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Between traditions and modernity: Technological strategies at three tequila firms

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Abstract

This paper presents the outcome of research conducted on the three major tequila-producing firms in Mexico. It analyses how the firms defined their technological strategies and the role of those strategies in the expansion of each firm. It is hypothesised that the competitiveness of these three firms and their penetration into international markets were phenomena that occurred before major technological changes took place in the agricultural and industrial segments of tequila production. This means that the decision to improve technological capacities was a result, rather than a cause, of globalisation in the industry. The technological capacities of these firms have developed slowly in order to preserve the original production processes and conserve this traditional product's rich culture and identity. By the 1990s, however, firms had accumulated the basic technological capacities that enabled them to improve both the agricultural production of agave and to increase productivity levels, and thereafter to increasing exports.

Keywords: Tequila; Mexico; Agriculture; Intra-organisational factors; Technological accumulation strategies; Alliances; Transnational firms

1. Introduction

This paper documents how traditional tequila firms, established in the 18th and 19th centuries in Mexico, developed their technological strategies, and the role that their technological capacities play in the firms' expansion and competitiveness. My findings suggest that these capacities were built slowly to preserve original production processes

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and to conserve this traditional product's rich culture and identity. I will show that by the 1990s these three firms had accumulated basic technological capacities that enabled them to improve both the agricultural production of agave and to increase productivity levels.

The paper has three main premises. The first is that the competitiveness of these three firms, and their penetration into international markets, were phenomena that occurred before principal technological changes took place in the agricultural and industrial phases of tequila production.

The second premise is that selected firms are advancing toward a definition of "new technological strategies," and "capacity building", which relies on a combination of two structural factors: (a) the internationalisation of tequila and the increasing demand for this product domestically and internationally since the 1980s, and (b) the globalisation process that these three firms have followed from the early 1990s, allowing them to grasp the importance of new knowledge and organisational practices.

The third premise is that the agricultural and productive technological strategies used by the three firms do not involve state-of-the-art technologies. The new strategies do not represent a break with traditional technologies and productive processes since these are necessary to ensure the authenticity and quality of the product.

In this paper, "technological strategy" is defined as the set of measures that firms have implemented to improve productivity and competitiveness through knowledge and technology, and the ways they have chosen to acquire, adapt, or develop these resources. In approaching the dynamics of firm capacities, Nelson [1] differentiates three related features: strategy, structure, and core capacities. By strategy, he means the broad commitments made by a firm that define and rationalise its objectives and how it intends to pursue them. In this paper, *technological strategy* is understood as the result of changes—already made by firms—in their structure and core capacities.

Some classifications developed by other authors help to characterise the strategies. Hobday [2] identified three types of firm strategies: the leader, the follower, and the late-entry firm. In addition, Dutrenit [3] characterised strategies such as: (a) the building of a minimum base of knowledge, (b) strategic capacity building, (c) technologically independent strategy, (d) fast-follower strategy, and (e) late-follower strategy. However, the specific characteristics that define these strategies need further development.

My methodology was based on qualitative information gathered through direct fieldwork and detailed case studies of the following firms: Casa Cuervo, Grupo Industrial Herradura, and Sauza (now part of the transnational group Allied Domecq). Interviews were conducted with key players in each firm, especially directors of factories, people in charge of R&D, and specialised engineers and technicians in each firm's factory. I sought to obtain explanations about the entire production process and characteristics of any technological changes implemented.[1] These firms were selected because: (a) they produce the largest amounts of tequila and have the greatest volumes of exports, and (b) they have built alliances and/or merged with transnational companies since the 1970s and currently engaged in joint actions with foreign firms. This permits a comparison between the

[1]Interviews and fieldwork took place between February and April 2004. They included the following firms' plants: (i) Camichines Plant, Grupo Cuervo, Zapotlanejo, Jalisco.; (ii) La Rojena Plant, Grupo Cuervo, Tequila, Jalisco.; (iii) EDISA Plant, Grupo Cuervo, Tlaquepaque, Jalisco; Agricultural Division, Grupo Cuervo, Zapopan, Jalisco; (iv) Ex-Hacienda San Jose del Refugio Plant, Grupo Industrial Herradura, Amatitán, Jalisco.; (v) Rancho El Indio, Tequila Sauza, Tequila, Jalisco.; (vi) La Perseverancia Plant, Tequila Sauza, Tequila, Jal.; and, (vii) Los Reyes la Paz Plant, Casa Pedro Domecq, Edo. De Mex.

technological strategies of firms that are mostly Mexican owned, such as Cuervo and Herradura, and those that are largely foreign-owned, such as Sauza.

