TECHNOLOGICAL REGIMES AND PATTERNS OF INNOVATION IN THE BRAZILIAN FOOD INDUSTRY

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Abstract:

The works by Abramovitz (1956) and Solow (1957), showing the impact of technological change on economic growth, underline the birth of a great interest in the field of economics related to the determinants of innovation, at the industry and the firm levels. Hence, this paper assembled a conceptual framework aiming to identify the relationship between patterns of innovation and technological regimes. It is based on the information collected through a survey on technological innovation in a sample of 242 food firms at the Brazilian industry. The study identified three clusters of innovating firms, which display similar patterns of innovation. Two overall conclusions are suggested. First, technological regime, defined as the result of a particular combination of major technological features, including knowledge bases, sources and degrees of technological opportunities, conditions of appropriability and forms and degrees of cumulativeness of technological advances, operates as a source of homogeneity, making up groups of innovating firms in terms of broad regularities in innovative activities. Second, since diverse patterns of innovation can be realized in the food industry, this industry should not be reduced to one analytical category in terms of technological environment. Hence, the main theoretical implication of the findings is that technological regimes are also firm specific. In other words, firms' resources and capabilities mediate the influence of technological regime on pattern of innovation. Finally, the study confirms the existence of features in firms' innovative activity that prevails over industrial or sectoral classification.

Keywords: technological innovation, economics of innovation, Brazilian food industry, technological regime, patterns of innovation

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1. Introduction

Taxonomical approaches relating technology environments and sectoral patterns of innovation provide justification for broad regularities in inter-industry variations in technological change, which is very useful for both analysis and policy-making at the macro-level and at the micro-level for technological strategy and management. However, due to the real possibility of varied technological environments for some industries, there is a "puzzle" about which level of aggregation these relationships are found. This "puzzle" was the motivation to test, in other paper (CABRAL, 1998), the research hypothesis of a homogeneous pattern of technological innovation to the food industry. The overall result of the referred test provides evidence for the existence of more than one pattern of innovation in the Brazilian Food Industry (hereafter BFI).

This evidence is the basis for the question that is formulated and tested in this paper: which are the patterns of innovation in the BFI and what are their relationships with the technological regimes? Thus, the identification of patterns of innovative activity in the BFI will be attempted. This attempt will draw on a conceptual framework, proposing that technological regimes determine patterns of innovation. In addition, it will also identify whether these patterns can be associated with sectors or groups of food sectors.

In order to achieve the objectives set above, item 2 primarily deals with a theoretical consideration and empirical results on the topic. Item 3 concentrates on the analytical techniques, and item 4 reports on the results obtained (i.e. the patterns of innovative activity in the BFI). Item 5 sets out the conclusions derived from the analytical considerations.

2. Technological Regimes and Patterns of Innovation

The concept of technological regime (NELSON; WINTER, 1982; WINTER, 1984; ORSENIGO, 1989) provides a complementary notion, which is very consistent with the conceptualisation of technological paradigms and trajectories, for the analysis of inter-industrial variations in innovative activity. Technological regime was defined as the result of a particular combination of major technological dimensions, including knowledge bases, sources and degree of technological opportunities, conditions of appropriability, and forms and degrees of cumulativeness of technological advances. Particular features of these technological dimensions, altogether, generate specific technological regimes, which in turn determine specific patterns of technological innovation. Malerba and Orsenigo (1990:286) propose that, besides rate and directions of innovation, the analysis of this pattern should include other important dimensions, such as the level of concentration of innovations by firm in the industry, the degree of ease for new firms to innovate, and the stability of the hierarchy of innovating firms over time.

This conceptual framework has also been tested empirically. Malerba and Orsenigo (1995; 1996), for instance, analysed the theoretical possibilities of the proposed relationship among several countries, and concluded that, in general, 'technology-specific factors (closely linked to technological regimes) play a major role in determining the patterns of innovative activities across countries' (1995:62). However, in line with the conclusion of Cabral (1998), studies have shown that some industries fail to comply with the conceptual proposal of presenting a single homogenous pattern of technological innovation. Malerba and Orsenigo (1996) found that the food industry presented a pattern that is characteristic of "Schumpeter mark I" in Germany and in France (i.e. low degree of firms' concentration of innovations, high degree of new innovating firms, low stability in the ranking of innovating firms and a predominance of small innovating firms); and a "Schumpeter mark II" pattern in USA, UK, Japan, and Italy (i.e. higher degree of concentration of innovations, lower degree of new innovating firms, higher stability in the ranking of innovating firms, and predominant role of large innovating firms).

