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Technological Fields and Concentration of Innovation Among Food and Beverage Multinationals

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Abstract

With a sample of nearly 18,611 utility patents, this paper studies the technology mix of 90 of the world's leading food and beverage multinationals (FBMs) over 1969-1994. It explores the statistical association between patenting in food technology and in non-food technological fields. Food patenting is always associated with patenting in Biotech, Chemistry, Machinery and Other patenting, whatever the home country of the company. The strength of the association, however, could vary. Herfindahl indices show that capabilities in core technology and in Machinery and Other fields are spread among many FBMs. Though to a lesser extent, technical capabilities in Biotechnology, Packaging and Refrigeration are also dispersed. By contrast, patenting in Tobacco, Chemistry and Drugs is concentrated.

1. The Food Industry, A Supplier Dominated Industry?

Innovation is one of the forces shaping competition in the food and beverage (F&B) industry of developed countries. Currently, an F&B company depends not only on food and agricultural expertise but also on new techniques in biotechnology, packaging, chemistry, etc. Non-food innovation accounts for around 45% to 50% of the innovations usable in this sector (Ettlie, 1983; Rama, 1996). Accordingly, Pavitt's (1984) taxonomy classified the F&B industry as "supplier-dominated" since the

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origins of technological change in this sector seem to reside chiefly in supplier industries, i.e. equipment manufacturers and so on.

Recent research work is, however, putting this view into perspective. Some studies point to within-industry differences. Unlike commodity producers, processors of high value-added foodstuffs rely more on food inventions than on innovation in machinery, chemicals, etc. (Rama, 1996). Other analyses note that the F&B industry nowadays actively combines a breadth of many different new techniques and scientific discoveries and plays a significant role in selecting and adapting them (Christensen et al., 1996).

Recent research also points to another factor that suggests the need to re-interpret the 'supplier-dominated' view in the light of new situations. The F&B firm itself (as opposed to upstream industries) generates some of the non-food inventions used to produce foodstuffs and agricultural products. The world's largest food and beverage multinationals (FBMs) generate a great number of such inventions in biotechnology, machinery, chemicals, etc. (von Tunzelmann, 1998). In part, FBMs innovate in non-food because some of them are conglomerates with a multiplicity of non-food interests in addition to agrifood (Tozanli, 1998; Anastassopoulos & Rama, 2003). It has been held that the FBM encompasses a series of disconnected techniques, related only by demand-side considerations. Such techniques coexist within the FBM, the argument goes, chiefly because the company produces products embodying them (for instance, food, drugs, textiles, etc.), not because of an integration of different types of capabilities. Here, we will argue that a substantial part of FBMs' non-food inventions are likely to be related to the food chain. On the other hand, given that R&D activities are a powerful mechanism for learning and absorbing external knowledge (Cohen & Levinthal, 1989), many FBMs could generate non-food knowledge, i.e. non-food patents, just to interact with their suppliers of equipment or inputs on a better footing. Thus, beyond simple coexistence within the FBM laboratory, different brands of knowledge could be functionally interlinked. Such links have seldom been explored.

The study of the interplay between the production of food and non-food innovation within F&B firms could, thus, throw new light on the nature of innovation in this industry. Analysing the largest FBMs is especially relevant because of their enormous share of the world's production of processed food, around one third (Rastoin et al., 1998), and food technology. The largest FBMs account for more than half the world's patented innovations in food and tobacco (Patel & Pavitt, 1991; Alfranca et al., 2002). Intense patenting activity could represent an ownership (O) advantage (Dunning, 1993) of FBMs versus other F&B companies. Moreover, their possibility to *combine,* 'in house', different types of knowledge and interact actively with suppliers could also positively affect the positioning of large FBMs. One-nation F&B companies or smaller multinationals are less likely to innovate intramurally in chemistry, biotechnology and other food-related fields. However, we ignore whether such capabilities are spread across the multinational agrifood sector or, instead, confined to a handful of companies. The elucidation of such questions could also help us to understand better competitive advantages in this international industry.

In this paper, we study the technology mix of 90 FBMs taken from the world's 100 largest FBMs (the top group) in order to: 1) identify recurrent relationships between patenting in Food and in other technological fields, and 2) analyze the spread of different types of capabilities within the multinational agrifood sector. Our aim is to contribute to the analysis of technological specificities of FBMs in order to understand their competitive advantages. To shed light upon such questions could also help us to reinterpret the supplier dominated view in a changing world. In doing so, we analyze panel data containing 18,611 utility patents granted in the US to our firms over 1969-94.

