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Key elements for the future of technology sourcing in the Peruvian industry: a prospective study

Rony Cabrera
Pontifical Catholic University of Peru, Department of Engineering, Lima, Peru
rony.cabrera@pucp.pe

Domingo González
Pontifical Catholic University of Peru, Department of Engineering, Lima, Peru
dgonzal@pucp.edu.pe

Carlos Hernández
Pontifical Catholic University of Peru, Department of Engineering, Lima, Peru
carlos.hernandez@pucp.edu.pe

Diego Mendoza
Antonio Nariño University, Industrial Engineering Faculty, Bogota, Colombia
diego.mendoza@uan.edu.co

Abstract
This article explore the future of technology sourcing in the Peruvian industry until 2030 in order to determine key elements to strategic formulation. Based on tool of prospective, we found the following axes of uncertainty that matter in the future of Peruvian technology sourcing: technological innovation, market dynamism and skilled people in R&D. Finally, and ideal scenario is described and present a discussion of the results and conclusions with limitations and futures directions.

Keywords
Technology sourcing, strategic prospective, Peruvian industry

Introduction

Peruvian technology procurement is attracting widespread attention due to recent evidences described by scholars (Cabrera, Corrales, Balarezo, & Almeyda, 2016; Heredia-Pérez, Geldes, Kunc, & Flores, 2018). Cabrera's case study report states that the sector is highly emphasizing in an external sourcing strategy meanwhile, Heredia's quantitative study found that Peru continues to concentrate its expenditure on machinery acquisition (78%) with minimal attention on R&D internal (3%) and R& D external (2%) compared to its neighboring country, Chile, who exhibits progress in transitioning to technological innovation reflected in its expenditure on R&D internal (37%), R&D external (28%) and machinery acquisition (27%).

Researchers have always seen external sourcing, in developing context, as a way to access to state of the art technology because most of the technology they use are outside their resources capabilities. In this sense, developing economies heavily engaged in gradual adoption and assimilation of incumbent technologies from advanced economies through the importation and purchasing of technology, technology outsourcing (local or overseas) or foreign direct investments. The excessively rely on external technology sourcing will soon be an issue for Peruvian firm due to increasingly rapid technological and environmental changes.

Few researchers have addressed the question of the key elements for the future of technology sourcing in developing countries. In this report, we explore possible scenarios of the technology sourcing in low-technological contexts like Peru. Authors believe that the temporal horizon until 2030 is a good starting point for an explorative and applicative-type study. The results can motive manufacturing firms to take on the challenge of building a sustainable future for the management of their governance mode.

This paper is organized as divided into five sections. The first section have given a brief overview of the problematic. The second section conceptualize technology sourcing and tools of strategic prospective literature that will be used. In the third section, the application of the prospective approach is presented. Finalizing with discussions and conclusion.

Theoretical Framework

Technology Sourcing

When firms establish the most appropriate source of technology acquisition, they are embarking on technology sourcing process. A firm's technology sourcing strategy is to choose between either external or internal technology acquisitions.

Internal acquisition is executed within the limits of the company and involves high degree of integration which generates that the company turns into a "real expert" (Haro, Ortega, & Tamayo, 2010). Reference (Pisano, 1990) states that it is considered as an ability to develop and take advantage of technological knowledge to transform it in innovation that helps the company to attain greater efficiency through differentiation (high prices) or productive processes (lower unit cost). For this reason, studies link it with the company's innovative performance (Laursen & Salter, 2006; Leiponen, 2005; Peeters & Martin, 2015; Tsai & Wang, 2007).

On the other hand, the acquisition by external sources (purchase of technology, outsourcing or collaboration) could make easier the fast development of products while the state of the art of the technology is accessed (Jones, Lanctot, & Teegen, 2001) and, the knowledge acquired, is integrated with that being currently generated internally (Peeters & Martin, 2015). Reference (Granstrand, Bohlin, Oskarsson, & Sjoberg, 1992) indicates that high costs and demand of highly qualified people in R&D have generated a clear tendency towards external acquisition. However, if a company relies too much on an external acquisition method, then it could have a negative effect on its long term internal capabilities (Ford, 1988) and alter its innovation incentives (Blonigen & Taylor, 2000).