The paper is organised into four sections. The second section summarises the major characteristics of the tequila industry, demonstrating the importance of productivity and exports, as well as other problems facing the industry. In Section 3 technological changes in the industry are documented and a short story of the technological development of the three firms is provided. Section 4 documents and compares the characteristics of the technological strategy employed by each firm, and some remarks and conclusions are found in Section 5, based on the premises and research questions of the paper.

2. Characteristics of the tequila industry

Tequila is a traditional Mexican alcoholic beverage that results from the fermentation and distillation process of the head of the plant known as *Agave Tequilana Weber azul*, commonly called blue agave. Although agave is not exclusive to Mexico, its place of origin is usually thought of as Mexico due to the variety of agaves found there. Blue agave is produced in specific regions and geographic conditions in Mexico, mainly in the State of Jalisco, which gives tequila its traditional characteristics. The technological mix used in tequila production reflects the combination of two cultures: fermentation was a technique used by the pre-Hispanic cultures in Mexico, while distillation was introduced by the Spanish conquerors in the 17th century, who in turn had adopted it from the Arabs.

Despite its current popularity, until recently tequila was produced only for local and regional consumption. It is an important symbol of Mexican culture, originating among the poorest groups of the population although its consumption has now extended to the upper classes.

The internationalisation of tequila began several decades ago, which means its popularity is not a phenomenon that can be explained by globalisation. The tequila industry was a pioneer in opening its commercial, well before the North American free trade agreement (NAFTA), at a time when Mexico's economic policy was based on import substitution, and foreign capital was beginning to appear in several financial areas, particularly in Jalisco.

Alliances, joint ventures, and acquisitions in the tequila industry have existed since the 1960s and 1970s, and were further accentuated by globalisation in the 1990s (see Table 1).

Table 1
National and foreign capital participation in tequila firms

Firm	Alliances or mergers	% of foreign capital participation	Firm's location
Jose Cuervo	—	—	Mexico
Tequila Sauza	Allied Domecq group	100	UK and Mexico
Tequila Viuda De Romero	Pernod Ricard (Jdc)	100	France
Tequila Cazadores	Bacardi	100	Bermuda
Tequila Don Julio	Diageo/Jose Cuervo	50	UK and Mexico
Tequila Orendain	Brown Foreman Corp.	33	United States
Tequila Herradura	Osborne	25	Spain

Source: Tequila regulatory board (CRT) and National Chamber of Tequila Industry. Data published by Velazco [4].

This allowed some Mexican firms to place their products on the international market, making tequila internationally famous as well as enabling firms to modernise their equipment and gain access to a new organisational culture.

External and context factors, such as the internationalisation of economies that took place during the 1980s and the globalisation of the 1990s, have significantly influenced the evolution of these firms and affected their technological behaviour and the role played by technology in productive processes, as documented in Section 3.

Since then, Luna [5, p. 249–50] has argued that a new generation of tequila entrepreneurs was born, linked to international markets and with access to new ideas and patterns of industrial organisation, representing a break with the traditional way of organising and running the tequila industry. New managers with university training have taken over the management of tequila firms, which are now linked to national and foreign capital groups.

The tequila industry has shown significant increases in sales, exports, and number of brands since the 1990s, which have contributed to the rise in productivity and competitiveness (see Table 2). Trends in total tequila production, which fell in 2000 and rose again in 2003, are indicators of the cycles of agave production, a situation that affects the entire industry. Several firms are coping with this situation by altering the cultivation of agave. What previously took 10 years to mature, now as a result of research and other cultivation techniques, takes only 5–7 years.

