Employment-oriented Industry Studies

Innovation in Resource-based Technology Clusters: Investigating the Lateral Migration Thesis

From Coffee Production to Machines for Optical Selection: Lateral migration in Costa Rica

E. Giuliani

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Abstract

This chapter presents an original case of lateral migration in Costa Rica. The case illustrated is about a domestic firm, Xeltron, producer of machines for optical selection, which was started up in the 1970s as a knowledge intensive input supplier of coffee producers. Triggered by an existing domestic demand, the company developed optical selectors for coffee beans, an innovation that allowed the increase of efficiency in the labour intensive phase of beans selection. After more than thirty years of expansion in the market of optical selectors for coffee beans, the firm is now launching new machines for the selection of plastics and emerald products. These new machines are based on the same underlying principles of those applied for the selection of grains but are directed to different, more knowledge intensive, clients. This is therefore considered to be a case of lateral migration. The chapter shows that lateral migration was facilitated by the firm founders' entrepreneurship and their technical background, and by the investment in the strengthening of the firm internal technological capabilities. Moreover, the formation of knowledge linkages with foreign actors has also been an important source of knowledge and technologies. In contrast, the linkages formed at the domestic level with the National System of Innovation seem not to have had a relevant impact on the firm process of lateral migration. Costa Rican industrial policies have also been marginally important in this respect.

Acronyms

CEO	Chief Executive Officer
EPZ	Export Processing Zone
FDI	Foreign Direct Investment
HS	Harmonised System
ICE	Instituto Costarricense de Electricidad
IS	Import Substitution
MNC	Multinational Company
NSI	National System of Innovation
R&D	Research & Development
SITC Rev.1	Standard International Trade Classification, Revision 1
USPTO	US Patent Office

1 Introduction

This chapter presents an original case of lateral migration in Costa Rica. I consider here "lateral migration" a process that occurs when a country or a region, whose production is originally highly specialised in natural-resource products, develops a new knowledge intensive industry or a new production process by way of the backward or forward inter-industry linkages formed by the natural-resource based firms. Backward linkages are formed with a firm's suppliers, while forward linkages are formed with clients. Normally, suppliers and clients are at different stages of the value chain and therefore they operate in different though interconnected industries. For example, backward linkages of coffee producers could be with providers of chemical fertilizers or, as in this case presented here, with producers of machines for selecting coffee grains. When the knowledge intensive industry, or the production process thus generated, becomes vertically related with new industries which are not natural-resource based, this is what I call lateral migration. It is lateral migration because the technology that is originally developed to supply a client operating in natural-resource industries, "migrates" to other more knowledge-intensive industries. The Costa Rican case offers an ideal setting for the study of lateral migration. During centuries the country has grounded its economy on the production of bananas and coffee. Coffee plantations are everywhere in the country. It was only at the beginning of the 1990s that the country specialization pattern shifted from natural-resource based industries to high tech sectors.

The case presented here is that of a domestic firm, which was started up in the 1970s as a knowledge intensive input supplier of coffee producers. Triggered by an existing domestic demand, the company developed optical selectors for coffee beans, an innovation that allowed it to increase efficiency in the labour intensive phase of beans selection. After more than thirty years of expansion in the market of optical selectors for coffee beans, which persists being the firm strongest market, the firm is now launching new machines for the selection of plastics and emerald products. These new machines are based on the same underlying principles of those applied for the selection of grains but are directed to different, more knowledge intensive, clients. This is therefore considered to be a case of lateral migration.

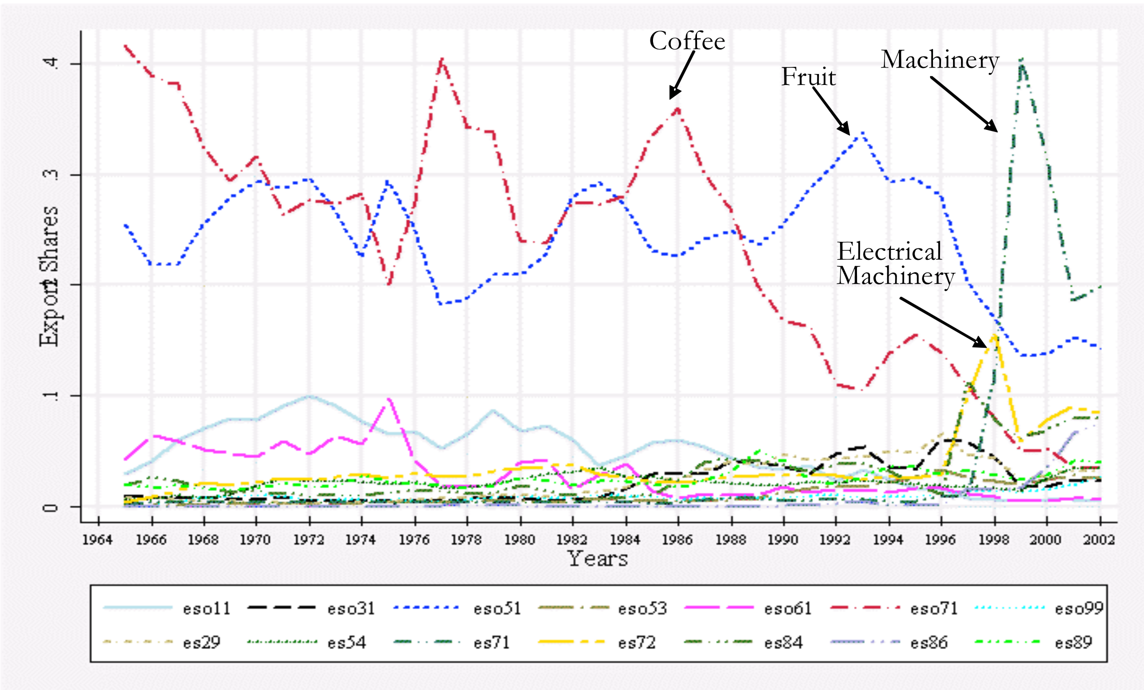
The chapter is organized as follows: Section 2 presents an overview of the Costa Rican economy in order to provide contextual information on the evolution of the country productive and export specialisation since the 1970s. Section 3 presents the firm case and provides an overview of the industry of machines for the selection of coffee beans. The remaining sections intend to understand the reasons and the factors that spurred on lateral migration. Section 4 discusses the process of firm accumulation of knowledge and the importance of absorptive capacity. Section 5 explores the role played by external and foreign linkages in the development of optical selectors. The linkages with the National System of Innovation and the country institutional and policy support are explored in Section 6 and 7. Section 8 concludes.

2 Costa Rica: from natural-resources to high tech industries[1]

The Costa Rican economy has experienced positive rates of growth since the 1950s. After a decade of high instability and strong dependence on terms of trade, in 1965 the country enforced import substitution (IS) policies, which lasted until the end of the 1970s. The first half of the 1980s was affected by the widespread Latin American financial crisis, while from 1985 onwards structural reforms and market liberalisations were promoted. In particular, the 1990s were characterised by fiscal policies to attract efficiency-seeking foreign direct investment (FDI), especially in high technology industries (Mortimore, 2002).