Strategic Prospective

Gaston Berger (1973) presented the term "Prospective" in 1957 claiming that the accelerating pace of technological and social change raises the significance of the need to envision the future and devise new techniques to do this. After, Michel Godet describes Strategic Prospective as acting as a management tool from anticipation to action through appropriation and participation (Godet, 2001). Such participation being structured and organised in as transparent and efficient manner as possible. He also recommends that the techniques used for the exploration of the future should: stimulate the imagination, reduce inconsistency, build a common language, structure the collective thinking process and enable appropriation. Likewise, Hines and Bishop (2006) outlines that the stages of a strategic foresight activity are framing, scanning, forecasting, visioning, planning and acting. And Horton (1999) conceptualize it as a process of developing a range of views of possible ways in which the future could develop, and understanding these sufficiently well to be able to decide what decisions can be taken today to create the best possible tomorrow. Overall, definition of strategic prospective is about creating a clear vision of what future is desired.

Methodology

Our steps proceed very much in the same way as indicated in (Ortega San Martín, 2013). Figure 1 indicates exactly the methodological process of the study.

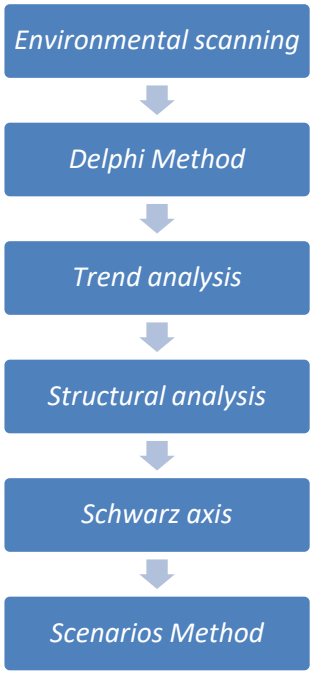


Figure 1. Methodological Process.

The methodological tools used were:

- Environmental scanning: It is based on the identification of change variables (drivers) using different thematic approaches.
- Delphi Method: the method consists of asking the group of experts their opinions about the future behavior of a certain group of drivers in order to have an idea as clear as possible of the future situation. The Delphi method aims to maximize the advantages of the methods based on groups of experts and minimize their drawbacks. In this way, the method obtain the most reliable consensus possible from the group of experts.
- Trend analysis: the method permits the identification of drivers with long-term impact from identifying relevant trends.
- Structural analysis: applying the structural analysis method it will be possible to observe the interrelation and influence among different variables which will let us classify them in order to understand the most relevant ones for the development of a specific area.
- Schwartz axes: drivers are analyzed and categorized into a scenario axis with high and low importance in y-axis and more or less uncertainty in the x-axis. As a result, it defines possibly four different scenarios, one scenario for each quadrant of the x-y axes.
- Scenarios Method: This method was proposed by Michel Godet and is based on the construction of narrative descriptions of a future, with a high probability of realization, a focus of specific attention on processes and decision points. These descriptions are called

scenarios. In other words, "it's about conceiving and describing a future (a possible future) and exploring the means that lead to that future."

Results

To asset the future of technology sourcing in the Peruvian industry until 2030, a strategic prospective method was used. First, Environmental Scanning was employed to determine key drivers by the selection of forces. For our study, four forces were selected: technology, social, economic and political forces. We initially identify twelve drives.

The next step was the identification of relevant trends that would affect the future of technology sourcing. In the literature ("Tendencias mundiales hasta 2030," 2016; Quintero, 2013) , trends usually refers to Asian and Emerging Markets Influence (T1), Shorter Product Life Cycle (T2), Industrial Revolution and new technologies (T3) and USA an European markets influence (T4). Once the trends were selected, we identified new drivers factors by applying again the Environmental Scanning method. It allowed reaching the 19 drivers that were validated by the Delphi Method.

Seven experts were recruited for interviews. We attempted to obtain multiple type of respondents to better ensure that the data represented different points of view. For our interviews, data came from three consultants, two academics and two industrialist. Moreover, concerns about potential reliability were further mitigated by relying qualified individuals that concern about the Peruvian innovation system and technology sourcing issues. The Delphi method represents a useful alternative to not only to validate drivers, but also it help to assign its level of importance and uncertainty that will be used in Schwartz Axes Method. Therefore, respondents evaluate the asseveration of each drivers regarding its importance (1: low importance, 2: medium importance, 3: high importance), their related expertise with the drivers (1: low expertise, 2: medium expertise, 3: high expertise) and indicated the range of years in which the fact described by the asseveration will occur (2019-2022, 2023-2026, 2027-2030). We added two additional option as ‘already happened’ and ‘never’. Figure 1 presents the structure of the Delphi interview.