In the mid-1970s, the *appellation d'origin* (denomination of origin) was created, and tequila was recognised first by the United States and Canada, and finally in 1997 by the European Union. In 2003, nearly 300 brands of tequila, recognised by the Tequila Regulation Board (CRT), were produced in Mexico. This Board was created 10 years ago to certify the quality and authenticity of tequila, since certain other countries were producing imitation tequila and ignoring the *appellation d'origin*.

Tequila has been exported since the late 1960s, then spiked in 1973, and has continued to expand ever since [5, p. 225]. In 2003, tequila was shipped to 68 countries, with 78% being sold to the US, 12% to Europe, and 6% to other countries [6]. Exports accounted for 72% of total tequila production, while national consumption was approximately 386,000 litres, reflecting a 26% decrease over 2002 [7]. The general trend over the past 5 years has been a decrease in domestic consumption coupled with an increase in exports.

In recent years, the tequila industry has been affected by several factors that have caused critical situations in the production of tequila:

- increases in agave diseases that have not been scientifically explained, causing a major decline in crop production,
- increased national and international demand for tequila,

Table 2
Total tequila production and exports, 1995–2004 (40% alcohol)

Production/year	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total production (l, millions)	104.3	134.7	156.5	169.8	190.6	181.6	146.6	141	140.3
Agave for tequila production (tons, millions)	278.7	429.6	522.3	672.1	780.2	615	443.1	413.9	412.9
Total exports (l, millions)	64.5	75.2	84.3	86.5	97.3	98.8	75.6	88	101.6

Source: Author's own elaboration. Based on CRT, *Statistical Information* 1995–2003.

- sharp increases in the price of agave,
- increases in the amount of taxes that tequila producers must pay the government as a result of changes in tax procedures implemented in 2002,
- enormous pressure on tequila firms since, in order to engage in international competition, firms are required to adopt quality standards and improve organisational and technological capacities. These two factors have led to an increase in costs—a situation that must be controlled to prevent a loss of price competitiveness in both domestic and foreign markets.

Grupo José Cuervo is the oldest of the three firms. It was created in 1758, and its La Rojena factory was established in 1795, meaning that it has been in existence for over 200 years [8]. Cuervo, a national firm, is considered the largest Mexican tequila firm, accounting for 35% of total tequila production. Cuervo has three factories: two tequila distilleries and a plant that bottles tequila and processes other beverages.

Tequila Sauza was founded in 1870. In 1879 it acquired its first tavern called *La Antigua Cruz*, now known as *La Perseverancia*, which is the main production plant for Tequila Sauza. Three generations of Sauza family members have run the plant, which in 1988 was acquired by Domecq, and in 1998 was integrated into the Allied Domecq Group. In 1997, Sauza and Cuervo dominated the tequila market, accounting for 47% of total production and 60% of total exports [9, p. 240], making them the two largest firms in Mexico. Sauza exports 65% of its production, mainly to the US; only 35% is distributed to the domestic market.

Grupo Industrial Herradura is a contemporary of Sauza, created in 1870. The distillery is located at the *Hacienda San Jose del Refugio* situated in Amatitán, within the town of Tequila in Jalisco state. It is one of the few firms that caters primarily to the domestic market despite the fact that 25% of its capital share is Spanish (Osborne). This firm has substantially increased its production and exports in recent years, and is currently one of the country's four most important firms.

3. Historical stages of technological development

The production of tequila relies on a combination of five technological methods: agricultural technology, milling, fermentation, distillation, and maturation. The characteristics of these technologies and the centuries-old formulation of tequila have evolved over time, and some original technologies have been modified. The Official Mexican Norm for tequila has also changed since the first one was issued in 1949, with seven modifications implemented from then until 1994.

The tequila industry has undergone several phases in its production and technological processes, which are summarised in Table 3. With the exception of the hydrolysis phase, all the other technologies in the tequila production process were derived from the processes of other distilled alcoholic beverages, mainly brandy and rum, as well as from other industrial process such as those in the sugarcane industry [9].

