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MAPPING TECHNOLOGICAL INNOVATION: METHODOLOGY AND IMPLEMENTATION

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ABSTRACT

Technological innovation is the underlying driving force of economic development, both in a nation's economy and in an organization's competiveness. The first objective of this paper is to map the innovation space available in the Saudi Arabian Basic Industries Corporation, one of the largest petrochemical companies in the Middle East. The second is to suggest modifications to an innovation mapping tool and apply the modified tool to the same company. First, data were collected over a three-year period. They were analyzed and mapped using the 4Ps innovation mapping model. Second, modifications were suggested to eliminate the weaknesses associated with this model. The results showed that the company introduced a total of forty four innovations that were all incremental; the majority fell in the product and process. The implementation process of the 4Ps model showed that it has deficiencies in some cases, due to not having clear dividing lines between pure and combined innovations. It does not allow for mapping innovations that combine product-with-process or position-with-paradigm innovations; furthermore, radical and incremental innovations cannot always be clearly positioned. A modified model was developed that overcomes these weaknesses. A modified model was developed and successfully implemented to map the innovation space in the same company.

JEL: O32

KEYWORDS: Innovation Management, Innovation Assessment, Innovation Measurement, Mapping Innovation, Modeling Innovation.

INTRODUCTION

Over the past few years, technological innovation management has become one of the most attractive and promising areas of studies. Nieto (2004) confirmed this fact as the number of academics who oriented their research towards this field of study has increased, the number of new scientific journals concentrating on the study of innovation has also increased and every year there is consolidation of different academic associations concentrating on innovation. Governments need to pay attention to innovation, particularly in the developing world, because it is the key driver of economic development and is the key instrument in overcoming major global challenges. In spite of the relatively high expenditure on education in some Arab countries such as Saudi Arabia, whose expenditure on education as a percentage of GDP was 5.6% in 2008 (UIS, 2009), the literature shows that Saudi Arabia lags far behind developed countries in terms of science and technology (S&T): most S&T indicators reveal weak performance (Nour, 2005). Moreover, a UNESCO report (2010) noted that there is weak co-ordination between public and private funding for R&D in the Arab states and there is often insufficient capacity within the R&D system to absorb fresh graduates seeking to work in the research fields, especially female graduates. Funding for research and development in the Arab countries remains far below that of most other regions (UNESCO, 2010). Table 1 demonstrates the expenditure on R&D as a percentage of their GDP in some Arab states and other countries from 2007 to 2009 (The World Bank, 2012). It shows that in 2009 expenditure on R&D

as a percentage of GDP in Saudi Arabia and Egypt was 0.08 and 0.21 respectively, while in Israel and Finland it was 4.27 and 3.96 respectively.

The first objective of this paper is to map innovation space in one of the largest petrochemical companies in Saudi Arabia in order to determine the dominant types of technological innovation produced by the company and to make recommendations for improving innovation. The second objective is to modify and improve a current model for mapping innovation. The paper consists of five parts. The first part examines the literature on the topic of innovation and innovation mapping. The second discusses the case company's background. The third part describes the data and used methodology while the forth part explains the results. And finally, the last part presents the conclusions from the case study *analyses*. This is followed by the references and authors' biography.

Table 1: R&D Expenditure as Percentage of GDP in Selected Countries (The World Bank, 2012)

Country	2007	2008	2009
Egypt, Arab Rep.	0.26	0.27	0.21
Finland	3.47	3.72	3.96
France	2.08	2.12	2.23
Israel	4.80	4.66	4.27
Saudi Arabia	0.05	0.05	0.08
Sweden	3.40	3.70	3.62

This table shows R&D expenditure as percentage of GDP in some selected countries

LITERATURE REVIEW

Innovation: The perceptions of technology and innovation have changed over time. Flichy (2007) summarizes the development of the perception of technology and innovation. Economists were interested in technological progress and its impact on employment. Adam Smith, David Recardo and Karl Marx had different theories about technology and its impact on economics. Lionel Roberts and Frederick von Hayek, on the other hand, excluded technology from the scope of economics. Schumpeter, the "godfather" of innovation, was the first to distinct between invention and innovation. Schumpeter, was one of the first economists to define innovation, he stated that innovation is "the launching of a new product or of new form of organization, the accomplishment of a merger or the opening of new markets" (Schumpeter, 1939, cited in Flichy, 2007). In our modern world, the term "innovation" has gained momentum, and everybody is being told that their businesses need to embrace innovation otherwise; they will not be able to grow and remain viable.