As a result of the application of the Delphi Method, it should be noted that three drivers was eliminated due to lack of relevance. Finally, sixteen drivers will used for the construction of the scenarios. These drivers is shown in Table 1 and the relation between drives and tendencies in Table 2.

Figure 1. Delphi Method.

	Asseveration	Importance			Expertise			Uncertainty				
		HIGH	MEDIUM	LOW	HIGH	MEDIUM	LOW	HAPPENED	2019-2022	2023-2026	2027-2030	NEVER
D1	1. In 2030, Peruvian manufacturing companies will manufacture products with technological added value in response to rapid global technological changes.	7	0	0	4	3	0	0	0	4	3	0
D2	2. In 2030, Peruvian manufacturing companies will engage on both internal and external R&D strategies in the manner of which they will balance them without neglecting one another.	6	1	0	6	1	0	0	1	0	6	0

Source: The Author.

Table 1. Final Drives.

Forces			
Technology	**Social**	**Economical**	**Political**
D1: Technological Intensity in products	D6: Number of Engineers and technicians	D10: Financial resources	D15: international commercial treaties
D2: Ambidexterity in R&D strategy	D7: Graduate employees	D11: Peruvian competitiveness	D16: R&D Government Funds
D3: Balance in innovation Activities	D8: Inter-firm mobility of employees	D12: Foreign Direct Investment (FDI) in Peru	
D4: Technological Importation Intensity	D9: Capacity of Local Suppliers	D13: Market Dynamism	
D5: Technological Change in the sector		D14: Availability of Venture Capital	

Source: The Author.

Table 2. Tendencies and Final Drives.

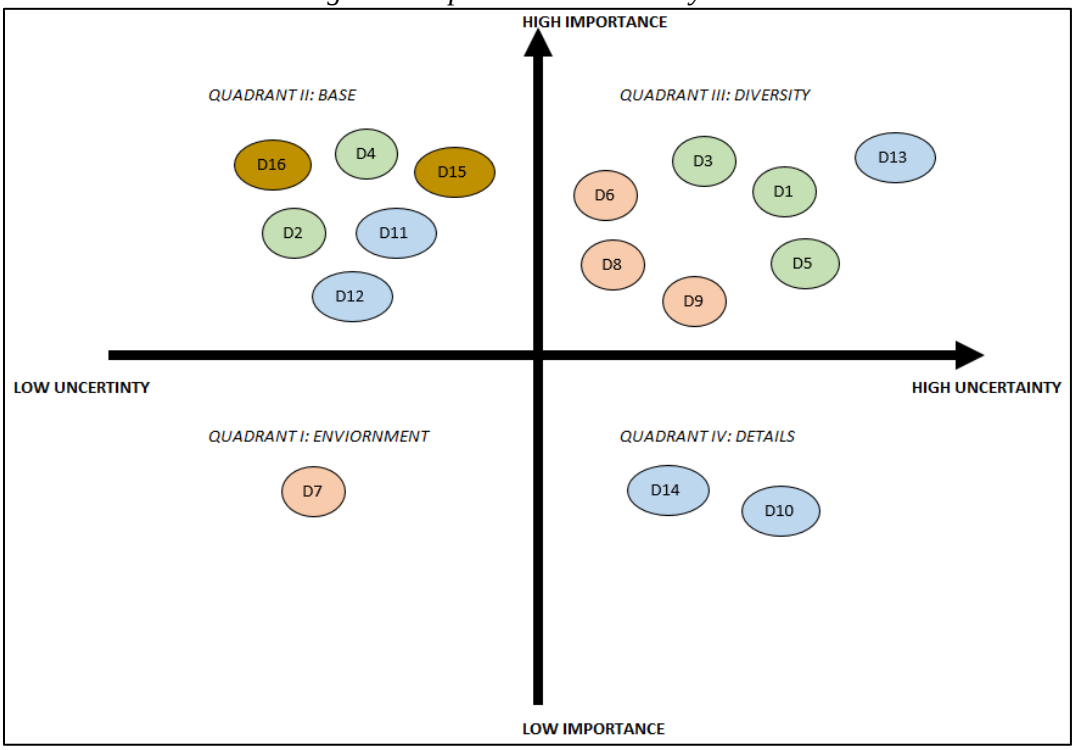
	Tendencies			
Forces	**T1**	**T2**	**T3**	**T4**
Technology	D4	D5	D1 D2	D3
Social		D8	D6 D7	D9
Economical	D11	D13	D10	D12 D14
Political	D15		D16	

Source: The Author.

