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A MODEL OF TECHNOLOGY STRATEGY DEVELOPMENT FOR IRANIAN NANO-COMPOSITE COMPANIES

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Abstract. In recent years, Iran's government has emphasized the development of nanotechnology-based industry, so many Iranian companies have gravitated to this subject, or some new companies have established on nanotechnology fields such as nano-composite products. Technology strategy (TS) is one of the most important aspects of any firm's strategic posture especially in dynamic environments; therefore this research is focused on adjusting a dynamic model of technology strategy development for Iranian nano-composite companies' conditions. This article spots four key environmental moderators (Iran as a developing country, high nanotechnology, nano-composite companies, and information availability) which affect Chiesa's dynamic model for technology strategy, and investigates these moderators' effects on the dynamic model's indicators. The results show that 22 indicators of Chiesa's model have changed for this case.

Keywords: technology strategy, nano-composite, Hi-tech companies strategy, developing countries, Iran, Nanotechnology.

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1. Introduction

Nanotechnology has been regarded as an emerging high-technology introducing new dimensions to science and technology with the multiple possible applications and its effects on various technological and social domains. Nanotechnology development will influence all social areas, including economics, hygiene, the environment, law, and education (Ghazinoory

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and Heydari 2008). In order to employ this high technology as well as its applications for economic growth and development, many policy-makers and researchers in both developing and developed countries have focused on nanotechnology. Developing countries are subject to the same global pressures as their developed counterparts, but have additional burden of dealing with domestic conditions which place them at a significant and perhaps insurmountable disadvantage. The national issues and problems such as poverty, unemployment, inequality, and inability to fulfil basic needs are common problems in developing countries (Akubue 2000).

The Islamic Republic of Iran (a developing country), located in the center of the Middle East, covers an area of 1,648,195 km^2 and has a population of over 71 million. There are over three million university students, and almost 65% of them are women. About 35% of the population is employed by either the government or the private sector, and unemployment rate is around 11% (Ghazinoory and Huisingh 2006). A large portion of Iran's economy is led by the government or affiliated companies, or through public entities. The share of the private sector is in the range 30–40%. Major industries such as oil, petrochemicals, and steel are active and have substantial exports. In addition, many food and agricultural products are produced and exported. The share of industry in Iran's gross domestic product is around 20%, which is lower than in most industrialized countries. The share of agriculture is around 25%. The share of the oil sector is 16% (average of the past 20 years) and the remaining portion comes from the service sector. About 80% of the export income and 50% of the public budget are provided by oil exports (Ghazinoory 2005).

Obviously, the role of the government has been changed in recent years. However, it has not been replaced by market mechanisms, and the government still has a role in national planning and development. This is especially true for developing countries like Iran that still lack free markets (90% of Iran's exports and 60% of its gross national product) is in the hands of the government and public institutions, so they cannot be expected to develop without government planning. In science and technology development (particularly emerging technologies such as nanotechnology), this is more pronounced (Ghazinoory *et al.* 2009b).

In order to enhancing scientific and technological development as an item of the highest national priority, Iranian policy-makers have placed special emphasis on a rapid development of emerging technologies, particularly nanotechnology (Ghazinoory and Ghazinoori 2006). The government's attention to nanotechnology in Iran started in 2001 when Iranian President Mohammad Khatami made Technology Cooperation Office (TCO) responsible for coordination of developmental activities for nanotechnology in the country. In 2003, after extensive studies and analysis, the TCO recommended creation of a council and was given a task of defining the direction for nanotechnology development in Iran. Additionally, the TCO has concluded that nanotechnology development in Iran requires national initiative. The National Iranian Nanotechnology Initiative (NINI) was subsequently approved by Iranian cabinet in July 2005 (Ghazinoory *et al.* 2009a).

As a result of the NINI's supports, many Iranian universities and institutions focused on different courses related to nanotechnology. About 18 university educational courses, 90 research institutions, 5 incubators, 40 specific laboratories, and 30 specific Medias have been established as some infrastructures of nanotechnology. As a result of these activities, in 2008, Iran was ranked 25th in the worldwide ranking nanotechnology articles.

Although in the academic section Iran could achieve most of its goals, in the industrial section there were some important problems. For instance, all of nanotechnology-based Iranian companies' managers were technical people who studied different fields of nanotechnology in university, but they didn't focus on the strategic aspects of a high-tech company's management; therefore, the NINI has established a department named the Iran Nano Business Network (INBN)[1], in order to improve the business activities of the Iranian nanotechnology-based companies.

