International Advances in Economic Research (2005)11:301–314
DOI: 10.1007/s11294-005-6659-5


# Innovation in the Portuguese Manufacturing Industry: Analysis of a Longitudinal Company Panel

JOSÉ MONTEIRO-BARATA*

**Abstract**

*Two projects on innovation were developed in the 1990s under the scope of a Portuguese university research center: the Industry/Innovation project (INDINOVA) (1989–1991) and the System for the Observation of Technology and Innovation in Portuguese Industry project (SOTIP) (1997–2000). The two main objectives in this paper are: 1) to compare the results of the first project and the last project; and 2) to explain the evolution that took place between these two periods in regard to the Portuguese 'system of innovation'. In particular, the aim is to focus attention on the evolution (trajectories) followed by a specific group of 165 companies included in both surveys during the 1990s. The final step is to link the evolution of economic and business performances to innovation management practices. In instrumental terms, we utilize factor analysis. (JEL O30)*

## Introduction

In Portugal—whose economy is a small and open one with a fragile scientific and technological system, despite enjoying considerable improvements of late—the experience of supporting industrial innovation is a fairly recent one. For this reason, there are not yet sufficient global empirical studies to permit a satisfactory assessment of firstly, the situation regarding innovative activities and secondly, the quantitative impact of innovation policies.

However, the need for this type of study has been frequently stressed. As a result, two projects were undertaken in the last decade, which will be addressed in this paper: the Industry/Innovation project (INDINOVA–1989–91) [CISEP/GEPIE, 1991] and the System for the Observation of Technology and Innovation in Portuguese Industry project (SOTIP–1997–99) [Monteiro-Barata, 1999, 2000, 2004]. These two projects took place under the scope of a university research center (CISEP/ISEG, Lisbon) and share the common feature of being based on a postal survey mailed to a random sample of companies.[1]

## The Innovation Concept: Paths for Applied Research

The concept of innovation, which was generically adopted in the projects under review, naturally resulted from a synthesis of the relevant literature (see for example,

*Technical University of Lisbon—Portugal. This paper is part of a project supported by Programa Empreender/IFEA-ISEG and by PRAXIS XXI. (Co-funded by FEDER). -Project No. PRAXIS/2/2.1/CSH/677/95.

Kline and Rosenberg [1986], Rothwell [1992], Freeman and Soete [1997], Dosi [1998], Beije [1998]) and the definitions proposed by international bodies, such as the Organization of Economic Cooperation and Development (OECD). Three fundamental areas of innovation were considered: innovation in products, processes, and management.

A product is regarded as technologically innovative when it displays a substantial difference in the materials or components used in comparison with similar products manufactured beforehand, or when it is designed for new uses. Innovation may refer to either an entirely new product (radical innovation) or improvements to a product (incremental innovation), i.e., intervention in parts or components that modify their functioning or performance. Products that are considered innovative may be so at a world level, at a national or industry level, or merely at the firm level and, as a rule, they will provide access to new markets.

A process is regarded as technologically innovative when it is used either for the production of new or improved products that could not be produced through conventional means or for the manufacture of products which were previously made by the firm but now require new techniques or the same techniques performed in a more effective manner. Here one should also draw a distinction between new and improved processes.

In the management area, innovative activities are considered to be practices that make it possible to exploit the company's resources (human, material, energy, etc.) and which may improve knowledge and access to new productive processes, besides adapting the company to the evolution of market structures [Tidd et al., 2001]. All these different specifications of innovation, its dynamic, economic and social impact (radical *versus* incremental innovation) and the difficulties of the empirical approach, point to the complexity of the phenomenon in question. Thus, the conceptual and methodological difficulties that arise when one endeavors to carry out empirical studies of innovation would seem evident, calling for sources of information that reflect this diversity [Monteiro-Barata, 1992; Grupp, 1998].

With the purpose of simplifying these studies, the OECD drew up a Manual of Innovation [OECD, 1992], which, similar to the Frascati Manual [OECD, 1980] specified for R&D activities, standardizes and systematizes the gathering of information on the different aspects of the innovation process in different countries. For the authors of this Manual of Innovation, the central aim was to gather coherent, compatible and analyzable data on:

1) The structure and characteristics of the innovation process in industry;
2) The principle sources of and obstacles to innovation activities (including the role of public initiatives); and
3) The levels of innovation activities and outputs, their intra and inter-industry distribution and their effects on the companies' performance [Sandven, 2000; Kleinknecht and Mohnen, 2002].

Moreover, through the Eurostat and DGXIII services, the European Commission has played an important role, complementary to that of the OECD, in the development of the new type of statistics in the context of the European Innovation Monitoring System (EIMS). The first, second, and third Community Innovation Surveys (CIS), covering the periods between 1990–1992, 1994–1996, and 1998–2000, respectively, fit into this framework [Arundel and Garrelfs, 1997; Sirilli, 2003].