Historically, the industrial specialisation pattern of the country has been in natural-resources. As shown in figure 1, at the beginning of the IS period, exports were composed mainly of coffee, bananas and processed fresh fruit. As argued by Azofeifa-Villalobos (1996) and Céspedes and Jimenez (1994) the favourable world coffee price during the 1970s and the first part of the 1980s, has favoured Costa Rican economic growth. However, at the end of the 1980s, the share of these commodities, especially coffee, collapsed due to the worsening of the international prices, and, until the second half of the 1990s, no other sector grew to balance this reduction.

Figure 1 - Evolution of main export sectors' shares (2-digit SITC Rev 1)

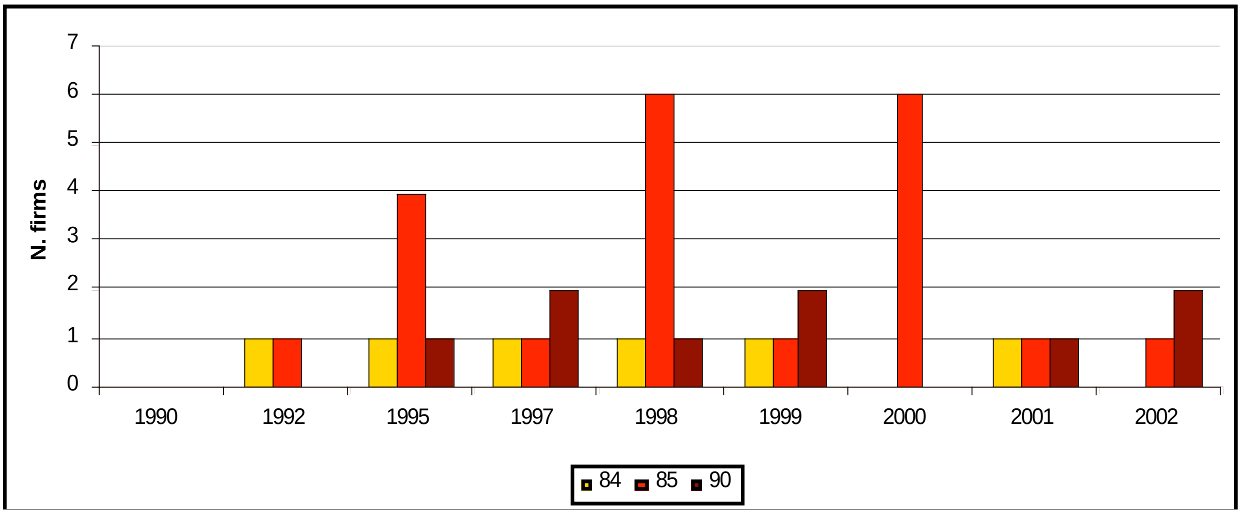


Source: Adapted from Ciarli and Giuliani (2005)

[1] This section is based on Ciarli and Giuliani (2005).

The change in the composition of exports in the second half of 1990s, especially after the investment of Intel Co. in 1997, is due to the wave of FDI investments in high tech industries, typically microprocessors (HS 84), electrical machinery (HS 85) and medical instruments (HS 90), occurred during the 1990s (see figure 2). It is worth mentioning that the change in the industrial structure towards more knowledge intensive activities has been driven and has involved only foreign investors, whereas domestic firms have only been marginally included. In fact, the domestic industry persists being dependent on resource-based industries. As reported by Ciarli and Giuliani (2005), "agricultural goods and manufactured coffee remain the two leading sectors in Costa Rican exports from the domestic economy." (p. 16) Coffee in particular, which represents more than 3 per cent of world imports, still accounts for 10 per cent of domestic exports. In this context, it is interesting to unravel the story of a small domestic firm, which has been triggered by the existence of a domestic natural-resource based industry, that of coffee production, and has managed to emerge as a highly sophisticated and knowledge intensive producer of optical selector machines.

Figure 2 - FDI in high-tech industries during the 1990s



Note: The sectors are classified using the Harmonized System 1996/2002. HS 84 indicates microprocessors, HS 85 indicates electrical machinery and HS 90 medical instruments. See http://unstats.un.org/unsd/comtrade/default.aspx.

Source: Own elaboration of Procomer (2004).

3 Introduction to the case and industry overview

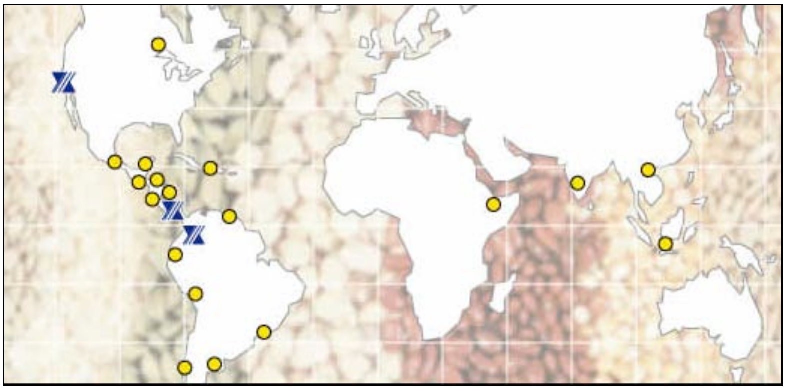
This case is based on evidence collected through a series of in-depth interviews to the CEO and the Director of R&D of Xeltron (http://www.xeltron.com), a Costa Rican producer of **machines for colour sorting** of food (e.g. coffee, rice, beans, nuts) and non-food products (i.e. plastics and emerald). The technology for colour sorting was originally developed as an input to the production of coffee, a natural resource historically driving the Costa Rican economy. This is considered a case of lateral migration at two levels: at the country level because a knowledge intensive industry was laterally created out of the production of coffee. At the company-level, as Xeltron started from modifying an imported technology used to sort coffee beans and 'migrated' to more sophisticated technologies, developing in-house new machines for sorting other types of grains, such as rice, beans etc. and even to other types of non-food materials. The firm is located in Tres Rios between the Capital city of Costa Rica, San José and Cartago, in a stand-alone export processing zone (figure 3).

Figure 3 - Xeltron: the plant

Source: www.xeltron.com

Xeltron is a domestic firm founded by two Costa Rican engineers in 1974. The company currently employs around 80 people, among which 10 are technical professionals with a university degree (2005 data). Their sales range among three and six millions dollars per year, depending on the trend of the markets for commodities. The company started exporting in 1988 and to date it exports about 98 per cent of its production. Over the years, the company has strengthened its marketing capabilities and built up a global customer-service network, which, by and large, includes countries with a strong specialisation the production of coffee (figure 4).

