

Impact of technological diversity on innovation performance in Chinese automobile industry

Sherzod Aktamov
School of Management, Shanghai University 99, Shangda rd. Shanghai, China
E-mail of the corresponding author: sherzodbekaka@gmail.com

Abstract
Studies on innovation are attracting a lot of researchers' attention all over the world due to its crucial role in today's competitive world. In our paper we made an attempt to find the nature of the relationship between technological diversity and innovation performance. We have collected the data for 59 firms from China's automobile industry, from the State Intellectual Property Office of the People's Republic of China. Then we used the Negative binomial regression to test the hypothesis with four models. We found that correlation between technological diversity and innovation performance has an inverse U-shape form.
Keywords: diversification, patents, specialization

1. Introduction

Innovation can be defined as the relationship between current business affairs and possible future ones. To that end, it is recognized that innovation is a process that can be represented metaphorically as a journey or a path (Van de Ven et al., 2008). As a process, innovation is required to guarantee long-term organizational survival and to overcome sub-optimal regimes (Elster, 2000). However, it is also a source of conflict and tension, since any innovation introduces a difference that can upset the forces of equilibrium in organizations, industry structures and markets (Gresov & Drazin, 1997).

In today's highly competitive business environment, an ability to continuously generate innovations is recognized as the critical sources of competitive advantages of the firms (Subramaniam and Youndt, 2005; Lin et al., 2006; Martı´nez-Ros and Orfila-Sintes, 2009).

Technological diversification of firm or industry has only recently attracted an interest among researchers. After pioneering work by Kodama (1986) and Pavitt et al. (1989), many researchers have shown in several micro-level case studies that cumulativeness or path-dependency is a fundamental property of innovative activities whereas diversity is another factor.

For example, Hamel and Prahalad (1994) emphasized from the respective managements' point of view that many once-successful companies had failed because of their lack of regeneration and their erroneous belief in persistence of yesterday' business practices. Among the ways to successful corporate regeneration they credited corporate persistent diversity of thinking. On the other hand, Patel and Pavitt (1997) and Granstrand et al. (1997) pointed out based on an analysis of US patent records and case studies that firms' technological competencies are diffused over a wider range of sectors than their production activities, and that firms are in general become more technologically diversified over time. They suggested that firms with high growth often followed a consistent strategy with technology diversification followed by product and/or market diversification. In their work they pointed out that Japanese firms typically have the most developed managerial capability for dovetailed technology and business diversification into new product areas, but they have not shown how such firms exploited and correlated their technological knowledge practically. Also Gambardella and Torrisi (1998) in their work found that a large electrical firm's performance was positively associated with its technology diversification.

Nowadays it became a crucial task for the managers to find methods of strengthening the innovation capacity of the firms. Questions arise when firms decide to go for strengthening their innovation capacity. What kind of technological diversity approach should be used? How firms with the selected technological diversity approach can leverage their organizational resources to improve the efficiency and effectiveness?

2. Literature review

Technological diversity refers to the extent of diversification of a firm's technology base (e.g. Breschi et al., 2003; Gambardella and Torrisi, 1998). Considering the increasing importance of technologies for the firms in attaining competitive advantage, scholars recently have paid attention to the corporate technological diversification issue (e.g. Dibiaggio, 2004; Suzuki and Kodama, 2004; Lin et al., 2006; Garcia-Vega, 2006; Granstrand, 1998). Two possible alternatives of technological diversity strategy exist for firms' choice (Breschi et al., 2003). One is to use well-diversified technologies in different markets and the other is to strategically specialize on a small amount of technologies in order to work out on new products in the certain markets. Prior studies have shown mixed and even promiscuous results on the choice of the two alternatives. Some researchers suggest adopting the diversification approach (e.g., Suzuki and Kodama, 2004; GarciaVega, 2006) while others suggest to employ the specialization approach for improving the performance of the firms (e.g., Lin and Chen, 2005; Gambardella and Torrisi, 1998). Recent research results propose that a non-linear relationship would exist between technological diversification and performance (e.g. Leten et al., 2007). Yi and Chung, 2010 argue that an optimal level of technological diversity exists for the firms to achieve better innovation performance due to the conciliation between the positive and negative forces governing the relationship between technological diversity and innovation outcome. It is believed that technological diversification is beneficial to the innovation performance in terms of economy of scope and knowledge-base view (e.g., Granstrand, 1998; Suzuki and Kodama, 2004; Turner and Fauconnier, 1997; Almeida and Phene, 2004; Lin et al., 2006). Granstrand (1998) illustrates the central role played by technological diversification in the evolution of a technology-based firm from the viewpoints of economies of scope, space, and speed. He argues that technological diversification strategy can help firms to boost innovation efficiency because diversification of technology can stimulate firms to generate more innovative ideas through the combination and recombination of various technologies. Similarly, Suzuki and Kodama (2004) suggest that if a technology-based firm aims to survive and grow in a long run it is necessary to take the advantage of economies of scope in technology through persistent diversification. By maintaining a broad technology portfolio, firms can explore and exploit new opportunities emerging from scientific and technological breakthroughs because of the likely economy of scope in technology commercialization and new product development across different fields (Lin et al., 2006). In addition, from the knowledge-based perspective, the existence of heterogeneous knowledge in the technology diversification context enriches the possibility of new combinations and thus enhances the likelihood of emergence of novel ideas (Turner and Fauconnier, 1997). A range of research approaches and expertise within technology diversified firms permit the cross-fertilization of ideas through knowledge spillovers between units and therefore lead to greater innovative output (Almeida and Phene, 2004).