One should also add that innovation—conceived of as a process [Kline and Rosenberg, 1986]—consists of a series of steps of a scientific, technical, commercial, and financial nature. Therefore, "R&D is just one of these steps" [OECD, 1980, pp. 132–3], and R&D activities and non-R&D activities, together forming the 'innovative activities,' will be the central aspects of the surveys. Non-R&D activities consist of design, engineering, tests, marketing, acquisition of non-incorporated technology (patents, technological know-how, etc.), and the acquisition of incorporated technology (machinery, equipment, etc.). Together, these aspects were the object of our analysis in the two projects on innovation dealt with in this paper.

### The INDINOVA Project (1989–1991)

The aim of the INDINOVA project, which was developed by CISEP and commissioned by the erstwhile Ministry of Industry and Energy, through its Study and Planning Bureau (GEPIE), was to characterize the state of innovation in Portugal's manufacturing industry. The general goal, included in this project, was to set up an observatory on technology and innovation in Portugal.

The main areas covered were: business strategies with regard to innovation; innovation factors at plants; barriers to innovation; innovation in products; new materials; innovation in processes; innovation in management; R&D activities and Other Scientific and Technical Activities (OS&TA); the impact of innovative activities on production factors; and the characterization of the equipment most commonly used at plants.

The study involved the launching and analysis of a postal survey sent to a representative sample of extractive and manufacturing industries according to the following strata: size, region and sector of activity. From a sample of 3,276 plants, 1,026 replies were obtained, with a response rate exceeding 30 percent, which amounts to good company participation, notwithstanding the complexity of the survey. One should note that, although the CISEP/GEPIE study was conceived without regard to the OECD Manual of Innovation experience, *a posteriori*, it showed a strong resemblance in its general aims, the themes analyzed and the specific framing of the questions.

The number of firms (strictly speaking plants) that replied to this survey may be characterized as follows: the majority of them are private firms financed by national capital; belonging to traditional industries of Portuguese manufacturing industry (e.g., textiles); included in the size scale of 'between 100 and 500 workers;' and preferentially competing in the national or EU markets. The main conclusions of this study may be summarized as follows:

1. Process innovations are more numerous than product innovations (in effect, 36 percent of plants introduced new processes and only 27 percent introduced new products). The main process innovations relate to improvements in existing processes. Likewise, the main product innovations relate to improvements in existing products;
2. In analyzing the data on management innovation, the most important is clearly 'management computerization' (48 percent), followed by 'market analysis' and 'vocational training and incentives for participation;'
3. The most dynamic plants are located in the industrial municipalities of the Lisbon–Braga coastal strip, produce capital goods, and belong to the larger-sized firms (over 100 workers);
4. The number of plants that perform intramural R&D activities is low and the amounts spent are limited and financed by their own funds. As for R&D investment, it is highly concentrated in a few companies;
5. Analysis of innovation factors at the companies highlights 'purchase of equipment' (incorporated technology) as the main path whereby innovations are spread throughout industrial enterprises. After this, in order of importance, come three

factors that are related to market pressures: product improvement, adapting to consumer tastes and the pressures of competition. Among less important factors are the policy of public incentives for innovation, contacts with research units, universities, and other public bodies. It can be concluded that "firms' strategy on innovation have been fundamentally passive or adaptive in view of the weak position attained by the factors that reveal high technological capacity or an aggressive commercial spirit." Technological modernization was fundamentally centered on the acquisition of new equipment;

6. Analysis of the barriers to innovation showed that entrepreneurs were inclined to make excuses by referring to the workers' age and lack of motivation and attached little importance to collaboration with the scientific community. In fact, very little importance is given to R&D activities or collaboration with the scientific community. This points to aversion to risk and technological domination by the equipment supplier and the important foreign customer;
7. Finally, three dimensions characterize the profile of the innovative enterprise:[2] (1) practices appropriate to management; (2) the performance of R&D activities; and (3) a greater emphasis on vocational training and market analyses. Innovation is a complex, interactive process which, to be successful, calls for reasonable performances in all areas and functions of the company.

## The SOTIP Project (1997–2000)

The SOTIP project is part of a much more extensive one entitled "Innovation and Technological Diffusion in the Portuguese Economy—Diagnosis and Assessment."[3] Its general aims are:

1. To set up a system to observe innovation processes in the Portuguese economy, with priority being given to the manufacturing industry (SOTIP);
2. To create a national capacity for assessing science and technology policies (S&T), with particular reference to observation and assessment of the conditions for absorbing and using support and interface structures for scientific and technological development.
3. As for SOTIP's specific aims, the project team decided on the following:
4. Knowledge of innovation movements and technological change in Portuguese industry, in terms of processes, products, and management;
5. Knowledge of the types of innovation strategies and the role played by certain agents and fundamental partners: the state, university, competition, suppliers of technology, and distributors;
6. Identification of the sources of technology: endogenous R&D, the Public S&T system, suppliers of technology, competition (through imitation), the patents market; and
7. Knowledge of total innovation costs at the company level.