Figure 4 - Xeltron customer services worldwide



Source: www.xeltron.com

The production of machines for cleaning, sorting, screening and grading seeds, corresponding to the HS 2002/1996/1992 classifications codes 843710 and 847410, is mainly concentrated in advanced countries (http://unstats.un.org/unsd/comtrade/). As reported in table 1 European countries, Japan and the USA are the world top exporters. Not surprisingly, then, within this classification Costa Rica contributes only to a small percentage of the worldwide export.[2]

Table 1 - The market of machines for cleaning, sorting, screening and grading seeds (six-digit)

HS2002 Code	Description	Statistics in 2003	
843710	Name: Machines for cleaning/sorting/grading seed/grain/dried leguminous vegetable ... Description: Machines for cleaning/sorting/grading seed/grain/dried leguminous vegetables	**Exporting country** EU-25 United Kingdom Japan Denmark USA	**Trade value** $124,900,989 $124,491,360 $89,006,450 $60,972,339 $56,862,362
847410	Name: Sorting/screening/separating/washing machines for earth/stone/ores/oth. min ... Description: Sorting/screening/separating/washing machines for earth/stone/ores/oth. min. subs., in solid (incl. powder/paste) form	**Exporting country** United Kingdom EU-25 Germany USA Canada Other countries (amongst which Costa Rica) Costa Rica	**Trade value** $672,118,730 $468,175,549 $344,082,688 $251,133,261 $101,513,623 $797,070,422 $41,072

Source: Comtrade

The worldwide niche of optical sorting machine producers is rather concentrated, with only a few global leaders, such as Sortex (UK, established in 1974), Satake (USA, established in 1931), Sanmak (Brasil, established in 1980) and Selgron (Brasil, established in 1980), besides Xeltron. Among them, Xeltron is a worldwide leader in the production of machines for the *selection of high quality coffee beans*. In the production of other types of machines, Sateke and Sortex are instead the market leaders, including technologies for the selection of low quality coffee beans. If we consider the market of machines for colour sorting of coffee beans, we observe a strong penetration of Xeltron in most of the Latin American markets (table 2). As mentioned, this is particularly so for high quality coffee grains (Arábigo Robusta (Calidad)). For other types of grains (Robusta) Xeltron's market share is sensibly lower, especially in Indonesia and Vietnam.

[2] One should acknowledge that this classification is an approximation of the size of the industry, since, even at the six-digit, the classification is quite broad: Besides machine for sorting and selecting grains or other materials, it includes machines for cleaning, grading, washing and so on.

Table 2 - Xeltron market share in the market of machines for the selection of coffee beans

Machines for the selection of coffee beans	Country	Xeltron (%)	Competition (%)
Arábigo Robusta (Calidad)	México	84	16
	Guatemala	86	14
	Honduras	82	18
	Salvador	88	13
	Nicaragua	80	20
	Costa Rica	97	3
	Panamá	100	0
	Colombia	85	15
	Venezuela	84	16
	Ecuador	90	10
	Perú	95	5
	Total Calidad	*87*	*13*
Robusta	Brazil	59	41
	Indonesia	35	65
	Vietnam	32	68
	Total Robusta	*55*	*45*
Total		*76*	*24*

Source: Courtesy of Xeltron (2005)

Recently, Xeltron has started the development of machineries for the selection of other types of materials, such as plastics. This represents the essence of the lateral migration process. However, in spite of having the sufficient internal capabilities to master the technology, the presence of Xeltron in these markets is still very minor. This is considered to be due to the lack of other complementary assets (Teece, 1986), such as access to markets. The company is making an effort in this direction, which classifies it as an incipient process of lateral migration.

4 The beginning and the accumulation of firm capabilities

The historical context in which Xeltron was created, the 1970s, was one where Costa Rica specialization pattern was based mainly on coffee and banana production. It was also a period of import substitution (Section 2). These conditions can be considered the seeds that spur on the entrepreneurship of two Costa Rican engineers, who, at that time, were often contracted to repair imported coffee beans selectors. During the 1960s and 1970s, in fact, coffee producers started to import specific machineries to automate the process of quality sorting in order to reduce the costs of such a labour intensive phase. When these machines incurred into technical problems that impeded their functioning, coffee producers resorted to domestic engineers. In those times, the country had already a very well trained pool of mechanical engineers, most of them working for the *Instituto Costarricense de Electricidad* (ICE), the national provider of electric power. With time, these engineers realized that they could not only adjust imported machineries but produce them, improving upon the existing technology.

Therefore in 1974, a group of engineers, formerly employed by a local chemical firm Kativo,[3] founded the firm Xeltron. The founders had been trained as engineers in domestic universities – the Tecnologico de Cartago and the Universidad de Costa Rica. They had skills in mechanical and electronic engineering. As such, the company was the result of a domestic entrepreneurial initiative, based on self-financing of the original founders.[4]

In developing new sorting machines, they introduced considerable innovations:

> They in fact took on the challenge of going beyond the existing colorimetric sorting and began extensive research and development to ensure the separation of the various defected beans as well as the removal of those that were unacceptable, based on one principal idea: measuring the colour of the beans. In 1974, they developed an optical analyzer that with a sophisticated electronic system and mathematical fundamentals, scientifically and precisely analyze the bean's colour. The first patents were obtained and Xeltron, a company that designs, makes and markets machinery that electronically sorts grains and seeds by colour, was formed (Source: www.xeltron.com).

More in detail, Xeltron was a pioneer in developing a system of colometric sorting based on a mathematical measurement of the beans colour. As the CEO of the company puts it:

> Xeltron technology was the first system of circumferential analysis of colours to be used in the selection of grains. In this technology we decompose the colour of the grain in three rays of different wave length and we analyse them with great precision, through mathematical means, in order to be able to determine precisely what is the colour of each grain (Own translation based on original interview with Xeltron CEO, September 2005).

Colour analyzers used by the competition up until that moment required a reference background, which ideally represented the colour of the grain which should be selected in. The selection was therefore based on comparing the grain with a reference colour, without measuring the colour *per se*. As the company CEO puts it:

> In the selection system adopted by our competitors, the grains are compared with a reference background or a cardboard specimen, which represents the ideal colour of a good product. In this way, the grain colour is not measured directly being it based on a simple comparison. (Own translation based on original interview with Xeltron CEO, September 2005).

As a consequence, the competitors' existing technology was very inaccurate and required constant re-calibration of the machine. The inaccuracy was due to the fact that the reference background represented an approximation of the ideal colour and was not able to detect all of the beans defects. In addition, this technology used analogical electronics, which was neither versatile nor user-friendly. As such, it was unsuitable for a developing country, where most of the coffee plants are located worldwide, since it required highly skilled engineers to operate.

The lack of an accurate selector for coffee beans, generated a market opportunity, which spurred Xeltron founders to develop the project of an optical colour sorting machine based on a mathematical algorithm that could actively see colours rather than passively compare them with a reference background. As said, this technology therefore did not need constant re-calibration and was more easy to use. Gerstenfeld (1998) reports that the machine developed by Xeltron makes the selection using

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[3] See www.protecto.net/Quienes_Somos/index.shtml for details on Kativo.
[4] When their previous employer, Kativo, was sold to a multinational company, the two engineers sold their shares of the company and used them to finance the new entrepreneurship.

photocells and fibre optics. Thus, "if the machines "sees" a bad bean, a solenoid puts a short blast of air against the bean and pushes the bad bean into a separate bin or on to a separate conveyor belt. This all happens very quickly, perhaps 300-600 times per second" (p. 2). See figure 5 for some examples of products developed by Xeltron.