However, excessive technological diversification would have detrimental impacts on firm performance from the perspectives of coordination costs and core competence (Argyres, 1996; Lin et al., 2006; Garcia-Vega, 2006; Lin and Chen, 2005). The coordination costs would increase as the level of technological diversity becomes higher (Argyres, 1996). The emphasis on technological diversity would fall into the over-diversification trap, where the increased R&D costs come from the heavy costs of coordination and integration of technological knowledge across a variety of technology disciplinary frontiers (Lin et al., 2006).

Accordingly, when technological diversity goes beyond a certain level, the internal operation costs may become higher than benefits of economies of scope and knowledge spillover, thus resulting in the decrease of innovation performance. Beside of it, firms using specialization strategy can concentrate on a small number of technology fields and thereby technology core competence would occur because specialization can facilitate the development and transfer of knowledge within the core technologies fields of the firm (Garcia-Vega, 2006), and thus enable the firm to build up a more focused technology base that can construct patent minefields to protect their core competence (Lin and Chen, 2005).

According to the above discussion of the positive and negative forces of technological diversity, we can say, as most researchers that the effect of technological diversity on innovation performance is curvilinear. As the two related forces, positive and negative, impact on the relationship, an optimal level of technological diversity for the innovation performance would exist. Before the optimal level, the increase of technological diversity would enhance innovation performance. On the other hand, innovation performance would decrease as technological diversity increases after the optimal level. Respectively, we can say that technological diversity would have a curvilinear effect on innovation performance, which will first increase and then decrease when technological diversity increases.

The evidences from study of Yi and Chung, (2010) suggest that firms should understand that two extremes, such as being too specialized or too diversified in technology development strategy cannot achieve better innovation performance. Instead, there exists an optimal level of technological diversity for the firms to achieve better innovation performance. This happens because of the conciliation between the positive and negative forces governing the relationship. Innovation performance can benefit from a diversified technology approach because of economy of scope and knowledge sharing while a specialized technology approach would be helpful in avoiding the harmful effects of coordination and conflict problems on innovation performance. Therefore, if managers willing to achieve better innovation results in their firms, they should realize that their technological diversity strategy should be carefully defined in the appropriate middle approach to compromise the two governing forces.

Firms achieve certain level of diversification because of their abilities to comprehend diverse technologies from external sources beyond firm boundaries. But this does not guarantee that knowledge inside the firm will be effectively shared, combined and turned into a new product or some kind of innovation. When units responsible for innovation processes in the firm get to be too specialized in particular area, the communication with other units might become more difficult. In such cases efforts on development and investment on diverse knowledge types can become a costly process, unless, the knowledge of these groups are not combined in novel ways. As we know there is no any empirical study to test it. Only close evidence is from Kogut and Zander (1992) which argue that the more specialization is there within the firm the more costly is communication within the firm. This means that specialization lowers the ability to form a common language among people in the company and prevents to transfer highly tacit knowledge that they possess. Usually creative knowledge within the organization is created and shared by informal communication mechanism tools and by joint discussions, rather than through formal mechanisms like management information systems.

