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Strategies for Innovation in the Saudi Glass Industry

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Abstract: **Innovation strategies in the Saudi glass industry were investigated in terms of its resource structure and the outcome of business performance results. Data gathered by conducting a survey over the four-and-a-half-year period 2016 to 2019 was subjected to factor and multiple regression analysis. Based on identifying how glass companies have implemented innovation for their products, services, processes, in the form of reducing costs and eco-innovation, and resources they dedicate to being innovative, the findings indicate their strategies are chiefly imitative and defensive. Although not all glass companies in Saudi Arabia were included, the sample is representative, and has practical implications for Saudi glass companies to redefine their innovation strategies. More favourable outcomes can be achieved by managing resources more effectively for generating and implementing innovative strategies. This study contributes by presenting an exploratory model in which two important factors are identified for an effective innovation strategy suitable for the Saudi glass industry.**

Keywords: **Saudi glass industry, business performance, innovation, innovation strategy.**

1. INTRODUCTION

Saudi context

The Saudi Arabian glass industry has undergone several socio-economic and industrial changes over the past few decades. Despite facing fierce competition from international glass companies since the joining the WTO, the Saudi glass industry has managed to sustain growth, as is reflected in its exports (Reda & Kanan, 2018). It is a very important sector for Saudi Arabia. The demand for glass, especially energy efficient glass, is expected to increase at a CAGR of 16.1% over the period 2019 to 2025, and the market is expected to increase from US$67,115 thousand in 2019 to a forecasted level of US$167,769.7 thousand in 2025 (Business Wire, 2019).

The glass industry

By not operating in a competitive environment, compared to other competitive industries such as telecommunications, and inadequate preparation, the focus of many such companies has been on increasing productivity (Laliberty & Christopher, 1984), modernising facilities (Finch, 2011), and improving their resource management processes, including HRM (D'Annunzio-Green et al., 2004). Investment in R&D in this industry has been generally lacking within the industry itself, and largely confined to research institutions and government bodies (Abbade & Dewes, 2014). The consequence of this situation is that the industry is very heterogeneous. Companies in the Saudi glass industry differ with respect to structure and administration despite the commonality of engaging in modernisation and attention to improving productivity and processes.

Most empirical studies conducted previously on the glass industry have been case studies (Miegeville, 2005; Hashemi et al., 2011; Segonds et al., 2016). Other empirical studies have focused mostly on technology (Coupland & Williams, 2005; Smirnov et al., 2011), particularly concern for energy efficiency and savings (Worrell, 2008; Frassine et al. (2016), and on applications of glass (Burrows & Fthenakis, 2015). Studies specifically on innovation are design related, rather than on innovation strategies for improving productivity, performance or processes. For example, Kahn (2014) examined the

Herodian innovation in the industry, and Uusitalo & Mikkola (2010) revisited the industrial revolution arising from the use of float glass through the design envelope.

There is a gap in studies on innovation strategies in glass industries, including specifically the Saudi glass industry. Addressing this gap would require analysing performance results of companies in this industry at the firm level to make a broad assessment of innovation at the enterprise level within this sector, and thereby identify likely differences in resources, outcomes and innovation strategies of glass firms. Understanding innovation strategies is important for examining the effects of innovation on performance. This can help to bring about improvements in institutional and public policies with respect to managerial knowledge and technological development (Spetic et al., 2012).

In view of this need, the objective of this study is to analyse innovation strategies of Saudi glass companies using primary sources of information on resources, outcomes and efforts at innovation directed at improving productivity and processes at the firm level. The aim is to devise an exploratory model in which the innovation strategies are linked to outcomes to enable examining innovation as a process.

2. LITERATURE REVIEW

Theoretical underpinning

As pointed out by Santos et al. (2014), innovation is recognised as an important feature of capitalism in economic theory, and Schumpeter (1927) formalised this understanding of how innovation takes place that is a basis for the theory of innovation (Lundvall, 2010: 323). According to Shumpeter, innovation refers to changes in methods of production and transportation, industrial organisation, production of new products, creation of new markets, and new supply sources. As per this theory of innovation, economic development is driven by innovations which emerge discontinuously that become more viable economically relative to the previous situation (Triguero et al., 2018).