Figure 5 - Machines for optical colour sorting by Xeltron (www.xeltron.com)

Rollers	Chutes	Prisma
		

The development of the new machinery was therefore based on the understanding of the functioning of existing beans selectors, used by coffee producers in the 1970s in Costa Rica. However, its development was not the result of an incremental innovation based on *reverse-engineering* but on a **true technological advance and architectural innovation** (Henderson and Clark, 1990).

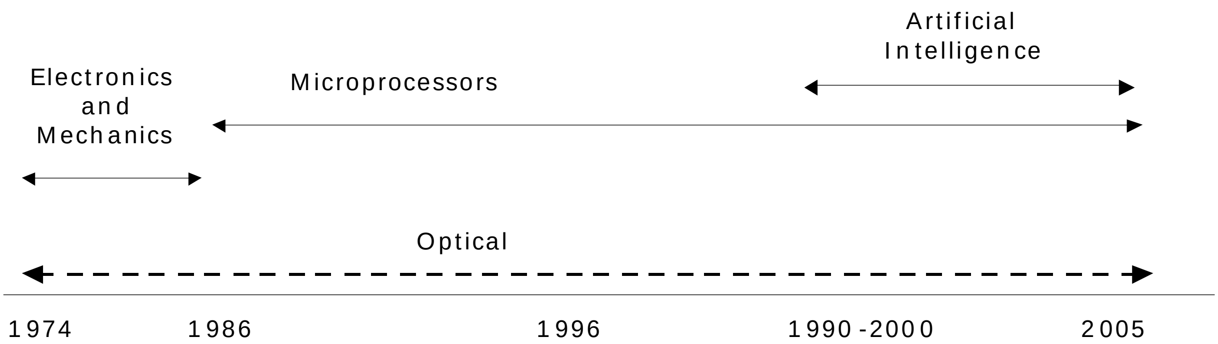
Since the very beginning Xeltron set up an R&D Laboratory, and most of the technological advances were developed internally. The R&D laboratory was established in 1975 and the first patent was granted in the 1974 by the US Patent Office (USPTO). Throughout its history, Xeltron has been granted five patents by the USPTO. Today Xeltron is a leading firm, which invests about 3-5 per cent of its sales in R&D with some peaks of 30 per cent when there is a new product development. It currently organizes the process of R&D in two stages: first, an experimental phase where they carry out basic research and second, a development phase where they carry out design and product development.

The firm employs ten technicians with skills in engineering and informatics and carries out regular training within the firm. The engineers come mainly from the neighbouring Tecnologico de Cartago and less frequently from the Universidad de Costa Rica. Training is mainly on the job, through intensive mentoring by the R&D and Production Managers. The CEO of the company says that it takes over a year before an engineer starts really contributing to the firm, as the technology is complex and very specific. This is due to the fact that engineers have to be versatile and specialized at the same time: any engineer has to learn, not only how to design and manufacture the component he or she is in charge of, e.g. motherboard and circuits design, but also how other components are designed and manufactured, thus mastering other engineering skills like optics or mechanics, software, etc. Accordingly, training involves learning about all the technologies involved in the product, and how they interact as well as the specifics of the technology in which each engineer specializes.

The process of learning within the firm was incremental and cumulative, with some technological jumps in the 1980s, 1990s and 2000s (see figure 6). As mentioned above, the firm's breakthrough was related with the introduction of optical technologies. Already in 1974, the group of founders had developed and patented an optical analyzer based on a mathematical model for absolute colour analysis that would revolutionize the local coffee industry (Gerstenfeld, 1998). Over the decades they augmented the efficiency of their machineries by incorporating new technologies, thus shifting from mechanics and analogical engineering in the 1970s to digital technologies (microprocessors) in the 1990s to artificial intelligence in 2000. The process of accumulation was based on a combination of internal R&D and the acquisition of external technologies.

This means that Xeltron generated internally, through in-house R&D, the necessary absorptive capacity (Cohen and Levinthal, 1990) to adopt and apply new technologies to their own machineries. For example, when microprocessors where introduced in the market they implemented this opportunity by introducing them in the machineries. Over the years what the firm seems to have strengthened is the development and mastering of a highly versatile and general purpose technology (Bresnahan and Trajtenberg, 1995), based on the combination of mathematical measuring of colours with other types of knowledge (optical, digital, artificial intelligences). This is at the **core** of the lateral migration process. The technology developed for the selection of coffee beans and other food grains was in fact based on underlying mathematical principles that allowed it to be used and adapted to other types of materials, such as plastics and emerald. The flexibility of the knowledge base underlying the machines is directly tied to the original method of colometric sorting, which generates opportunities for diversifying the product into other industries. Incremental changes in the calibration and mathematical measuring of colours allows the machines to be applied to different materials, and therefore has permitted the migration from natural-resources to plastics.

Figure 6 - Accumulation of technological capabilities over time



Source: Own elaboration based on interviews to Xeltron.

The accumulation of technological capabilities is also documented by a series of patents that have been granted to Xeltron by the USPTO in-between the years 1974 and 1996 (table 3).[5]

[5] Interestingly enough, the company tried once to patent in Costa Rica but the patent application was rejected. They ultimately were granted the same patent in the US.

Table 3 - History of Xeltron's patents

Year granted	Investor(s), Assegnee, Application no.	Title. Abstract
1974(*)	Not available	Not available
1977	Castaneda F. and Jimenez R.; Xeltron S.A.; 568761	**Optical sorting apparatus**. Apparatus for optically sorting small light objects such as beans and/or grains on the basis of size and color. A feeding mechanism separates the objects one from another and delivers them in a free falling condition to an optical analysis means where each object is uniformly illuminated. The analysis is based on the amount and spectrum of reflected light which is conveyed to a pair of light transducers having different response characteristics. The electrical signals developed by the transducers are simultaneously analyzed for absolute values to determine object size and relative value of the integrated signals to determine object coloring. An annular analysis head is employed with the objects being analyzed falling through the central opening. The head is comprised of a pair of annular rings with a predetermined gap between the rings located at the central opening. Plural fiber light conducting rods are uniformly spaced about the circumference of the gap so as to collect light reflected from the object. A pair of fiber bundles are formed, each made up of rods uniformly disposed about the circumference. Each bundle of the pair provides light to a different transducer. Low pressure air introduced at the gap prevents dust or the like from masking the rod ends.
1988 (1)	Castaneda F.; Xeltron S.A.; 762543	**Control panel.** A control panel having a display for displaying selected statements from a plurality of stored statements containing one or more separate elements of alterable information; four selectively operable push-button switches; and a computer for storing the stored messages and controlling the display. The switches include left and right scroll switches and up and down-increment switches. The computer controls a cursor on the display movable left and right between one or more pre-programmed positions in each displayed statement in response to operation of the scroll switches. Each of the pre-programmed positions corresponds to one of the segments of alterable information. The scroll switches cause the computer to scroll left or right for sequentially displaying the next left or right statement. Scrolling to the next stored statement is in response to the scroll switch indicating an attempt to move the cursor left or right beyond the leftmost or rightmost pre-programmed position for the displayed statement. The computer increments up and down the segment of alterable information corresponding to the pre-programmed position to which the cursor has been moved in response to operation of the increment switches.