Technological development in this industry has been slow, as Table 3 illustrates. It was not until the 19th century that tequila production, based on a plantation economy with local incentives, became important. At the end of the century, major technological innovations were introduced, such as improved, large-scale stills, replacement of pre-Hispanic underground ovens with masonry ones, and building modern plants instead of

Table 3
Evolution of the tequila industry: productive process, technology, and markets

Stages	Evolution
Stage 1: 1600–1870	Agriculture: collection of wild agave plants Production process: by hand Markets: local consumption
Stage 2: 1870–1977	Agriculture: low investment. Selection of agave plants Production process: technologies based on hydrolysis, sugar extraction and fermentation. Markets: regional and national
Stage 3: 1977–97	Agriculture: medium investments in agave plantations Production process: large distilleries Markets: international and national
Stage 4: 1997–...	Agriculture: high investments; intensive agriculture: monoculture; tissue culture improvement of plants Production process: technological improvements in sugar extraction, fermentation and distillation; productive phase integrated with agricultural phase Markets: increase in exports

Source: Adapted from Del Real [10].

old distilleries. Until the1970s, however, there was very little investment in agriculture technology. In the late 1970s gradual improvements in the technological process took place—just as exports were increasing—although this process did not intensify until 20 years later.

With all these increases in productivity and exports, and the technological evolution of the industry, one could argue that the technological dynamism of this sector began as a result of its internationalisation, i.e., when exports began to increase in the mid-1970s. Such dynamism became even more apparent in the late 1990s as the result of a tequila "boom" both domestically and internationally, reflected in another upward trend in tequila production and exports. As other authors have documented for products such as Mexican beer [11, p. 269–70], increases in exports of tequila and its expanded presence in international markets explains the importance that certain tequila firms placed on improving technological capacities and production process in the late 1970s.

4. Technological strategies: a comparative analysis

The strategies adopted by firms to build their technological capacity are influenced by both internal and external factors. During fieldwork, the following elements were observed, which help identify the current technological strategies of each firm: (a) commercial alliances, diversification, and networks; (b) production processes and operating orientations; (c) technological mix of traditional and modern; (d) R&D capacity; (e) organisational culture and training; and (f) external sources of knowledge.

4.1. Commercial alliances, diversification, and networks

All three firms have formed commercial alliances with international consortia, and began entering into agreements to acquire foreign capital investment in the 1960s and 1970s. For example, Grupo Cuervo alliances with several international groups, including one with the Diageo Group (alcoholic beverages), an alliance that was ratified when Cuervo bought Diageo Tequila Don Julio in 2003. Sauza built a close relationship with Domecq, starting with agreements for the commercialisation of tequila, followed by Domecq's total acquisition of Tequila Sauza in 1988, and eventually the acquisition of Domecq by the English transnational group Allied Lyons, which has since become the powerful Allied Domecq Group. Herradura also formed an alliance with Osborne to commercialise tequila in Europe.

As for diversification, although Cuervo concentrates on tequila production, it also commercialises other alcoholic beverages such as vodka, rum, gin, beverages with low alcohol content, and sports drinks. Recently it has begun to produce cheaper tequila brands for the low-income population. Herradura has begun to produce and commercialise carbonated drinks.

Building alliances and networks with suppliers, universities, and research centres is also part of the business strategy of these firms. However, networks among tequila firms are less common, and there has been no trend toward establishing productive arrangements or alliances between the firms themselves. Although there is an active National Chamber of Tequila Industry (CNIT), the firms considered in this paper have few interactions among them, and information and knowledge sharing is scarce. Unlike dynamic firms in the new emerging economies, Mexico has no tradition of association, even though the alcoholic beverage market is extremely large.

4.2. Production processes and operating guidelines

Each of the three firms has applied different concepts to the production process, ranging from respect for traditional phases and quality controls, to guaranteed product quality, to complete modernisation and optimisation of processes that ensure high levels of production and time and costs savings. These concepts are found in the distillery process worldwide to guarantee quality or quantity, which implies different production process conceptions [9].

