

DO WORKERS SHARE INNOVATION RETURNS?

A Study of the Spanish Manufacturing Sector



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ABSTRACT: This paper explores whether workers share innovation returns and how the size of innovation returns is affected by market conditions. Using a panel data of Spanish manufacturing firms during the period from 1990 to 1993, we answer affirmatively to both questions. Product and process innovations both generate returns, but such returns are higher for process innovations. The size of innovation returns seems to be affected positively by demand growth, by product standardization, and by low product market concentration. The three empirical results are in agreement with the theoretical predictions, such as Schmoockler's (1966) theory of demand-pool innovation, the price-elasticity of demand effects postulated by Kamien & Schwartz (1970), and the replacement effect suggested by Arrow (1962). At the time of generating returns, process innovations are more affected by market conditions than are other innovations.

RESUMEN: Este artículo investiga dos cuestiones: primero, si los trabajadores captan parte de las rentas derivadas de la introducción de innovación en las empresas; segundo, si el tamaño de dichas rentas dependen de las características y condiciones del mercado. El trabajo se realiza utilizando una muestra de empresas manufactureras españolas en el período 1990–1993. Los resultados apuntan que efectivamente los trabajadores captan rentas de innovación sobre todo cuando la innovación que se introduce es en procesos de producción. Además, las características del mercado afectan el tamaño de las rentas en la línea que plantean las diversas teorías contrastadas. Se confirman que el impulso de la demanda (Schmoockler, 1966), el efecto de la elasticidad-precio (Kamien y Schwartz, 1970) y el efecto reemplazamiento (Arrow, 1962) constituyen elementos a tener en cuenta en el estímulo de la actividad innovadora de las empresas.

Innovation is a managerial issue that is influenced by characteristics of the firm and by the firm's environment. When a firm engages in innovation activity, it is with the expectation that its competitive advantage and market position will be improved, leading to increased profits. If profits grow, workers may or may not be offered the incentive of a share of the extra rents generated.

This paper addresses two questions. Do workers capture a share of the innovation returns or rents? And, if so, how is the measurement of those rents and the evaluation of their deter-

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minants affected? The empirical data for this study were obtained from a survey of Spanish manufacturing firms, *Encuesta Sobre Estrategias Empresariales* (ESEE), which was conducted by the Spanish Ministry of Science and Technology during the period from 1990 to 1993.

There is empirical evidence that U.K. (Van Reenen, 1996) and Spanish (Martínez-Ros, 1999) manufacturing firms that engage in either product or process innovation pay higher salaries than do noninnovating firms when factors such as size of the firm and quality of the workforce are controlled. Conolly, Hirsch, & Hirschey (1986) demonstrated in a sample of American firms that a strong union reduces the contribution of R&D (research and development) investments to firm profits, which was interpreted as evidence that the workers had acquired a greater share of the rents gained through innovation.

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If workers capture part of the innovation returns in the form of higher wages, the reported net profits of innovating firms will obviously measure only part of the total innovation returns. This is the phenomenon that we test in this study. Thus, we needed a methodology that would properly estimate the size of the net innovation returns.

The size of the innovation return is an important determinant of the incentive to innovate. Firms will undertake innovation activities if the expected revenues of such activities provide an acceptable compensation or return on investment for the resources dedicated to them. Therefore, if we are able to isolate and measure the net benefits of innovation activities, and if we can relate them to characteristics of the firm and of the market in which the firm operates, we can better understand the determinants of the incentives to innovate. Galende & Suárez González (1999) provide arguments that support the role of intangible factors in determining the probability of conducting internal R&D. In fact, most of the previous literature has focused on the factors that determine the resources that a particular firm dedicates to R&D activities.

If a firm dedicates increased resources to R&D, it is presumably because it expects to receive higher profits from the new processes or products that will result from the innovation activity. However, we believe that it is of interest to determine (1) if R&D activities do in fact increase profitability, (2) if the increase in profitability varies between product or process innovation, (3) if there is a relation between the size of innovation returns and such variables as the growth or concentration of the market, and (4) if this possible relation is affected by the way the innovation returns are measured.

We believe that an adequate framework for the development of the analysis must include two perspectives: competitive strategy and a resource-based view. Porter's treatment of competitive strategy (1991) focuses on the role of a firm's activities and positioning as a fruitful venue for the development of a dynamic theory of strategy. Hence, strategy is a consistent array or configuration of activities aimed at creating one of two specific types of competitive advantage: differentiation (product innovation) and low cost (innovation process). Barney (1991) and Rumelt (1991), on the other hand, present a resource-based view, a view that focuses on the relations between a firm's internal characteristics and its performance, and includes two assumptions: that firms are heterogeneous in their resources and capabilities, and that these resources and capabilities are not perfectly mobile across firms, resulting in heterogeneity among industry participants. As Spanos & Lioukas (2001) have pointed out, the competitive strategy and the resource-based perspectives are complementary. Value creation stems from the fit of internal capabilities to the strategy pursued and from the fit of the strategy to the competitive environment.

The research design to test our empirical model employed

panel data techniques. Given the dynamic nature of the model, we applied a new instrumental variables method to achieve consistency in the estimation of the parameters and to improve efficiency (Arellano & Bover, 1995; Blundell & Bond, 1995). The estimation procedure accounts for the endogeneity problem generated by the simultaneous determination of profits and such explanatory variables as market share.

Our results show that innovation generates rents and that firms therefore have economic incentives to pursue innovation activities. We also find that process innovations generate greater rents than do product innovations, and that controlling for the proportion of the rents that are captured by the employees has significant effects on the estimation of the size of such rents. Finally, the empirical results show that innovation returns are inversely related to the product market concentration, that is, they are lower in more concentrated markets than in less concentrated ones. If less concentrated markets are also more competitive, then innovation returns are higher in more competitive markets. This result is consistent with the predictions of Arrow (1962), who postulated that firms in more competitive markets are able to obtain greater rents from innovations because a high level of competition tends to create lower profits before the innovation is introduced. Monopolists, on the other hand, begin with higher profits, so the replacement effect means that innovation has a lower incremental effect on them.