3. Hypothesis

According to the above discussion of forces of technological diversity and literature review we made, our research proposes that the effect of technological diversity on innovation performance is curvilinear. As the two related forces, positive and negative, govern the relationship, an optimal level of technological diversity for the innovation performance would exist. Before the optimal level, the increase of technological diversity would enhance innovation performance. On the other hand, innovation performance would decrease as technological diversity increases after the optimal level. Accordingly, we can expect that technological diversity would have a curvilinear effect on innovation performance, which will first increase and then decrease when technological diversity increases. In light of the above reasoning, the following hypothesis is developed.
Hypothesis: The relationship between technological diversity and innovation performance is inverse U-shaped, with the slope being positive at low levels of technological diversity and negative at high levels of technological diversity.

4. Model and variable measurements.

We will use negative binomial regression model due to count nature of our data. We will run regression models on Gretl software and will present results in results section.
Dependent variable - Innovation performance. In general most studies categorize innovation performance into two dimensions: innovation quantity and innovation quality. Innovation quantity is measured as the number of patents granted to a firm in a given year. Due to more objectivity of this way of measurement of innovation performance we will use number of patents as our dependent variable in the model. We will measures the number of successful patent applications for firm i in year t. We will use the State Intellectual Property Office of PRC to collect yearly patent counts for each of the firms. One patent could be invented by several companies, and it will be aggregated into each company's patent counts, respectively. In our research we will check 5 models and different innovation measurements will be used: first we will use Overall number of patents for firm i in year t, then we will use number of radically new "clear" patents, which represent pure technological innovation, also we will use number of Utility models for the firm i in year t, and finally the number of Technological Designs for the firm i year t.
Independent variable - Technological diversity. The estimation of technological diversity is one of the most important parts in our model. In general as we mentioned before there were too few researches where technological diversity has been used and where researchers have estimated it. Following the methods of previous studies in this area (e.g., Ahuja and Katila, 2004), we can measure a firm's technological diversity by calculating the Blau index of the firm's patenting across patent technology classes. This index measures how diversely distributed a firm's patents are across patent classes. Blau index and the Herfindahl index are the same except that 1 is the lowest diversity value for Herfindahl and the highest for Blau index (Blau = 1- Herfindahl). We will use Blau index so in our paper a high score would mean a high degree of diversity.
We use the entropy measure of technological diversity (TD) to measure the extent of diversification of a firm's technology base. According to prior studies, patent classification can be categorized by four-digit IPC subclasses (e.g. Lerner, 1994) or by 30 technology fields (e.g. Breschi et al., 2003). In our study, we focus on examining the effect of technology diversity on innovation performance for firms in a specific sector, namely China's automobile industry. Therefore, we follow Lerner's (1994) study and use four-digit IPC subclasses as a proxy for technological diversity. The entropy measure of technological diversity is defined as
Technological diversity = (number of patent classes/ number of patents)× log(number of patents/number of patent classes) [1]

where Patent classes are the proportion of a firm's patent counts in a given 4-digit international patent classification (IPC) subclass. IPC classification has been used in many innovation studies as a proxy for patent scope (e.g. Lerner, 1994) and technology breadth (e.g. Miller, 2004), and is recognized to provide helpful information of a firm's technology base.

Control variables.

Firm age. The number of years since a company was found. This variable has been used in some researches as a control variable (Sorensen and Stuart, 2000) and can have control function, because of its availability of data for all companies. Firm age is related, to a certain extent, to the level of experience and managerial competences of the firm in carrying out innovations (Huergo and Jaumandreu, 2004). We calculate a firm's age from its starting year of operations to 2009.

Firm size. The link between innovation and firm size has long been a debated issue in the innovation literature (Freeman and Soete, 1997). Most empirical studies regarding innovation performance include firm size as a control variable. We use the logarithm of sales as a control variable for the firm size effect (Lu and Beamish, 2004).

R&D centers. As we mentioned in literature review part of our paper in all innovation related researches R&D factor has been taken as crucial and the one with highest probability to influence on innovation capability. Here we use presence of own R&D centers in firms. We do not include research centers which are in balance of other branches or institutions, also we do not include R&D centers hold by maternal company and owed by universities. We use dummy variable, where, if 0 firm does not have any R&D center for its own, and 1 if there is any R&D center owed by the firm.