For the construction of the scenarios, two methods were used: the Schwartz Axes and the Structural Analysis. According to the results obtained from the application of the Delphi Method, the 16 validated drivers were distributed among the four quadrants according to their level of importance and uncertainty (we consider 80% of consensus, meaning that five experts must have the same responses) as represented in Figure 2.

As the present study is exploratory, the next step was to apply the Structural Analysis Method to drivers located in Quadrant III (Diversity). The following criteria were chosen to assess the dependency relationships between drivers: 4 when the relationship was highly dependent, 2 when the relationship was moderately dependent, 1 when the relationship was lowly dependent and zero for non-dependent relationships. Hence, the Structural Analysis was constructed with the 7 drivers of quadrant 3, as detailed in Table 3.

Figure 2. Importance-Uncertainty Axes.



Source: The Author.

Table 3. Structural Analysis for quadrant III-drivers.

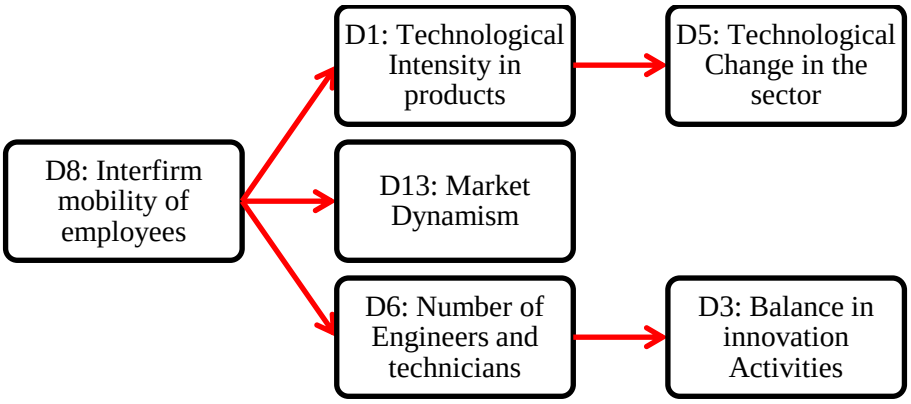
	D1	D3	D5	D6	D8	D9	D13	Influence
D1		0	4	4	1	1	0	10
D3	0		1	2	0	1	1	5
D5	1	1		0	2	2	4	10
D6	4	4	1		0	0	0	9
D8	4	2	2	4		1	4	17
D9	2	2	1	2	0		2	9
D13	2	2	4	0	2	2		12
Dependence	13	11	13	12	5	7	11	72

Source: The Author.

The relationships of the Structural Analysis Matrix determined the existence of three axes of uncertainty, which are drivers strongly linked to each other. These axes can be described as follow:

- Technological innovation axis: composed by drives D8, D1 and D5. Transitioning to technological innovation will permit Peruvian firms to manufacture high value-technological added products and catch-up with more complex technologies and reap a global technological spillover from more advanced countries.
- Dynamism market axis: composed by drives D8 and D13. A Peruvian market characterized by its dynamism may allow Peruvian manufacturing firm to maintain innovative against technological changes and new competitor's entries. This innovativeness would be related with an increase in new products introductions and number of patents.

Figure 3. Axes of uncertainty.



Source: The Author.

- Skilled people in R&D axis: composed by drives D8, D6 and D3. The level of human resources provides the intellectual skills needed for technology development. The possession of essential human resources is important for the internal development of key technologies within developing countries.

After the characterization of the axes of uncertainty, a morphological box of combinations was established (see Table 4). Moreover, using dichotomous criteria, we generated eight total scenarios (23=8). However, scenarios No. 2, 3, 4, 6 and 7 turned out to be not possible because inconsistent.

Table 4. Scenarios generated from the three axis of uncertainty.