To anticipate our results, we find that some links between patenting in food and in some non-food technological fields[1] are recurrent in different types of FBMs, which suggests that the association between different types of capabilities could go beyond demand side reasons. We also find that core capabilities, i.e. patenting in food and agriculture, and most types of capabilities in non-food technology, are fairly spread among FBMs.

Section 2 discusses the data. Section 3 presents the theoretical and empirical background that informs our research, and our hypotheses. Section 4 displays our results and Section 5 the conclusions.

2. The Data

The companies

We selected the 90 FBMs in our sample from AGRODATA (Padilla et al., 1983; I.A.M.M., 1990; Rastoin et al., 1998), a database from the Institut Agronomique Méditérranéen de Montpellier (France). Since the seventies, the IAMM has gathered information on the world's 100 largest FBMs.[2] The companies in our sample are processors of dairy products, canned specialties, alcoholic drinks, etc.; some of them also produce agricultural products or diversify into non-food.

Using patent data to measure innovation

We measure innovation (or capabilities)[3] by counting the patents granted to the company in the US. In spite of some drawbacks of this methodology (Rosenberg, 1982; Archibugi & Pianta, 1992), which lose their importance in homogeneous samples of firms such as that in this study, patent statistics provide a "*unique long-term time series of inventive efforts on a worldwide basis*" (Freeman, 1994, p.476). Moreover, patents reflect, at the firm level, innovative activities and R&D

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[1] "Technological fields" are not equivalent to "industries". As will be seen below, F&B companies also produce chemicals, drugs, etc. innovations. Technological fields indicate the nature of the patented innovation but do not identify its industrial origin or usage.

[2] Among others, its sources are Moody's Industrial Manual, the Fortune Directory of the 500 largest US and the 500 Largest non-US corporations, the "Dossier 5.000" of the largest European companies published by *Le Nouvel Economiste*, Dun & Bradstreet, and the annual reports of the enterprises. The firms included in the database meet the following criteria: 1) their annual agri-food sales are more than US$ 1 billion; 2) their sales of processed food and beverages amount to more than 50% of their total sales, and 3) they hold at least one foreign affiliate (Rastoin et al., 1998). By the mid-90s, 151 firms met these criteria. The 100 largest, according to their sales value, were included in AGRODATA

[3] In this article, we focus on innovation *produced* by FBMs. Of course, such companies also *use* innovation produced by upstream industries.

expenditures (Bound et al., 1984; Acs & Audretsch, 1989). As in other international analyses of innovation (Fagerberg, 1987; Soete, 1987), here we analyze foreign patenting in *one* particular country. We study patents granted to FBMs in the US because patenting in such a country, as shown by the results of Soete (1987, p.110) probably reflects accurately the world's stock of technology.

The 18,611 utility patents in our sample were granted from 1969 to 1994 to the sample companies; they protect their intellectual property rights in a variety of technological fields. Science and Technology Policy Research (SPRU) at the University of Sussex (UK) collected the patent data[4]. Owing to limitations of the USPTO information, we could not distinguish between patents leading to product and process innovation (see Alfranca et al., 2002). All the firms in our sample have patented at least one invention over the period.

Boundaries between non-food innovation and the food-chain are often blurred

We analyze 11 technological fields in which our FBMs have been granted a patent[5]: Agriculture, Biotechnology, Chemistry, Drugs, Food, Instruments, Machinery, Other, Packaging, Refrigeration and Tobacco[6]. As stated, we consider as 'non-food' the patenting in technological fields other than Food and Agriculture.

Boundaries between non-food technological fields and the food chain are often blurred. 'Other', for instance, could include new products and processes in textiles, paper or electronics, apparently unrelated to the food chain. However, improvements in electronic devices could equally be destined for the food processing plant (Christensen et al., 1996; Morgan et al., 2003). Furthermore, a substantial portion of Other patents that are classified, for instance, as textile or paper patents could relate actually to by-products of agriculture. FBMs produce size, starch, glue, etc. and sell them to textile and other manufacturers (Gonard et al., 1991). Some Chemical patents could also relate closely to the food-chain. F&B companies produce gluconic acids (used as inputs for detergents) and other organic acids, gluconates, cyclodextrines, polymers, sorbitol (used in production of polyurethanes), etc., from agricultural products. To exploit new industrial usages of traditional organic substances, F&B companies deploy a considerable R&D effort. Patents related to such chemical products could display synergies with innovative activities in Food or Agriculture. Such a role of FBMs as *suppliers* of innovations usable by non-food manufacturers is little known and contrasts with the "supplier-dominated" view of food companies as receivers of innovation produced elsewhere.