### *The SOTIP Survey*

From early 1997 onwards, the research team considered the general configuration of the SOTIP questionnaire. Following considerable reflection and the analysis of both international experiences, namely the one referred to in the previously mentioned Community Innovation Surveys (CIS) and national ones [CISEP/GEPIE, 1991], the final result can be found summarized in the SOTIP questionnaire used in this research—a postal survey.

TABLE 1
Product and Process Innovation

| | Product Innovation (Percentage of Companies (%)) | Process Innovation (Percentage of Companies (%)) |
|---|---|---|
| General innovative characteristics ('innovation') | 20.7 | 25.2 |
| Incremental improvements | 16.9 | 22.0 |
| Radically distinct | 4.8 | 5.9 |

One important research phase concerned the definition and implementation of the sample for the survey. The following section briefly summarizes this phase.

*Definition of the Sample*

The universe to be considered in this project was defined as the universe of companies with 10 or more workers operating in the extractive and manufacturing industries. The size of the universe drawn up from the Employment Records of what was the Employment Ministry in 1995 indicated a figure of 14,875 plants (with 10 or more workers). It was agreed that the study would be based on the survey of a representative sample of the universe of extractive and manufacturing industries. It was also decided that it would comply with the criteria of industry representativity and size (volume of employment) of companies[4]—the method of stratified random sampling.

From a sample of 3,126 companies, 516 replied (rate of response: 17 percent). For a degree of confidence equal to 95 percent, the accuracy associated with the global sample is around 4 percent. However, the final accuracy levels will certainly be better than this because they are calculated as if it were a simple causal sample, when, in fact, our sample was stratified, which reduced the variance of estimations and, thus improved accuracy levels.

This distribution is similar to the one obtained in the previous survey (INDINOVA) and, broadly speaking, shows the importance of light industries, which is a structural feature of Portuguese industry.

*The Dynamics of Innovation: Product and Process Innovation and R&D*

In the group of answers about product and process innovation (rate of innovation), lower global figures were obtained for product innovation as compared to process innovation, in the case of incremental as well as radical innovations (Table 1).[5] The two types of innovation (product and process) evolve favorably with the increase in company size [Monteiro-Barata, 1999].

In regards to R&D and OS&TA, the main indicators obtained point to figures below those of the previous survey (INDINOVA). However, we think that these figures more accurately reflect the present situation of the respondent enterprises and are more in keeping with the R&D panorama in Portuguese industry (Table 2).

TABLE 2
R&D Activities

| | Percentage of Companies (%) |
|---|---|
| The company has an R&D department | 3.1 |
| The company participates in external R&D activities | 3.4 |

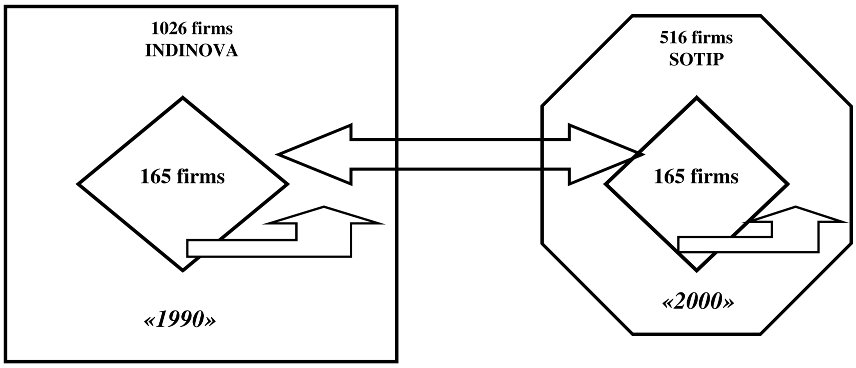


FIGURE 1. Research Design.

In terms of external participation in R&D activities, preferences range from (1) technology centers to (2) universities, while one should stress a new external source of R&D activity within the value chain: clients. In the 1991 survey, relations with universities were the most commonly indicated option. However, in the present survey, technology centers are favored. This is a point that may suggest the diversification and upgrading of the Portuguese technological and scientific system, with specific reference to the relations it establishes with companies [Monteiro-Barata, 1999, 2000].