5. Research sample and level of analysis.

The data is suitable for using panel form. We collected number of patents, utility models and designs for 59 firms from the web-site of State Intellectual Property Office of People's Republic of China www.sipo.gov.cn for each year from 2002 to 2009. These 59 firms have been chosen from the Thomson Reuters Corp. data base according its belonging to China automobile industry. The initial data has been translated into Chinese and has been checked in open sources to identify the correct names of firms, in order to avoid mistakes and double counting. To get the data for main variable - technological diversity of the firm we had to access to all the patents and find 4 digit codes given to each patent. We took first four digits of patent code to know to which category this patent belongs.

The measurement of technological diversity has been done as in following example: if there are 10 patents for the year 2002 for company N and there are 5 categories where these patents belong, so technological diversity of the company will be equal to 0.15 according to the formula 1. As closer this index to 0 as less the diversity is, as bigger the index is as higher is the level of diversity of technology. We have looked through more than 10 000

Table 1. Summary Statistics

Variable	Mean	Median	Minimum	Maximum	Std. Dev.	C.V.
Overall patents	35.7076	2	1	1139	114.251	3.19962
Clear patents	6.22881	1	0	231	19.5396	3.13696
Utility models	11.4470	0	0	691	45.6631	3.98908
Designs	9.12076	0	0	555	39.4387	4.32406
Technological diversity	0.0207168	0	0	0.159763	0.0459516	2.21808
Technological diversity (square)	0.00253626	0	0	0.0255242	0.00624134	2.46084
Firm age	26.9725	16	0	162	29.4987	1.09366
R&D centers	0.663136	1	0	1	0.473140	0.713488
Firm size	21.1889	21.0799	15.4249	25.6649	2.29055	0.108101

*Calculated by using the observations 1:1 - 59:8, (missing values were skipped)

patents in mentioned web-site and found categories for all 59 firms in period from 2002 to 2009. Then we calculated the technological diversity index to use it in our regression analysis.

The highest amount for number of overall patents was 1139 for one observed year and minimum was 1 patent which has been registered for one year of observation. 231 patents were the highest amount for one year to be patented for radical patents and 691 for utility models. 555 designs were registered record high amount for one

year observation, where most years were without registering of any new design patents. For technological diversity index, it was supposed to be in range from 0 to 1, and we got 0.0207 mean for this parameter.
Standard deviations for control variables such as firm age, R&D centers availability and log of firm size are 29.49, 0.47, and 2.29 correspondingly. We present summary statistics in table 1.
In table 2 we can see correlation matrix results. It shows that parameters which we have are suitable to make regression analysis. None of our variables have a multicolinearity problems regarding to each other. We have checked data with VIF test and couldn't find any evidence of multicolinearity. Zeroes in initial data for control variables are only due to the factual results and not because of missing value. For example firm age can have zero value if the company has not been yet established in the year of observation and for firm size it can have zero value in case of absence of revenue for the year of observation or the reason can be that the company has not been established yet for the time of observation.

6. Analyses and model results

In order to check our hypotheses we have used Negative binomial regression model on software Gretl. We did not use Poisson regression to avoid overdispersion problem. In our regression analysis data has been interpreted in time-stacked panel form. We use Negative binomial regression also because our data regarding dependent variable is count data. We generated 5 models where in all models innovation
performance is presented as dependent variable.

Table 2. Correlation matrix

		1	2	3	4	5	6	7	8
1	Innovation performance	1							
2	Clear patents	0.4186	1						
3	Utility models	0.6315	0.3848	1					
4	Designs	0.5988	0.3322	0.5377	1				
5	TD	0.5263	0.5985	0.3828	0.2914	1			
6	TD square	0.5377	0.6346	0.3767	0.2965	0.9755	1		
7	Firm age	-0.0059	0.1153	0.0244	-0.0378	0.1764	0.1724	1	
8	RnD centers	0.2003	0.1707	0.1719	0.1512	0.2291	0.2027	0.2328	1
9	Firm size	0.1252	0.1898	0.1683	0.0874	0.2351	0.2223	0.5638	0.4364

*Correlation coefficients calculated by using the observations 1:1 - 59:8, (missing values were skipped), 5% critical value (two-tailed) = 0.0903 for n = 472