Innovation Classifications: Innovation is classified according to its degree of novelty, continuity, form and many other characteristics. There are different degrees of novelty associated with innovation. Previous studies (Dosi, 1982; Dewar & Dutton, 1986) divided innovation into two categories, radical and incremental. Radical innovation is extremely risky and uncertain, which is why it is harder to explore; it is, however, seen as a source of long term growth. Incremental innovation on the other hand is easier as it is a continual process of making additional improvements. Dosi (1982) and Tushman & Anderson (1986) distinguished between innovations according to whether they affect existing ways of doing things (continuous) or develop new products, services or processes, individually or in combination (discontinuous). Continuous innovations happen in stable routines under clear rules, whereas discontinuous innovations are competence-destroying and very ambiguous. Innovation is also classified according to its form (OECD & Eurostat, 2005; Tidd & Bessant, 2009). Both publications classified innovation into four primary forms. They both named two of the forms as 'product' and 'process' innovations; the other two forms differ, the former categorized them as organizational and marketing, and the latter as position and paradigm.

Mapping Innovation: Mapping is defined as "a graphic pictorial tool to arrange key concepts" (Bradshaw & Lowenstein, 2007). Bailey and Martin (2009) state that visual models help visualize how something functions within the real world by providing some graphic or visual outputs. The literature has several tools with different objectives that are used to map innovation. Some of these tools are used to check the state of innovation across the world such as (McKinsey, 2008; O'RouRke, 2007); some are used to analyze innovation performance, such as the one proposed by Cutter (2012), while others are used to determine the dominant types of innovations presented by organizations, like the tool proposed by Sniukas (2010) and Tidd & Bessant (2009).

Francis & Bessant (2005) introduced an approach to identify innovation types. They suggested a diamond shape model to map innovation space which classifies innovation into four types that all start with a "P" and called them the 4Ps of innovation, these are: Product, Process, Position and Paradigm. Francis and Bessant (2005) tested the framework in five different companies in the pharmaceutical industry and found that it was useful. As the diamond shape model only allowed mapping innovation activities under a steady state of "do what we do, but better", Tidd, Bessant & Pavitt (2005) changed its shape into a circular model to show the degree of novelty of an innovation in addition to the 4Ps classification. The mixture of the degree of novelty with the 4Ps of innovation resulted in a map of innovation space. The area indicated by the circle in Figure 1 is the potential innovation space within which an organization can explore. The model helps organizations identify where they currently have innovations and where they might move in the future. It also helps explore different types of innovation instead of focusing on only one or two types. Another useful way to apply this concept is by comparing maps for different organizations competing in the same market, to determine where they might find innovation opportunities by looking at unexplored spaces. The framework has since been mentioned in several books and studies.

Figure 1: 4Ps Mapping Innovation Model (Tidd & Bessant, 2009)