About 100 members of the INBN include three groups of companies that are related to nanotechnology fields in Iran. The first group is those who have different fields and are interested in nanotechnology, but they don't know "how" they can enter and develop their business. In the second group, people want to start a new foundation in this area, but they need some deliberation about their business. Finally, those who have established a nanotechnology-based business but they made a lot of mistakes, so they should be conducted. In order to support these three groups, the NINI needs some general and specific technology strategies on the firm level.

Technology strategy (TS) is one of the most important aspects of any firm's strategic posture, especially in dynamic environments such as the nanotechnology-based industry. Not only do new businesses face the pressures that accompany all young companies (e.g., shortages of capital), but also they have to keep up with the rapid rate of technological change. Consequently, TS as the sum of a firm's choices on how to develop and exploit its technological resources can profoundly affect a company's performance and survival (Zahra and Bogner 1999).

This paper investigates a comparative model of technology strategy development for Iranian nano-composite companies (Table 1). These companies produce several materials such as nano-composite powders, nano-composite foams, nano clays, nano-composite polymers, anti-bacterial nano-composites, etc. There are all of the three groups of companies in this category, their experts deal with different fields, and also nano-composites are a priority of Iran's nanotechnology activities, so in this research we focus on these companies.

Table 1. Ten case study Iranian nano-composite companies

Name and Location	Product (s)	Number of Employees	Mode of Entry	Year of Entry
Baspar Nano Bon Co.	Nano-composite	12	Start-up	2002
Persian Nanotechnology Pioneers Co.	Anti-bacterial Nano-composite Polymer	4	Start-up	2007
NanoNasb-e Pars Co.	Nano-composite, Colloidal Silver	50	Start-up	2002
Asian Technology Pioneers Co.	Nano-composite Polymer	9	Start-up	2003

[1] http://inbn.ir/en/index.php

Continuation of **Table 1**

Name and Location	Product (s)	Number of Employees	Mode of Entry	Year of Entry
ZarrinKar-e Talaee Co.	Nano-composite Foam, Nano-composite Powder	?	Start-up	2000
Iramont Inc.	Nano Clay	17	Takeover	2004
NanoFanavaran-e Sabz Co.	Nano-composite Polymer	15	Start-up	2007
NanoPars-e Spadana Inc.	Nano-composite, Nano catalyst	15	Takeover	2007
KaraShimi Inc.	Composite (Nano-composite)	15	Takeover	2003
Parsa Polymer Sharif Co.	Nano-composite	8	Start-up	2007

This paper also seeks to determine how the managers of Iranian nano-composite companies can develop suitable technology strategies in order to be successful. The structure of the paper is as follows: theoretical framework and relevant literature, model adjusting, the research and its results are described; the findings are examined with some suggested explanations; finally, the implications are discussed in a broader context.

2. Theoretical framework and relevant literature

This study looked into technology strategies of high-tech companies, or new technology-based firms. Such firms are technology-based because they exploit advanced technological knowledge developed in-house or acquired from external sources to create new technical solutions, and they are entrepreneurial because they are managed by individual or group owner(s) (Autio 1997). Thus, their technological resources and capabilities are most critical for their product/service and market development. In order to survive, they must build the competence to continuously adapt and create new products and develop the processes to produce and deliver them to the customer (Igel and Islam 2001).

The environmental conditions imposed to these entrepreneurial firms separate the technology strategy development process into two parts, selection of a technology strategy model and adjusting this model with regard to moderators.

2.1. Technology strategy perspectives

An Effective management of a company's technological resources requires the development and implementation of a sound technology strategy. This strategy embodies several components: a company's technological posture, technology sourcing, technology portfolio, and distinctive technological skills and resources. Links between a company's technology and competitive strategy are usually clarified in its "technological strategy". Traditional views on the relationship between a company's competitive and technology strategy have emphasized two different perspectives: hierarchical and resource-based (Zahra *et al.* 1999).

From the 'hierarchical' view, a company's external environment and its internal skills, resources and capabilities were believed to provide the starting point for formulating its competitive strategy (Stonham 1998). This competitive strategy embodies the company's formal long-term plan which typically outlines its goals, scope of business, and the way the company intends to achieve its goals. Each competitive strategy favors a particular technological orientation. Thus, a company's technology strategy is expected to flow directly from a clear understanding of its competitive advantage in the form of low costs, product differentiation, or both. Clearly, this perspective places much emphasis on understanding the competitive context of the firm. It also highlights the need for technological choices that reflect the demands of the competitive strategy (Zahra *et al.* 1999).