In model 1 we use only control variables to check their significance and they show the high level of significance and it has been proved by other researchers. Coefficients for control variables show that firm age has a negative relation with innovation performance, which means that younger the company is better its innovation activity, which does not coincide with previous researches. It can be the result of own specifics which China automobile industries have, where old companies registered most of their novelties as patents and new designs much before the time of our observation, and by the time of observation they were already strong, financially stable and with comparatively less need for innovations.
On the other hand young companies make stronger and more active efforts towards innovation to present a new product in market, due to their still relatively week positions. Another assumption is related with the market conjuncture. Our observation period is from 2002 to 2009 when there was a tremendous growth in China automobile market and when China became main consumer of automobiles, which is naturally pushed market players to hold more active innovation related measures. Firm age showed negative relationship with innovation performance in all our models.
Control variable R&D centers availability was in form of dummy variable and has shown high significance level. These results can be explained with that when firms use their own R&D centers they have more freedom in conducting researches and technically it becomes easier to organize and pass all formal procedures. With Universities or Independent Research Centers or with R&D centers of other firms the communication and managing problems can occur and in the end may cost more in long term.
Firm size in our analysis has been measured by the revenue of the firm for observation period and we used natural logarithm of this parameter. It showed very strong significance as it has been predicted, based on previous researches. It shows that there is a positive relationship and the growth of revenue can increase the

number of patents, which is also similar to most studies done before.
As our hypothesis proposes the relationship between innovation performance and technological diversity is in form of invers U shape. Inverse U shape form of relationship can be achieved in case if the parabola has inverse U shape, which means $ax^2 + bx + c = 0$ should get the negative sign. For this we used one more additional variable the square of technological diversity and included it into regression. If the sign of *TD* (technological diversity) is positive and TD^2 is negative our hypothesis is confirmed. According to results (Table 3) of Negative binomial regression in all models, *TD* has a positive sign and TD^2 has a negative sign, which means that there is inverse U shape curve relationship and confirms our hypothesis. The predictor variable here is significantly related to innovation performance. We measured innovation performance with other variables as well. So we made three more models with estimation of technologic patents ("clear patents"), designs and utility models in relation to technological diversity.

Table 3. Negative binomial regression: Innovation performance (n=59)

	Model 1: Innovation performance - Control only		Model 2: Innovation performance		Model 3: "Clear" patents		Model 4: Design patents		Model 5: Utility models	
	C.	S.e.(sig)	C.	S. e. (sig)	C.	S.e. (sig)	C.	S.e.(sig)	C.	S.e. (sig)
TD			35.29	5.86***	25.71	3.83***	16.13	12.85	48.37	11.68***
TD square			-113.01	42.06***	-31.53	26.77*	-19.05	92.32	-218.52	81.66***
Firm age	-0.01	0.00***	-0.01	0.00***	-0.00	0.00***	-0.03	0.00***	-0.02	0.00***
R&D centers	2.51	0.19***	1.42	0.15***	0.35	0.12***	2.16	0.33***	2.19	0.38***
Firm size	0.14	0.04***	0.20	0.03***	0.13	0.02***	0.45	0.08***	0.29	0.09***
Constant	-1.43	0.83*	-2.78	0.68***	-2.64	0.56***	-9.50	1.67***	-6.41	1.77***
Log likelihood		-1751.14		-1623.74		-945.26		-829.62		-855.38
Alpha	2.34	0.13***	1.53	0.09***	0.51	0.04***	7.65	0.76***	6.87538	0.68***

***P<.01,**P<.05, *P<.10

In the models not all predictor variables were significant, which still does not give us any doubt that the research question can be answered and that hypothesis is supported. Only in model 4 TD was not enough significant, but still shows us the inverse U shape form relationship with design patents. We can assume that in model 4 p-value has shown statistical insignificance due to low amount of patented designs in firms' overall patent portfolio. "Clear" technologically radical patents and utility models have shown statistically high significance.