THEORETICAL FRAMEWORK

The decision to innovate is determined by the relation between the benefits and costs associated with such a decision. In this section, we present an overview of the literature on the determinants of innovation returns, in particular, the relation between the rents and the type of innovation (product or process) and the relation between innovation returns and the product market (demand growth, product differentiation, and market competition) and labor market conditions. Baldwin & Scott (1987), Kamien & Schwartz (1982), Levin, Cohen, & Mowery (1985), and Scherer (1980), report on surveys of the two main factors—firm size and market structure—that influence the level of R&D. Cohen and colleagues (Cohen, 1995; Cohen & Levin, 1989) are also excellent sources on this subject. Cohen & Klepper (1996a, 1996b) and Tether (1998) review the relation between firm size and innovation propensity. Bughin & Jacques (1994) and Malerba & Orsenigo (1996) emphasize the necessity of linking innovation and market structure in order to understand managerial efficiency.

Innovating Rents

Innovation is a heterogeneous activity. According to Schumpeter (1942), innovation can be associated with the

introduction of a new product or service, or with improvements or changes in the production process, materials, and intermediate inputs; innovation is also associated with management methods. Some of these activities may be related, such as when the introduction of new products and the use of new designs (innovation in products) accompany improvements in the procedures used to manufacture products (innovation in process). We are interested in the factors that explain why companies engage in product innovation and/or process innovation. As Milgrom & Roberts (1990) point out, product and process innovation activities are mutually reinforcing: An increase in the level of one leads to an increase in the marginal profitability of the other, and vice versa. Except for a brief description, however, this issue is beyond the scope of this investigation.

Some empirical observations of behavior in firms have led to the conclusion that firms choose strategically between the two innovation alternatives of product versus process, usually avoiding a complete specialization in one. Pine, Victor, & Boyton (1993), however, have demonstrated that firms structure their organization to allow for engagement in both types of innovation. The literature provides scarce evidence on the relations between product and process innovations. Giacomo & Haworth (1998), Kraft (1990), and Lunn (1986), have introduced the possibility that innovation could be divided into different categories, depending on its final purpose.

More recent articles (Flaig & Stadler, 1998; Fritsch & Meschede, 2001) have demonstrated that product and process innovation are related. Implementation of a product innovation can render corresponding process innovation necessary, whereas process innovation may enable a firm to improve the quality of its products significantly or to produce completely new products. Bonano & Haworth (1998) considered a vertically differentiated industry and a firm's decision to choose either product or process innovation under Cournot and Bertrand competition. Rosenkranz (2003) analyzed simultaneous product and process innovations in a situation in which demand is characterized by a preference for product variety. After investigating the strategic decisions of two identical duopolists that choose production technology as well as product differentiation through R&D investment, Rosenkranz concluded that a firm's investment is driven to product innovation if the consumer's willingness to pay is high. An attempt was made in these studies to expand the literature on the most profitable direction for R&D—toward product innovation or process innovation—while controlling for the degree of market competition faced by the firm.

In general, process innovations are aimed at introducing technological advances, which reduce production costs, and eventually help the innovating firm to gain a market share from its competitors. Product innovations, on the other hand, expand the set of production opportunities, and in some cases,

allow for gains in efficiency due to scope economies. If innovation activity results in a greater degree of product differentiation, the innovating firm may face a lowered price elasticity of demand, and consequently, increased profit margins. Product and process innovations often occur in parallel, producing a complementary effect: A product innovation may require a process innovation, for example, to accommodate a new product design or a change in a product characteristic.

It is more difficult to determine differences between the size of innovation returns attributed to one type of innovation versus those attributed to another. It may be argued that product innovations will be easier to imitate because competitors will immediately become aware of them and patent law may not be able to protect the property rights of the innovator effectively. On the other hand, since the innovating firm does not exteriorize process innovations, it may take rival firms a considerable amount of time to discover the origin of a particular competitive advantage. All these factors may suggest that the rents of process innovations will tend to be higher than the rents of product innovations, assuming the same degree of "innovativeness."

Market Conditions

The size of innovation returns will be affected not only by the nature of the innovation, but also by the conditions of the market in which the innovating firm operates. Among those conditions, the degree of firm rivalry or market competition is particularly emphasized in the literature. Market conditions involve the familiar Schumpeterian hypotheses about the extent to which firm size and competition in the industry environment stimulate innovation. It is sometimes claimed that innovation is fostered by a climate in which firms have market power or in industries with less competition.

Market structure is viewed as a key determinant of the sustainable performance of firms. Typically, industrial organization studies have approached the *degree of competition* by assessing market concentration (Cohen & Levin [1989] give a complete overview of the relation between R&D and concentration, and provide an extensive discussion of the ambiguous predictions obtained in empirical studies). In general, the empirical evidence supports Schumpeter's arguments that firms in concentrated markets can more easily appropriate the returns from inventive activity. The Schumpeterian view of innovation argues that monopolistic power will foster innovation activity. According to this viewpoint, innovation returns will be substantial for the monopolistic firm, and will persist over time as barriers to other firms trying to enter the market limit imitation. A firm with market power and a monopolistic position will be subject to an "efficiency effect," in the sense that innovation will be perceived as the only way to protect its privileged position in the market. A potential

entrant, on the other hand, will anticipate a lower compensation for its innovation activities because, after entry, a competitive battle will take place with the incumbent monopolist (Gilbert & Newberry, 1982).

Other investigators have found evidence that market concentration does not promote R&D. Indeed, they suggest that the higher the degree of competitiveness, the larger the expected incremental rents from the innovation activity will be (Arrow, 1962; Bozeman & Link, 1983; Delbono & Denicolo, 1990; Yi, 1999). This opposite view of the relation between market competition and innovation returns illustrates the so-called replacement effect (Arrow, 1962). If we start with a competitive market in which price equals cost and profits are zero, then if innovation is sufficiently important to give market power to the innovating firm, the new equilibrium price should be higher and the innovator's cost and profits will increase substantially. On the other hand, if the market is non-competitive, a situation in which prices are above costs and firms earn positive profits, an innovation will increase profits, but to a lesser degree, because current firms are already making positive profits. In this case, an innovating monopolist will end up replacing itself, whereas when the market is competitive, innovation may change the market structure toward a monopoly, with the resultant substantial increase in profits. All this implies that innovations should produce higher rents for firms operating in more competitive markets because initial profits in such markets are expected to be lower.