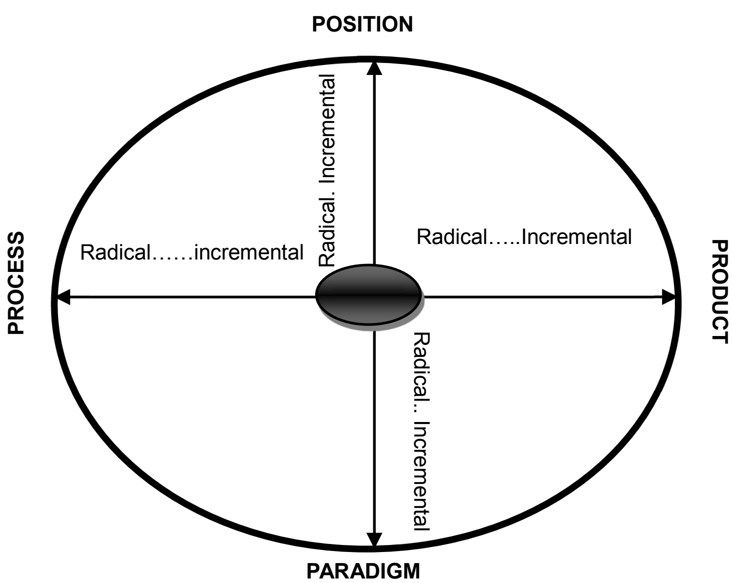


Figure 1 shows the traditional illustration of the potential innovation space within which an organization can explore.

MAPPING INNOVATION IN THE SAUDI ARABIAN BASIC INDUSTRIES CORPORATION

Petrochemical Industry in Saudi Arabia: Petrochemicals are making their impact worldwide as they are an essential part of our everyday lives. There is a wide range of petrochemicals products, such as cables, book covers, rubber, plastic and a multitude of everyday items. Two decades ago, Saudi Arabia appeared an unlikely location for a major industrialization drive (Ramady, 2010). Today the Saudi economy is controlled by two key sectors, oil and petrochemical (AlRajhi Capital, 2010). A report published by the Oxford Business Group (2007) stated that Saudi Arabia is one of the largest petrochemical-producing countries in the world, and that in recent years it has managed an output almost equal to China's. Another report stated that Saudi Arabia is supplying over one hundred countries and accounting for about seven percent of the worldwide supply of basic petrochemical products (SAMBA Financial Group, 2009). An AlRajhi Capital report (2010) declared that, nowadays, the petrochemical industry is a crucial driver in the Saudi market as it accounts for 5% of Saudi GDP and 34% of the value of the stock market.

Saudi Arabian Basic Industries Corporation (SABIC): SABIC is a public company based in Riyadh and was established in September 1976 to produce commodities such as chemicals, polymers and fertilizers for export, in order to create new industries to help Saudi Arabia to diversify and develop. The Saudi Arabian government owns 70% of its shares, and the remaining 30% are held by private investors in Saudi Arabia and other countries of the Gulf Cooperation Council (SABIC, 2011). The company's main manufacturing facilities in Saudi Arabia are located in two industrial cities: Al Jubail on the east coast and Yanbu on the Red Sea coast. According to a report by Oxford Business Group (2007), SABIC is often called the second pillar of the Saudi Arabian economy, after Saudi Aramco. It is now a regular on the Fortune Global 500, Fortune Magazine's list of the 500 largest world corporations by revenue, and ranked 210th in 2011, with revenue equal to around $41 billion (Cable News Network, 2011). A report by SAMBA Financial Group (2009) indicated that SABIC is the largest listed company in the Middle East. Another report stated that SABIC alone represents 21.6% of the market capitalization of the Saudi stock market and 64% of the market value of the petrochemicals sector (AlRajhi Capital, 2010). Today, the company operates in more than 40 countries with more than 33,000 employees across the world. It has ownership rights or licenses to about 3,760 active patents, and 3,394 pending patent applications around the world. In one year it has submitted more than 18 papers for publications or to be presented in conferences (SABIC, 2009). SABIC has received many awards for its innovativeness. One of these was from the European Polycarbonate Sheet Extruders (EPSE), which honored SABIC Innovative Plastics with its 2009 Best Project and Innovation Award for the contribution of SABIC's technology to Dublin's Aviva Stadium.