## Analysis of a Longitudinal Company Panel (INDINOVA/SOTIP Projects)

*Research Design*

After the previous subjects dealing with the general aspects of two innovation surveys undertaken in Portugal during the 1990s, the aim is now to focus attention on the trajectory followed by a specific set of 165 companies included in both surveys. These 165 companies form a longitudinal panel of companies that were specially surveyed at the time of the SOTIP survey (and which were, naturally, in activity at that time), resulting from an automatic search in the two databases used (through a match of company designations).[6] The research design is shown, in schematic terms, in the following figure (Figure 1).

The distribution by industry of these 165 companies may be seen in the following table. As can easily be observed, the most commonly found company size is 100 to 500 workers. Roughly two thirds of the number of companies in the panel falls into seven

TABLE 3
Companies Grouped by Size and Number of Workers

| | Frequency | Percentage (%) |
|---|---|---|
| $10 \leq N \leq 19$ | 14 | 8.5 |
| $20 \leq N \leq 49$ | 50 | 30.3 |
| $50 \leq N \leq 99$ | 33 | 20.0 |
| $100 \leq N \leq 499$ | 59 | 35.8 |
| $N \geq 500$ | 9 | 5.5 |
| Total | 165 | 100.0 |

TABLE 4
Industries Composing the Panel

| | Cases | Percentage (%) |
|---|---|---|
| 1. Extractive | 2 | 1.2 |
| 2. Food | 13 | 7.9 |
| 3. Beverages | 2 | 1.2 |
| 4. Textiles | 15 | 9.1 |
| 5. Clothing | 21 | 12.7 |
| 6. Leather and footwear | 2 | 1.2 |
| 7. Wood, furniture, and cork | 23 | 13.9 |
| 8. Pulp and paper | 5 | 3.0 |
| 9. Graphic arts and publications | 10 | 6.1 |
| 10. Basic chemicals | 2 | 1.2 |
| 11. Light chemicals | 3 | 1.8 |
| 12. Rubber and plastic-made articles | 8 | 4.8 |
| 13. Ceramics | 6 | 3.6 |
| 14. Glass | 4 | 2.4 |
| 15. Other non-metallic minerals | 10 | 6.1 |
| 16. Ornamental stones | 2 | 1.2 |
| 17. Ferrous metallurgy | 1 | 0.6 |
| 18. Non-ferrous metallurgy | 2 | 1.2 |
| 19. Metal products | 13 | 7.9 |
| 20. Moulds for plastic | 2 | 1.2 |
| 21. Non-electrical machinery and equipment | 6 | 3.6 |
| 22. Electrical and electronic machines and equipment | 6 | 3.6 |
| 23. Automotive and other transport material | 1 | 0.6 |
| 24. Other manufacturing | 6 | 3.6 |
| Total | 165 | 100 |

(traditional) industries (Tables 3 and 4). Approximately 11 percent are foreign capital companies and most of them follow a cost-based leadership strategy (36 percent).

In view of the common difficulties in effectively comparing the innovation levels obtained in the two surveys (given the dissimilar nature of the questions asked), the existence of this actual set of companies—objectively the same at the beginning and end of the process—makes it possible to carry out a special exercise that helps us to elucidate the dynamics of innovation and its explanatory variables.

TABLE 5
The Company Panel and the Dynamics of Innovation

| | (Base Index)- = 100) | |
|---|---|---|
| | 1990 (1,026 Cases) | 2000 (516 Cases) |
| Innovation in products | | |
| Panel (165 cases) | 106.9 | 140.1 |
| Sample | 100.0 | 100.0 |
| Innovation in processes | | |
| Panel (165 cases) | 107.3 | 134.7 |
| Sample | 100.0 | 100.0 |

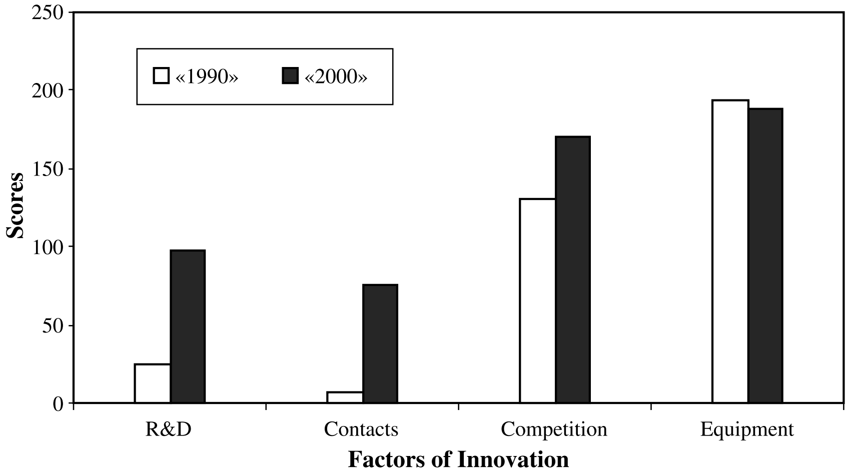


FIGURE 2. Most Important Factors of Innovation (Company Panel).