Scenario	Technological innovation axis	Dynamism market axis	Skilled people in R&D axis	Analysis
1	**+**	**+**	**+**	**Possible**
2	+	+	-	Not possible
3	+	-	+	Not possible
4	+	-	-	Not possible
5	**-**	**+**	**+**	**Possible**
6	-	+	-	Not possible
7	-	-	+	Not possible
8	**-**	**-**	**-**	**Possible**

Source: The Author.

These tools highlight that scenario No. 1 is the ideal scenario as possible future. This scenario describes that a technological change occur in the Peruvian industry that arise firms to manufacture high value-technological added products. Products that are difficult to maintain profitable due to market dynamism that arises from this technological changes and new competitor entries. For that reason, the presence of skilled people in R&D and their inter-firm mobility (generating firm spillovers) engage firms to invest in both internal and external R&D in a balanced fashion.

Discussion and Conclusion

As far as we aware this is the first time that future of technology sourcing is investigated in the Peruvian Industry. This result has further strengthened our confidence in transitioning to technological innovation, in establishing a more dynamic market and in continuing investments in human capital in R&D. Transitioning to technological innovation will permit Peruvian firms to manufacture high value-technological added products and catch-up with more complex technologies. In addition, a Peruvian market characterized by its dynamism may allow Peruvian manufacturing firm to maintain innovative against technological changes and new competitor's entries. This innovativeness may be related with an increase in new products introductions and number of patents. Finally, Peruvian industry must consider that the future of science and engineering, and Peru's ability to contribute significantly to the solution of global problems, depends on human capital.

These considerations have several implications for the future of technology sourcing. First, if Peruvian manufacturing firms become organizational entities that are in line with the technological state of art, their technology sourcing strategy will be influenced. This is in good agreement with Blonigen and Taylor (2000, p. 68) who argue that firms in high-technology industries may have different sourcing strategies for survival and growth. This diversity of technology sourcing is defined as the extent to which firms decentralize in technology search from a variety of sources (Guo, Li, & Chen, 2016, p. 755). Second, if Peruvian market becomes more dynamic and less stablished, then technology-sourcing strategies will shift away from manufacturing process technology to more technological-base product technology. The current situation of Peruvian technology sourcing strategy is characterized by an excessively rely on external sourcing of machinery (78% percent of the sample firms in the 2015-innovation survey) with minimal attention on internal R&D (3%) and external R&D (2%) (Heredia-Pérez et al., 2018). Then, this procurement of process technology is explained by their focuses on cost and productivity factors in which their products are mainly low technology-intensive and further along in its life cycle. Peruvian industry is seemingly characterized by a dominant design in which product architecture does not significantly vary in futures product introductions (Abernathy & Utterback, 1978). Hence, a more dynamic market may allow Peruvian firms to achieve ambidexterity using both exploration and exploitation strategies to manufacture more technological products. Finally, as mentioned in (Calantone & Stanko, 2007; Cánez, Platts, & Probert, 2000; Cho & Yu, 2000; Haro et al., 2010; Stock & Tatikonda, 2004) industry's participants that has great value in training and high level of knowledge is unlikely to outsource innovation activities. For this reason, capacities in R&D and technical know-how are an important source of heterogeneity that results in competitive advantage (Mahoney & Pandian, 1992).

Our work clearly has some limitations. The most important limitation lies in the fact that respondents were only interviewed to validate the first drivers found in the environmental scanning method. Respondents can validate each step's outcomes across prospective study (Ortega San Martín, 2013). Further studies, which take technology sourcing into account, will need to be undertaken in other developing countries may broaden our understanding of the matter and show the variation of the axes of uncertainty.

To sum up, our work has stressed the importance of technological innovation, market dynamism and skilled people in R&D as relevant axes in the future of technology sourcing in the Peruvian industry until 2030. Creating strategies to pursuit those axis will allow Peruvian manufacturing firms to enrich their menu of technology sources and growth. The diversity of technology sources that Peruvian industry can explore, are the follow:

- Domestic technology transfer.

- Foreign technology transfer.
- Inter-industry R&D spillover.
- Intra-industry foreign direct investment (FDI) spillover.
- Inter-industry FDI spillover.
- Internal development.
- Technology purchasing.
- Technology outsourcing.
- Technology Licensing.
- Technological Joint Venture.
- Technological Alliance.
- Technology Cooperation.
- Merge and Acquisitions.

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