[4] The data are taken from the numbers of patents granted at the US Patent Office (USPTO). The data from 1975 onwards are available online from the USPTO (http://www.uspto.gov). However, working the data from online sources or CD-ROM into usable results still involves intensive research efforts. The USPTO assignees are given according to the name of the organization to which they are directly affiliated, rather than the name of the corporation. A large firm such as Unilever or Philip Morris may have hundreds of these patenting subunits in addition to the core corporation, and the task of consolidating them into corporate totals is a major one, since the USPTO database does not record their ownership. The latter information has to be constructed from sources such as *Who Owns Whom?*, before searching the database and then aggregation.

[5] There are 332 three-digit classes, which have been classified into 11 technological fields.

[6] 'Food' patents cover the three-digit classes of the USPTO as follows: 426 ("Food or edible material: processes, compositions and products"), 127 ("Sugar, starch and carbohydrates"), and 99 ("Food and beverages: apparatus"). Tobacco patents are from class 131. A full concordance with the 400-odd USPTO classification is too long to publish here but is available from Prof. von Tunzelmann on request.

3. Theoretical Background

Large multinationals tend to be multi-technology companies (Patel & Pavitt, 1997). It folows from what has been noted above that FBMs are no exception and devote a large part of their efforts to innovation in non-food technical fields. In a sample of 106 large FBMs analyzed over 1969-1994, one of us observed that non-food amounted, on average, to nearly 73% of the patents granted in the US to such firms (von Tunzelmann, 1998). Even making allowance for possible differences in propensities to patent in different lines of business and for smaller technological opportunities in food, this is a very high share for non-core technologies. In chemical multinationals, for instance, non-chemical patents account for only 29% of the total (Patel & Pavitt, 1997).

There are several reasons why FBMs allocate such a great deal of innovative effort to non-food fields. It is evident that many of them are conglomerates, but such an explanation is only part of the answer. Among the top group, the evolution of sales and innovation in non-food has been divergent. Sales of non-food products as a proportion of total sales fell from 25.7% over 1981-88 to only 10.2% over 1990-1996 (Anastassopoulos & Rama, 2003). By contrast, the percentage of non-food inventions rose from 70% in 1969-1974 to almost 77% in the mid-1990s (von Tunzelmann, 1998). On the other hand, if FBMs undertook non-food innovation chiefly because they held non-food businesses, why would core-centered FBMs innovate in chemicals, biotech, etc.? Japanese FBMs, the companies with the highest food to total sales ratio (more than 94% in 1990-1996) in the whole group (Anastassopoulos & Rama, 2003), display the highest ratio of non-food to total number of patents (78.7% versus 72.5% in all FBMs) (von Tunzelmann, 1998). The share of biotechnological and chemical patents in such companies is about twice as high as in US or European FBMs and amounts to nearly two-thirds of those Japanese patents. This suggests that FBMs innovate in non-food for other purposes aside from conglomeration.

FBMs could generate intramurally, at least part of the non-food innovation they need to produce food. As early as 1979, an OECD (1979) report stressed the “horizontal coordination and management of inter-industrial technology transfers” by FBMs like Unilever, Nestlé or CPC International – all in our sample. For instance, some equipment used by F&B firms, such as food packaging machinery, often needs to be customized (Petroni, 2000). Following the rationale established by other multinationals (Patel & Pavitt, 1997), even if the FBM does not manufacture ‘in house’ such equipment, it could need some intramural expertise to deal with suppliers; eventually, such expertise could lead to patenting in the equipment field.

There are other reasons why FBMs produce non-food patents. From the processing of sugar, corn, potatoes or wheat, food companies often obtain a variety of products for the food and feed industries but also inputs for the cosmetics, drugs, paper and carton, and textile industries (Gonard et al., 1991). As stated, many of the patents they generate when involved in such activities are classified in non-food technological fields. Yet, the inventions are, in some way, related to the food chain and could eventually display synergies with innovation in core technology. Finally, processors nowadays frequently set quality criteria across the food chain. Responsibility for the final quality and safety of foodstuffs could encourage them, especially when vertically integrated, to innovate in agriculture or other related fields. Potato processors, for instance, could be interested in variety breeding, and hence in biotech research, since their equipment is finely tuned to specific varieties (Bijman & Enzing, 1995).