Molero and Buesa (1996), following this framework, examined the configuration of the innovation process in firms located in the Madrid (Spain) region. They found that the variety and diversity of the processes of technical change could be resumed into groups of firms following similar technological regimes. Despite recognising influential sectoral characterisation in the groups, they emphasise that, as a whole, their taxonomy was less sector-dependent. In other terms, 'firms can follow different trajectories [technological] in spite of belonging to the same economic branches' (p.662). Cesaratto and Mangano (1993), based on technological sources and innovative performance variables, identified the patterns of innovation in the Italian industry. Their patterns also confirm the possibility of classifying the varied behaviour in innovative activity emphasised by the studies above. Nevertheless, they could not associate the identified clusters to industrial sectors, concluding by 'the existence of different technological trajectories and [firms] strategies within the same sector' (p.237).

From the foregoing results, the objectives of this paper include: identifying the patterns of innovative activity in the BFI; and analysing the relationship among the patterns of technological innovation and technological regime dimensions.

3. Survey Methodology and Analytical Techniques

3.1. Survey

The empirical basis for achieving the paper's objective is a data set assembled from a survey focusing upon innovative activity in the BFI (CABRAL, 1998). At the outset, the food processing industry was defined based on the official industrial classification approved by the Brazilian Government. In this classification, the food industry is one of the twenty-one (21) two-digit industry groups that comprise the country's manufacturing industry and it is distinguished by nine food sectors (three-digit level), as can be seen in Table 1. From this definition, the list of firms in the food industry was taken as basis for sample selection. A firm, in turn, is defined as a legal social unit that is exclusively or predominantly concerned with the manufacture of raw animal, vegetable or marine material into intermediate foodstuffs or edible products, in one or more places (establishments).

In accordance with the definitions above, 38,916 firms in the food industry constituted the initial population on which to base sample selection. Since some questions were considered as very new to firms, demanding, therefore, a very organized internal file system, the smallest firms (with fewer than five employees) were excluded from this population basis. Hence, the definitive population basis was composed of 19,045 firms or 48.9% of the industry's total, but corresponding to 92.4% of the employment, 96.2% of the payroll, 97.9% of the output and 97.6% of the value-added[1].

From this population, a relatively large stratified random sample of 1,000 firms[2] was selected. The stratification was undertaken by firm economic activity (food three-digit manufacturing line of business), firm size (number of employees), and geographical region of

[1] Source: FIBGE - Industrial Census 1985. Actually, these shares refer to establishments with more than five employees, due to the lack of this information by firms. In addition, it is noted that the year 1985 was chosen because it represented the last quinquenal (every fifth year) industrial census by FIBGE. From this year on, the FIBGE began to publish an annual industrial research with the information aggregated at a greater level.

[2] Estimating the sample size by Newman-Pearson inference method in the case of sample proportion with allowable error (E) of 0.05 (5%), confidence level of 95% (Z=1.96) and expecting the proportion (π) of the phenomenon measured in the population to be 0.3, one has:

$n=\pi(1-\pi)Z^2/E^2 = 0.3\ (1-0.3)\ (1.96)^2 / (0.05)^2 = 323.$

If the margin error is allowed to be 0.06 (6%), then "n" becomes 224. The number of respondent firms is above of this figure.

However, the decision to survey a large relative sample aimed at working above the statistically defined

Brazil. As the numbers of medium and, mainly, large firms are relatively very low, the proportions of selected firms in these groups were relatively greater than that of small firms. This was necessary in order to guarantee the correct analysis of innovative activities in all size groups and to make comparisons among them. In fact, the likelihood of inclusion for large firms was almost one. Due to the absence of information about the number of firms by geographical region in the industrial census, the proportions of firms by region were defined based on the number of establishments in a region. In addition, the selection of firms by food sector was by chance, also due to the lack of information in the census[3].

FOOD SECTOR	SAMPLE	SHARE(%)	RESPONSES	SHARE(%)	RATE
Meat and Fish Processing	145	14.5	32	12.9	22.1
Fruits and Vegetables	83	8.3	19	7.7	22.9
Fat and Oils	41	4.1	10	4.0	24.4
Dairy	90	9.0	27	10.9	30.0
Grains and Animal Feed	192	19.2	53	21.4	27.6
Sugar	46	4.6	13	5.2	28.2
Coffee	44	4.4	10	4.0	22.7
Miscellaneous-Cocoa-Bakery	359	35.9	60	24.2	16.7
Others[4]	0	0	24	9.7	-
TOTAL	1000	100	248	100	24.8

Table 1: Sample Stratification by Food Manufacturing Sector (three-digit)

Sources: Brazilian States' Statistics Yearbooks; Own survey

In order to collect the qualitative and quantitative information needed, the selected firms were asked to fill in a questionnaire about their organizational characteristics and their innovative, strategic and managerial activities, during a three-year period. This period of three years was established due to yearly fluctuations of innovative activities in industries and firms, taking into account that technological innovations may not be a very steady event at a firm's level. Actually, the longer the period, the better the information, especially for longitudinal studies[5]. The three-year period began in 1994, as this was the starting point of a large restructuring of the Brazilian economy.

minimum for the analysis of all units of observation (food sector and firm size).