Year granted	Investor(s), Assegnee, Application no.	Title. Abstract
1988 (2)	Castaneda F.; Xeltron S.A.; 787534	**Process and apparatus for sorting samples of material.** An optical sorter for beans and grains, including a detector providing a signal pulse for each of the sampled objects, and a signal processor for receiving and amplifying the pulse. The signal processor measures the amplitude of the amplifier pulse and compares the amplitude value to a predetermined standard value. The pulses are counted up to a predetermined count, and the number of pulses having an amplitude value above the predetermined standard value out of the total number of counted pulses, is counted. The counted number of pulses having an amplitude above the standard value is compared to a preselected number, and the gain of the signal processor is adjusted with a negative feedback signal to adjust toward the preselected number, the counted number of pulses in the next count having an amplitude value at the predetermined standard value. The sorter uses the peak amplitude value of the pulse which is determined by taking a derivative of the signal and determining the zero crossing time of the derivative signal.
1996	Castaneda F. and Aguero A.C.; Xeltron S.A.; 129848	**Process and apparatus for sorting material.** An apparatus for optically sorting small objects such as beans has an annular analysis head with an opening through which the objects fall. Three sets of optical fibers are positioned around the analysis head opening. A first set receives radiant light reflected from the falling objects. This reflected light is digitized and input to a comparator where the reflected light is compared to a reference value and a determination as to the quality of the object is made based on color. The second set of fibers is connected to an infrared light source and transmits a curtain of light across the opening, intercepting the travel of the objects. The third set of fibers receives the infrared light and is connected to a light detector which detects when objects pass through the curtain of light. The curtain of light is preferably wider than the objects. The light detector outputs a signal having peaks caused by the widest portions of objects passing through the light curtain. The peaks correspond closely with the centers of gravity of the objects. A comparator outputs an ejection signal in response to a signal from the quality detector below the reference value and the peak produced by that object. The peaks are used to time an ejection mechanism.

Source: USPTO (http://www.uspto.gov/)

Note (*): The first patent is not recorded in the USPTO database that is available only from year 1975. The patent granted in 1974 refers to the first optical sorting machine, developed by Xeltron's engineers, as described in the beginning of Section 3.

Although patents are considered by the economic literature as a way to protect a firm's innovation and to retain a certain competitive advantage on the usage of the patented technology, the respondents at Xeltron considers that their patents in general are not very important to maintain market leadership: "*patents are worthless, product innovation is the best protection in the market*" (Own translation based on original interview with Xeltron CEO, September 2005). For example they were granted a patent in Brazil, and they had no benefits after having sustained high legal costs.[6]

5 The role of foreign technology in indigenous technological development

5.1 The importance of loosely-coupled linkages with foreign partners

Xeltron has never been foreign-owned, nor has it established equity agreements with other foreign firms. However, foreign technologies have definitely played a central role in the development of new machines by Xeltron. As shown in Section 3, over time, the firm has upgraded its knowledge base, shifting from mechanics and electronics to artificial intelligence. Apart from internal R&D, the technical knowledge is sourced externally. The upgrading process has been made possible by the advances of digital and microprocessor technologies at the international level. Foreign knowledge has been acquired through consultancies, as well as through the outsourcing of the production of key technological components mounted in Xeltron's machines.

A couple of examples of how external knowledge is integrated in the firm internal processes are reported below:

- One important breakthrough in the history of Xeltron was the development of machines that applied microprocessors, during the 1980s. This technological change was first based on a consultancy by a US engineer. During a whole year the consultant engineer developed a dedicated motherboard that could be mounted on Xeltron's machines. Since then, all the incremental changes on the motherboard were carried out internally by Xeltron.
- A second breakthrough was the development of a new polychromatic platform applied in Xeltron latest product, Genius (see table 4), which implied an architectural innovation and incorporated electronics, informatics and optical technologies. They carried out the development process with an independent US engineer (after several attempts with other consultants, which all failed), who collaborated with the internal team and finally led to the development of the new machine. Genius required 9 months to be developed and it also required several visits of Xeltron engineers to the US and to US providers of components (as, for example, Motorola).

[6] The higher costs were due to litigation. Apparently, the benefits related to the payment of the damage received by the competitor were lower than the legal costs of the litigation.

Table 4 - Genius: Xeltron latest technology - technical details

Variable Multiple Vision System (Vmvs): Latest generation technology on the modular camera and lens system (multiple), an exclusive Xeltron innovation, independently controlled or in group (variable), enable each camera to sort simultaneously and automatically a particular color defect. Module independency provides reliability and machine updating is easier.
Polychromatic Variable Illumination Systems: The innovative illumination system allows changing the color and intensity of the light, maximizing sorting precision and operating in a color spectrum that ranges from ultraviolet to infrared. Xeltron developed the best technology variable referential, to maximize color discrimination.
Colorimetric: The assignment of different cameras to basic colors and the combination of multiple tonalities is an innovation that makes the GENIUS, the only machine in the market that is truly polychromatic.
Highest Resolution: Xeltron developed sophisticated optical system, achieves a precision up to 0.3mm, which could be adjusted according to user needs; allowing clean rejections of the sorting products. As a result, minimum acceptable product is rejected.
Highest Production Capacity: (6 tray model). There are 3 variations of Genius machine, depending of the type of grain to be selected: Large Grains (almonds, nuts, pistachios, hazelnuts; among others); Average Grains (coffee, corn, beans, peanuts; among others); Small Grains (rice, sesame, pepper, sunflower seeds; among others).

Source: www.xeltron.com

In other cases, Xeltron outsourced the production of technological components which were designed internally. For example, most of the electronics components have been historically outsourced. Until 2003 Xeltron's engineers designed mechanical parts in-house and outsourced the production in the US, with the exception of valves which were produced by domestic suppliers. Since 2003 they have been outsourcing the assembly of robotized cards, which they also design internally. Genius, for example, has a higher content of foreign-produced components, since it employs more electronic parts. In general, the company has increased the number of components that are outsourced for production and focus more on its core activity, which is the development of optical competencies.

The components outsourced to be manufactured by the suppliers are very specialised pieces of work. They are not easily available on the market since they tend to be customized to Xeltron's needs. Thus, the cooperation agreements with other firms are based on the outsourcing of key components of the machineries that are designed and partially manufactured by Xeltron. Normally, this entails long-term agreements, in order to control that the specific components are manufactured according to the necessities of Xeltron. For this reason, Xeltron has a tendency to maintain the same suppliers over time, unless they prove not to be able to comply with the required quality standards. In other cases they even allow suppliers to try different solutions and share relevant knowledge with them. This behaviour is consistent with Sanchez and Mahoney (1996) idea of modular corporation. Thanks to the existence of standard interfaces among the product's components, the firm is able to form loosely coupled linkages with other partners worldwide, and, without the need to establish equity agreements, the partners cooperate on the manufacturing and development of the product's components.

Therefore, the company does import foreign technologies. It incorporates external technologies into colour sorting machines to improve their efficiency and accuracy. In order to do so, they either carry out joint-product development with external foreign consultants or they outsource production to foreign suppliers but control the design of the components.[7] This is likely to be due to the high specificity of the product, whose technical features are not standardized.