DATA AND METHODOLOGY

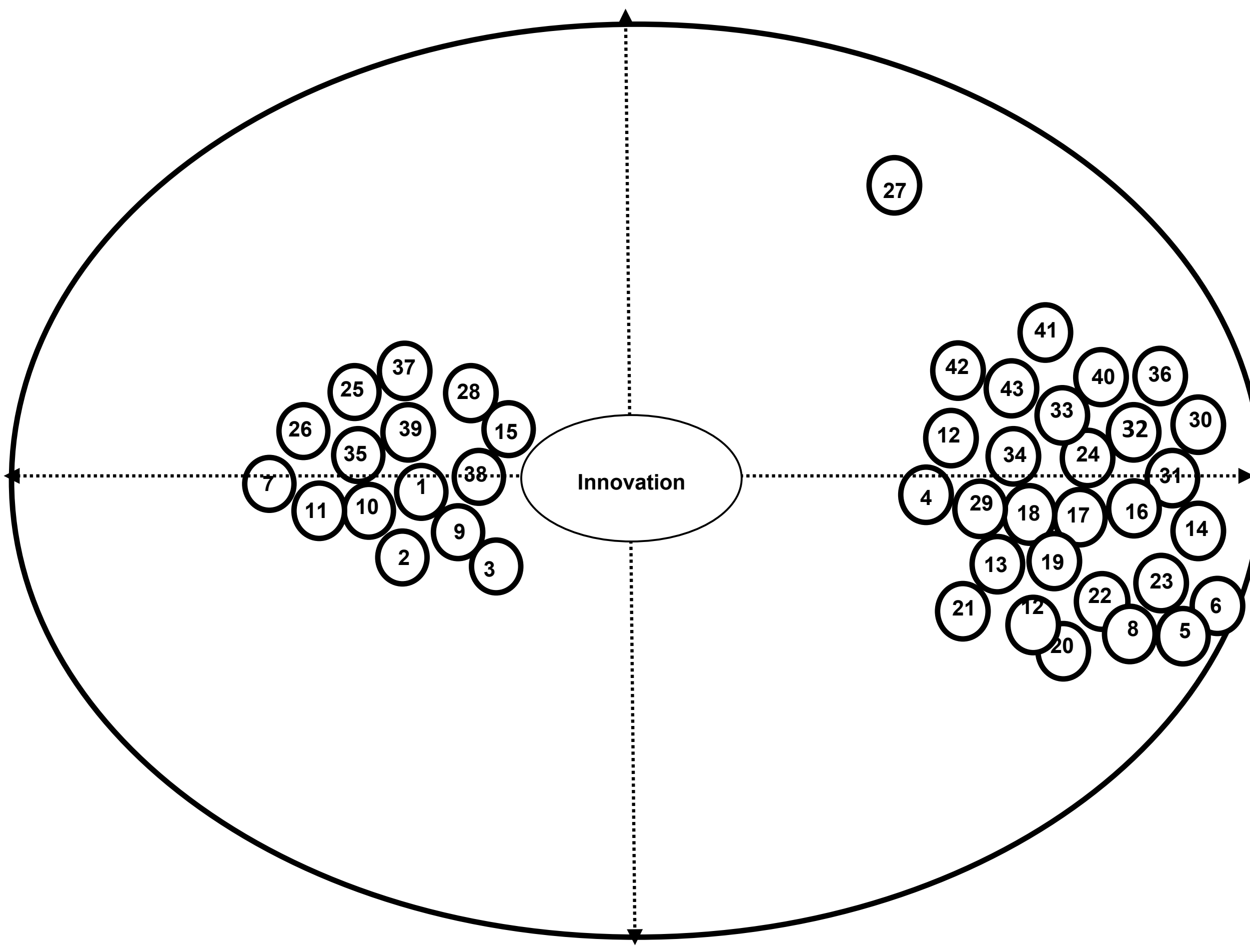
The company consists of six Strategic Business Units (SBUs) organized by products: Chemicals, Performance Chemicals, Polymers, Innovative Plastics, Fertilizer and Metal. The data needed for the mapping model for each of the SBUs for three years, from 2008 to 2010, were gathered from the company's website and from primary sources such as the company's reports and accounts (SABIC, 2008, 2009, 2010 and 2012). The data were then analyzed and categorized into the four forms of innovation for the company and for each SBU. This was done for each of the three years from 2008 to 2010 (AlSanad, 2012).