Innovation may also be defined as a creation or improvement to products, processes and management systems, or to developing new ways of selling existing or new products or services. Innovation can influence productivity, performance, processes and other outcomes positively and significantly, and there is empirical evidence that supports this relationship (Atalay et al., 2013; Maldonado-Guzman et al., 2019). In the context of competitive business environments, implementing innovation strategies to gain competitive advantages is important can also be vital for survival and continuation (Yusuf & Trondsen, 2014).

The innovations may be related to products, services and processes, including management processes, as mentioned before, and also to marketing practices and organisational innovations (Maldonado-Guzman et al., 2019). Product innovation refers to the development and use of new components, resources or technologies (Prajaogo, 2016); process innovation to adding a new process of production, and marketing innovation to implementing new methods involving changes in the design, packaging, promotion or pricing of products and services (Chen & Tsou, 2012). Additionally, organisational innovation refers to changes in organisation-wide practices that lead to changes in products, services or processes, and to enhanced competitiveness.

It has been shown that product, process and organisational innovation have positive performance impacts in terms of finance, customers, internal business processes, learning and growth (Karabulut, 2015). According to the results of a survey in the Turkish automotive supplier industry, it is product and process innovation, referred to collectively as technological innovation, that has more significant and positive impact on firm performance whereas the same was not found for organisational and marketing innovation (Atalay et al., 2013). The improvements to products and services result in continuous advances that help firms to survive, grow more quickly, be more efficient, and to ultimately be more profitable than if they are not innovating.

R&D plays an important role in making innovation successful. Successful innovation is determined by factors such as conducting basic research; identifying potential measures to take and markets to engage in; education and training; good communication with customers and other researchers; having a strong entrepreneurial spirit for production; being quicker than competitors; marketing and coordinating R&D; sufficient R&D in terms of amount or finance; strong investment in it, and having patents to protect innovations and for negotiation with competitors (Freeman & Soete, 1997).

The results of innovation efforts need to be evaluated due to the complication of relating investment for innovation with business performance, and this is especially the case in emerging countries (Santos et al., 2014). A survey conducted on Saudi enterprises during 2019 revealed 61% of a sample of 362 Saudi enterprises indicated the need for more innovative business practices to make strategic plans more effective (Alotaibi, 2020).

Innovation strategies

Companies devise and implement innovation strategies in order to make improvements in their pursuit of gaining competitive advantages (Bowonder et al., 2010). Previous studies on innovation strategies have presented or proposed different strategies for innovation (Morgan & Berthon, 2008; Fauchart & Keilbach, 2009). This resource of literature on innovation strategies allows to categorise organisational behaviours and extending the analysis in this study to compare with other contexts.

The present study is delimited to innovation strategies with respect to company behaviour based on their resource management. However, the use of other approaches in a complementary manner for the purpose of analysis is also included to support the discussion of the results, as in the study of Morgan & Berthon (2008). Innovation strategies need to be described first, which may be classified on the basis of whether they are offensive, defensive, traditional, imitative, dependent and opportunistic.

If the innovation strategy is offensive, the company typically seeks to gain competitive advantage over other companies in the industry through innovation, such as producing innovative products and services so that the company's own product or service stands out from the offering of its competitors. This competitive edge may be gained especially through R&D and investing in science and technology, as these measures can help to quickly develop or advance scientific and technical knowledge, something that would not be possible to obtain externally (Fey & Birkinshaw, 2005; Bischi & Lamantia, 2015). This ability to utilise knowledge to make achievements and maintain competitive advantage is especially important for organisations with global amibitions (Massa & Testa, 2009).

Under the defensive strategy, companies wait to see what mistakes their competitors make in order to find ways of taking advantage of this information to gain an edge (Bowonder et al., 2010). The investment in R&D in a defensive strategy is usually similar to that in an offensive strategy, but the company seeking to gain competitive advantage learns from competitors' mistakes.