The proponents of the 'hierarchical' perspective have sometimes failed to recognize that technology strategies, as other important organizational choices, are politically negotiated outcomes. The creation, acceptance and adoption of a new technology strategy are a socio-political process that requires attention to the value system that dominates the firm's culture. Clearly, there is a need for an alternative perspective, one that recognizes the inter-connectedness of a firm's technological resources with its other assets. The resource-based perspective offers one such view. From this view, technology strategy is a component of the company's resources and capabilities that provide the foundation for a distinctive competence from which a competitive strategy can be developed. Accordingly, companies need strategies that capitalize on the synergy between their technology and other resources. The resource view further suggests that a competitive advantage is achieved by the accumulation, integration, and effective development of technological resources (Grant 1991).

Despite the success companies have achieved using the resource perspective, this approach has some shortcomings. Specifically, it ignores the dynamic interaction between a company's technology and competitive strategy variables. Consequently, it fails to inform executives on 'how' and 'when' technological factors may change a company's competitive strategy and vice versa. Over-emphasis on technological resources can be as dangerous as ignoring these factors in designing the firm's competitive strategy (Zahra *et al.* 1999).

The hierarchical and resource perspectives are increasingly inadequate in today's business environment because they ignore the dynamic links that exist between a company's technology and its strategy. They also ignore the learning that occurs as the firm implements its technology and competitive strategies. Therefore, a third perspective, 'dynamic' view, exists in order to fill this gap. This dynamic perspective allows a firm to capitalize on the dynamic interplay between its technological capabilities and strategic initiatives (Chiesa and Manzini 1998; Itami and Numagami 1992). In 2001, one of the dynamic perspective's technology strategy models was developed by Chiesa.

2.2. Chiesa's dynamic model

In the era of rapidly changing technology (Kotabe and Swan 1994; Kuemmerle 1999), intense global competition (Schendel 1991; Yip 1995), and a patent system that offers incomplete protection (Teece 1987; Goel 1995), the need to develop and implement an internationally inclusive technology strategy is increasingly important for business success (Hayes *et al.* 1988).

As mentioned above, in order to achieve this goal, companies need to develop a dynamic model of technology strategy. According to Chiesa's theory, formulating a technology strategy means to define the trajectory by which resources are accumulated, acquired and used. The sustainability of the competitive advantage relates to the capability to develop technological competencies and resources along a given trajectory which is stable in the long term. More generally, selection of technologies, timing of new technologies introduction and acquisition mode should be seen as three dimensions of one strategic decision about technology. In fact, technology strategy is like designing a "trajectory" that defines how to acquire and internalize technical resources and knowledge. Each step in a technology strategy is strongly dependent on previous actions and programs. An overall picture which more precisely illustrates the process of technology strategy in a dynamic context is presented in Figure 1 (Chiesa 2001).

Decisions are taken on the basis of information gathered on the future shape of competition and industries, the forecast of technological progress and the evolution of the external and internal context of the firm. This information provides the base for future scenarios which, in turn, are the basis of strategy formulation. This phase is called context foresight and provides key inputs to the phase of decision-making.

The key categories of decision in technology strategy are selection, timing and acquisition mode (Chiesa 2001). This model includes four levels which are shown in Table 2:

Level 1) 3 main dimensions in the first level,

Level 2) 9 variables in the second level,

Level 3) 22 factors and indicators in the third level,

Level 4) 32 indicators in the fourth level.

In order to use Chiesa's model for developing the technology strategy in Iranian nano-composite companies, it is necessary to consider some issues indicated in the next sections.

2.3. Technology strategy in developing countries

Country condition is one of the most important factors that can affect the firm's strategies (Kim 1998). Companies functioning in developing countries face some extra limitations and

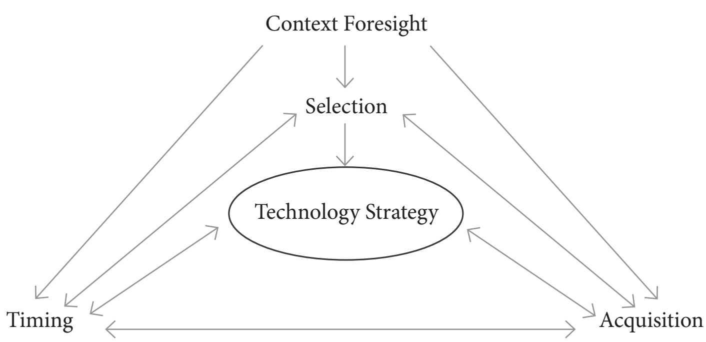

Fig. 1. The dimensions of technology strategy (Source: Chiesa 2001)