MAPPING RESULTS

Mapping Overall Company Innovation

The innovations by all the six SBUs, from 2008 until 2010 are mapped in the 4Ps model in Figure 2. The total number of innovations is forty four. The model shows that the company's focal area was in products, with twenty nine out of forty four innovations. Point number (27) is both a product and a position innovation, which is why it was positioned in the area between them. Likewise, point 7 is both a process and a product innovation, but it was positioned in the process area because the model does not have an area that combines these two types. It is clear from Figure 2 that all the innovations made by the company are incremental, which indicates that the company lacks the necessary capabilities to undertake radical and revolutionary innovations that are risky, yet can change the rules of the game and are a source for long term growth. The trend of the company's innovations was also investigated. The results showed that the number of innovations increased by 100% from 2008 to 2009, and by only 25% from 2009 to 2010. The breakdown of all innovations was analyzed. The results indicated that the strength of the company lies in product and process innovations, as 64% of its innovations are in the product area, 32% in the process area, 2% fall in the area between product and process, and the remaining 2% are a combination of product and position innovations. There are, however, weaknesses in the position and paradigm innovation, as none of the innovations fell into these areas.

Figure 2: Mapping SABIC Innovation (2008 to 2010)



This figure shows the mapping of the innovations by all the six SBUs, from 2008 until 2010 in the original 4Ps model.

<u>Mapping Innovations of the Company's SBUs</u>

The innovations by each of the company's six SBUs were analyzed and mapped. The results showed that most of the innovations were produced by the two units which specialize in plastics, Polymers and Innovative Plastic. These two SBUs each produced around 36% of the company's total innovations. Product innovations dominated, followed by process. The Chemicals Unit ranked third in producing innovations, with a total of five during the three years; 80% of its innovations fell in the process area, and 20% fell in the area between product and position. The Metals Unit came slightly behind the Chemicals Unit, producing only three innovations that all fell in the product area. The Performance Chemicals and Fertilizers Units produced the least number of innovations, with only four in the three years. The innovations of the Performance Chemicals were in the process area, whereas the Fertilizers produced one in product and the other in process innovation. The innovation trend was assessed for each SBU in each of the three years from 2008 to 2010. The results showed a steady increase in the performance of both the Chemicals and Polymers Units. The Innovative Plastic Unit ranked best among the six units in the first two years in terms of the number of innovations produced. However, the number of its innovations decreased in the following year. The Metals Unit performance was stable during the three years, as it presented one innovation each year. The SBUs with the weakest performance were the Performance Chemicals and Fertilizers, as they only produced two innovations each during the three years. The Performance Chemicals contributed to the company's innovation portfolio with one innovation in 2009 and another in 2010, while the Fertilizers presented two in 2008 and none in 2009 and 2010.

SUGGESTED MODEL FOR MAPPING INNOVATION

The original 4Ps model has some weaknesses that were revealed in the process of the mapping explained above. For example, with reference to Figure 1, the innovation presented as point number 7 is both a process and a product innovation, but it was positioned in the process area because there is no location for these types of innovation and the model does not have an area that combines these two types. Likewise, point 27 is both a product and a position innovation, so it was placed between them since there is no defined location for these types of innovation on the model. The modified model is used to map the innovation of SABIC using the same data collected during the three years 2008-2010. A square-shaped model was designed using Excel. It is divided into ten areas and called 10Ps. It has four pure types of innovation: Product, Process, Position and Paradigm. In addition, six clearly defined areas were created, each representing a combination of two types of innovation: Product-Process, Product-Position, Product-Paradigm, Process-Position, Process-Paradigm and Position-Paradigm. Figure 3 illustrates the 10Ps areas of innovation.