7. Discussions and conclusions

There were a lot of argues about strategies, where diversification was in one side and concentration or specialization on another. The positive force, echoed with arguments of prior studies (e.g.,Granstrand, 1998, Suzuki and Kodama, 2004,Turner and Fauconnier, 1997; Almeida and Phene, 2004; Lin et al., 2006), suggests that technology diversification is beneficial to the innovation performance in terms of economy of scope and knowledge-base view while the negative force, consistent with the suggestions of previous research (e.g. Argyres, 1996; Lin et al., 2006; Garcia-Vega, 2006; Lin and Chen, 2005), proposes that excessive technological diversification would have detrimental impacts on firm performance from the perspectives of coordination costs and core competence. The findings echoed with arguments of prior studies (e.g. Leten et al.,2007) and indicate that the relationship between technological diversity and innovation is inverse U-shaped rather than linear form. Some researches still take one or another point of view, when we in this research proved that neither too much concentration nor very wide diversification can bring the maximum level of innovation in the company. From the first view it seems that diverse technology should give us more chances to invent more, because of quantity of operating fields. And from another side the strong focus on one field seems enough convincing that it can lead us for more innovation, because firms can have comparative advantage when they focus all resource on one particular field. But as practice shows both approaches are not very helpful if we are talking about increasing of innovativeness of the firm. So, there is an optimal point which is somewhere in the curve. This curve starts from strong focus and finishes with a huge diversity. And an optimal point, which is with other words - the highest innovativeness lies in the top of that curve. The question of finding the optimal point can be left for further researches. Our main goal was to find the relationship vector and results coincide with some previous researches. We can conclude that there is low level of innovation performance when technology is not diverse, high level of innovation performance when index is somewhere around 0.5 and again low when the technology is very diverse. We try to explain this with the following: when firms have an optimal level of technological diversity they are in the same time quality and quantity oriented. We have not discussed or tested the quality of innovation, and only mentioned the quantity of innovation. Even with this approach it is clear that when firms have only few technological fields and diffuse their financial, intellectual, administrative and other resources on those fields, it can bring more effect and increase the innovation performance. We can suggest that each company should first choose the strategy of innovation development based on their resources and in case of excess investment capacity focus on several existing technological fields first, instead of trying for more new fields, which might be new to the firm, to firm's staff, to designers and engineers, and can bring time-cost problems for adaptation to new technological fields.

Also we found that firm age was negatively related to innovation, contrary to what has been expected from logic. And we explained it with conjuncture in the automobile market and also with overall world's technological progress. Firms are making more innovation in recent years, despite of fact that they are still young, because there is strong and consecutive overall technological progress. Beside of it, most of companies in China start their business with a sufficient investment amounts, due to their state support with financial privileges.

The managerial implications of the results are that managers need to know that there are two underlying governing forces on the choice of their technological diversity strategy. A diversified technology approach is beneficial to the innovation performance because of economy of scope and knowledge sharing while a specialized technology approach would avoid the detrimental effects of coordination and conflict problems on innovation performance. Therefore, managers should understand that their technological diversity strategy should be carefully defined in the appropriate middle approach to compromise the two governing forces in order to achieve better innovation outcome.

Executives in developing new strategies with focus on increase of innovativeness also may take into consideration those factors which were analyzed in our research. Still our recommendations are based on empirical analyzes and are based on one particular industry, of one particular country, they should be used with caution. These findings have recommendatory character and play the role of supplementary argument in decision making, when other primary factors already have been taken into consideration.

In summary, our results shed some light on the effect of technological diversity on innovation performance under different contexts of network positions but also leave some limitations for the consideration of further research. First, we derive our empirical results from a sample of China's automobile industry, thus raising the concern about the external generalizability to other sectors and industries. Future research is therefore suggested to empirically test the validity of the framework and hypothesis in other high-tech industries. Secondly, we use only patent counts and they are proxy measures of innovation performance. We suggest for further studies use also other measures such as patent citations or number of new products. Future research can include other sources, such as survey data, of innovation performance measures to supplement the objective measures. We have not examined the moderate effect of various factors, future research can explore how these or other factors contingently contribute to improve or deprave the impact of technological diversity on innovation outcome.