Summary calculations show that the levels of innovation in this panel of companies are systematically higher than in the overall sample of respondent companies, both for the first and the second period (Table 5). The same positive evolution can be seen in the setting up of R&D laboratories, where the index rose from 89 to 218 percent.

It is also interesting to analyze the evolution of factors of innovation (perceptions). If we select four important items that are representative of the internal and external framework of innovation, it is easy to understand the greater relative importance attributed by the panel to R&D, as well as to outside contacts with the world of science and technology, in detriment to the purchase of equipment (Figure 2). As far as barriers to innovation are concerned, the company panel also shows itself to be more aware of the difficulties involved.

*Innovative Characteristics of the Company Panel: Synthesis*

After establishing the basic profile of these companies—with there being a tendency to display higher levels of innovatory performance—a factor analysis is now carried out, using the data for the two periods. The innovative phenomenon requires general frames of reference. In this way, the discovery of the principal dimensions or underlying factors proves useful. Factor analysis helps to identify these factors, which are not directly observable, by starting from a set of variables observed [Monteiro-Barata, 2000].

From this exercise in factor analysis, there emerged four factors, which together accounted for 67 percent of total variance (with the first factor alone accounting for 26 percent). The matrix of the factor loadings may be seen in Table 6.[7]

This analysis allowed to confirm:

1. The importance of research activity (R&D). Bearing in mind this first factor extracted (factor analysis), it may be said also that product innovation is more closely associated with research practices;
2. The 'purchase of equipment' factor—which is so often highlighted in studies in several countries—seems to be very closely associated with pressure from competition, foreshadowing a dependent innovation;
3. Process innovation tends to be relatively more centered upon technological activities undertaken outside the company; and finally

TABLE 6
Dimensions of Innovation (Factors and Barriers of Innovation)

| | Rotated Component Matrix Components | | | |
|---|---|---|---|---|
| | C1 25.9% | C2 15.5% | C3 13.2% | C4 12.2% |
| Factor of innovation—R&D (perception) | 0.731 | 0.211 | 0.167 | −0.046 |
| Factor of innovation—purchase of equipment (perception) | −0.154 | 0.860 | −0.010 | −0.050 |
| Factor of innovation—contacts with technological centres (perception) | −0.060 | 0.309 | 0.436 | −0.643 |
| Factor of innovation—pressure from competition (perception) | 0.454 | 0.715 | −0.089 | 0.086 |
| Introduction of new/better products | 0.683 | −0.014 | 0.080 | −0.205 |
| Introduction of new/better processes | 0.072 | −0.059 | 0.835 | 0.085 |
| Existence of R&D laboratory | 0.776 | −0.088 | 0.062 | 0.128 |
| R&D undertaken outside company | 0.443 | −0.044 | 0.568 | −0.045 |
| Considers there to be barriers to innovation | −0.126 | 0.151 | 0.236 | 0.845 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

4. The fourth component shows a perfect connection between the perception of the existence of barriers to innovation (0.843) and the non-use of the external technological environment (innovation system) (−0.643), increasingly considered to be a factor affecting the success of innovation.

## Techno-Economic Trajectories of the Panel Companies

The next step will be to use the information about this company panel to describe, analyze and map out the innovation trajectories followed by companies and groups of companies during the 1990s (Table 7). Or, in other words, to undertake a study in which it is possible to link the evolution of economic performance to innovation management practices [see, for example, Tidd et al., 2001; Monteiro-Barata, 2004].

Based on some of the variables and indicators presented above, a factor analysis was once again undertaken of the group of panel companies, or, in other words, of the companies that, for the sake of convenience, will be referred to as the '1990 companies' and the '2000 companies.' The aim is to represent them in the same space and to understand the trajectories that they followed according to the different factor plans. From this exercise in factor analysis, there emerged three factors, which together accounted for 77 percent of total variance (with the first factor alone accounting for 33 percent). The matrix of the factor loadings may be seen in Table 8.[8]

According to the results, the first component (C1) may be considered the one that reveals the 'innovation dynamics;' the second component (C2) represents the 'size and capacity of physical investment'; and the third component (C3) represents 'performance and immaterial investment' (which includes all investments, excluding equipment and hardware).