The traditional innovation strategy is not characterised by changes in products and services if there is no demand for making them or the competition does not compel the company to make them. This strategy however, makes companies vulnerable to any external changes introduced by other companies, as they would inevitably become excluded if they are not capable of innovating (Freeman & Soete, 1997).

As the name suggests, the imitative strategy describes the imitational practices of companies in terms of technological gaps, pioneers, technical service, and training. However, these are typically much less than found in innovative companies. It is important for imitators to have the capacity to imitate by gaining their own scientific and technical information, and also sufficiently developed production engineering and design capability. Without this, it would not be possible for them to imitate the products and services, or processes of the other companies (Bowonder et al., 2010 4).

The dependent strategy differs in that there is no attempt at imitation of the technical aspects of product or service changes unless requested by customers. Usually, only larger or influential customers are able to make the company advance its technology this way, and such companies rely on R&D investments instead of owning R&D facilities and patents. Their innovation is thus dependent on external sources, hence the name (Mattes et al., 2014). As shown by Mattes et al., companies can still compete innovatively even with little R&D to avoid incurring high costs through such cooperation.

The opportunistic innovation strategy, also known as niche strategy, seeks to identify products and services needed by consumers which are not yet being supplied. This opportunity is availed whilst maintaining control of ongoing operations, and its success relies on controlling costs and the marketing innovations (Bowonder et al., 2010). This type of behaviour is usually also evident in open innovation strategies where new technology-based companies develop from spinoff companies in line with research developed internally that is supportive of development outside the firm based on budget, culture, strategy and other internal processes.

Innovation in glass industries

Innovation in glass industries around the world have been taking place in terms of both products and processes. For example, there are more energy efficient grinding technologies available (Worrell, 2008), other energy saving options for furnaces used in the glass industry (Frassine et al., 2016), and stirrer technology for creating uniform, homogeneous glass (Coupland & Williams, 2005). R&D is also ongoing globally geared to transforming to low-carbon economies (Wintour, 2015).

Internal innovative capacity is held by both private and public research organisations, but companies tend to find it difficult to develop this capacity due to their narrow focus on dealing with short-term problems. Many findings are made, for example, in the agricultural industry, but are not followed through by other companies (Salles-Filho et al., 2017). The connection between researchers has been improved by research organisations participating in multistakeholder platforms with respect to their roles as innovators, and this has led to contributions in terms of improved focus in research and enhanced production, which present opportunities and challenges known by value-chain actors (Devaux et al., 2018). This kind of cooperation between companies and research organisations is an effective means for accessing new markets and segments through innovation (Najib & Kiminami, 2011).

3. METHOD

Evaluation of innovation

The present study adopted a quantitative approach for collecting data by means of a questionnaire adapted from PINTEC by including only those items relevant to gaining information about innovation and innovation capacity. The PINTEC is an innovation survey devised by the Brazilian Institute of Geography and Statistics for comparing innovation activity results of national companies with data from other countries (Al-Hakim et al., 2016). This validates the instrument for use in this study.

The questionnaire was made available to participants by converting it to digital form on an online survey site.[1] Participants were invited by emailing glass companies throughout the Kingdom. The email was responded to by 74 glass companies of which 46 completed the online survey, giving a response rate of 62%. These questionnaires were completed during the months of February to April 2020. The questions included objective response and closed-ended types on a 5-point Likert scale, and the items were accompanied by descriptions.

Further evaluation of innovation strategies was made based on data gathered from another survey conducted over a longer 3.5-year period between July 2016 and December 2019. This instrument is shown in the table below. The first 8 items were on the importance attached to innovative activities, and the remainder 15 items were on the importance attached to various impacts of innovation.

Applied methodology

Besides giving a descriptive statistical profile of positions, dispersions and associations to identify important sectoral attributes, both sets of survey data were subjected to factor and multiple regression analysis in order to group the variables into categories to express the strategic characteristics of innovation. The factor analysis helped ascertain whether the innovation efforts converge to innovation capacities, or they are disassociated. The variables in the factor analysis are used to measure the various impacts of innovation.