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References

1. Ahuja, G. & Katila, R. (2004), "Where do resources come from? The role of idiosyncratic situations", *Strategic Management Journal*, 25 (8-9) 887-907.
2. Almeida, P. & Phene, A. (2004), "Subsidiaries and knowledge creation: the influence of the MNC and host country on innovation", *Strategic Management Journal,* 25 (8–9) 847–864.
3. Argyres, N., (1996), "Capabilities, technological diversification and divisionalization" *Strategic Management Journal,* 17 (5), 395–410.
4. Breschi, S., Lissoni F., Malerba, F. (2003), Knowledge-relatedness in firm technological diversification. *Research Policy*, 32 (1), 69–87.
5. Elster, J., (2000), "Ulises y las sirenas", México: Fondo de Cultura Económica.
6. Freeman, C. & Soete, L. (1997), "The Economics of Industrial Innovation", 3rd Ed, Pinter, London
7. Gambardella, A. & Torrisi, S. (1998), "Does technological convergence imply convergence in markets? Evidence from the electronics industry". *Research Policy,* 27 (5) 445–463.
8. Garcia-Vega, M. (2006), "Does technological diversification promote innovation?: an empirical analysis for European firms". *Research Policy*, 35 (2) 230–246.
9. Granstrand, O. (1998), "Towards a theory of the technology-based firm" *Research Policy*, 27 (5) 465–489.
10. Granstrand, O., Patel, P., Pavitt, K., (1997) "Multi-technology corporations: why they have "distributed" rather than "distinctive core" competencies". *California Management Review*, 39 (4) 8–25.
11. Gresov, C. & Drazin, R., (1997), "Equifinalty, Functional Equivalence in Organizational Design" *Academy of Management Review*, 22(2) 403-428.
12. Hamel, G. & Prahalad, C.K. (1994), "Competing for the Future" Harvard Business Press.
13. Huergo, E.E. & Jaumandreu, J. (2004), "How Does Probability of Innovation Change with Firm Age? *Small Business Economics*, 22 (3/4)
14. Kodama, F. (1986), "Technological diversification of Japanese industry" *Science*, 233, 291–296.
15. Kogut, B. & Zander, U. (1992), Knowledge of the Firm, Combinative Capabilities and Replication of New Technology, *Organization Science*, 3(3) 383-97.
16. Lerner, J. (1994), "The importance of patent scope: An empirical analysis" Rand Journal of Economics, 25, 319-333.
17. Leten, B., Belderbos, R., Van Looy, B., (2007), "Technological diversification, coherence, and performance of firms" *Journal of Product Innovation Management*, 24, 567–579
18. Lin, B.W. & Chen, J.S. (2005), "Corporate technology portfolios and R&D performance measures: a study of technology intensive firms" *R&D Management*, 35 (2) 157–170.
19. Lin, B.W., Chen, C.J., Wu, H.L., (2006), "Patent portfolio diversity, technology strategy, and firm value" *IEEE Transactions on Engineering Management*, 53 (1), 17–26.
20. Lu, J.W. and Beamish, P.W. (2004), "International diversification and firm performance: The S-curve hypothesis" *Academy of Management Journal*, 47(4)
21. Martı´nez-Ros, E. & Orfila-Sintes, F. (2009), "Innovation activity in the hotel industry" *Technovation*, 29(9) 632–641.
22. Miller, D.J. (2004), "Technological diversity, related diversification, and firm performance" *Strategic Management Journal*, 27, 601-619.
23. Patel, P. & Pavitt, K. (1997), "The technological competencies of the world's largest firms: complex and path-dependent, but not much variety" *Research Policy*, 26, 141–156.
24. Pavitt, K., Robson, M., Townsend, J. (1989), "Technological accumulation, diversification and organization in UK companies 1945–1983" Management Science, 35, 1.
25. Sorensen, J.B. & Stuart, T.E. (2000), "Aging, obsolescence and organizational innovation" *Administrative Science Quarterly*, 45 (1) 81-112.
26. Subramaniam, M. & Youndt, M.A. (2005), "The influence of intellectual capital on the types of innovative capabilities" *Academy of Management Journal*, 48, 450–463.
27. Suzuki, J. & Kodama F. (2004), "Technology diversity of persistent innovators in Japan: two case studies of large Japanese firms" *Research Policy*, 33 (3) 531–549.
28. Turner, M. & Fauconnier G. (1997), "A mechanism of creativity" *Poetics Today*, 20 (4) 397–418.
29. Van de Ven, A.H., Polley, D., Garud, R., Venkatraman, S. (2008) "The Innovation Journey" Oxford: Oxford University Press.
30. Yi Fen, H. & Chung, J.Ch. (2010) "The impact of technological diversity and organizational slack on innovation" *Technovation*, 30, 420–428.