Table 2. Levels and factors of Chiesa's model

Level 1	Level 2	Level 3	Level 4
Selection	Relevance	Market Potential	Market Size
			Firm's Market Share
			Commercialization time
		Applicability	The Number of Technology applications
		Customer Value Creation	Analysis of the key functional performance of the product
			Technology Contributing to fulfill the required performance
	Risk	Technical Risk	Level of technology progress
			Difficulty of the objectives
			Resource Adequacy
		Commercial Risk	Economic Return
		Financial Risk	Amount of Required investment
	Appropriability	Firm's Relative Strength to Competitors	
		Capability/Opportunity of Firm's the technical knowledge base protection	
	Option Creation	Creation of new technological trajectories	
		Acceleration of Technological Learning	
		Increase of Value External Sources	
		Seed for Future Technological Development	
	Interdependencies	Technical Interdependency	
		Commercial Interdependency	
Timing	Time Based Competition	Leadership or Followership	Pioneering Costs
			Market Demand
			Changes in Costumer's needs
			Specific Investments
			Technological Discontinuities
			Imitation Costs
	Time Compression Diseconomies	Introduction or Development of Technology	Possibility to postpone or accelerate the Introduction without Profit Loss
			Degree of Market Control
			Cannibalization
			Acceleration Trap
			Standard Setting
			Availability of Complementary Assets
Acquisition	Technology Development	1. Make 2. Cooperation 3. Buy	Availability and Level of External Sources
			Spent Time
			Appropriability
			Costs
			Technical Risk
			Learning Acceleration
	Technology Introduction	1. Make 2. Sell 3. Cooperate	Availability of Complementary Assets
			Commercial Risk
			Standard Setting

pressures. For example, globalization presents formidable challenges to developing countries as they struggle to compete in world markets (Lall 1993). The extent to which firms in developing countries are able to enter the global market depends on their ability to acquire and use new technologies, and on how they can foster knowledge-based competitive advantage. A decisive feature will be the development of core technologies into a knowledge, competence and high-technology skills context (Hipkin 2004).

Technology strategy requires a balanced assessment of product complexity (for value maximization) and process complexity (for cost minimization) (Sharif 1997). These are a function of a product's performance and design characteristics, and the technical specifications for manufacturing facilities. In both instances, resources, competencies and financial constraints will restrict the selection of technologies in developing countries. When technology is transferred to developing countries, owner and acquirer companies should determine what technology is appropriate in the acquiring country. Technology suppliers can no longer dump obsolete technologies from a developed country, or deliver a technology designed to produce low value added items. Technology policy in developing countries must nevertheless take into account the technological barriers between low value and high value products, and high value and state-of-the-art products (Jegathesan *et al.* 1997). High value may be achieved by improving technology through purchases, foreign direct investment and licensing; state-of-the-art requires substantial capital investments, product differentiation, full technology transfer and highly trained personnel.

Technology activity between one country and another may be aimed at technological capabilities emphasizing the desire of the technology acquirer to establish "knowledge-creating activities". This emergence of technological proficiency is a continuum extending from the purchase of equipment by an acquirer (essentially constituting a financial transaction with no technology transfer) to total technology transfer giving the acquirer equal technological partnership with the owner. Along this continuum, Leonard-Barton (1995) identifies four levels in a technology capability ladder: 1) assembly or turnkey operations; 2) adaptation and localization of components; 3) product redesign; and 4) independent design of products. The first two levels are more likely to be encountered in developing countries. However, if they are not to remain followers in their endeavors to compete internationally, they will increasingly have to direct their technology policies to the third and fourth levels. This will require an element of realism as achieving first-mover advantage on the basis of redesigned or independently adapted technology will not be easy for developing countries.

2.4. Technology strategy in high technology companies

Strategic management theorists have long maintained that those firms who strategically exploit the broad effects of emerging technologies significantly contribute to creating substantial and sustainable competitive advantage (Ansoff and Stewart 1967; Rumelt 1974; Porter and Millar 1985; Teece 1986). In industries such as information technology, technology evolution is a major force affecting strategic behavior in firms through changing or influencing drivers of cost or uniqueness (Porter 1985). In other words, the authors posit that traditional strategy research focused on how strategy capitalized on technology while focus on how technology drives cognition of strategy may result in a more visionary perspective and a realistic and comprehensive strategy for today's businesses (Wilbon 1999).