Cuervo has chosen to develop in both directions. An emphasis on guaranteed quality is the focus at the La Rojeña plant, where a traditional process is applied. The focal point at the Camichines plant is large-scale orientation using renewed technologies and scaling up production levels through cost reduction and a faster fermentation and distillation process. Its operating system integrates all the plant's work areas. Collective work and a scheme based on a bottom-up process involve all the workers and technicians in the plant's production process. Following the style of large transnational consortia, this firm is broadening its brand production and distribution portfolios.

Sauza has moved to a production process based on quantity, low costs, and achieving on-time product delivery of high-quality products. Its operating guidelines changed when it was integrated into Allied Domecq, and it is now oriented by principles such as quality, security, and respect for the environment. This firm integrates product and process engineering with product verification. Since the 1970s, it has expanded its markets, capital, and access to new technologies, and has established better practices through mergers with

large consortia. It has developed a network of quality and verification laboratories to improve operations.

Herradura's production process displays both characteristics. However, an orientation toward quality can be seen in its tequila production, whereas a large-scale, modern orientation is part of the production process for carbonated tequila drinks. Production installations use traditional equipment and processes. Its operating strategies are based on strategic planning with both short- and long-term views, development of new tequila brands, and product diversification primarily in the form of carbonated drinks.

4.3. *Technological mix of traditional and modern*

Given the five technological areas on which tequila production is based, it was important when this investigation discovered that, over time, each firm has defined its own specific combination of technologies, referred to in this paper as a *technological mix*. I have not attempted to describe its evolution or specifics in this short paper, but refer only to the current technology mix in use by each firm.

4.3.1. *Agricultural technology*

Regarding agricultural technology, the industry challenge is to improve production so as to guarantee the availability of pathogen-free agave with high-quality sugars, on which tequila production is based. Each firm has developed a technology mix in which the main differences lie in techniques used to reproduce the agave plant: micro-propagation or reproduction by selected plant shoots.

Sauza's agricultural technology mix comprises four elements. The first is the use of micro-propagated agave plants, which began 3 years ago after obtaining plants from a company that specialises in plant tissue culture (PTC) in Mexico. Sauza cultivates PTC plants in greenhouses, then transfers them to nurseries, and eventually to the fields, resulting in the large-scale production of PTC agave. To date, the firm has produced 100,000 micro-propagated plants, with nearly 5 million plants already cultivated. On the basis of this strategy, the firm estimates that over the next few years, 100% of its tequila will be produced using PTC techniques. The second element of Sauza's technology mix is the use of cartography by means of satellite technology to choose sites where plants can be cultivated and to control inventory and risk in order to guarantee that the volume of plants will be available on time. The third element involves mechanisation of agave seeding and harvesting using new machinery that has been designed in-house. The fourth element involves consideration of the growth cycle of wild species in an attempt to introduce similar growth in agave and thus reduce its cycle to 5.5 years. Here agrochemical management and its adaptation to this crop are essential.

Herradura also uses micro-propagation, but it is developing the experimental phase in its laboratories and then reproducing agave in its greenhouses. The strategy is to produce its own PTC agave plant, and it has adopted the agricultural technology used by Sauza. Despite the fact that Herradura is developing in-house experimental PTC, it has established close links with a public research centre named CICY, which has extensive experience in PTC agave and somatic embryogenesis. The firm is currently working toward establishing its first PTC plantations.

Cuervo has adopted a different agricultural technology. This firm is also interested in natural and soil-friendly technologies to guarantee new and healthy agave plants. Some

years ago, Cuervo experimented with micro-propagation techniques, but after evaluation decided they were not much different from other reproductive forms. In addition, they involved considerable risk given that PTC plants are not yet strong enough when they are transferred to the fields. Instead, the firm developed a new technology mix based on techniques such as high-quality, selected agave shoots; highly productive land; and nutritional scheme for plants that consider soil, sun, and water conditions. By focusing on these technologies, Cuervo has increased its crop productivity.