TABLE 7
Data on the Evolution of the Panel Companies (165 Companies)

| | INDINOVA | SOTIP | Overall |
|---|---|---|---|
| *Perceptions* | '1990' | '2000' | |
| Innovation factor—R&D | 0.08 | 0.59 | 0.34 |
| Innovation factor—purchase of equipment | 0.77 | 1.14 | 0.95 |
| Innovation factor—contacts with technological system | 0.02 | 0.45 | 0.24 |
| Innovation factor—pressure from competition | 0.55 | 1.04 | 0.79 |
| Existence of barriers to innovation | 0.68 | 0.71 | 0.70 |
| *R&D (%)* | | | |
| R&D—The company has a R&D department | 8 | 11 | 10 |
| R&D—The company participates in external R&D | 9 | 12 | 10 |
| *Variables (Average Values)* | | | |
| Size (no. of workers) | 184 | 199 | 192 |
| Sales (€) | 5,346,333 | 10,922,543 | 7,978,007 |
| Manufacturing investment(1) (€) | 471,421 | 472,788 | 472,004 |
| Acquisition of knowledge and technological services(2) (€) | 56,329 | 35,470 | 45,466 |
| R&D (€) | 70,246 | 934,841 | 317,272 |
| Vocational training (€) | 29,414 | 39,849 | 32,252 |
| Marketing (€) | 55,482 | 243,170 | 108,374 |
| Consultancy (€) | 9,038 | 24,182 | 12,879 |
| Material investment (€) | 471,421 | 472,788 | 472,004 |
| Immaterial investment (€) | 110,619 | 332,380 | 196,717 |
| (1) Equipment and hardware | | | |
| (2) Software, services, patents, brands, and design | | | |
| *Innovation (%)* | | | |
| Product innovation | 25 | 37 | 31 |
| Process innovation | 42 | 40 | 41 |
| *Indicators* | | | |
| Productivity (sales per worker) (€) | 29,056.16 | 54,887.15 | 41,552.12 |
| Manufacturing investment per worker (€) | 2,562.07 | 2,375.82 | 2,458.36 |
| Intensity of knowledge acquisition and tech. services (in relation to sales) | 0.011 | 0.003 | 0.006 |
| Intensity of R&D (in relation to sales) | 0.013 | 0.086 | 0.040 |
| Intensity of vocational training (expenditure per worker) | 159.86 | 200.25 | 167.98 |
| Intensity of marketing (in relation to sales) | 0.010 | 0.022 | 0.014 |
| Intensity of consultancy (in relation to sales) | 0.002 | 0.002 | 0.002 |

TABLE 8
Global Dimensions of Innovation and Managerial Variables

| | Rotated Component Matrix Components | | |
|---|---|---|---|
| | C1 32.7% | C2 27.9% | C3 16.1% |
| Size | 0.038 | 0.941 | 0.033 |
| Productivity | −0.067 | −0.053 | 0.876 |
| Material investment | −0.003 | 0.923 | 0.166 |
| Immaterial investment | 0.116 | 0.331 | 0.687 |
| Product innovation | 0.764 | −0.106 | 0.126 |
| Process innovation | 0.828 | 0.118 | −0.015 |
| General innovation | 0.956 | 0.056 | −0.081 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Based on this general characterization, it is possible to represent the trajectories followed by the panel companies between, more or less, the beginning and the end of the 1990s. It should be noted that, given the listwise deletion procedure used, many panel companies disappeared in this analysis, with only 37 remaining for comparison purposes. The following figures show the differences between 1990 and 2000 in the value of the scores for the first component (Figure 3), the second component (Figure 4), and the third component (Figure 5).

As is clearly shown by the graphs, the innovation differentials—for this smaller number of companies—-were positive overall; the evolution of (material) investment slowed down; and there was a clear increase in immaterial investment (mainly vocational training and marketing), associated with the improvement in productivity.

## Concluding Remarks

The above work highlighted the main general results regarding the dynamics of innovation in Portuguese manufacturing industry in the 1990s. In particular, informa-

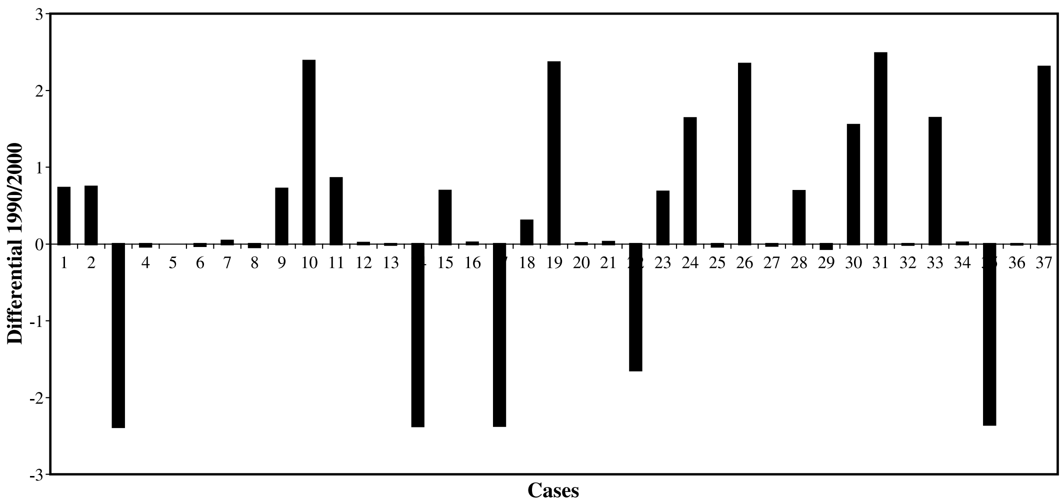


FIGURE 3. Innovation Dynamics (Product and Process)—Component 1.