Some studies have stressed the importance of organizational flexibility in high-tech firms (Maidique and Hayes 1984; Nakamura 1986; Bahrami and Evans 1987; Bourgeois and Eisenhardt 1987; Scherer and McDonald 1988; Covin *et al.* 1990; Dodgson 1991; Berry and Taggart 1998). In this respect, Dodgson and Rothwell (1991) argue small firms to possess considerable potential advantages over large firms in that they have less organizational rigidity than large multidivisional firms, which results in an ability to facilitate effectively information and communication flows within the organization and to respond quickly to marketplace stimuli. Extensive empirical investigations by Covin *et al.* (1990) and Bahrami and Evans (1987) led them to conclude that small firms operating in high-tech industries tend to have entrepreneurial management styles and structures which are characterized by informal control mechanisms, adaptability, flexibility, and open communication channels. Bahrami and Evans (1987) argue that in the high-technology arena, the time lag between decision and action is typically short. Therefore, the planning and formulation of strategy must be tightly coupled with its implementation in a dynamic feedback loop.

2.5. Technology strategy in nanotechnology-based companies

Nanotechnology as one of the high technologies refers to the field of applied science and technology whose theme is the control of matter on the atomic and molecular scale, generally 100 nanometers or smaller, and the fabrication of devices or materials that lie within that size range (Naschie 2006). Much of the impact of nanotechnology will occur through its convergence with other fields, especially biotechnology, information technology, and new technologies based on cognitive science. So it is natural that most of nanotechnology affecting mechanisms will occur through other technologies and, as a consequence, not all the people in a society will realize the real source of changes (Ghazinoory and Ghazinouri 2009). Due to the far-ranging claims that have been made about potential applications of nanotechnology, a number of serious concerns have been raised about what differences these will have with other high technologies such as information technology or biotechnology (Staggers *et al.* 2008).

At the first area of concern, nanotechnology is a highly multidisciplinary field drawing from a number of fields such as applied physics, material science, interface and colloidal science, device physics, supramolecular chemistry, self-replicating machines and robotics, chemical engineering, mechanical engineering, biological engineering, and electrical engineering. On the other hand, other high technologies focus on the limited fields of science and technology.

Moreover, wide range of nanotechnology products (from medicines to building materials) can be found in every industry or division while other high technology products provide restricted applications (Rejeski and Lekas 2008).

Because of these differences, nowadays most of the large companies focus on nanotechnology activities, but the companies that ignore the role of this new technology are highly exposed to failure. Some worldwide reports (for example, Lux Research Report 2005) indicate large companies have applied three strategies for their nanotechnology-based activities:

1) 45% of companies follow an intensive strategy and assign a specific group of experts for developing and implementing this strategy;
2) 42% of companies don't have any intensive strategy or specific structure devoted to nanotechnology activities; and
3) 12% of companies apply an integrated strategy just employing a supporting group and not an expert group.

Regarding all the above mentioned nanotechnology considerations, it seems that nanotechnology-based firms need to apply specific technology strategies in order to attain their goals, so new or comparative formulations of technology strategy are necessary.

3. Model adjusting

Inasmuch as there was not any specific model of Technology Strategy Development (TSD) for nanotechnology-related companies, this empirical study adjusts a dynamic model of TSD for Iranian nano-composite companies. To this end, we had to select a fundamental dynamic model and then, by focusing on research conditions and analyzing their effects on this model, the study offers insights into the factors that can influence the technology strategy of companies in a fast-paced environment. This study also examines key environmental moderators i.e. the external environmental forces that can significantly impact the factors of the final comparative model.

In this research, Chiesa's dynamic model of TSD has been selected as the fundamental model for two important reasons. First, Chiesa's model includes all three important dimensions of TSD indicated in the related literature: technology selection (Hipkin 2004), technology introduction and development timing, and technology acquisition (Jones *et al.* 2000; Husian *et al.* 2002; Vilkamo and Keil 2003; Hipkin 2004; Smith and Sharif 2007). Second, this model spots a dynamic view of both internal and external analysis of a firm, so it is suitable for nano-composite companies' changing environment. In addition, some experts believe that this model is more appropriate for Iranian companies, because it can be adjusted better than other models.