The latent variables from this factor analysis were then used as variables in the regression analysis given that the ability to innovate is a resource that aggregates multiple innovation efforts which manifests in different ways. The regression analysis allowed for analysing the influence of the innovation efforts on the companies' earned profits in order to draw conclusions for the Saudi glass industry. The effects of the investments on innovation capacity were analysed using regression for each factor of innovation impact. Validity tests (autocorrelation, f-test, t-test, r2, KMO, Bartlett's coefficient) were then conducted for the factor and regression analyses. According to Denicolai et al. (2018), this typology allows us to establish different degrees of innovation, which enables for classifying the companies, and it supports the analysis of interrelationships companies have with both sectorial and national innovation systems, as is relevant for this research (Marin et al., 2015).

1 www.kwiksurveys.com

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4. RESULTS

Treatment of data

Descriptive analysis of the data is presented in Table 1 below for both innovative activities and the impact of innovations. The number of responses was 46, and the minimum and maximum are the lowest and highest importances attached to the variables mentioned, which are 1.0 and 5.0 respectively. The mean and standard deviation for each item is stated to 3 decimal places.

Table 1: Descriptive analysis of questionnaire items

Variable	n=46, min=1.0, max=5.0	
	Mean	SD
Importance attached to innovative activities		
Acquisition of equipment and machinery	4.351	0.878
Other preparations for production and distribution	4.120	1.065
Training	3.995	1.166
Introduction of technological innovations	3.876	1.182
Acquisition of external R&D	3.646	0.935
R&D based activity	3.628	1.227
Acquisition of software	3.509	1.181
Acquisition of external knowledge	3.487	1.086
Importance attached to impacts of innovation		
Production or service capacity increased	4.064	1.063
Quality of products/services improved	3.932	1.114
Energy consumption reduced	3.847	1.068
Costs of production/services rendered reduced	3.838	0.876
Company allowed to control aspects of health/safety	3.771	1.155
Range of products/services offered expanded	3.646	1.274
Company allowed to reduce environmental impact	3.527	1.136
Flexibility in service production/rendering increased	3.508	1.204
Company allowed to maintain its market share	3.442	0.667
Labour costs reduced	3.219	0.915
Raw material consumption reduced	3.207	1.092
Water consumption reduced	3.058	1.318
Compliance with rules/regulations of domestic/foreign market	2.957	1.242
Company's market share expanded	2.836	1.077
Company allowed to open new markets	2.864	1.183

It can be seen from Table 1 that the most important innovative activity is the acquisition of equipment and machinery with a mean score of 4.351 and SD of 0.878. Of next importance are other production and distribution related preparations (4.120, SD 1.065) and training (3.995, SD 1.166). The lowest of the mean values for all eight innovative activities is 3.487 (SD 1.086) for acquisition of external knowledge. Notably, the standard deviations being lower than the mean values suggest managers' perceptions converge to the mean.

The second part of the table, which presents descriptive analysis of impacts of innovation, shows the most important item is increase in production or service capacity with a mean of 4.064 (SD 1.063). Next in importance are improvement in the quality of products and services (3.932, SD 1.114) and reduced energy consumption (3.847, SD 1.068), and the lowest mean value (2.864, SD 1.183) is for the allowing the company to open new markets. As is the case for innovative activities, all the standard deviation values are lower than the mean values, which again suggests convergence to the mean for managers' perceptions.

Another important observation apparent from the above data is the lower priority on items relating to business model expansion. For instance, the two items directly related to R&D as innovative activities, namely external R&D acquisition and R&D based activity, have a close mean value of approximately 3.6, which is at least 0.5 less than two highest items with mean values above 4. Importantly, this suggests the overall strategic position of the Saudi glass companies is

traditional and defensive rather than innovative, as may be expected and is the case, for instance, in the Saudi telecommunication industry in which organisations are flexible, adaptive and foresightful (Alotaibi, 2019). The overall strategy of the industry may also be described as imitative given that the companies are dependent on the innovations made by their technology vendors rather than being their own initiatives.