The relation between market competition and innovation returns is, therefore, an empirical question. Although Arrow (1962) made a claim contrary to Schumpeter (1942), there is mixed evidence that either position is accurate (Scherer, 1992). Because of its importance, this issue continues to be researched using U.S. (Cohen & Klepper, 1996a, 1996b) and Spanish data (Martínez-Ros & Labeaga, 2002).

Some auxiliary hypotheses have been formulated to guide the empirical research. For example, Kamien & Schwartz (1970) show that under the replacement effect assumption, innovation returns will increase with the absolute value of the price elasticity of demand, that is, they will be higher for firms facing more elastic demand functions. One reason a firm might face a more elastic demand curve is that there are more substitutes in the market, that the market itself is more competitive.

Kamien & Schwartz's analysis assumes a process innovation that lowers production costs. If the cost reduction is translated into lower prices, the size of the market served will expand more, as the demand function is also more price-elastic. This phenomenon will, in turn, determine a positive association between innovation returns and price elasticity of demand. As Spence (1975) has shown, however, when the innovation is in a product but not in a process, improvements in product quality will produce higher innovation returns in markets with more inelastic demands because they will allow

for higher margins. Therefore, the relation between innovation returns and price elasticity of demand may be sensitive to the type of innovation being considered.

Another market characteristic that we want to consider is demand growth. Schmookler (1966) argues that growth in market demand is the primary force behind technological change. Walsh (1984) elaborates on this idea, and highlights the fact that innovation activity requires a high investment cost that does not depend on the demand of the product once the innovation is made. Given the indivisibility of the innovation costs and investments, innovating rents will depend largely on the size and growth of the market for the final products for both product and process innovations.

Labor Market Conditions

The innovation returns distribution. Thus far, our attention has focused on the generation of innovating rents. For methodological reasons, we now turn to the important consideration of the distribution of rents. The innovation process will contribute to improvements in products and processes that will, in turn, increase the value added by conventional inputs such as labor and physical capital. Therefore, innovation should contribute to improvements in total factor productivity. Productivity gains will, in turn, be distributed in the form of higher profits, higher wages, or both. When labor markets are competitive, the productivity gains from innovation will be revealed in higher profits. Consequently, the measurement and evaluation of innovation returns can be made either from total factor productivity gains or from increases in profitability. But when workers have bargaining power and capture part of the productivity gains in the form of higher wages, innovation returns are no longer equal to increments in profitability.

As we have indicated, there is empirical evidence of a positive association between salaries and innovations, although it has been explained in different ways. For example, Bartel & Lichtenberg (1990) and Bound & Johnson (1992) argue that higher wages are the result of complementarities between innovation activity and human capital, as there are higher quality human resources in innovating as compared with non-innovating firms. The workers in the innovating firms earn higher wages because they are more productive.

Other researchers believe that workers in innovating firms earn higher wages because their bargaining power gives them the power to capture part of the rents resulting from innovation activities. In an early paper, Conolly et al. (1986) found that when workers are organized into trade unions, firms earn lower profits than is the case in nonunionized firms. Moreover, the presence of unionized workers tends to lower the contribution of R&D expenditures to the firm's profits. The final result is that unionized firms invest less in R&D than do

nonunionized firms. The authors conclude that the capture of innovation returns by the workers turns out to be a negative factor for dynamic efficiency. Other studies associate the capture of rents by workers with the extra profits obtained by firms with higher market power (Clark, 1984; Salinger, 1984). However, Hirsch (1990) finds no empirical evidence that this capture of rents emanates from the market power of the firm. Hildreth & Oswald (1997) have reviewed the literature on this subject, showing evidence for some ability-to-pay effect on wages in the U.K. Looking at Spanish firms, Andrés & García (1991) and Jaumandreu & Martínez-Ros (1995) arrive at different conclusions regarding the determinants of wage differentials by demonstrating that market power, profitability, export propensity, or market share are relevant variables in the determination of wage differentials.

More recently, however, Menezes-Filho, Ulph, & Van Reenen (1998) found no empirical support in a sample of U.K. firms for the hypothesis that unionization affects the level of R&D effort. Finally, Martínez-Ros & Salas (1999) have obtained evidence that innovating firms pay higher salaries, and that higher salaries, in turn, seem to have a positive effect on innovation activity. The authors interpret this result in terms of the premise of the “mutual gains” enterprise as postulated by Kochan & Osterman (1994).

The model. The exposition above may be represented by a model that will be helpful in the specification of the empirical equations.

Define the rents of the firm i in a period t as

$$QR_{it} = p_{it}Q_{it} - w_{it}^c L_{it} - r_{it}^c K_{it}, \quad (1)$$

where p_{it} is the price, Q_{it} is the output, w_{it}^c is the competitive salary, L_{it} is the number of employees, r_{it}^c is the market cost of capital, and K_{it} is the physical capital. QR_{it} includes economic profits plus the costs of the innovation activities that are considered sunk costs. Assuming that the costs of innovation are sunk allows us to talk about rents instead of rents of innovation.

The rents per unit of monetary output, $QR_{it}/p_{it}Q_{it}$, are assumed to be a function of the innovation activity, I_{it} , and of market conditions, M_{it} , that is,

$$\Pi_{it}(I_{it}, M_{it}) = \frac{QR_{it}}{p_{it}Q_{it}} \quad (2)$$

For each firm and time period, only accounting profits are observed. It is therefore important to link $\Pi(I_{it}, M_{it})$ with such profits. Define gross profit margin as

$$m_{it} = \frac{p_{it}Q_{it} - w_{it}L_{it}}{p_{it}Q_{it}}, \quad (3)$$

where w_{it} are salaries actually paid. It can be easily shown that m_{it} and Π_{it} are related:

$$m_{it} = \Pi_{it}(I_{it}, M_{it}) + \frac{r_{it}^c K_{it}}{p_{it}Q_{it}} - \frac{(w_{it} - w_{it}^c)L_{it}}{p_{it}Q_{it}}. \quad (4)$$

In other words, gross profit margin from accounting profits will be equal to rents plus the costs of physical capital, minus the differences between labor costs at actual and at competitive salaries, all of them normalized by the monetary value of the firm’s output.

