 if the firm reports that it sets salary categories based on internal regulations or collective contracts. 0 otherwise.
wages	0.741	0.440	0	1	1 if salary levels and/or categories are regulated by collective contract or other internal rules. 0 otherwise.
remun	0.830	0.377	0	1	1 if salaries and benefits are regulated by collective contract or other internal rules. 0 otherwise.
ln_avg_wage	4.414	0.687	2.674	5.749	Log of average monthly salaries
ln_hour_rem	1.186	0.898	-0.734	3.618	Log of average remunerations per hour. Includes salaries and benefits.
ln_hour_wage	0.864	0.909	-1.197	3.385	Log of average salary payments per hour
union1	0.741	0.440	0	1	1 If there is a labour union inside the company. 0 otherwise.
pow_union	0.250	0.435	0	1	Interaction term, presence of a labour union and involvement of workers in decision making.
temp_rot_cc	0.179	0.385	0	1	1 if the firm reports that it governs rotation assignments for employees through collective contracts. 0 otherwise.
temp_rot_ir	0.321	0.469	0	1	1 if the firm reports an internal regulation, other than collective contracts, to govern temporary rotation assignments for employees. 0 otherwise
Hire_trust					1 if the firm possesses precise regulations about hiring of employees for permanent position. Regulation may be set by collective contract or other internal negotiations. 0 otherwise

Annex 2. Results Multinomial Logit Analysis

Learning Strategy	Variable	(I)	Mg Effects	(II)	Mg Effects	(III)	Mg Effects
Internal	external_tr			1.081	0.937	1.269	0.941
				0.737	0.0682	0.916	0.075
	tr_internal			2.227	1.045	2.975	1.062
				1.662	0.0608	2.115	0.063
	ln_avg_wage			3.261**	1.092*	3.057**	1.072
				1.664	0.0522	1.599	0.054
	empower2			1.603	0.995	2.066	1.009
				0.695	0.0398	1.002	0.049
	temprot			0.111**	0.814***	0.096***	0.785***
				0.099	0.0565	0.085	0.061
	mod_pract1	0.917	0.881			0.530	0.892
		0.575	0.0732			0.416	0.091
	exptsize	2.524	1.054			1.997	1.024
		1.476	0.0627			1.016	0.055
	fdisize	0.638	1.048			0.463	1.056
		0.405	0.0703			0.266	0.06
	Constant	0.345**		0.041***		0.040***	
		0.16		0.048		0.0471	
External	external_tr			0.546	0.862*	0.473	0.861**
				0.386	0.0718	0.337	0.061
	tr_internal			1.075	0.97	0.832	0.938
				0.805	0.061	0.695	0.063
	ln_avg_wage			2.227	1.035	2.628	1.029
				1.323	0.047	1.761	0.044
	empower2			1.768	1.005	1.352	0.975
				0.813	0.0347	0.689	0.028
	temprot			0.943	1.031	1.068	1.033
				0.739	0.0572	0.827	0.047
	mod_pract1	3.544	1.044			2.684	1.054
		3.079	0.0499			2.616	0.052
	exptsize	0.797	0.937*			0.516	0.920**
		0.32	0.0344			0.287	0.037
	fdisize	1.15	1.074*			1.214	1.105**
		0.475	0.0432			0.680	0.051
	Constant	0.141**		0.0733*		0.051**	
		0.116		0.107		0.075	
Int_&_Ext	external_tr			5.328***	1.496***	6.372***	1.541***
				3.217	0.154	4.505	0.176
	tr_internal			1.809	1.11	2.523	1.195
				1.095	0.144	1.773	0.182
	ln_avg_wage			1.534	1	1.991	1.064
				0.64	0.084	1.103	0.126
	empower2			2.238***	1.159**	2.845***	1.224**
				0.649	0.072	1.132	0.104
	temprot			0.767	1.066	0.822	1.106
				0.415	0.118	0.498	0.145
	mod_pract1	3.731**	1.324***			1.431	1.109
		2.007	0.135			0.877	0.152
	exptsize	2.552**	1.189**			2.443**	1.224**
		0.994	0.0861			0.932	0.11
	fdisize	0.242***	0.722***			0.116***	0.610***
		0.117	0.0685			0.077	0.093
	Constant	0.632		0.093***		0.031***	
		0.281		0.079		0.031	
N		112		112			112
Log Likelihood Full model		-123.7***		-115.6***		-104.0***	
X^2		(9) 29.2		(15) 41.1		(24) 67.4	
ML (Cox-Snell) R^2		0.196		0.305		0.435	
Count R^2		0.518		0.580		0.625	
Adj Count R^2		0.085		0.203		0.288	

Reference category: No internal/External strategy. Huber/White/sandwich estimators; coefficients in odds ratios; robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; marginal effects for dummy variables are discrete changes from 0 to 1: from none to adoption of given practice; rest of variables estimated at mean values; degrees of freedom for X^2 within brackets; processed with STATA ver. 10®

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