Researchers continue to disagree on the best way to conceptualize the environment (e.g., Boyd *et al.* 1993). Fortunately, the literature suggests three points that have guided the design of the study about key environmental moderators. At the first point, because environmental conditions vary significantly from one country to another, especially for developing countries (Hipkin 2004), control of these variations is necessary. This study accomplishes this by focusing on Iran conditions at one point in time. At the second point, the nature of the environmental characteristics is inextricably linked to the kind of the industry (Smith *et al.* 1993). To minimize the confounding effects of these variations, the study examines the nano-composite-based industry as a high-tech industry. At the third point, the specific characteristics of the nano-composite firms which have distinctive differences from other high-tech firms are acknowledged. Although these external characteristics reflect this industry's conditions, the study also emphasizes internal limitations of sample companies in terms of information availability, because this factor can restrict the implementation of developed technology strategies. Figure 2 shows four key internal and external environmental moderators of the comparative model.

4. Procedure of research

The study data were collected through a questionnaire survey of nano-composite companies which contains management information on over 100 nanotechnology-based companies. In this database, there are only 10 nano-composite companies, and this research focused on all of them as a large group of Iranian nanotechnology-based companies.

The Iranian nano-composite industry offered an interesting setting to test the study model; it has been one of those most prolific in new product development and introduction. The phenomenal growth of the industry has also encouraged the emergence of companies that depend heavily on commercializing new products, which has spurred further innovation and encouraged market aggressiveness among companies. This union of technology and marketing has made the nano-composite industry one of the most dynamic and fiercely competitive arenas.

The nano-composite industry was also chosen for the study because it is one of the key industries of Iran's future (Ghazinoory and Ghazinouri 2009). This nano-composite priority

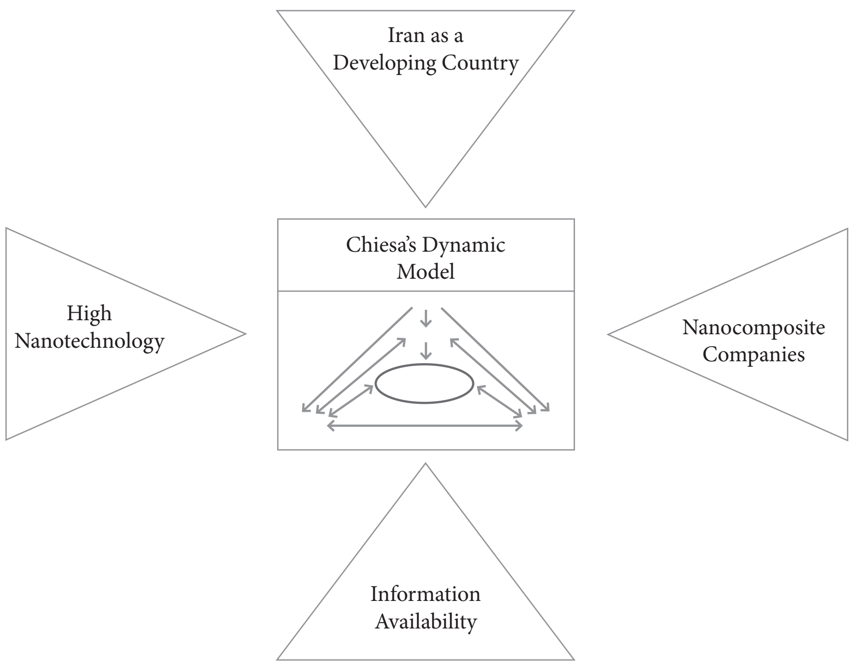

Fig. 2. Key internal and external environmental moderators of comparative model

implies that these companies can obtain more supports from governmental organizations. Developing the technological strategies of Iranian nano-composite companies, therefore, can be helpful in discovering the sources of their competitive advantage. Finally, despite the limitations of single-industry studies, focusing on one industry has the advantage of providing respondents with a common frame of reference and reducing the potentially confounding effects of diverse macro-environmental conditions (Dess *et al.* 1990).