4.3.2. Production technology

In this area, each firm combines traditional with modern technologies, the trend always moving toward greater efficiency. Cuervo operates one of its plants in the traditional way, while the other is a modern, automated, large-scale facility. All three firms have introduced a major technological change—the diffuser—to increase the percentage of sugars obtained when milling the agave heads. Cuervo was the first firm to introduce the diffuser by changing the traditional process in which agave heads were cooked first and then milled. The new process extracts juice from raw agave (dysfunctional hydrolysis) which loses very little of the sugar (only 1%), then follows with cooking. The diffuser it designed is based on the sugarcane extraction system. Although the other two firms have also introduced a diffuser, the one installed at the Sauza plant is a "new-generation diffuser" that was developed through an internal redesign of a machine usually used for grapes in Spain but adapted to agave.

4.3.3. Fermentation technology

As for fermentation technology, the three firms use batch fermentation and yeast characterisation and recycling, meaning they obtain their own yeast rather than use commercial ones. Herradura uses native yeasts and its milling, fermentation, and distillation processes are slow and costly. However, the firm prefers to work this way to preserve the product's sensual richness. Cuervo's modern plant has automated the entire fermentation process, achieving a fermentation time of 15 h compared with the 60 h common at other plants.

The technological base for producing distilled alcoholic beverages is known worldwide; indeed, many other alcoholic beverages, such as cognac, brandy, and whisky, are produced using this process. The distillation process uses copper or steel stills that have been in use since medieval times. The three firms analysed use some variation of these stills: Cuervo and Sauza utilise copper stills, whereas Herradura prefers steel stills, which that firm believes is better because it eliminates bad flavours. In the late 19th century, another method of distillation involving columns was introduced which permits a continuous process and reduces costs and distillation times. Cuervo's modern plant has adapted a distillation column that considerably reduces distillation time. However, it has a negative effect on the flavour of the product, which would suggest some degree of backwardness in the distillation process. The adoption of column distillation technology does not guarantee a better quality product, which is why these three firms continue to use copper or steel stills, as is the case with other distilled beverages, such as cognac and certain whiskies [9, p. 30].

4.4. R&D capacity

The three firms have adopted a policy of scientific and technological research because these activities are conceived as a source of competitiveness. At present, all three have

specific areas for R&D that are organised in different ways. Another important finding of this research was that firms are interested in both basic and applied research, as borne out by the long-term view and prospective strategies they have adopted.

Herradura is especially important for the development of its research capacities, as reflected in its clear definition of research lines, the nature of the personnel employed in its laboratories, and the quality infrastructure acquired by the firm. This can be explained somewhat by the fact that the director of the plant, formerly an academic researcher, has transmitted his scientific research attitudes to the firm. It is the only tequila firm recognised in the National Register of Scientific and Technological Institutions (RENIECYT), since it has invested in R&D activities in recent years.

A similar pattern can be seen at *Sauza* (Allied Domecq), which has formal R&D agricultural activities also overseen by a former academic researcher. However, in this firm industrial R&D has just started to develop as a result of the merger with Allied Domecq, which has centralised the infrastructure that will provide all its plants with industrial research.

Cuervo, despite being larger than the other two firms, has only just begun to formalise its R&D activities. Agricultural research is part of the Agricultural Division, and is the largest in Mexico, with 17,000 ha for the cultivation of agave. However, the technological factor in the production process lies in the process itself, and did not rely, until very recently, on a formal R&D structure.

4.5. Organisational culture and training

These three firms, each linked in different ways to transnational consortia and competing in the international markets, have been influenced by a new organisational culture that is transforming the way people work within the firms.

The initial training of new resources and ongoing retraining are regarded by all three firms as an important strategy for technological development and competitiveness. All three firms have different mechanisms for internal training, each aimed at solving the firm's needs and introducing necessary changes.

Cuervo has shifted from worker mobility based on union decisions to mobility based on knowledge and multiple technical abilities. Collective work through self-directed groups is one way to generate bottom-up new ideas. Procedures to certify worker abilities have been introduced, which permits quality certification of other processes within the firm. Cuervo is seeking to become a world-class manufacturing firm, and so has created a school to train employees and help workers advance in their formal education. The firm also has a training programme for engineers that is equivalent to a Master's degree.

As a result of its merger with Allied Domecq, Sauza established training programmes, good manufacturing practices, and a minimum-quality platform demanded of firms belonging to this consortium. It has instituted a professional practices' programme with 18-month stages for BA students.