[3] Although it would be possible to obtain this information from the states' statistics yearbook, this would too time consuming since sector classifications differ from the those of the FIBGE census. This work would not be changed considerably because the selection was "by chance", thus the likelihood of representative distribution of firms among sectors is very high.

[4] In this case, "Others" means salt, cashew nut, addictives, frozen food, nutritional supplements and herb processing firms.

[5] It is important to anticipate that, albeit adopting a "time-series" design in the data collection, all analysis will adopt the cross-sectional method through average or cumulative figures. Hence, this work will examine the relationships between technology features, firm behavior and innovation patterns at a given time, not addressing the analyses of changes in the co-evolution of firms and industry.

The questionnaire comprised a total of 27 questions divided into two parts. Questions in part one were about firms' organizational characteristics (structure, activities and strategies) and related innovativeness. This part profiles firms' principal and complementary activities, production stages, ownership structure, organizational status, age, turnover, export performance, advertising intensity, innovative inputs, employment level, innovative external alliances, and the intensity of strategic functions including technological innovation policy, long term strategic plan, and marketing research. The second part referred to specific questions about the innovations and their nature, including a list of firms' innovations introduced in the period and their institutional sources of knowledge, types, sources, degree of protection, novelty, newness, internal department of development, impact on input factors, and major motivations to innovate.

Before the definitive design, the questionnaire was submitted to two managers of food firms and to three experts in food technology, to test clarity and layout. Their suggestions contributed to a reformulated design. In addition, this "new" design was pre-tested through its mailing to twenty representative firms, selected from the defined sample. The first definitive contact with firms came from mailing the questionnaire to firms' senior manager. That is, to the individual who is formally the head of the executive structure of the organization, usually, albeit not necessarily, with the job title of general manager or director president. To encourage the responses, the questionnaire was sent with a covering letter from the Chairman of EMBRAPA-CNPAT (Brazilian Agricultural Research Company – National Research Centre of Tropical Agroindustry). This covering letter aimed to convince the firms that the achievement of the research objectives would have a "utility" function to the firms themselves and to the BFI.

In addition, to increase the rate of responses, the questionnaire was followed by two follow-ups (postcards). The first postcard was addressed ten days after the first mailing to thank those who had already returned their questionnaires and to remind those who had not. The second was sent six weeks after the original mail out and consisted of a new covering letter and a replacement questionnaire. This method consisted of an adaptation of the TDM (The Total Design Method) proposed by Dillman (1978) and the result was very positive, since it is close to the previous estimation (footnote two). The rate of response (Table 1) was of 24.8%. This is also a very positive rate compared to the rates obtained by similar surveys sent to Brazilian firms.

3.2. Underlying Variables and Statistics

In order to identify groups of firms presenting similar patterns of innovative activity and relating them to technological regimes, the first step was the definition of the suitable group of variables, from the great amount available in the survey. Since the characteristics (dimensions) of patterns of technological innovation have been broadly discussed and empirically tested in the economics literature, their definition is not a very difficult task. However, regarding indicators of the dimensions of technological regime, some limitations should be stressed in advance. First, it is recognized that one is dealing with a very new area of inquiry and a strong and convincing group of indicators regarding technological regime has not been proposed and empirically tested. In general, this reflects the fact that the dimensions of technological regime are multidimensional and complex. Malerba and Orsenigo (1990:287), for instance, indicate that, at the present stage, it is very difficult to define a satisfactory synthetic measure for knowledge base. Secondly, while the research period (three years) presents a strong point in the measurement of most indicators of patterns (for example, employment), since it minimizes the negative effects of yearly fluctuations, it is short for the analysis of some indicators of technological regime (cumulativeness).

The theoretical literature reviewed above, however, proposes that the technological regime dimensions are the determinants of the patterns of technological innovation. In the proposal, this would be a tautological matter in the sense that from the existence of varied patterns, varied technological regimes might be predicted. As concluded in works cited by Audrestch (1992:32), while the concept of technological regimes does not lend itself to precise measurement, the existence of distinct regimes can be inferred from different patterns. Therefore, the identification of the patterns of technological innovation in the BFI is stated as the paper's primary objective. Relating the patterns identified to technological regimes is a complementary and confirming objective in this context. In addition, not all variables indicating technological regime are being measured for the first time. Some of them have been tested before in the empirical literature with positive results. Taking into account all of these, it is believed that the above limitations shall not undermine the achievement of the objectives of this work.

The relevant dimensions regarding patterns of technological innovation have been described in terms of the rate of innovations, sources of innovations, types of innovations, firms' concentration of innovations at industry and food sector levels, relevance of new innovating firms, and size of innovating firms.