The research methodology and technology strategy literature was used to identify the necessary features of the research methodology for this project. The literature offered a number of important points about research techniques in this area. For example, Zikmund (1994) contends that descriptive research seeks answers to questions such as who, what, when, where and how to describe characteristics of a population or phenomenon, while Denzin (1989) suggests that since different research methods such as observation and interviews "reveal different aspects of empirical reality", a variety of methodologies should be adopted for this type of research. For this reason, multiple methods of data collection were used, combined with a generative research approach in which informal techniques were included so that the target population itself could also identify important research issues (Simon 1994). Some formalization was also included so that "the objectives of the study determined during the early stages of research are included in the design to ensure that the information collected is appropriate for solving the problem" (Zikmund 1994).

The literature also suggested that the assessment of model's factors was potentially problematic. Manager-reported findings were likely to be the most common forms of data collection, and in many cases the research had to rely on responses of a single manager from each company. According to Swink and Way (1995), disagreement among different functional managers' perceptions places the task of determining the acceptable degree of variation.

In this research, a combination of interviews and questionnaire surveys was therefore used to reduce the potential for observer bias. As a result of these requirements, the methodology finally used was exploratory and standardized. It utilized a combination of a questionnaire to produce quantitative data and in-depth interviews to produce rich qualitative data, which complemented each other. The questionnaire was developed and refined as follow: 1) nearly 22 of 40 indicators in Chiesa's TSD model from its two last levels (third and fourth) of the main dimensions, 2) decisions on why these items must be changed or omitted for the sample according to the related literature of the key environmental moderators, and 3) a five-point Likert-type scale about the degree of respondents' agreement (1 = very low, 2 = low, 3 = medium, 4 = high and 5 = very high).

5. Results

Table 3 lists all Chiesa's model indicators thet were found to apply to the nano-composite companies changed during the project, using the methodology described above. In addition, it shows the degree of respondents' agreement in terms of average percent and standard deviation of ideas which were determined using the questionnaire survey data.

As shown in Table 3, the average degree of total agreement of respondents with the proposed changes of the model's factors was about 68%, so we could conclude on the final

Table 3. Results of Questionnaire survey about proposed changes of Chiesa's model indicators

Moderator Title	Model Dimension	Indicator	Proposed items	Average Percent	Standard Deviation
Developing Country	Selection	Commercialization time	– Continuous economical and political evolutions (Kim 1998)	63%	1.251
		Capability/Opportunity of Firm's the technical knowledge base protection	– Lack of copy write rules (Akubue2000) – Lack of patent rules and supporting organizations (Akubue 2000)	89.2%	0.648
	Timing	Standard Setting	– Lack of national standard setting organizations (Akubue 2000)	77%	1.511
	Acquisition	Standard Setting	– Lack of national standard setting organizations (Akubue 2000)	60%	1.519
High Nano-technology	Selection	Market Size	– Forecasting by market research centers (Chiesa 2001) – More government investments (Lall 1993)	75.4%	0.973
	Timing	Pioneering Costs	– More venture capital investments (Ghazinoory *et al.* 2009b) – Advanced computer systems (Naschie 2006)	78.4%	1.246
		Market Demand	– High risk investments (Naschie 2006) – Erratic demand (Scherer and McDonald 1988)	83%	1.292
		Changes in Costumer's needs	– High speed changes in costumer's needs (Vilkamo and Keil 2003) – Flexibility (Berry and Taggart 1998)	77%	1.350
		Cannibalization	– Shorter life-cycle of nano-composite products (Wilbon 1999)	69.2%	1.088
	Acquisition	Costs	– More costs of participation or purchase (Staggers *et al.* 2008) – Limited resources	80%	1.300
		Learning Acceleration	– Learning as a competitive factor (Hipkin, 2004) – Less technological sale or participate (Lux Research Report 2005)	80%	1.468
Nano-composite Companies	Selection	Firm's Market Share	– Lack of ripe market (Lux Research Report 2005)	81.6%	0.730
		The Number of Technology applications	– Wide range of nano-composite applications	85%	1.090
		Economic Return	– More innovative activities (Autio 1997) – High risk economical conditions (Ghazinoory *et al.* 2009b)	67.6%	0.079
		Firm's Relative Strength to Competitors	– Limited industry background	85%	0.722
	Timing	Specific Investments	– Advanced laboratory (Staggers *et al.* 2008) – Special instruments and tools (Staggers *et al.* 2008)	83.1%	0.662
		Degree of Market Control	– Lack of ripe market (Lux Research Report 2005) – Market control by Pioneer	80%	0.877
	Acquisition	Commercial Risk	– High risk (Staggers et al. 2008) – Lack of ripe market (Lux Research Report 2005)	84.6%	0.421
		Technology Introduction	– Different sale and marketing plans and techniques	81.5%	1.071
Information Availability	Selection	Amount of Required investment	– Lack of documentation especially financial reports – Lack of up-to-date information	69.2%	1.278
		Acceleration of Technological Learning	– Inactive R&D departments – Lack of technological documents	56.9%	1.561
		Increase of Value External Sources	– Limited communications with international companies and organizations	55.4%	1.649