Product market conditions, M_{it} , will affect both economic profits and the rents of innovation. Our underlying assumption is that firms compete in an oligopolistic market with product differentiation. Efficiency in production across firms will determine part of their respective competitive advantages, while market concentration and demand growth may affect the opportunities for collusive behavior. On the other hand, product market conditions are expected to affect the size of the innovation returns. This may be summarized as follows:

$$\begin{aligned} \frac{\partial m_{it}}{\partial M_{it}} &= \frac{\partial \Pi_{it}(I_{it}, M_{it})}{\partial M_{it}} \neq 0, \\ \frac{\partial^2 m_{it}}{\partial M_{it} \partial I_{it}} &= \frac{\partial^2 \Pi_{it}(I_{it}, M_{it})}{\partial M_{it} \partial I_{it}} \neq 0, \end{aligned} \quad (5)$$

where the particular sign of the cross-derivative is determined by the theoretical predictions outlined above. From Schmoockler’s predictions, for example, we expect that the cross-derivative between innovation rents and demand growth will be positive.

The determinants of wages. The underlying model to explain the actual wages, w_{it} , is taken from Layard, Nickell, & Jackman (1991). The authors consider that wages of firm i in period t are determined by a Nash bargaining solution between workers and the firm, which has previously invested in specific assets, such as those required to create new products or new processes. Part of the rents correspond to these investments, but it is possible that workers capture rents from other sources, such as those resulting from market power and/or resulting from more efficient work practices.

The reduced form of the model is as follows:

$$w_{it} = F(\omega_{it}, I_{it}, X_{it}). \quad (6)$$

Where w_{it} is the observed wage of firm i in period t , ω_{it} is a proxy of the workers’ opportunity wage, I_{it} is the innovation variable defined above, and X_{it} is a vector of control variables to be explained below. We implicitly assume that

$$\frac{\partial w_{it}}{\partial I_{it}} > 0, \quad (7)$$

that is, firms that innovate, ceteris paribus, pay higher wages.

Notice that, contrary to previous work, we directly mea-

sure the innovation returns captured by workers. In other works, we test whether workers in innovating firms do in fact earn higher salaries, where innovation is measured in terms of output, not of input (R&D expenditures, for example). In this way, we avoid indirect measures of workers' bargaining power, such as whether they are unionized.

RESEARCH DESIGN

The Empirical Model and Methodology

Wage equation. The wage equation defined above will be explicitly stated as

$$w_{it} = \alpha_o + \alpha_1 w_{it-1} + \sum_{j=1}^3 \alpha_2 I_{ijt} + \alpha_3 \omega_t + \alpha_4 X_{it} + v_{it}, \quad (8)$$

where i refers to the firm, j to the type of innovation (product, process, or both), and t to the time period. The variable w_{it} indicates the average wage paid by firm i in period t ; ω_t is the average wage in the industry in which firm i belongs in period t ; I_{ijt} is a dummy variable that takes the value of 1 if the firm i innovates in period t , and takes the value of 0 otherwise (where $j = 1, 2, \text{ or } 3$ for product, process, or both); X_{it} is a vector of control variables, which accounts for the quality of the labor force, the market share of the firm, and the possible industry effects beyond the industry's average wage.

Profit margin equation. To evaluate the innovation returns, we estimate the equation

$$\begin{aligned} m_{it} = & \beta_0 m_{it-1} + \beta_1 I_{it} \\ & + \beta_2 M_{it} + \beta_3 I_{it} * N_{it} + \beta_4 KSA_{it} + \beta_5 Z_{it} \\ & + \beta_6 Y_{it} + \epsilon_{it}, \end{aligned} \quad (9)$$

where m_{it} is the gross profit margin; m_{it-1} is the lagged gross profit margin; I_{it} is the set of innovation variables; M_{it} is the set of proxy variables for market and efficiency conditions; $I_{it} * N_{it}$ is the interaction between innovation and a subset, N_{it} , of the market conditions variables; KSA_{it} is the ratio of physical capital to sales; Z_{it} is the set of variables measuring the innovation returns appropriated by the workers; Y_{it} is a set of other control variables; and ϵ_{it} is the error term. In the following paragraphs, we explain the construction of each of the variables.

The error term, ϵ_{it} , includes unobservable firm-specific effects, μ_{it} , and random-time varying effects, v_{it} , that is, $\epsilon_{it} = \mu_{it} + v_{it}$. The firm-specific effects may be justified by the fact that the managerial choice of the strategy for a particular firm will be related to the sources of profits in the past. The error term ϵ_{it} will be correlated with the lagged dependent variable because of the fixed-time invariant effect, μ_{it} , and the econometric estimation will have to account for this correla-

tion to avoid estimation biases. One way to solve this problem is to transform the variables into differences and to use these differences in $t - 2$ values of the dependent variables as valid instruments of the variable in $t - 1$ (Anderson & Hsiao, 1982; Arellano & Bond, 1991).

A more recently developed solution to this measurement issue is presented by Arellano & Bover (1995), who measure the lagged variable, m_{it} , with Δm_{it-1} , thereby increasing the efficiency of the estimation, and given that there is no serial correlation in the error term, ensuring that the estimated coefficients are consistent estimators. The estimation procedure also accounts for the fact that market share will be endogenous and jointly determined with profit margins; for this reason, market share is measured by its lagged value (Geroski, Machin, & Van Reenen, 1993).