1. Rate of Innovations is defined by the ratio of a firm's total number of innovations over the firm's employment. It has been used to standardize the number of innovations by the number of employees, regarding the size of firms in any given industry. According to Audrestch (1997:59), this is, probably, the best measure of innovative activity.
2. Sources of innovations, as before, refer to the origin (internal or external) of the innovation development regarding the innovating firm.
3. Types of innovations, also as before, refer to the classification of innovations in product, process, and combined innovations (product and process).
4. Concentration refers to the degree in which innovations are concentrated in a few firms or spread by many firms, at the food industry (two-digit) and the food sector (three-digit) levels.
5. New innovator is defined by Malerba and Orsenigo (1990:284) as the rate of entry of new innovating firms. In other words, it refers to the degree of firms innovating for the first time in a given period of time.
6. Size is defined by a quantitative measure of some resources such as employment and turnover (gross sales), employed or internalized by firms, As surveyed in chapter three, this has been one of the most investigated variables about determinants of innovation. However, there is now a tradition of considering it not only as determinant, but also as an effect of innovation. Pavitt *et al.* (1987:298), for instance, stress that 'size is [also] a function of technological opportunities, appropriability and demand, and that these vary amongst sectors'.

The technological regime relevant dimensions are comprised of:

1. Knowledge base, as above, refers to cognitive sources and learning procedures related to technological advances. This has not been a measured dimension in empirical works. However, the prevalent structure of a firm's learning has been used as an indicator of this dimension. The premise is that firms using more complex and specific (tacit) knowledge are expected to show a higher score to innovations developed through R&D activities. Hence, a firm's R&D efforts are often related to the most complex and tacit learning processes in innovation development. Accordingly, the internal source of innovation development, in terms of functional department, will be used as a measure of the knowledge base, with the R&D department as source, meaning a more formalized, complex and a firm-specific knowledge.
2. Technological opportunities, referring to the level of possibilities to innovate given some amount of effort, are considered one of the most important determinants of technological

change in any industry. In addition, these opportunities are considered to vary amongst industries. Hence, as opposed to the knowledge dimension, this one has been extensively measured in empirical studies about determinants of innovations. However, how to measure it cannot be considered as a simple and apparent task. Since it is accepted that some industries present richer opportunities than others, the most common attempt to measure technological opportunities has been associated with Scherer's (1965) proposal to classify industries, at two-digit SIC level, according to their closeness to scientific and technological field. Scherer (1965) classified the industries in four classes, from richer to less rich in opportunities. Widening this proposal, Klevorick, Levin, Nelson and Winter (1995:188) suggest the definition that the level of opportunities is based on three different sources of an industry's opportunities: advances in related scientific understanding; technological advances in related and non-related industries and institutions; and the extent to which an industry's technological opportunities feed back on themselves (innovation possibilities of the technological "trajectory"). These sources and corresponding industries' technological opportunities were defined according to respondent manager's perception to the correspondent questions addressed by these researchers. In turn, Wakelin (1998:833) claims that the level of the firm's technological opportunities might be indicated by its relative performance in innovations developed internally. The higher the opportunities, the higher the proportion of innovations developed internally by innovating firms. In turn, adopted innovations developed externally show innovation spillovers from other firms in the economy. Similarly, Pavitt *et al.* (1987:308) define high technological opportunities in terms of one of these indicators: number of innovations, patenting, or R&D effort. Hence, the variable "innovation count" shall capture this dimension in this study.

3. Appropriability refers to the level of innovation's protection from imitation. As in the case of technological opportunities, this dimension has been extensively measured. The main measures being based on the variety of protection strategies, including patenting and uses of other mechanisms, namely secrecy, lead-time, learning-curve effects, and complementary sales or services. This work will measure appropriability by these two variables. However, as firms differ in the most effective means of protecting their innovations depending upon the industry, it is expected that the "other mechanisms" is a more effective strategy in the case of the food industry.
4. Cumulativeness is associated with the extent to which early innovators, at the firm or industry levels, have greater likelihood to innovate thereafter. This dimension also has not

often been tested empirically. As at the firm level, it refers to how steady the process of innovation is. In this work, cumulativeness will be measured, through one indicator of innovations over time in each innovating firm.

The dimensions and selected variables of regimes and patterns are described in Table 2.