comparative model regarding these approved changes. The proposed change of the capability/opportunity of the firm's technical knowledge base protection is ranked as the most agreeable indicator, followed by proposed changes of the number of technology applications and firm's relative strength to competitors' indicators. On the other hand, omitting the item of an increasing value of external sources from the model shown the least agreement, but its deviation was most significant. The interview data indicated that this was due to the different conditions of information documents in nano-composite companies.

6. Conclusions

The process of developing a comparative model is confined in some aspects such as the limited number of nano-composite companies, the lack of a ripe market for nano-composite products, and unknown aspects of nanotechnology-based industry. Therefore, the model can still remain under development. Nevertheless, a comparative model of technology strategy development for Iranian nano-composite companies is offered. It assures selection of an effective alternative in the process of technology strategy development, especially taking into consideration a selected high-technology industry in a specific developing country. We can conclude on some important points of this research in two sections: hints on nano-composite companies and Chiesa's model of technology strategy.

6.1. Hints on nano-composite companies

One of the most difficult problems of nano-composite companies was technical managers who didn't know about formulating the up-to-date technology strategies for high-tech industry, so the best solution for these companies can be instruction of their managers, especially company's top managers. This training should include both marketing management skills and strategic management capabilities for developing and implementing suitable strategies along with the company's success.

In addition, some of the model's indicators were omitted because of the lack of information and documents, while a greater volume of information can contribute to elaborating more accurate strategies for a company; therefore, if these companies invest in providing technological documents and information, they can obtain more success.

6.2. Hints on Chiesa's model of technology strategy

Chiesa's dynamic model of TSD has been adjusted in a way characterizing selected moderators subject to the analysis. The research explores how four moderators (Iran as a developing country, high-nanotechnology, nano-composite companies, and information availability) can change the fundamental model's indicators. It has been demonstrated how these moderators' effects can change or eliminate some model's indicators. Among the 22 indicators proposed to change, three were omitted and the rest were changed. These changes result from some important reasons such as resource limitations, high risk of high-tech products, the lack of a ripe market, the unpredictable market of high-tech products, a wide range of nano-composite applications, the lack of up-to-date information in nano-composite companies, product complexity, the lack of R&D sections in companies, the necessity of more investments, specific tools and equipped laboratories, the shorter products' life-cycle, the lack of standardization organizations, and higher marketing costs.

Finally, the studies presented here are preliminary. More research and more elaborate studies are needed in order to apply this comparative model practically in Iranian nano-composite companies and to examine this possibility in other nanotechnology-based companies. Of course, the application of the comparative model by other companies needs some revisions, especially in terms of the effects of the third key moderators- nano-composite companies.

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TECHNOLOGIJOS STRATEGIJOS VYSTYMO MODELIS IRANO NANOKOMPOZITŲ KOMPANIJOSE

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Santrauka

Pastaraisiais metais Irano Vyriausybė pabrėžė nanotechnologijomis pagrįstos pramonės plėtros svarbą, todėl labai daug Irano kompanijų pradėjo orientuotis į šią sritį, susikūrė naujų kompanijų, gaminančių nanokompozitų produktus. Technologijos strategija (TS) yra vienas svarbiausių bet kokios firmos strateginių aspektų, ypač dinamiškoje aplinkoje. Šiame straipsnyje bandoma sukurti dinaminį technologijos strategijos vystymo modelį Irano nanokompozitų kompanijoms. Straipsnyje atskleidžiami keturi pagrindiniai veiksniai (Iranas kaip besivystanti šalis, aukštoji nanotechnologija, nanokompozitų kompanijos, informacijos prieinamumas), kurie veikia Chiesa dinaminį technologijos strategijos vystymo modelį, ir tiria, kaip tie veiksniai daro įtaką dinaminio modelio rodikliams. Rezultatai rodo, kad 22 Chiesa modelio rodikliai buvo pakeisti.

Reikšminiai žodžiai: technologijos strategija, nanokompozitas, aukštųjų technologijų kompanijų strategija, besivystančios šalys, Iranas.

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