In the first case (conglomerates) reported here, patent activities in core and in non-food technology within the FBM are likely to be independent of each other because lines of businesses – and hence their related R&D activities – are autonomous, and few intra-corporate transactions are expected (Dosi et al., 1992). By contrast, in the other cases reported here patent activities in Food and in other fields are more likely to be interdependent and follow similar trends.

In the light of the previous discussion we explore the following questions:

1. In relation to the technology mix in FBMs, we try to identify recurrent associations between patenting in Food and in other technology fields at the company level.

2. We hypothesize that the strength and characteristics of associations will vary with the home country of the company.

3. We also investigate the spread of different types of technical capabilities in the multinational agri-food sector. We hypothesize that the degree of capability concentration varies by technological field, with a more decentralized spread of capabilities in core technology.

4. Results and Discussion

Patenting in Food and in some non-food fields is always associated

For each firm, we correlate the patenting in Food with that in the ten other technological fields (Table 1). As stated, we are interested in their recurrent association. We calculate the following bivariate correlations[7].

[Table 1]

Whatever the home country, patenting in Food is *always* positively associated with patenting in Biotech, Chemistry, Machinery and Other fields. Coefficients are positive and statistically significant in the whole multinational agrifood sector, and in three groups of FBMs (North-American, European and Japanese), which shows our results are robust. The strength of the association between patenting in Food and in such technological fields varies from moderate (0.50 less than r greater than or equal to 0.30) to strong (r greater than or equal to 0.50). Links between Food and Chemistry and between Food and Other are the stronger in all groups. These

[7] We use non-parametric correlations because the distributions of variables are non normal.

results do not imply a cause-effect relationship between different types of technological output within the FBM but rather that companies active in the Food technological field tend also to be innovative in the other four. Conversely, even low patentors of Food inventions produce a small amount of patents in the related fields. This recurrent association is noteworthy because FBMs from different origins show different average sizes and food/total sales ratios (Tozanli, 1998; Anastassopoulos & Rama, 2003). Thus, specific technological associations seem to recur across groups of FBMs of different origin, size and degree of core product specialization. This finding suggests that, within FBMs' laboratories, such different types of innovation could be more integrated than often believed.

That even low patentors of Food innovation also patent small quantities of non-food inventions suggests that such firms try to improve mutual technical understanding with their suppliers and keep up with new developments in food-related R&D (not just to manufacture equipment of other inputs themselves).

However, the strength of the associations varies by home country. For instance, coefficients of correlation between Food and Biotech are much higher for Japanese than for Western FBMs. The former could be more prone to internalize markets for biotech technology than the latter (von Tunzelmann, 1998). In addition, some Japanese FBMs position themselves in markets for biotech inputs they sell to other food processors. For instance, Ajinomoto, the principal patentor of Biotech patents in our sample, is a world leader in fermentation processes and amino acids used in F&B processing (G.E.S.T., 1986). By contrast, the association between Food and Packaging is much stronger (and statistically more significant) in Western than in Japanese FBMs, which denotes the positioning of the former in consumer (as opposed to input) markets.

Different degrees of dissemination of technological capabilities

Leading companies in different technological fields are not systematically the same, which could suggest that FBMs compete, each with different technological advantages. Though complete information is not supplied here because of insufficient space, it suffices to mention some of the leading patentors in core technology and Biotech:

Food: Philip Morris Co (22.5% of patents in field), Nestlé (8.0%) and Unilever (8.0%)
Agriculture : Hanson PLC (20.4% of the field), Philip Morris Co. (11.2%) and Geo Hormel Co (9.2%)
Biotechnology: Ajinomoto Co (25.7% of the field), CPC International (10.9%) and Unilever (6.2%)

In other fields, the share of the most important patentor is much larger (not displayed).

To investigate to what extent knowledge in different technological fields is disseminated in the multinational agrifood sector, we calculate Herfindahl indices

(Table 2). The value of the index, H, is the sum of the squares of all FBMs' shares in a technological field.

$$H = \sum_{1}^{9'0} \left(share_J\right)^2$$

where SHARE is the share of each FBM in patenting in *j* technological field.

In a specific technological field, low values for H indicate that production of patents is dispersed among many FBMs, while high values suggest that it is concentrated in a few of them.

[Table 2]

The fields where innovation is more widely spread among a great deal of companies are those in core technology, Machinery and Other (Table 2). Since conglomerates are a minority among FBMs (Anastassopoulos & Rama, 2003), why would all types of FBM innovate in the Other field? Our finding seems to confirm that a large part of innovations included in it could be embodied in byproducts of agriculture or used in the food processing plant itself.