DIMENSION	VARIABLE	MEASUREMENT	MEASUREMENT LEVEL	SCALE / CODING
Rate of Innovations	Ratein	Total number of innovations divided by employees (thousands) in each firm.	Metric	> 0
Sources of Innovations	Prosin	Firm's proportion of innovation internally developed	Metric	0 -100
	Prosex	Firm's proportion of innovation externally developed	Metric	0 -100
Types of innovations	Prodou	Firm's proportion of product innovations	Metric	0 -100
	Proces	Firm's proportion of process innovations	Metric	0 -100
	Combin	Firm's proportion of combined innovations	Metric	0 -100
Concentration of Innovations	Concsec	Proportion of firm's innovation regarding total innovations within its food sector.	Metric	0 -100
	Consind	Proportion of firm's innovation regarding total innovations of the industry (two-digit)	Metric	0 -100
New Innovators	Newin	Firms innovating in just one of year from the research years. 1 for positive answer.	Nominal (dummy)	0 –1
Firm Size	Empme	Firm's mean of all employees full-time equivalent in the research period	Metric	> 0
	Turmo	Mean score regarding firm's yearly turnover (gross sales)	Metric	1 – 7
Knowledge Base	Prored	Proportion of innovation originated in the R&D department	Metric	0-100
	Propro	Proportion of innovation originated in the production department	Metric	0-100
	Prooth	Proportion of innovation originated in others department	Metric	0-100
Opportunities	Innov	Number of firm's innovations introduced in the research period	Metric	≥ 0
Appropriability	Propat	Proportion of firm's innovations patented.	Metric	0-100
	Mipro	Mean score attributed to protection of firm's innovations from competitors' imitation.	Metric	1-7
Cumulativeness	Cumul	Firms innovating in at least two years from the research years. 1 for positive answer.	Nominal (dummy)	0-1

Table 2 - Technological Regime and Pattern of Innovation Variables*

* Cabral (1998) details the definition and measurement of theses variables

As showed in Table 2, 11 variables, from the total set of variables surveyed were selected, regarding the characteristics (dimensions) of patterns of technological innovation, and seven variables to indicate the characteristics of technological regime. Given this figure, the multicollinearity amongst these variables, and in particular the paper's objective, the most adequate analytical techniques were selected from the toolbox of multivariate analysis. Specifically, two techniques shall be applied. Firstly, through factor analysis, the relatively large number of variables will be reduced to a smaller number of factors, expected to represent the relationship among sets of interrelated variables. Secondly, from the factors, the technique of cluster analysis will be applied with the aim of identifying groups of homogeneous firms based on their similarities in innovative activities.

The justification for the application of the two foregoing techniques is that factor analysis, which is based on correlated variables, leads to the formation of uncorrelated factors. Cluster analysis directly applied to a relatively large number of observations should lead to a result that would be very difficult to interpret[6].

In the application of factor analysis, the principal component analysis was computed, which extracts factors by combinations of variables that account successively for the greatest variance, in order to assess the adequate number of factors for the analysis. The number of factors was extracted on the basis of eigenvalues greater than one, according to the first criterion generally applied. In this case, the initial statistics shows three factors explaining 69.5% of the total variance, which has been considered an acceptable figure in the literature.

The first factor explains, after rotation, 27.1% of the total variance and is comprised of variables regarding the nature of innovation and technological autonomy. It entwines the level of innovations internally developed with the level of product innovations (positively) and with the level of process innovations (negatively). The second factor reflects size and innovative results, explaining 21.5% of the total variance. It shows high loadings in firms' employment and turnover level (positives) and also in rate of innovations (negative). Hence, it suggests that among the innovating firms the rate of innovation increases with size until a threshold level. The third and last factor explains 20.9% of the variance and is comprised of variables related to firms' level of concentration and continuity in innovative activity. It positively links the degrees of concentration of innovations, by firms, at industry and sector levels. In turn, these variables are negatively associated with the rate of entry of new innovating firms.

These three factors were utilised as the input variables of the cluster analysis. In order to achieve this analysis, one has first to decide about which clustering algorithm to select for forming clusters. In this case, it was decided to follow the solution advocated by many experts

[6] Notwithstanding the technical limitations to evaluate all possible partitions.

(e.g. HAIR *et al*. 1998:498, KETCHEN; SHOOK, 1996:446), combining hierarchical and non-hierarchical methods, gaining the pros and avoiding the cons of both.

As the aim of cluster analysis is to sort out groups of homogeneous units with K<N, it is necessary to define the adequate number of clusters for analysis. There is no absolute criterion to carry out this selection. A rule of thumb to guide the decision is to use the agglomeration coefficient that expresses the squared Euclidean distance between clusters being combined. The summarised agglomeration schedule unveils that the greatest incremental change occurs in the 62nd stage (29.05%), being three clusters the indicated solution.

In addition, for improving the interpretation of the clusters, cluster membership is now related firstly to the variables that were the basis for the factor analysis, secondly to the two variables regarding the pattern of technological innovation not utilised in the factor analysis, and thirdly to the seven variables regarding the technological regime construct. The second and third procedures, besides simplifying and improving the interpretation of the clusters (what discriminates one from another), increases the validation of the applied method, since to be meaningful, cluster membership should be distinguished by certain other theoretically related variables. This meaning was assessed through the resource of one-way analysis of variance, testing the null hypothesis of equal variable means amongst clusters. The results are presented in Table 3.