In Table 2, results are presented for the factor analysis conducted on the data pertaining to innovative activities. In presenting this data, variables related to innovative activities are divided into two factors: the first comprises six variables considered to be directly related to innovative activities since they converge to a single capacity for innovation, and the second comprises the items on introduction of technological innovations, and training efforts. Factors loads less than 0.4 were excluded from the analysis. Both items of the second factor are high in the list of innovative activities, being in the third and fourth positions in terms of importance. This indicates the attention given by management on their employees, and in introducing new technologies in the industry are both high, which is encouraging for valuing human resources and technological capital.

Table 2: Rotated component matrices for innovative activities and impact of innovation

Variable	**n=46**		
	Factor 1	**Factor 2**	**Factor 3**
Importance attached to innovative activities	**capacity to innovate**	**introduction of innovation**	**-**
Acquisition of external knowledge	0.829		
R&D based activity	0.805		
Acquisition of external R&D	0.786	0.425	
Other preparations for production and distribution	0.773	0.541	
Acquisition of software	0.724		
Acquisition of equipment and machinery	0.691	0.535	
Training		0.886	
Introduction of technological innovations		0.834	
Importance attached to impacts of innovation	**Process and product**	**Component Eco-innovation**	**Labour costs**
Production or service capacity increased	0.851		
Flexibility in service production/rendering increased	0.814		
Company allowed to maintain its market share	0.788		0.436
Company allowed to open new markets	0.765		
Company's market share expanded	0.733		0.425
Quality of products/services improved	0.707		
Raw material consumption reduced		0.835	
Water consumption reduced		0.817	
Compliance with rules/regulations of domestic/foreign market		0.776	
Energy consumption reduced		0.734	
Costs of production/services rendered reduced		0.681	
Labour costs reduced			0.826
Company allowed to control aspects of health/safety		0.618	0.748
Range of products/services offered expanded			0.647
Company allowed to reduce environmental impact			0.552

It may be noted from the factor analysis in Table 2 above that the sampling arranged in this study was adequate given that the KMO value is greater than 0.75; the null hypothesis of poor specification was rejected by the Bartlett's test, and the two factors explained the variance of 76.32% of the two factors out of the total variance. The factor analysis for impacts of innovation involving 15 variables measured this impact. The three factors, namely process and product (1), component eco-innovation (2) and labour costs (3), account for more than three-quarters of the total variation. Many of the traditional variables associated with innovation are gathered by the first factor. The result of the KMO test is considered as 'good', and the null hypothesis of the specification being poor is rejected as per Bartlett's test.

It is also encouraging from the factor analysis relating to importance attached to impacts of innovation that there is an effort underway and attention is being given to process innovation, and making gains in terms of efficiency and productivity. This is evident from the increase in production or service capacity having the highest importance (0.851). In comparison, product innovation, such as improvement in the quality of products and services, is also given importance but to a lesser extent.

Considering the second factor of eco-innovation, sustainability is prioritised by the Saudi glass companies as well. The values for consumption of raw material, water and energy, and other related items range between 0.618 and 0.835, which shows their importance. The reduced consumption of the three aforementioned items confirms the attention to improving efficiency in the industry, and compliance with rules, and control of health and safety aspects, shows the government's role in environmental regulation is also positively affecting the industry.

The third factor of labour costs concerns the item of reduced labour costs the most, as may be expected, with a value of 0.826. Additionally, it is associated with health and safety aspects (0.748), and range of products and services offered (0.647) the most, and to a lesser extent three other items, as shown in the table. Labour costs constitute an important component of the total costs incurred by glass companies. Innovation to reduce these costs without compromising with return on investments can allow for improved benefits and working conditions (Santos et al., 2015).

It should be noted that the traditional, defensive and imitative nature of the strategies of the glass companies indicated by the data gathered does not necessarily mean the companies are passive towards innovating. The companies need to have a framework in place to support the innovation and facilitate their introduction and implementation, which are active measures. Regardless, the defensive strategy is itself a competitive positioning indicative of process innovation through investment, and its impact is evident from the data in terms of products and processes, efficiency and sustainability. The product innovations, being limited relative to process innovations, could mean that the range of glass-based products has not diversified substantially, or that there are not many alternatives to using glass. The latter is not the case, since metal, plastic and other alternatives are available.