Measurement of Variables

In the wage equation, we construct the variables as follows. The dependent variable WAGES is measured by dividing the labor expenses of firm i in year t by the total number of workers of the firm; we also include WAGES lagged one year. The industry average wage, AVGWAGE, is obtained by dividing the total labor expenses of the firms in the industry (disaggregated at the two-digit level)¹ by the total number of workers in those firms. Market share, SHARE, is the ratio of the sales of firm i in year t to the industry sales, also in year t . The quality of the labor force is measured by two variables: HIGH SKILLED is the proportion of workers with university degrees in firm i in period t , and MEDIUM SKILLED is the proportion of workers with high school degrees in firm i in period t . Finally, X_{it} contains time and industry dummies.

In the profit margin equation, the dependent variable, PROFIT, is measured as the percentage of gross margin over total value of production for firm i in period t . Gross margin is equal to the value of production, minus cost of inputs from other firms, minus labor costs; the value of production is equal to sales plus changes in inventories. The regression includes the lagged values for gross profit margin among the explanatory variables to capture the time-varying effects that are furthest away from the equilibrium solution.² For example, lagged profit margins could capture the influence of cash flows attached to profitability on innovation activity, as greater or lesser cash flow implies more or less funds available to finance innovation activities.

In this line of research, one important methodological issue is how to approximate innovation activity. Most often, input measures such as R&D effort (expenditures in R&D relative to value added, and number of workers in R&D activities relative to total number of workers) are selected. However, it takes time for R&D inputs to generate outputs such as new products, patents, and process improvements. Moreover,

because they are often treated in the short run as current expenditures by the firms, there may be a negative association between R&D effort and accounting profits. As Kamien & Schwartz (1982) have pointed out, in this case the R&D is measured as a cost rather than as an investment, and one might expect to find an inverse relation.

Innovation activity is measured in terms of output flow. This measure is preferred over other variables often used as inputs to the innovation activity, such as R&D expenditures or R&D personnel, because innovation output is not always the result of formal innovation processes.³ Innovation counts are also preferred over other measures of output, such as number of patents, as there are many innovations that are not patented by the firms. Townsend, Hendwood, Thomas, Pavitt, & Wyatt (1981), Pavitt, Robson, & Townsend (1987), Robson, Townsend, & Pavitt (1988), and, more recently, Blundell, Griffith, & Van Reenen (1995), use the number of innovations developed by the firms as their output measure. The main problem in using this indicator is the difficulty in identifying the significant innovations because of the numerous biases of waste heterogeneity in the economic value of innovations. On the other hand, patent counts (Bound, Cummins, Griliches, Hall, & Jaffe, 1984; Griliches, 1990; Scherer, 1965) cause problems in comparisons within and between industries because they are heterogeneous in economic value as well.

The choice of an output, such as a number flow, instead of a stock measure of knowledge, has been imposed by data limitations. To obtain a more accurate measure of the knowledge base, it would have been desirable to measure whether or not the firm reports innovations in product, process, or both; its actual *number* of innovations; and, ideally, the economic value of the innovations. Unfortunately, we were only able to obtain data for the number of innovations in the case of product innovations.

The variables for innovation activity, I_{it} , are measured in terms of three dummy variables: PRODUCT, PROCESS, and BOTH. The variable PRODUCT (or PROCESS or BOTH) takes the value of 1 when the firm i indicates that in period t , a product (or process, or both) innovation has occurred, and a value of 0 when there is no such innovation. These measures have limitations, because it is not possible to measure the importance of the innovation. Nevertheless, we include all the innovations recognized by the firms.

If innovation activities generate rents, a positive value of the vector β is expected. Moreover, the size of the β_1 coefficient for the variables PRODUCT, PROCESS, and BOTH, will indicate whether or not innovation returns differ for each type of innovation.

The model includes two main variables to account for *firm heterogeneity* in terms of productive efficiency and market competition. The first is market share, SHARE, and the second is

industry concentration, CONCENTRATION. More efficient firms will capture higher market shares; therefore, *ex post* differences in market share may serve as good proxies of differences in efficiency across firms. Since collusion tends to be easier in more concentrated markets, we would expect that firms in more concentrated markets will earn higher profits. However, if differences in efficiency across firms in the market are important, a more concentrated market will be the result of differences in efficiency and market share across firms rather than evidence of collusive practices. One way to isolate the efficiency or collusion effects of concentration on profits is to incorporate into the regression the product of market share and concentration, SHACONC. With this in mind, the vector M_{it} will include three variables: SHARE, CONCENTRATION, and SHACONC.

The variable SHARE is measured as the ratio of sales of firm i in period t over total industry sales (at the two-digit level) in the same period. CONCENTRATION, on the other hand, is measured as the sum of percentages of sales shares of the four largest firms in the industry in each period t . Assuming that differences in concentration across industries respond to efficiency effects, we expect that the coefficient of SHACONC will be negative. On the other hand, a positive coefficient for the interactive variable could be an indication that concentration facilitates collusion, and that it is collusion that explains why profits are higher in more concentrated markets.

The innovation variables, PRODUCT, PROCESS, and BOTH, are viewed as interacting with proxies for market conditions such as growth, elasticity of demand, and competition. Firms in the ESEE database indicate whether their products are sold in a recessive market. Using this information, we defined the dummy variable DEMAND, which takes the value of 1 if the firm responds affirmatively to the question about recessive markets, and 0 if it does not. According to the theory outlined in the "Theoretical Framework" section above, innovation returns are lower in markets with low demand growth, and consequently, we expected the coefficient of the interactive variables DEMPROD (DEMAND * PRODUCT), DEMPROC (DEMAND * PROCESS), and DEMBOTH (DEMAND * BOTH) to be negative.

Price elasticity of demand is not directly observed, but the database informs us about the characteristics of the products sold by the firms. In particular, firms collaborating with the ESEE survey that produced the data for our study indicate whether or not their products are standardized. Accordingly, the dummy variable HOMOGENEOUS takes the value of 1 when the firm's products are standardized, and 0 when they are not. The underlying assumption is that standardized products face a more elastic demand, and according to the theory, the interaction variable HOMOPROC should have a positive coefficient in the regression (higher innovation returns for process innovations). On the other hand, if prod-

uct innovations imply improvements in product quality, the innovation could contribute to differentiation of the product and to increased profit margins. But it is also true that profit margins for standardized products will tend to be lower to begin with, so quality improvements to them will tend to yield lower incremental profits. This implies that the coefficients of HOMOPROD and HOMOBOTH will have an ambiguous sign.