Table 3 shows that the null hypothesis of equality of cluster means can be rejected at statistical significant level ($p<0.1$) for the 11 variables regarding pattern of technological innovation and for four out of seven variables regarding the technological regime. This result unveils that, excepting the dimension appropriability, technological regime dimensions are also associated with patterns of innovation. This exception supports the description advanced in Cabral (1998) of a general very low level of appropriability presented by innovating firms in the food industry. This result also reinforces the validation of the cluster membership and presents additional insights for their interpretation.

VARIABLES	CLUSTERS MEANS VALUES			F-VALUE
	I. R&D Innovation Based Mode	II. Inventive innovation mode.	III. Reactive Innovation Mode	
Prodou	45.63	13.23	2.50	12.09***
Proces	40.83	83.07	97.50	20.03***
Concsec	13.57	29.27	5.26	23.77***
Consind	1.79	2.17	.76	11.84***
Newin	.22	.33	1.00	29.43***
Empme	1.989	817	511	8.64**
Turmo	4.31	2.50	3.05	12.09***
Prosin	73.96	50.00	27.50	7.46***
Ratein	7.82	47.18	14.53	10.90***
Combin	13.54	3.70	0	2.44*
Prosex	26.04	50.00	72.50	7.46***
Prored	41.25	7.41	10.00	5.68**
Propro	49.89	83.33	70.00	2.78*
Prooth	8.85	9.26	20.00	.89
Innov	2.47	3.00	1.05	11.84***
Propat	7.81	0	5.00	.55
Mipro	2.37	2.08	2.25	.15
Cumul	.78	.67	0	29.43***

Table 3 - Cluster Variables Profiling

*, **, *** Significant at less than 10%, 5% and 1%, respectively. Source: Own survey.

4. Technological Regimes and Patterns of Innovation in the BFI

The result derived from the previous application of the cluster analysis allows the general consideration that there exist three groups of firms, in terms of innovative behaviour, in the BFI. This analysis follows below.

Cluster I. R&D Innovation Based Mode - This is the largest of the three clusters. It comprises 32 firms, which means exactly half of the surveyed innovating firms included in the analysis. Its pattern of innovation is characterised by the smallest average rate of innovations and predominance of large and medium firms, both in terms of employment (*empme*) and turnover (*turmo*). In this cluster only two small firms are found. In addition, it also presents the highest proportions of product (*prodou*) and internally developed innovations (*prosin*) and combined (*combin*) innovations. This level of combined innovation suggests that this cluster presents the most relevant innovations. Finally, it is also characterised by a medium level of concentration of innovations, at sector and industry levels (*concsec and consind*).

In terms of technological regime variables, this cluster presents the second largest average of absolute innovations (*innov*) and the largest level of cumulative innovations (*cumul*). These results, linked to the levels of rate and concentration of innovations, unveil that the innovative activity of this group of firms, although not relatively intense, is a continual process and also suggests a high level of technological opportunities. In addition, it presents the greatest average proportion of innovations originated from the R&D department (*prored*). Taking into account the high levels of combined and product innovations, and also the low level of external innovations, this importance of the R&D department suggests that this group makes use of relatively more complex and tacit knowledge. In turn, albeit not significant but important, and also associated with the predominant types of innovations, this cluster presents the highest relative rate of appropriability, as measured by proportion of innovations patented (*propat*) and protection degree from imitation (*mipro*). This aspect is also linked with high level of innovations internally developed.

Cluster II. Inventive Innovation Mode - This is the smallest of the three clusters. It consists of 12 (19%) very intensive innovating firms, since it presents the largest rate of innovations (*ratein*) and relatively small-sized firms (*empme and turmo*). This low size distribution is particularly a result of the smallest turnover mean of all clusters, and predominance of small firms (seven out of 12) in terms of employment. However, the cluster mean of employment is larger than that of the cluster III due to the presence in this cluster of three very large firms. In turn, it presents a predominance of process innovations, equally distributed in external (*prosex*) and internal innovations (*prosin*). Furthermore, this cluster presents the highest levels of concentration of innovations, by firms (*concsec and consind*).

The relative position of this cluster in terms of technological regime variables is a mix of the first and third clusters. Hence, in common with the first, this cluster presents a high level of cumulativeness (*cumul*) and the highest average of absolute innovations (*innov*). These levels are associated with the levels of concentration and rate above. Similarly to the third cluster, the majority of innovations originated from the production department (*propro*).

The distinguishing aspects of this cluster are the intensity of innovations, suggesting that its firms are very efficient in innovative activity, and the degrees of concentration of innovations, suggesting its firms are unconventionally innovative at sector and/or industry levels. These aspects are related to the presence in the cluster of very small innovating firms and very innovative large firms. In turn, it combines varied internal learning procedures (e.g. by doing and by using) and external sources of innovations. It is named “inventive innovation mode”.