Finally, another way of obtaining technical knowledge is through the internet, since the company has already reached a minimum level of absorptive capacity to decode what is available on the net. Clients represent a stimulus to upgrade since they propose changes, but are not themselves sources of knowledge. No other relevant international actors or sources of knowledge are observed.

5.2 The limited role of knowledge spillovers from high tech foreign direct investors

As discussed in Section 2, in the past twenty years Costa Rica has adopted an industrialization strategy based on the attraction of high tech foreign investors, operating in the electronics, microprocessors and medical device industries. It is therefore interesting to understand to what extent Xeltron may have benefited from FDI inflows. In this respect, it should be noted that the recent wave of FDI into the country is of an efficiency-seeking nature, with very limited R&D undertaken by MNC subsidiaries at the local level (Ciarli and Giuliani, 2005). Xeltron CEO thus suggests that very limited knowledge spillovers are being generated by these subsidiaries, and that, with few exceptions, Xeltron has not established collaborative linkages with them. Collaborative linkages and transfer of knowledge have occurred in one case, with the subsidiary of AETEC (www.aetec.com/) in Costa Rica, a supplier of electronics components for Xeltron. On the whole, however, the company seem to have not benefited from the presence of foreign investors.

Having benefited little from knowledge spillovers by foreign investors operating in similar industries (e.g. microprocessors and electronic machineries) is not entirely surprising. Two interpretations are offered here. First, the company has a long history of product development. As explained in Section 3, Xeltron has undertaken a path of product development and innovation since the beginning of its operations in the 1970s. An R&D laboratory was constituted immediately afterwards, and during the 1970s and 1980s the firm has searched abroad for engineering solutions and technical knowledge. This was driven by the fact that, in that historical period, the domestic industrial structure was based on agricultural products. It was therefore difficult to find solutions and knowledge at the domestic level. This has certainly affected the behaviour of the firm in a path dependent fashion. Xeltron tailored an appropriate organisational setting through the formation of loosely coupled linkages with a selected number of foreign partners (e.g. MOTOROLA and FESTO) and used this as a strategy to innovate and compete. The formation of this type of linkages is based on the creation of trustful relationships and it takes time to consolidate (Granovetter, 1985). Therefore, when the wave of inward foreign direct investments arrived, in the second half of the 1990s, the company had already a consolidated portfolio of foreign partners. This implies that the presence of new investors in the country did not generate an immediate adjustment of the firm to the new basin of local resources. This may eventually happen, but did not happen so far.

A second interpretation of why this has not taken place is because the sharing of knowledge that underpins the generation of knowledge spillovers, is based on the complementarity of firms' knowledge bases. As suggested by Lane and Lubatkin

[7] *It should be noted that Xeltron acquires only about 10 per cent of its inputs in the domestic market. Besides, according to Giuliani (2005) the inputs procured locally are of low technological content, so that the vast majority of component manufacturing is outsourced to foreign firms.*

(1998) in their study on pharmaceutical-biotechnology R&D alliances, the capacity of one firm to internalise valuable knowledge from another firm depends on the similarity among them in terms of knowledge bases, organisational structures and compensation policies. In such a perspective, then, inter-firm *cognitive distance* inhibits firms to interact and it also functions as a limitation for the firm to share its proprietary knowledge.

These results are consistent with several studies which show that firms tend to establish alliances with firms that have overlapping technological capabilities (Arora and Gambardella 1990; Mowery et al., 1996; Mowery et al. 1998). And in fact, as suggested by Hamel (1991): "*if the skills gap between partners is too great, learning becomes almost impossible.*" (p. 97). Accordingly, a second reason for so limited interaction is the fact that high tech subsidiaries operate in different technological niches and, also, given the fact that they are primarily manufacturing plants with no R&D laboratories (Ciarli and Giuliani, 2005), the knowledge that they master is different from the one that Xeltron may potentially need (Xeltron CEO, 2005).

6 Linkages and interactions at the local level

The linkages with the National System of Innovation (NSI) or with the actors that may be part of a NSI (firms, institutions, universities etc.) are rather weak at the domestic level. Xeltron has a several suppliers and clients in Costa Rica but none of them represents a valuable source of knowledge or technology. In spite of geographic proximity, the company has established very limited knowledge linkages with domestic actors in the value chain and, as described in the previous section, it tends to source globally. Operating in the global economy and in a macroeconomic framework that supports the liberalisation of markets, the company selects worldwide the partners that are more likely to be efficient and effective. Moreover, Costa Rica is affected by a severe structural heterogeneity in the domestic industry (Ciarli and Giuliani, 2005), which implies that a wide technological gap exists between foreign and domestic firms, so that domestic firms are, by and large, more inefficient if compared with international standards.[8]

Xeltron appears to be an exception to this. Attempts to establish linkages with domestic firms have tended to fail. As an example, Xeltron tried to outsource the production of simple mechanical components at the local level, but domestic suppliers had problems of quality and precision. According to our respondent, domestic suppliers do not possess the necessary productive capabilities (Bell and Pavitt, 1993), and those which have them, are very expensive and are therefore not competitive, if compared to foreign alternatives. Therefore, Xeltron did not meet suitable domestic partners – an aspect that pushed the company to procure internationally. As the CEO mentions: "*when we need help, we do not doubt it, we go abroad*" (Own translation based on original interview with Xeltron CEO, September 2005).

As concerns the linkages with institutional bodies, Xeltron has benefited from the training of engineers, mostly by the *Instituto Tecnologico de Cartago* and also by the *Instituto Nacional de Aprendizaje,* the national training institute (http://www.ina.ac.cr/). It is worth noting that Costa Rica devolves a ratio of resources to tertiary education

[8] The concept of structural heterogeneity has been developed by the Latin America structuralist school (Pinto, 1970; Prebisch, 1973). An industrial structure is conceived as heterogeneous when it is characterized by the co-existence of sectors or activities with normal or high labour productivity and sectors or activities with remarkably low productivity.

that is quite similar to the most developed countries (UNDP, 2003). This is consistent with the huge investment that country has undertaken since the 1960s to improve higher education and university research, setting up three universities during the 1970s.[9] The public universities generated the supply of scientists and engineers needed for the industrial sectors that grew in the 1960s and 1970s under the import substitution model, and also for the state owned companies and institutions in telecommunications, electricity, agriculture, industry, water supply, and infrastructure." (Rodríguez-Clare 2001, p. 4)

Even within this frame, the company CEO at Xeltron believes that the Costa Rican universities do not provide sufficiently trained engineers in the areas in which the firm specializes. This is an often-heard complaint from the private sector making the point that the programs offered by these institutions do not correspond to the needs of the productive sector (Rodriguez-Clare, 2005). In this case, the complaint concerns, first, the lack of mechanical engineers who are not only skilled in plant maintenance but also in design, and in the conceptual and creative phase of development of mechanical machinery and mechanical parts of complex electromechanical machinery. Second, the lack of engineers that posses skills specific to the firm, like optics and optotronics. As an example, the CEO at Xeltron argues that:

> [Engineers trained in Costa Rican universities] have some basis in mechanics, a little bit more in the Universidad Costa Rica and a bit more in electronics in the Tecnologico de Cartago. However, they [the domestic universities] do not manage to train the profile that we need to employ in here [Xeltron]. For example, in optics we have to train our engineers in-house, because there are no engineers trained by the university with skills in optics. In electronics isn't so bad, in mechanics is not yet fully satisfying, you do not find creative designers. What you have in the market are mechanical engineers oriented to maintenance of plants and machines, not to development or design…they are not creative…- How did you solve this lack of skills? – We have employed Costa Rican that have been educated abroad, e.g. in Israel, or that have been working abroad. The last one that we employed had worked in Suisse for 20 years. (Own translation based on original interview with Xeltron CEO, September 2005).