The third market characteristic that may affect the size of the innovation returns is intensity of product market competition. Market competition is approximated by market concentration in an inverse way. With this in mind, the variables PRODCONC, PROCCONC, and BOTHCONC are constructed. Their coefficients will indicate whether or not market concentration affects the size of innovation rents. A positive value of such coefficients would be consistent with the “efficiency effect,” in the sense that firms in more concentrated markets tend to capture more rents because there is less imitation. On the other hand, a negative coefficient would be consistent with the “replacement effect.”

The variable, CAPITAL, is defined as the ratio of the monetary value of physical capital (total assets at replacement cost) to the monetary value of production of the firm i in period t . We expect the coefficient β_4 to be positive, according to the theoretical model (Equation 4).

According to Equation 4, the variable that measures the part of the profit margin that is transferred to the workers of the innovating firm is

$$(w_{it} - w_{it}^c) L_{it} / p_{it} Q_{it} \quad (10)$$

The estimation of the wage in Equation 8 provides estimates of the average value of wage rents $(w_{it} - w_{it}^c)$ across firms and each type of innovation, α_{2j} , $j = 1, 2, 3$. The vector α_2 is then multiplied by the matrix (PRODUCT, PROCESS, BOTH). Therefore, we assume that workers capture the same amount of rents for each type of innovation in all firms. Finally, the resulting values are divided by the inverse of labor productivity (sales per worker); the variables PRODUCT RETURNS, PROCESS RETURNS, BOTH RETURNS obtained in this process are the empirical constructs used to approximate the theoretical variable that measures the rents captured by the workers. The model includes the export activity of the firm as a control variable, EXPORT. Export activity is a dummy variable, which takes the value of 1 if the firm exports, and 0 if it does not export.

Results

The data used to estimate the empirical model and to test the hypotheses outlined above are derived from the ESEE survey and cover the period from 1990 to 1993. We used a balanced

panel of the data consisting of 973 firms at four time periods. Table 1 presents descriptive statistics of the dependent and explanatory variables for the entire sample and for two subsamples, each selected by accounting for the innovation activity of each firm over time. We selected the data in the column headed “Output in R&D” using an indicator of innovation (measuring whether product or process innovation is conducted). The column under the heading “Input of R&D,” includes all observations with positive R&D expenditures. Obviously, the sample size for these two columns is different because not all firms investing in R&D have successful innovation output. In fact, we observe that only 65 percent of the innovating firms get results, thereby confirming the idea that not all investment in R&D directly results in technological advances.

We performed the estimation of innovation returns in two steps. First, we measured the size of innovation returns, and second we investigated their relation with market characteristics. Table 2 provides the results of estimating the wage Equation 8. The coefficients of PRODUCT, PROCESS, and BOTH are all positive and statistically significant. We therefore have evidence that workers in innovating firms earn higher wages than do workers in noninnovating firms. The difference increases from 4 percent higher wages in the case of process innovations to 7 percent higher in the case of firms that innovate in processes and products.

Tables 3 and 4 present estimates of the effect of innovations on profits and the relation between profits and market conditions, respectively. As the first column of Table 3 shows, all the explanatory variables not related to innovation activity have statistically significant coefficients. Notably, all these coefficients are positive, except the one for the interactive variable SHACONC, which is negative. This means that the firms’ profits are sensitive to both market characteristics and firm characteristics. The coefficient of the lagged dependent variables is .229, which is highly significant; therefore, the short-run effects of the explanatory variables on profit margins are approximately one-fifth of their long-run effects. Profit margins are positively associated with market share and market concentration; the negative coefficient of the interactive variable indicates that market share and market concentration are related to profits through the efficiency effect. Engaging in export has positive effects on profits. The positive coefficient of CAPITAL indicates that part of the gross profit margins goes to pay a competitive return to capital.

Column 2 in Table 3 shows the same results after the innovation variables have been included in the regression. The coefficients of the innovation variables are, as expected, positive and highly significant. The coefficients of the remainder of the explanatory variables are slightly reduced, but all remain statistically significant except the coefficient for the variable that measures market share. The effect of both types of innovation on rents is not homogenous. At only a .14 level

TABLE I
Descriptive Statistics of the Variables

Variable	Definition	All firms, mean (SD)	Output of R&D, mean (SD) ^b	Input of R&D, mean (SD) ^c
PROFIT	Added value, minus cost of production, divided by total production	0.108 (0.143)	0.107 (0.135)	0.104 (0.142)
SHARE	Total firm sales divided by two-digit industry total sales of the sample	0.035 (0.125)	0.053 (0.164)	0.073 (0.184)
CONCENTRATION	Four-firm, two-digit industry concentration ratio by sales	0.215 (0.204)	0.233 (0.211)	0.233 (0.202)
EXPORT	Dummy equals one if firm exports	0.544 (0.498)	0.707 (0.455)	0.844 (0.363)
CAPITAL	Capital divided by total firm sales	6.177 (27.48)	2.734 (11.07)	1.328 (7.432)
Knowledge capital				
PRODUCT	Dummy equals one if firm conducts only product innovation	0.096 (0.294)	0.236 (0.425)	0.138 (0.345)
PROCESS	Dummy equals one if firm conducts only process innovation	0.151 (0.358)	0.372 (0.484)	0.186 (0.390)
BOTH	Dummy equals one if firm carries out both product and process innovation	0.159 (0.366)	0.392 (0.488)	0.325 (0.469)
Workers' rents^a				
Rents obtained by the introduction of innovations:				
PRODUCT RETURNS	Only in product	0.057 (0.216)	0.141 (0.321)	0.069 (0.204)
PROCESS RETURNS	Only in process	0.065 (0.212)	0.160 (0.309)	0.067 (0.168)
BOTH RETURNS	In both product and process simultaneously	0.097 (0.265)	0.240 (0.373)	0.181 (0.315)
Number of observations		3,892	1,580	1,442

^a Variables constructed using wage equation.
^b Innovating firms were selected if they had developed some innovation during the period independent of the innovation type.
^c Innovating firms were selected using technological effort as the indicator.