Cluster III. Reactive Innovation Mode - This is the intermediate cluster in terms of size, being composed of 20 (31%) innovating firms. However, in terms of innovative characteristics it is at odds with the first cluster. Its pattern of innovation is characterised by the second largest average rate of innovations and medium average size of firms. In this latter aspect, medium size firms predominate in terms of average turnover and small size firms in terms of average employment (*empme*). However, the presence of firms in terms of employment level is nearly equally distributed by small (eight), medium (six) and large (six) firms. In turn, it practically presents only process innovations (97.5%), externally developed (72.5%). These levels of process (*proces*) and external (*prosex*) innovations suggest that the cluster presents a "follower" technology strategy. Finally, it is also characterised by the highest level of new innovating firms (*newin*).

In terms of technological regime variables, this cluster presents the smallest average of absolute innovation (*innov*) and "zero" level of cumulativeness (*cumul*). These figures, connected with the low levels of concentration of innovations, unveil that the innovative activity of this cluster is a sporadic process and also suggest a low level of technological opportunities. In addition, this cluster presents a very low averaged proportion (10%) of innovations originated from the R&D department (*prored*). Taking into account the predominant type and origin of innovations, this indicates the use of a relatively simpler and codified knowledge.

Thus, the pattern of innovation in this group suggests that its firms present a cost-reducing technological trajectory, being orientated for the identification of production bottlenecks and their correction through the acquisition of new technologies (equipment and machinery). The predominant innovative behaviour in the cluster is based on technologies embodied in capital goods, acquired from external suppliers, and it is, in accordance with the characterisation of the food industry in studies previously cited, "supplier-dominated". It is named "reactive innovation mode".

4.1. Patterns and Regimes Linkages

The three clusters analysed above provide evidence for the proposal that the food industry is subject to more than one pattern of innovation. Hence, one might claim that some industries fail to comply with the conceptual proposal of industrial homogeneous patterns of innovation, due to the existence of diverse technological regimes in these industries. These links between patterns of technological innovation and technological regimes in the BFI are summarised in Table 4 below.

CLUSTERS	I. R&D BASED	II. INVENTIVE	III. REACTIVE
PATTERN OF INNOVATION			
Rate of Innovations	Low	High	Medium
Sources of Innovations	Internal	Balanced	External
Type of Innovations	Product + Combined	Process + Product	Process
Concentration	Medium	High	Low
Rate of New Innovators	Low	Medium	High
Size Distribution (mean)	Large	Small	Medium
TECHNOLOGICAL REGIME			
Knowledge Base	R&D and Internal Learning	Internal Learning and External Sources	External Sources
Cumulativeness	High	High	Low
T. Opportunities	High	High	Low

Table 4 - Patterns of Innovation and Technological Regimes Linkages

Source: Own survey.

The R&D based cluster links high cumulativeness and high technological opportunities, which in turn generate a medium level of concentration. These technological regime characteristics are linked with a predominant use of complex and tacit knowledge, based on formal R&D and internal learning, affecting and sustaining the low rate of entry of new innovating firms. These aspects are also linked to relevant product and combined innovations in large firms, and a continual but not very intensive process of innovation.

The linking of high cumulativeness, high technological opportunities, and the variety of internal learning procedures and external sources of knowledge, in the inventive cluster, form a technological regime leading to a high rate of innovations and a high level of concentration. In addition, this regime favours small and medium innovating firms and predominant process innovations, followed by product innovations, with a balanced source of development (internal and external).

The last cluster, reactive, entwines low cumulativeness and low technological opportunities to produce low concentration and high entry of innovating firms. These aspects, linked with a knowledge base that is predominantly external, hence simple, generic, public and codified, lead to one technological trajectory characterised by process innovations in firms, of medium size on average, solving technological bottlenecks and/or taking advantage of economies of scale.

The foregoing analysis confirms the reliability of the conceptual proposal that technological regime is linked with specific pattern of technological innovation. Further, it is suggested that the cluster III presents the pattern proposed in Schumpeter mark 1 (low concentration, high rate of new innovators and predominantly medium/small sized firms) and the cluster I presents the pattern proposed in Schumpeter mark 2 (medium concentration, low rate of new innovators and large sized firms). The cluster II is literally "stuck in the middle", falling in between clusters I and III, presenting high concentration and rate of innovations, low rate of new innovating firms, small/medium sized firms, internal and external sources, and process and product innovations.

5. Concluding Remarks

The foregoing results confirm that the food industry is not confined to just one pattern of innovation, advancing that, although under similar industries, firms may present different innovative behaviour. In other words, this study confirms the existence of features in firms' innovative activity that prevails over industrial or sectoral classification.