Shifting from training to research does not improve the picture. Barely any linkage has been established by Xeltron with domestic public institutions or universities for research purposes. The respondents argue that Costa Rican universities are not sufficiently "applied", meaning that they focus more on theoretical issues than on practical ones, making it difficult for Xeltron to interact. In the past, the company has made some attempts to connect with local universities but they never worked out. This is in line with most of the literature on university-industry linkages in Latin America, showing a very low interaction of companies with public research organizations (Arocena and Sutz, 2001). Rodriguez-Clare (2005) offers another perspective to this low interaction: "I asked Arturo Agüero [the firm R&D Directior, n.d.r.] of Xeltron why his firm did not contract out this R&D project to a university. His response was that their knowledge of this particular technology was much superior to what could be found at Costa Rican universities. This points to a more fundamental problem, namely that firms accumulate a great deal of specific knowledge that is essential for conducting new R&D. Were they to contract out an R&D project to a university, they would first have to transfer this knowledge to the university, and this would be a costly process that could easily wipe out the potential savings discussed above.

[9] *Now Costa Rica has four public and 50 private Universities (Buitelaar, Pérez, and Urrutia-Alvarez 2000, Rodríguez-Clare 2001, MIDEPLAN 2004)*

Arturo Agüero mentioned an additional reason why Xeltron was and remains reluctant to contract out its R&D with a university: university R&D carries a high potential for knowledge leaks. Thus, even if it is efficient to have universities perform a sizable share of privately-financed applied research, this would not happen because companies want to minimize leaks. This is obviously inefficient from a social point of view, and it explains why governments would want to transfer resources to universities to perform research." (p. 81) Basically, Xeltron's limited interaction with universities has to do with the appropriability of knowledge (Arrow, 1962). As universities' historical function is that of producing public knowledge, a risk exists that the interaction with a university on research projects would limit the capacity of the firm to capture acceptable benefits associated with the exploitation of the research results (Dosi and Orsenigo, 1988).

7 Industrial policy

As stated at the beginning of this chapter, Costa Rica has implemented import substitution policies from 1965 to 1979 and, after the 1980-1984 crisis, it has opened to structural reforms and macro stabilization policies. It should be therefore noted that Xeltron was started up during the IS period and may have benefited from *infant industry* protection policies. More recently, the implementation of industrial policies directed to firms is rather scattered and limited to two main initiatives: on the one hand, the implementation of free trade zones for the attraction of foreign direct investment (http://www.procomer.com/regimen/)[10] and, on the other, the support of small and medium enterprises (Parrilli, 2003). Xeltron has benefited from 8 years of total or partial tax exemption, since it opted for an Export Processing Zone (EPZ) regime. More specifically, they have benefited from total tax exemption for 4 years, from half tax exemption for other 4 years and, until 2002, they had 30 per cent exemption. However, being part of an EPZ entails high bureaucratic loads, and strict regulations. For this reason Xeltron CEO believes that they have not benefited strongly from this type of policy for their technological advances.

> We benefited from the export processing zone regime, but bureaucracy is very complex and expensive, and controls are very strict. For example, if a piece or component is imported under a export processing zone regime, and you do not use it, you cannot dispose of it, you have to keep it or use it in some way, or carry out all the bureaucracy to dispose of it (…). It is so complicated that many entrepreneurs have exited the export processing zone regime in order to avoid all this bureaucracy. The export processing zone helps, but it could be much more efficient. Also you have to consider that we are penalized by the low service offered by the Costa Rican government, if compared to other countries where there are other EPZ (Germany, Japan, US). We pay high fees and we receive a low quality of services and infrastructures (electricity, internet, telephone..) since they are public monopolies (…). We had to pay ourselves in order to have broadband cables to get up to here. (…) The benefits of export processing zones are not enough to compensate the competitive disadvantage we have with developed

[10] *The industrialization strategy of Costa Rica has been implemented via the establishment of free trade zones, through the Export Processing Zone Law issued in 1981. The law includes special agreements such as i) export contracts, ii) Export Processing Zones (EPZ), and iii) regimenes de perfecionamento activo, which involve different measures including tax exemptions (for both import and exports), and the provision of infrastructures and services. On the characteristics of Costa Rican EPZ see also Singa Boyenge (2003).*

countries…" Own translation based on original interview with Xeltron CEO, September 2005).

Accordingly, the CEO feels that the company would have benefited from higher government support in marketing and trade and policies to reduce taxes on R&D expenses would, for example, be most welcome.

8 Conclusions

What lessons can be learned about lateral migration from this study? Certainly, this is a story of a rather successful entrepreneurial initiative, given the fact that, after the liberalisation of the economy (1985), Xeltron has not been displaced by foreign competitors, as it has often occurred to domestic industries in other Central and Latin American countries (Katz, 2001). On the contrary, it has strengthened its internationalisation over time.

The first lesson that can be drawn from this study about lateral migration is related to the company starting up phase, and the second one, to its expansion and strengthening over time. The starting up of Xeltron has been spurred by an existing market opportunity generated by a domestic natural-resource intensive industry, that of coffee production. Given these conditions, a combination of fortuitous events has triggered the start up and development of the firm. An important factor in this process has undoubtedly been the professional experience of the founders and their capability to grasp the opportunity, generating an entirely innovative product. This study thus suggests that the presence of qualified engineers, trained by Costa Rican public universities, have eased the success of this entrepreneurial initiative and, eventually, it seems that they have constructed the basis for lateral migration. Furthermore, the company investment in R&D has allowed it to become progressively more competitive in the international markets. The restless effort undertaken by its engineers to pursue product innovation - also documented by the patents granted by the USPTO during the past two decades - has played a big role in this respect.

It must be acknowledged that this is a very special case of lateral migration. An aspect that makes it special is that it is basically an initiative of "lonely entrepreneurs" (Lorentzen, 2005), who have conveyed a firm to build and accumulate relevant resources for lateral migration. Lateral migration is in fact likely to be a long term process, full of impediments and accidents, and this story suggests that what matters in the first place is the firm long term effort to build internal technological capabilities, an effort which is necessarily triggered by a market opportunity. The national system of innovation and the business environment in Costa Rica seem to have only marginally affected the development of the firm, which has tended to recur to foreign sources of knowledge to sustain product innovation. This is probably due to the fact that during the 1970s and 1980s the country's domestic knowledge resources were not sufficient to endorse Xeltron innovative and pioneering effort. Domestic institutions, such as universities, have played a role in the training of human resources, but have not directly contributed to R&D or to enhance the firm innovative capability. Likewise, limited impact is attributed to the industrial policy implemented by the country. Therefore, a good combination of *chance*, firm *internal effort* and *market opportunities* seems to be what has triggered a trajectory towards lateral migration.