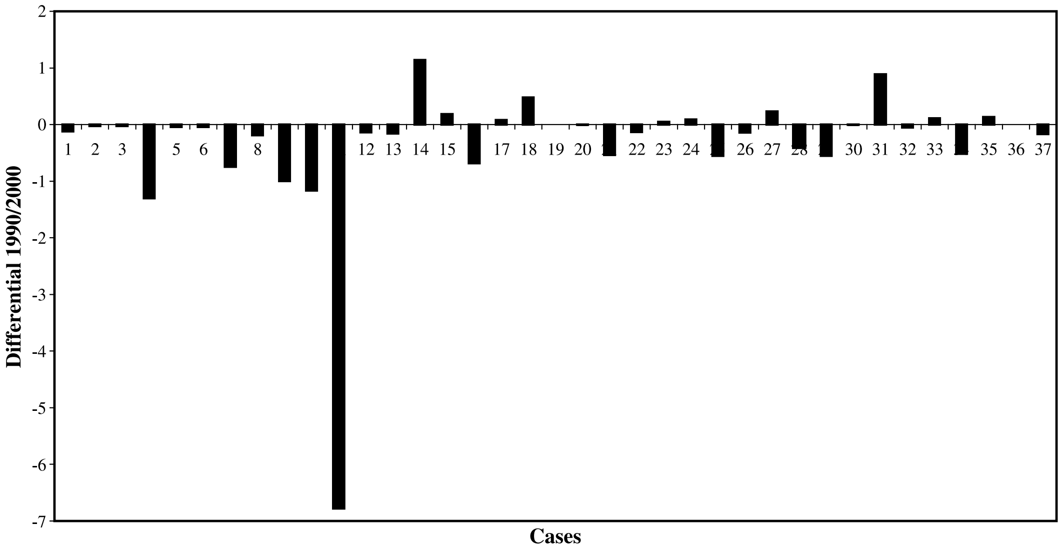


FIGURE 4. Material Investment and Company Size—Component 2.

tion about a company panel has been used to describe the innovation trajectories followed by these companies during this period. In other words, an attempt has been made to link the evolution of economic performance to innovation management practices. Innovation and material and immaterial investment were the central concepts of this analysis.

Overall, the data obtained show that there was a scientific and technical evolution at the companies, together with a development of immaterial investment and productivity. As far as innovative practices are concerned, product innovation seems to be the element sustaining the improvement in entrepreneurial performance.

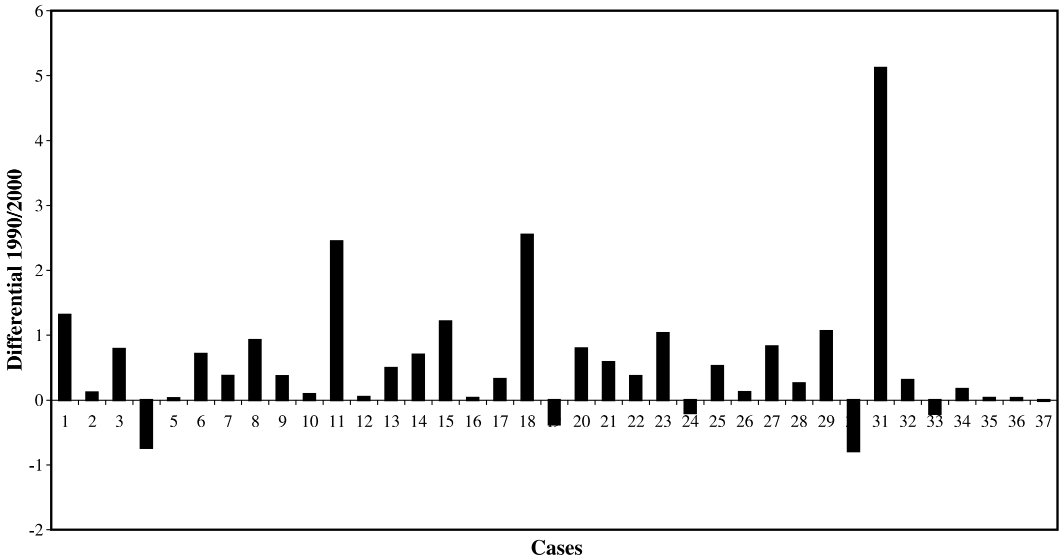


FIGURE 5. Immaterial Investment and Performance—Component 3.