One can claim that these differences may be attributed to poorly defined industrial classification, however as Jensen and McGuckin (1997:30) stated, 'this source of error is unlikely to eliminate the heterogeneity (of firms in the dimensions analysed by them) since it is observed in virtually all industries and even in product class groupings'. This also confirms partially the important study by Rumelt (1991) showing that differences between firms in the same industry are far more important than differences between industries.

The results have at least two explanations: first, it reinforces the proposals that some industries may present diverse technological regimes; and secondly that the relationship between technological regime and pattern of innovation is mediated at the firm level. Regarding the former, Christensen (1995) suggests that the food industry follows at least two trajectories: part of the industry is strongly focused on process-orientated innovations, and part of it is more akin to science-based chemical or biotechnology innovations. Regarding the latter, a firm's innovative behavior is not only shaped by incentives and constraints of the industry's technological regime(s), but also constrained by resources and capabilities.

To finalise, the analyses confirm that from the innovative incentives and constraints posed by technology characteristics, there is room for a firm's innovative strategic choices. In other words, whilst technology matters for innovative activity, there is room for managers' discretionary power in choosing different and conscious innovative strategies and actions.

REFERENCES

ABRAMOVITZ, M. (1956) Resource and output trends in the United States since 1870. *American Economic Review* **46,** 5-23.

AUDRETSCH, D.A. (1992) The technological regime and market evolution: the new learning. *Economics of Innovation and New Technology*. **2**, 27-36.

______ (1997) Technological regimes, industrial demography and the evolution of industrial structures. *Industrial and Corporate Change*. **6,** 49-83.

CABRAL, J.E.O.(1998) Survey on technological innovative behavior in the Brazilian food industry. *Scientometrics*. **42,** 129-169

CESARATTO, S. and MANGANO, S. (1993) Technological profiles and economic performance in the Italian manufacturing sector. *Economics of Innovation and New Technology*. **2**, 237-256.

CHRISTENSEN, J.F. (1995) Asset profiles for technological innovation. *Research Policy* **24,** 727-745.

DILLMAN, D.A. (1978) *Mail and Telephone Surveys: The Total Design Method*. John Wiley & Sons, New York.

FIBGE (1991) *Censos Econômicos - 1985: Censo Industrial*. FIBGE, Brasília, DF.

HAIR, JR. J.F., ANDERSON, R.E. TATHAM, R.L. and BLACK, W.C. (1998) *Multivariate Data Analysis: with Readings*. Prentice-Hall, Inc, Englewood Cliffs, NJ.

JENSEN, J.B. and McGUCKIN, R.H. (1997) Firm performance and Evolution: empirical regularities in the US microdata. *Industrial and Corporate Change* **6,** 25-47.

KETCHEN, JR. D.J. and SHOOK, C.L. (1996) The application of cluster analysis in strategic management research: an analysis and critique. *Strategic Management Journal* **17**, 441-458.

KLEVORICK, A.K., LEVIN, R.C., NELSON, R.R. and WINTER, S.G. (1995) On the sources and significance of interindustry differences in technological opportunities. *Research Policy* **24**, 185-205.

MALERBA, F. and ORSENIGO, L. (1990) Technological Regimes and Patterns of Innovation: A Theoretical and Empirical Investigation of the Italian Case in *Evolving Technology and Market Structure: Studies in Schumpeterian Economics*. (Eds A. HEERTJE and M. PERLMAN). The University of Michigan Press, Ann Arbor.

_______ (1995) Schumpeterian patterns of innovation. *Cambridge Journal of Economics* **19**, 47-65.

_______ (1996) Schumpeterian patterns of innovation are technology-specific. *Research Policy* **25,** 451-478.

MOLERO, J. and BUESA, M. (1996) Patterns of technological change among Spanish innovative firms: the case of the Madrid region. *Research Policy* **25**, 647-663.

NELSON, R. R. and WINTER, S.G. (1982) *An Evolutionary Theory of Economic Change*. Harvard University Press, Cambridge.

ORSENIGO, L. (1989) *The Emergence of Biotechnology: Institutions and Markets in Industrial Innovation*. Pinter Publishers, London.

PAVITT, K., ROBSON, M. and TOWNSEND, J. (1987) The size distribution of innovating firms in the UK: 1945-1983. *The Journal of Industrial Economics* **35**, 297-316.

RUMELT, R.P. (1991) How much does industry matter? *Strategic Management Journal* **12,** 167-185.

SCHERER, F. M. (1965) Firm size, market structure, opportunity, and the output of patented inventions. *American Economic Review* **55,** 1097-1125

SOLOW, R.M. (1957) Technical change and the aggregate production function. *Review of Economics and Statistics* **39,** 312-320.

WAKELIN, K. (1998) Innovation and export behaviour at the firm level. *Research Policy* **26,** 829-841.

WINTER, S. (1984) Schumpeterian competition in alternative technological regimes. *Journal of Economic Behaviour and Organization* **5**, 287-320.