It is hard to foresee an alternative scenario in which industrial policies played a more central role. This story suggests that the government did not interfere much with the firm operations, not at least to facilitate them, and yet, the firm has managed to become competitive. The challenge now is to complete the process of lateral migration and to gain market shares in knowledge intensive sectors, such as plastics. A conversation with Xeltron CEO suggests that they have the necessary internal technological capabilities but lack complementary assets that would facilitate access to this new market. Should the government intervene and support this process? It is hard to say.

On the one hand, this is a case of a single entrepreneurship and not that of an entire industry, therefore a policy tailored to this specific case would not be justifiable. On the other hand, policies to facilitate the access to international markets of domestic firms could favour Xeltron's process of lateral migration. This type of policy, however, would apply to this specific case, and it may not be relevant to others. Finally, it is interesting to note that the government may have already generated the domestic conditions for lateral migration. The policies to attract high tech FDI have generated an internal demand for plastics by foreign investors (Ciarli and Giuliani, 2005). This suggests that if domestic plastic manufacturers expand their production by virtue of this new demand, this would in turn generate an internal demand opportunity for Xeltron. Accordingly, the change in the Costa Rican industrial structure, which has shifted from natural resources to more knowledge intensive products, may be what will eventually fuel the completion of the lateral migration process at Xeltron.

9 References

Arocena, R., Sutz, J. (2001). Changing Knowledge Production and Latin American Universities. Research Policy, 30(8): 1221-1234.

Arora, A., Gambardella, A. (1990). Complementarity and external linkages: the strategies of the large firms in biotechnology. The Journal of Industrial Economics, XXXVIII(4): 361-379.

Arrow, K. J. (1962). Economic welfare and the allocation of resources for invention. In R. R. Nelson (Ed.), The Rate and Direction of Inventive Activity: 609-626. Princeton: Princeton University.

Azofeifa-Villalobos, A. G. (1996): "Estimación de una Función de Produccción: Caso de Costa Rica," Departamento de Investigaciones Economicas DIE-PI-06-95/R, Banco Central de Costa Rica, Division Economica, www.bccr.fi.cr/ndie/produccion.htm.

Bell, M., Pavitt, K. (1993) Technological Accumulation and Industrial Growth. Industrial and Corporate Change, 2(2): 157-211.

Bresnahan T., Trajtenberg M. (1995). General Purpose Technologies: Engines of Growth? Journal of Econometrics, January, 65(1), 83-108.

Buitelaar, R., R. P. Pérez, R. Urrutia-Alvarez (2000): "Costa Rica: Sistema Nacional de Innovación," Serie Desarrollo Productivo 82, CEPAL, Naciones Unidas, http://www.eclac.cl/publicaciones/DesarrolloProductivo/4/lcl1404/lcl140%4.pdf

Céspedes, V. H., R. Jimenez (1994) Abertura Comercial y Mercado Laboral en Costa Rica. Academia de Centroamérica, San José, Costa Rica.

Ciarli T., Giuliani E. (2005). Reformas estructurales y cambio estructural en Costa Rica. Dinámica industrial, heterogeneidad estructural y eslabonamientos: el papel de las Inversiones Extranjeras Directas, forthcoming (available by the authors: Giuliani E. eg20@sussex.ac.uk).

Cohen, W.M., Daniel A.L. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. Administrative Science Quarterly 35, no.1: 128-52.

Dosi, G., Orsenigo L. (1988), Industrial Structure and Technical Change, in: A. Heertje, ed., Innovation, Technology and Finance, Basil Blackwell (for the European Investment Bank).

Gerstenfeld A. (1998) Xeltron, in CaseNet, South Western College Publishing.

Giuliani E. (2005) A successful case of industrialisation? Foreign Direct Investments and Technological Externalities in the Costa Rican Electronic and Medical Device belt, Paper presented at the XI Seminario de Gestion Tecnologica - ALTEC Conference, Salvador de Bahia, Brazil 25-28 October. (Submitted to a Journal, and available by the author: Giuliani E. eg20@sussex.ac.uk).

Hamel, G. (1991). Competition for competence and inter-partner learning within international strategic alliances. Strategic Management Journal, 12: 83–103.

Henderson R., Clark K. (1990). Architectural innovation: the reconfiguration of existing product technologies and failure of established firms. Administrative Science Quarterly, 35, 9-30.

Katz, J. (2001). Structural reforms and technological behaviour. The sources and nature of technological change in Latin America in the 1990s. Research Policy, 30(1): 1-19.

Lane P. J., Lubatkin M. (1998). Relative Absorptive Capacity and Interorganizational Learning. Strategic Management Journal, 19(5): 461-477.

Lorentzen J. (2005), "Lateral Migration" in Resource-Intensive Economies: Technological Learning and Industrial Policy, Paper prepared for Globelics Africa Conference 2005, 31 October – 4 November, Tshwane University of Technology.

MIDEPLAN (2004) Sistema de Indicadores sobre Desarrollo Sostenible (SIDES), http://www.mideplan.go.cr/sides/index.html.

Mortimore, M. (2000). Corporate strategies for FDI in the context of Latin America's new economic model. World Development, 28(9): 1611-1626.

Mowery, D. C., Oxley J.E., Silverman B.S. (1998). Technological overlap and interfirm cooperation: implications for the resource-based view of the firm. Research Policy, 27: 507-523.

Mowery, D. C., Oxley, J.E., Silverman, B.S. (1996). Strategic alliances and interfirm knowledge transfer. Strategic Management Journal, 17: 77-91

Parrilli, M. D. (2003): "Le Piccole e Medie Imprese Latinoamericane nell'Era della Globalizzazione: Approcci di Politica per lo Sviluppo Industriale a Confronto," Quaderni del Dipartimento 19/2003, Dipartimento di Economia, Istituzioni, Territorio, Università di Ferrara

Pinto, A. (1970): "Naturaleza e implicaciones de la 'heterogeneidad estructural' de la América Latina", El trimestre económico, 37(1), 145, México, D.F., Fondo de Cultura Económica, enero-marzo.

Prebisch, R. (1973): La interpretación del proceso de desarrollo latinoamericano en 1949, serie conmemorativa del XXV aniversario de la CEPAL, Santiago de Chile, Comisión Económica para América Latina (CEPAL).

Rodríguez-Clare, A. (2001): "Costa Rica's Development Strategy based on Human Capital and Technology: How it got there, the Impact of Intel, and Lessons for other Countries," Written for the human development report of 2001, UNDP, United Nations.

Rodriguez-Clare, A. (2005). Innovation and Technology Adoption in Central America. Inter-American Development Bank, Research Department, Working Paper #525.

Singa Boyenge J-P. (2003), *ILO Database on Export Processing Zones*, Geneva: International Labour Organization.

Teece, D. J., (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy 15 285-305.

UNDP (2003): "Human Development Indicators 2003," www.undp.org/hdr2003/indicator/cty_f_CRI.html.

9.1 Other sources:

COMTRADE (2005): unstats.un.org/unsd/comtrade/default.aspx

Procomer (2004): www.procomer.com/

USPTO (2005): www.uspto.gov/