4.6. External sources of knowledge

It is worth underscoring the strong links among three firms vis-à-vis their machinery and equipment suppliers. As mentioned earlier, the design or redesign of equipment is jointly undertaken with suppliers, particularly in the case of Sauza and Cuervo. Sauza has participated in the development of engineering with international suppliers (New Holland and Bartra) for agricultural equipment, as well as the design of the diffuser and the

creation of new equipment for the fermentation process. Herradura has developed laboratory equipment jointly with suppliers, but limited the availability of the new equipment to other firms.

Interaction with universities and public research centres has developed over time, and in recent years has been stimulated by specific demands from firms. Contacts with academic institutions in the state of Jalisco, other Mexican states, and international institutions have been established. Certain factors have helped foster these relations: (a) philosophical changes among the people who operate these firms, who now recognise the relevance of knowledge and have contributed to the formalisation of R&D activities; (b) changes in academic culture and policies due to the realisation that solving problems is an important way to produce new and basic knowledge and contribute to raising financial resources for academic institutions; and (c) a conviction by the firms that they cannot develop all the knowledge they need, particularly the basic knowledge required to solve their production problems. As a result of these factors, major collaborations and contracts are being developed, particularly a macro-project financed by Sauza (Allied Domecq) with UNAM, designed to solve the cyclical availability of agave and other problems related to milling, fermentation, and distilling.

5. Conclusion

This paper has documented the fact that the competitiveness of these three firms and their penetration into international markets were phenomena that occurred prior to the time when the principal technological changes in the agricultural and industrial stages of tequila production took place. This means that the decision to improve technological capacities was a result rather than a cause of the internationalisation and globalisation of the industry, as has been the case with other firms in the alcoholic beverage industry in Mexico [11]. The three firms regard technology and knowledge as a way to sustain and increase their productivity and competitiveness in the international markets.

This investigation identified basic characteristics that define the technological strategies of the three firms: (a) increasing exports; (b) commercial diversification; (c) integration of agricultural and industrial production processes; (d) combining traditional and modern technologies in the milling, fermentation, and distillation processes; (e) the systemising, documenting, and restoring learning process in the firms; (f) building networks with external knowledge sources; and (g) supporting tequila firms in consortia for the commercialisation phase.

Among the factors that permit acquisition of technological capacity, the following are shared by the three firms: purchases of technology nationally and from abroad; adaptation and redesign of existing technology; design of new machinery and its manufacture by suppliers; internal development of R&D activities; use of external sources of knowledge; and internal training and updating of personnel.

The technological capacities of these firms have been built slowly, preserving original productive processes as a way of conserving the rich cultural values and identity of tequila. However, by the 1990s, the three firms had introduced technologies that enabled them to improve the agricultural production of agave, increase product productivity levels with the support of external sources of knowledge, and increase their exports.

With regard to strategy type, as discussed by Hobday [2] and Dutrenit [3], Cuervo could be considered the national technological leader, with Sauza and Herradura being

followers. However, the technologies adopted by the latter two firms include many of the principal conceptions but are not exact copies of Cuervo. The three firms have built a minimum base of knowledge and are advancing toward building strategic capacity. By observing the technological mix of each firm, it is possible to argue that the technological bases of the three are very similar, but the way each firm combines them is different.

The agricultural and production technologies used by the three firms are not state-of-the-art. The firms are using already-known technologies such as PTC (identified with second-generation biotechnology), batch fermentation, yeast improvement, and column distillation, among others. They have also adapted agricultural practices and are attempting to control the factors that affect agave development. The three firms have an explicit strategy of not using induced, genetically modified agave plants, given the debate on transgenic plants currently raging among consumers and civil society.

As part of the definition of their technological strategies, these firms have observed technological changes being introduced in other distilled industries, but they appear to be trying to develop an independent strategy with regard to other beverages. This suggests that during their long, 200-year journey, the three firms have acquired basic and strategic technological capacities. As a result of the internationalisation and globalisation of tequila, these capacities are being identified, systematised, and redesigned in order to increase productivity and efficiency, improve quality control, prevent environment pollution, and maintain international competitiveness.

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