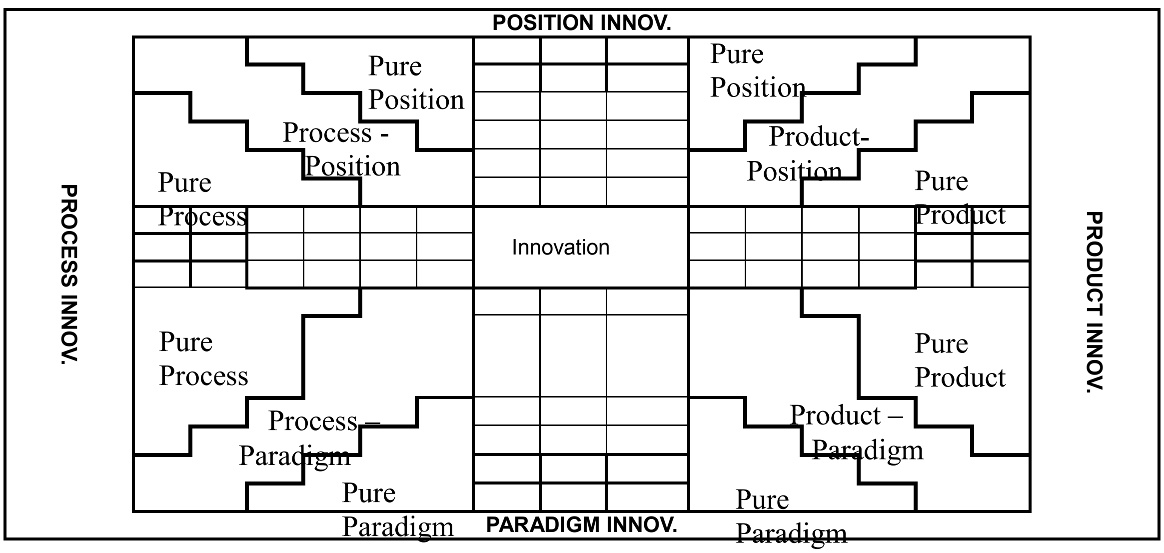
The 10Ps modified model overcomes the shortcomings of the original one by having the following three features. First, it is easy to apply, as it is used through a simple computer program that asks users to enter the innovation, its number and type into a table and then automatically places them in their matching spaces on the model. Second, the 10Ps model allows mapping a combination of Product-Process innovations and Position-Paradigm innovations. The 4Ps does not enable the user to map Product-Process or Position-Paradigm innovations. The 4Ps model does not have an area that combines these two types while the 10Ps model does. Third, in the modified 10Ps model, it is easy to distinguish the degree of novelty of an innovation by looking at its background color instead of looking at the axis. If the color is black it is radical, otherwise it is incremental. Note that the confusion regarding the degree of novelty that might arise in some cases when using the 4Ps model is overcome.

CONCLUSIONS

An innovation mapping model, known as the 4Ps, was used to map innovation in one of the largest Saudi petrochemical companies (SABIC). The implementation process of the 4Ps model showed that it has deficiencies in some cases, due to not having clear dividing lines between pure and combined innovations. It is weakened by the fact that it does not allow for mapping innovations that are combined product-with-process or position-with-paradigm innovations; furthermore, radical and incremental innovations cannot always be clearly positioned. A modified model was developed that overcomes these weaknesses and makes the implementation easier with the help of a computer program. The modified model was tested and used to map the innovation space in the same company. It succeeded in eliminating the confusion caused by the deficiencies of the original model. It is concluded that the modified mapping tool is valid, successful and useful.

The results showed that the company produced a total of forty four innovations, mainly in the areas of product and process, with 60% and 35% of total innovations respectively. However, the company has neglected position and paradigm innovations. Furthermore, all innovations fall in the incremental area with none in the radical. A major increase in the number innovations occurred in 2009, as total innovations increased by 100% of what they were in 2008. However, the number decreased by 25% in 2010 compared to 2009. Mapping of innovations was also done for each of the Company's six SBU's. The results revealed that the most innovative SBUs were the Polymers and Innovative Plastic. Together they contributed over 70% of total innovations. The Chemicals and Metals units participated with 11% and 6.82% of total innovations respectively. The Performance Chemicals and Fertilizers units produced together less than 10% of the total innovations. Product innovations were dominant as they accounted for 63%, 82% and 100% of the Polymers, Innovative Plastic and Metals SBUs' innovations respectively. The Chemicals and Performance Chemicals SBUs focused on process innovation, which accounted for 80% and 100% of their total innovations respectively.

Figure 3: The Modified 10Ps Mapping Model



This figure illustrates the modified model (!)P) with ten areas of innovations.

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