Regression analysis was conducted to understand the two factors pertaining to innovation efforts in the three aggregated results. The results of the three sets of analyses for the empirical model are presented in Table 3, which considers the impact of the products and processes as a dependent variable, along with key test statistics for all three in Table 4. The overall coefficient for R^2 is low at 0.315, and the null hypothesis of the model specification being bad can be rejected since the F-statistic and model do not present autocorrelation as per the Durbin-Watson statistic. Furthermore, the low R^2 value indicates difficulty in analysing innovation and investment impacts on performance.

Table 3: Regression model results for product/process factor as dependent variable

Model/Variables	Standardised Coefficients	SE	t-statistic	Sig.	95% confidence interval	
					Lower limit	Upper limit
Product and process factor						
Constant	0.000	0.158	0.033	1.021	-0.326	0.318
Innovation capacity	0.586	0.161	2.964	0.005	0.214	0.925
Innovation introduction	0.214	0.160	0.935	0.417	-0.093	0.534
Eco-innovation factor						
Constant	0.000	0.173	0.000	1.000	-0.338	0.347
Innovation capacity	0.408	0.171	1.941	0.078	-0.204	0.477
Innovation introduction	0.314	0.172	1.676	0.128	0.134	0.813
Labour costs factor						
Constant	0.000	0.167	0.000	0.998	-0.386	0.427
Innovation capacity	0.152	0.159	0.791	0.411	-0.206	0.376
Innovation introduction	0.434	0.160	1.968	0.031	0.094	0.814

Table 4: Test statistics in the regression model

Statistic	Factor as dependent variable		
	Product and process	Eco-innovation	Labour costs
R^2	0.315	0.204	0.272
Adjusted R^2	0.279	0.145	0.182
F-statistic	5.089	3.324	4.263
p-value F-statistic	0.057	0.068	0.034
Durbin-Watson	1.892	2.149	1.699

The results of the regression analysis show that although innovation capacity investments are important for generating product and process innovations, the variables comprising innovation capacity must be aggregated, as they cannot be treated in isolation from each other. Planning related to innovation investments should therefore be treated by companies as part of their strategy to help them develop the required actions together.

In analysing the dependent variable of input costs in terms of their impact on innovation, the factor of capacity to innovate was found to be important for eco-innovation. This indicates the need for innovation efforts in the glass industry to improve conditions or devise new solutions due to their potential social and environmental consequences (Haner, 2005). In analysing labour costs for their impact on innovation, the same capacity to innovate was found not to be significant in explaining the reduced labour costs, but the introduction of the technological innovation involving training is significant regardless. The coefficient of this factor is positive, which suggests the value of conducting an integrated analysis of innovation strategy in order to prioritise innovative activity effects as a function of expected investments.

5. DISCUSSION

For acquiring equipment and machinery, this study showed the importance of making investments, confirming the same by Santos et al. (2015), and highlighting the need for the Saudi glass industry to continue modernising and automating its capital. Furthermore, the need for investing in R&D should not be underestimated by the Saudi companies in this industry given their low attention in this regard. The difficulty seems to be attributable to the integrated structures of large companies whereby they become dependent on international market leaders, since it is they who are more likely to be early adopters of process innovations (McElheran, 2015).

The results also show the focus of the innovation efforts are mostly on socio-environmental needs and regulatory requirements. The efforts to improve the quality of products, reduce costs, and for the companies to maintain their market shares indicates the Saudi glass companies have adopted a traditional, defensive and imitative strategy for innovation. As per the classification of Levins & Cochrane (1996), these companies may be described as ‘followers’ or ‘laggards’, and they are typical of a cost-based strategy (Leaptrott et al., 2015). Cost management is therefore relevant for this industry because of the potential to significantly streamline production processes, and thereby save resources and increase investment and margins (Ogden, 2010). The study of Reda & Kanan (2018) on the Saudi glass industry reached the same conclusion of a need to reduce costs through reducing waste to increase productivity, as well as training, which according to the results of the present study is already being given high priority.