## Footnotes

[1]One should also refer to the surveys launched by JNICT (the body designated by the Portuguese Statistical Institute to deal with issues relating to technology and innovation) within the framework of the European Economic Union (Community Innovation Survey).

[2]Results supported by factor analysis.

[3]This, in turn, was developed under the scope of the PRAXIS XXI program (Foundation for Science and Technology)—a national program designed to stimulate research and technological development.

[4]The project defined 24 industries and five categories of size.

[5]Only those companies that replied affirmatively to any of the items regarding 'innovative activities' could answer this block of specific questions on product and process innovation.

[6]This process gave rise to a very large reduction in the number of companies obtained. In fact, from one year to the next, companies undergo natural changes in their designations, as well as frequently appearing as being registered under slightly different forms.

[7]The methods used for extracting and rotating factors were the 'principal components' method and the 'varimax' method, respectively. The measure obtained of sample adequacy (KMO) was 0.60 and of Bartlett's test of sphericity 75.1 (Signif. = 0.000).

[8]The measure obtained of sample adequacy (KMO) was 0.51 and of Bartlett's test of sphericity 408.9 (Signif. = 0.000). The option for missing values was to exclude cases listwise.

## References

Arundel, Anthony; Garrelfs, Rick (eds.). *Innovation Measurement and Policies*, EUR 17019 EN, Luxembourg: European Commission, 1997.

Beije, Paul. *Technological Change in the Modern Economy*, Cheltenham, UK: Edward Elgar Publishing Limited, 1998.

CISEP/GEPIE. *A Inovação na Indústria Portuguesa-O Observatório MIE,* Relatório Técnico, Volumes I e II, Lisboa, Portugal: Ministério da Indústria e Energia, 1991.

Dosi, Giovanni. "The Nature of the Innovative Process," in *Technical Change and Economic Theory*, Giovanni Dosi, Christopher Freeman, Richard Nelson, Gerald Silverberg, Luc Soete (eds.), London, UK: Pinter Publishers, 1988.

Freeman, Christopher; Soete, Luc. *The Economics of Industrial Innovation*, London, UK: Pinter Publishers, 1997.

Grupp, Hariolf. *Foundations of the Economics of Innovation. Theory, Measurement and Practice*, Cheltenham, UK: Edward Elgar Publishing Limited, 1998.

Kleinknecht, Alfred; Mohnen, Pierre (eds.). *Innovation and Firm Performance. Econometric Explorations of Survey Data*, Basingstoke: Palgrave, 2002.

Kline, Stephen J.; Rosenberg, Nathan. "An Overview of Innovation," in *The Positive Sum Strategy: Harnessing Technology for Economic Development*, Ralph Landau, Nathan Rosenberg (eds.), Washington, DC: National Academy Press, 1986, pp. 275–305.

Monteiro-Barata, José. "Inovação e Desenvolvimento Tecnológico: Conceitos, Modelos e Medidas. Pistas para a Investigação Aplicada," *Estudos de Economia*, XII, 2, 1992, 147–71.

—. "The Innovative Firm Profile in the Portuguese Manufacturing Industry," Paper Presented at 48th International Atlantic Economic Conference, Montreal, Canada, October 7–10, 1999.

—. "Innovation in the Portuguese Manufacturing Industry. Some Recent Developments," Paper Presented at 49th International Atlantic Economic Conference, Munich, Germany, March 14–21, 2000.

—. "Innovation in the Portuguese Manufacturing Industry: Analysis of a Longitudinal Company Panel," Paper Presented at 57th International Atlantic Economic Conference, Lisbon, Portugal, March 10–14, 2004.

OECD. *The Measurement of Scientific and Technical Activities—Proposed Standard Practice for Surveys of Research and Experimental Development (Frascati Manual)*, Paris, France, 1980.

—. *Proposed Guidelines for Collecting and Interpreting Technological Innovation Data (Oslo Manual)*, Paris, France, 1992.

Rothwell, Roy. "Successful Industrial Innovation: Critical Factors for the 1990's," *R&D Management*, 22, 3, 1992, pp. 221–39.

Sandven, Tore. *Innovation and Economic Performance at Enterprise Level*, Oslo, Norway: STEP Group, 2000.

Sirilli, Giorgio. "New Frontiers in the Measurement of Innovation," Paper Presented at 7th International Conference on Technology Policy and Innovation, Monterrey, Mexico, June 10–12, 2003.

Tidd, Joe; Bessant, John; Pavitt, Keith. *Managing Innovation. Integrating Technological, Market and Organizational Change*, London, UK: Wiley, 2001.