TABLE 2
Wage Determination and Workers' Rents

Variables	Coefficients
WAGE _{t-1}	0.400 (1.16)
SHARE	1.352 (1.90)
PRODUCT	0.054 (1.79)
PROCESS	0.040 (1.83)
BOTH	0.069 (2.03)
HIGH SKILLED	1.070 (1.60)
MEDIUM SKILLED	0.427 (1.62)
AVGWAGE	0.149 (0.926)

Note: Includes time and industrial dummies.

of significance, we reject the null hypothesis $\beta_{\text{prod}} = \beta_{\text{proc}}$.⁴

The last column of Table 3 introduces into the estimation the variables that account for the fact that part of the innova-

tion returns go to the workers by way of higher wages. The coefficients of these variables are negative and statistically significant, as predicted by the theoretical model. But the most important result is that the coefficients of the innovation variables displayed in column 3 are almost twice the values compared with column 2. When we control for the rents captured by workers, differences in profit margins attributed to differences in innovation output are equivalent to the effect of innovation in total factor productivity. The results show that innovation returns, as measured by total factor productivity, are substantially higher than those associated with differences in profit margins (column 2).

The final step in the estimation of the model is to determine if the size of the innovation returns is sensitive to characteristics of the product market. Table 4 shows the result of estimating the model with the interactive variables $I_{it} * N_{it}$

TABLE 3
Profit Margins and Innovations

Variables	(1)	(2)	(3)
PROFIT _{t-1}	0.229 (4.04)	0.232 (4.19)	0.228 (4.10)
SHARE	0.346 (1.93)	0.311 (1.76)	0.280 (1.58)
CONCENTRATION	0.092 (6.01)	0.076 (5.06)	0.077 (5.11)
SHACONC	-1.055 (2.53)	-0.987 (2.41)	-0.947 (2.27)
EXPORT	0.034 (4.72)	0.020 (2.78)	0.018 (2.52)
CAPITAL * I0	0.002 (2.10)	0.002 (2.18)	0.002 (2.40)
PRODUCT		0.030 (3.40)	0.050 (3.35)
PROCESS		0.040 (4.52)	0.063 (4.20)
BOTH		0.032 (3.68)	0.058 (3.46)
PRODUCT RETURNS			-0.031 (1.47)
PROCESS RETURNS			-0.055 (1.58)
BOTH RETURNS			-0.041 (1.53)
Wald test ^a	38.19 (3)	26.71 (3)	27.57 (3)
Sample size	1,946	1,946	1,946

Notes: *t* statistics robust to heteroskedasticity. All regressions pass the hypothesis of joint significance of regressors using the Wald test.

^a The Wald test is different in each specification: In (1) it refers to CONCENTRATION, SHARE, and SHACONC; in (2) and (3) it refers to innovation variables.

among the explanatory ones. As expected, innovation returns are lower for firms selling products in recessive markets than for firms operating in nonrecessive markets (Table 4, column 1). This is especially true for process innovation and for product and process innovations together. The coefficient of DEMPROD is not statistically significant.

Product standardization affects only the size of innovation returns, with respect to the rents of nonstandardized (i.e., differentiated) products, for joint product and process innovation situations. The positive coefficient indicates that joint product and process innovations generate more rents when products are standardized than when they are not. Market concentration affects the size of innovation returns in a negative and statistically significant way (Table 4, column 3).⁵ This effect is especially strong for process innovations and for both product and process innovations. The last column of Table 4 shows the estimated coefficients of the model when all the variables are included. Collinearity effects are more severe here, but the basic results obtained step by step are maintained.

DISCUSSION

The essential finding of this research confirms the postulation that firm-specific effects and industry effects condition the determination of profits and, therefore, the effects of workers' rents. In combination, the two theoretical perspectives mentioned in the introduction to this paper produce a good explanation for the heterogeneity of firm performance. Our analysis uses this framework to explain the behavior of Spanish companies.

We addressed two main questions in this paper: Do innovations generate rents for workers and are the size of rents affected by market conditions? The answer to both questions

is yes. Product innovations, process innovations, and both types of innovations generate rents, and such rents appear to be higher for process innovations. The significance of the three technical variables included in our study confirms the hypothesis that there is no homogenous innovation activity, a position that accords with Kamien & Schwartz (1982), Lunn (1986), and Kraft (1990), among others.

The size of innovation returns seems to be affected positively by demand growth, product standardization, and by low product market concentration. Therefore, product innovation seems to be equally effective in generating rents in growing and in nongrowing markets. As indicated above, product standardization implies, *ceteris paribus*, higher price elasticity of demand. Either type of innovation alone does not appear to be sufficient to affect rents differently from nonstandardized products. When both innovations occur together, however, the opportunity to lower price and expand demand (from process innovation), and the opportunity to soften competition and improve the product (from product innovation), produce higher innovation returns in firms with standardized products than in firms with nonstandardized products. As higher concentration is associated with lower competition, the empirical evidence is in favor of the replacement effect: Innovation returns are higher in more competitive markets because firms start with lower profits before the innovation takes place.

The three empirical results are in agreement with theoretical predictions, such as Schmoockler's theory of demand-pool innovation, the price elasticity of demand effects suggested by Kamien & Schwartz (1970), and the replacement effect postulated by Arrow (1962). The effect of market conditions at the time of generating rents is stronger for process innovations than for product innovations.