The lack of attention to the business model is not unusual when dealing with short-terms issues has priority over developing innovation capacity internally (Salles-Filho et al., 2017). Innovation related investments seem not to be compatible with overcoming challenges. The results in this study showed convergence to one innovation capacity, as opposed to exhibiting a structure based on capital. This convergence to a single factor integrates internal and external knowledge to reflect technological demands which tend to be complex.

The responses of the Saudi glass companies on the importance they attach to various innovation efforts suggest that beside being defensive and imitative, as found in this study for these companies, innovation may alternatively be described as an exploitation (Fauchart & Keilbach, 2009), which would be to take more. Irrespectively of the label, the

study has shown the importance of innovation efforts and how they are implemented in the industry given the prominence of regarding innovation as a process. Investment, particularly in equipment and machinery was found to be important, as is investment in innovation capacity with respect to input costs.

However, these investments in innovation are insufficient as far as creating leadership in the sector globally is concerned, and for dealing with the challenges facing the industry. The Saudi glass sector is not immune from the uncertainty and turbulence in the Saudi economy, especially whilst there is a major economic transformation underway, particularly to reduce dependency on oil and to diversify it (Alotaibi, 2019).

6. CONCLUSION

This study focused on innovation in the Saudi glass industry analysed the innovation strategies of 46 glass companies located in Saudi Arabia over a four-and-a-half-year period from 2016 to 2019. A review of the literature showed that investment in innovation in this sector is incompatible with challenges it faces, and that the sector is having to cope with being both conservative and competitive at the same time. Although various private and public organisations in the kingdom have developed innovative capacities through R&D, the glass companies overall are not active participants in these innovation processes.

The results from the empirical data obtained from the glass companies show the strategies in the glass sector to be rather defensive and imitative, as per the scheme of Freeman & Soete (1997). This is in contrast with an exploitation strategy, as described by Fauchart & Keilbach (2009), or rather, a more offensive strategy given that the activities of the glass companies do not engage so much in R&D and introducing innovations, which are given relatively less importance but could potentially bring about more technological paradigm transformations. Furthermore, the innovation efforts only led to incremental improvements in efficiency with respect to products, processes and socio-economic costs. This distinction of the nature of the innovation strategy between passive and active reflects the efforts to innovate being initiated internally or externally.

In the case of the Saudi glass companies, most of the innovation efforts are directed at acquiring equipment and machinery followed by other preparations for production and distribution, by training employees, and to a lesser extent introduction of technological innovations. The priority given to production is corroborated by the study of Reda & Kanan (2018) who found evidence of quality tools being adopted in the industry to exploit more advanced measures of quality, and an enthusiasm for gaining international quality awards. Their passive strategies are in alignment with their competitive positioning according to their needs for innovating in terms of processes and their cost leadership. This was evident from the focus of the innovation on processes over products, and to efficiency and sustainability.

An implication stemming from the findings of the study is that a sound structure of innovation efforts, both internal and external, are necessary for planning innovation strategies, as this enables innovation efforts to drive the results of the innovation. Based on the findings of this study, it would be advisable for the Saudi glass companies to apply more R&D from the fields of science and technology with a focus on creating more new viable glass-based products. This could lead them to enter new markets, and importantly, to migrate toward a more pro-active or offensive innovation strategy. For this to be realised however, public policies would also have to be formulated to support more product innovation. This is recommendable as it could make the Saudi glass companies work more closely with Saudi R&D organisations, and help to make the Saudi glass industry more competitive globally.

It may be noted that the study was limited to a sample of 46 glass companies, and a more representative sample would be necessary to increase the validity of the findings to generalise to the industry as a whole. In addition, the socio-economic importance of the glass sector at a time when Saudi Arabia is already seeking to diversify and strengthen the non-oil based sectors of its economy, justifies the need for further research on identifying more factors that may support or hinder innovation, ways of improving investments in innovation management, and on methods to further improve efficiency through implementing public polices and innovative managerial practices to help evolve the sector to fit within Saudi Arabia's economic visions.

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