The fields where innovation, by contrast, is more concentrated among a few companies are (in decreasing order): Tobacco, Drugs and Chemistry. Biotech, Packaging and Refrigeration are in an intermediate situation.

5. Conclusions

We have researched the technological mix in the world's largest FBMs with a patent database containing 18,611 utility patents. We have explored whether, as sometimes held, the FBM encompasses a series of disconnected techniques, only related by demand-side considerations (conglomeracy), or if different types of innovations produced 'in house' are associated with capacities in Food technology.

We have correlated, at the company level, the patenting in Food and in ten other technological fields. We have found that 'in house' production of Food innovation is always positively associated with that of Biotech, Chemistry, Machinery and Other inventions, whatever the home country of the company. The recurrence of such associations across companies with different characteristics suggests that FBMs produce non-food technology 'in house' for purposes other than diversifying into a portfolio of autonomous non-food businesses, as is often held. In addition, within the FBM laboratory, the production of different types of knowledge is likely to be more inter-connected than often believed.

Thus, the FBM could differ from most other F&B companies not only because it is more innovative, as is commonly held (Caves, 1996), but also because of its varied yet cohesive technological endowment. The co-development of capabilities within the FBM could be very difficult to replicate by its rivals. To confirm whether this characteristic of the FBMs is one of its **O** (ownership) advantages versus one-nation firms, more research on innovation in the latter is needed.

We have also found that the strength of the association between Food patenting and patenting in other fields varies by home country, probably depending (in addition to the incidence of conglomerates) on FBMs' strategies of internalization (**I**) of technological markets and the company positioning across the food-chain.

We have also studied the diffusion of capabilities among FBMs. Herfindahl indices show that capabilities are fairly broadly spread concerning core technology, Machinery and Other, and to a lesser extent Biotech, Packaging and Refrigeration. By contrast, technological capabilities in Tobacco, Drugs and Chemicals are less well diffused. This suggests that, concerning most technological fields, FBMs could enjoy the advantages of integrating complementary capacities (even if each is on a modest scale). Such broad diffusion of non-food technical knowledge across the multinational agrifood sector also suggests that many FBMs could research just to keep updated with food-related technological developments and interact with supplier industries.

The apparent cohesion of their technological portfolio together with the diffusion, across this international industry, of non-food capabilities confirm that the role of the F&B industry, or at least its largest companies, is currently more active than the supplier dominated view implies (Christensen et al., 1996).

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Table 1. Bivariate non-parametric correlations of US patenting (1) in Food and ten other technological fields
The world's largest FBMs by home-country,1969-94

Technological Field	TOTAL		North-American FBMs (2)		European FBMs		Japanese FBMs	
	Kendal's ô	Spearman's ñ	Kendal's ô	Spearman's ñ	Kendal's ô	Spearman's ñ	Kendal's ô	Spearman's ñ
AGRIC	0.423***	0.534***	0.436***	0.555***	0.314**	0.384**	0.106	0.140
BIOTECH	0.387***	0.513***	0.405***	0.531***	0.329**	0.415**	0.469**	0.632***
CHEMISTRY	0.524***	0.688***	0.548***	0.711***	0.465***	0.612***	0.546***	0.714***
DRUGS	0.361***	0.461***	0.598***	0.723***	0.187	0.245	0.337	0.473
INSTRUMENTS	0.403***	0.525***	0.369***	0.511***	0.403***	0.507***	0.262	0.347
MACHINERY	0.450***	0.584***	0.352***	0.491***	0.365***	0.474***	0.380	0.526**
OTHER	0.558***	0.713***	0.470***	0.627***	0.603***	0.764***	0.529***	0.740***
PACK/PRINT	0.441***	0.560***	0.470***	0.622***	0.443***	0.543***	0.180	0.224
REFRIG	0.283***	0.348***	0.166	0.207	0.471***	0.555***	-0.70	-0.80
TOBACCO	0.150	0.183	0.121	0.158	0.148	0.175	0.261	0.307
N	90	90	33	33	37	37	17	17

*** Significant at 1% (bilateral)
** Significant at 5% (bilateral)
(1) Utility patents. (2) US and Canadian
Source: Authors' calculations

Table 2. Herfindahl indices. Concentration of innovation in the multinational agri-food sector, 1969-1994 (patenting by technological field)

Technological field	
Agriculture	0.083
Bioengineering	0.100
Chemistry	0.192
Drugs	0.244
Food	0.084
Instruments	0.120
Machinery	0.076
Others	0.064
Packaging and Printing	0.101
Refrigeration	0.139
Tobacco	0.369
TOTAL	0.080

Source: Authors' calculations

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