TABLE 4
Innovation Returns and Market Conditions

Variables	Demand growth	Product standard	Market competition	All effects jointly
PROFIT _{t-1}	0.246 (4.37)	0.249 (4.46)	0.230 (4.20)	0.244 (4.32)
SHARE	0.290 (1.56)	0.265 (1.40)	0.219 (1.25)	0.275 (1.50)
CONCENTRATION	0.073 (4.74)	0.072 (4.61)	0.105 (5.82)	0.073 (4.77)
SHACONC	-0.950 (2.17)	-0.927 (1.99)	-0.774 (1.90)	-0.880 (2.11)
EXPORT	0.016 (2.14)	0.016 (2.23)	0.013 (1.83)	0.016 (2.21)
CAPITAL * 10	0.002 (2.41)	0.002 (2.40)	0.002 (1.93)	0.002 (2.43)
PRODUCT	0.050 (3.48)	0.038 (2.02)	0.070 (3.37)	0.041 (1.45)
PROCESS	0.073 (4.49)	0.049 (2.66)	0.109 (5.35)	0.076 (3.34)
BOTH	0.078 (4.70)	0.038 (1.76)	0.086 (3.99)	0.080 (2.95)
PROD RETURNS	-0.030 (1.37)	-0.031 (1.45)	-0.035 (1.66)	-0.030 (1.25)
PROC RETURNS	-0.045 (1.26)	-0.047 (1.35)	-0.069 (1.95)	-0.048 (1.31)
BOTH RETURNS	-0.032 (1.24)	-0.046 (1.74)	-0.043 (1.66)	-0.041 (1.49)
DEMPROD	-0.009 (0.55)			-0.009 (1.49)
DEMPROC	-0.032 (2.17)			-0.028 (1.90)
DEMBOTH	-0.060 (4.15)			-0.057 (4.07)
HOMOPROD		0.010 (0.60)		0.011 (0.66)
HOMOPROC		0.021 (1.42)		0.018 (1.28)
HOMOBOTH		0.034 (2.12)		0.030 (1.98)
PROD CONC			-0.080 (1.84)	0 (0.00)
PROCCONC			-0.137 (3.72)	-0.070 (1.31)
BOTH CONC			-0.097 (2.42)	-0.095 (1.34)
Wald test ^a	23.05 (3)	6.49(3) (3)	37.32 (3)	24.12 (3)
Sample size	1,846	1,846	1,946	1,846

Notes: *t* statistics robust to heteroskedasticity. All regressions pass the hypothesis of joint significance of regressors using the Wald test.

^aThe Wald test is different in each specification: In column 1; it refers to demand variable; in column 2, it refers to product homogeneity; and in column 3; it refers to market competition.

The empirical results in this paper are obtained from a panel data of Spanish manufacturing firms during the period from 1990 to 1993. The econometric estimation has controlled for long-run effects and has corrected for endogeneity problems as well as for the correlation between explanatory variables and the error term. There are other important methodological considerations in this paper: Innovation activity has been measured in terms of output, and the estimation of the size of innovation returns has accounted for the distribution of such rents between higher wages and higher profits. This means that the final estimation of innovation returns is a measure of the contribution of innovation to total factor productivity. From another perspective, our results highlight the biases that may be incurred if innovation returns are measured only in terms of differences in the profitability of firms.

The results of this paper have important implications. First, the fact that innovation generates rents raises the question of why some firms innovate and others do not. We cannot answer this question with these data, because the costs of innovation are treated as sunk costs and are not incorporated into the analysis. Therefore, for some firms, the expected rents *ex post* may not be sufficient to cover the costs *ex ante*, and a decision is made not to conduct formal and costly innovation activities. One possible extension of the paper would be to

investigate whether the conditions that favor higher rents *ex post* are also the conditions that tend to induce higher investment of resources in innovation activity *ex ante*.

Implications for Managers

The evidence that innovation returns are partially captured by the firm's workers in the form of higher wages may, in principle, be a discouragement to investing resources in innovation activity, given that the workers do not pay for such investments. But the higher wages may be an incentive for workers to participate actively in incremental innovations (such as those that are part of total quality management practices). If this were the case, higher wages would be a way of stimulating innovations and, *ex post*, innovation activity may be even higher than when workers do not share in the innovation gains. Analyzing the relation between innovation activity and the share of innovation returns should prove to be another fruitful area of research.

Our results show that for firms that operate in recessive markets, product innovations may be more effective in generating rents than are process innovations. Therefore, the innovation strategy of a particular firm should be designed by accounting for market conditions such as demand growth. The same recommendation can be made for firms that pro-

duce and sell standardized products; if they introduce product *and* process innovations, these firms may obtain higher innovation returns than do firms that differentiate their products. Hence, the marginal returns of innovation appear to be higher in firms with standardized products, probably because these firms have already differentiated their products and have obtained higher incremental gains from past innovations.

Market concentration lowers innovation returns, especially for process innovations. If market concentration is an inverse measure of market competition, then innovation returns, and presumably innovation activity, are positively associated with product market competition. This result supports Arrow's (1962) thesis and is contrary to that of Schumpeter (1942): Firms in competitive markets obtain a higher price from innovation because their starting level of profits is low. This result has implications for competition policy, for dynamic efficiency also appears to be positively associated with product market competition.

Limitations of the Analysis

Several limitations of this study are worth noting. Although the data cover a four-year period, a decade would have provided a larger and more diverse sample. The innovation in this study was a yes–no binary variable, and more precise information could have been provided by obtaining the number of product or process innovations. A third shortcoming results from our measure of rents, which did not include information about the firms' human resource policies or workers' perceptions of their captured rents. These additions would have provided richer results in the present study and serve as suggestions for future research.

NOTES

¹ This was done following the NACE-CLIO classification.

² Geroski et al. (1993) present a similar specification except that the dependent variable is the rate of return.

³ Each measure presents problems. The number of people involved in R&D activities ignores resource flows from research equipment and materials, whereas R&D expenditures include purchases that do not confer significant technological advances to the firm, that is, the expenditures on old equipment.

⁴ It is a typical *F* test with one degree of freedom in the numerator corresponding to one restriction.

⁵ We were concerned about the possibility that industry concentration was endogenous, but a Hausman test ($F = 0.00078$) allows us to reject the null hypothesis of endogeneity at any significance level.

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