Investigating the role of firm resources and environmental variables in new product commercialization

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Abstract

Purpose – The purpose of this paper is to explain the role of firm resources and environmental variables for pursuing new product commercialization in high-tech markets.

Design/methodology/approach – The research design employed for the study consisted of both exploratory and descriptive phases. To begin with, a focused literature review was performed to develop a theoretical framework with seven research hypotheses, which was then empirically validated through a carefully executed survey conducted on the products managers of high tech firms.

Findings – The study results have supported six research hypotheses, *viz.* technology acquisition intent (TAI) to new product commercialization relationship, direct influence of dominant design, market heterogeneity, and network externalities on the firm's TAI relationship. The results of hierarchical regression analysis indicated that the "dominant design to TAI" and the "network externalities to TAI" relationships are significantly moderated by firm resources. However, the "market heterogeneity to TAI" relationship is found to be not moderated by firm resources.

Practical implications – Findings of the study have significant implications to extant product management theory and practice. The study highlights the most important environmental variables in high-tech markets that act as antecedents to a firm's TAI and the effect of TAI on new product commercialization. Further, the study reveals the differential effects of these antecedent variables across firms owing to the varying levels of resource availability.

Originality/value – The paper reports the significant outcomes of an important study on product management that attempted to establish the linkages across environmental variables, firm resources, and firm's technology strategy in pursuing the new product commercialization.

Keywords New product commercialization, Technology acquisition intent, Dominant design, Market heterogeneity, Network externalities, Firm resources, Resource based view of a firm, Resources, New products

Paper type Research paper

1. Introduction

High-tech industries are characterized by turbulent environment owing to dynamic customer needs, shorter technology life-cycles, and higher competitive intensity that together makes the existing product offering obsolete at much faster pace (Mohr, 2001; Saji and Jain, 2006). The window of opportunity for products and technologies is typically narrow in these industries, and firms are left with no choice but to rely on technological innovation and their transformation into successful new products for their survival and growth (Atuahene-Gima and Murray, 2007; Christensen *et al.*, 2008; Prahalad and Hamel, 1990). Firms respond to the environmental challenges of high-tech industry by indulging in continuous innovation and commercialization of new products. A typical high-tech firm spends about 10 to 20 per cent of its annual revenue in developing new products (Goyal and Menke, 2006); and the firm's market capitalization is predominantly influenced by the projected commercial success of new technologies (Sood and Tellis, 2009). Hence, technology selection for new product commercialization is termed as an important managerial decision in high tech firms (Krishnan and Bhattacharya, 2002; Morone, 1989; Clark, 1989).

Technology selection for pursuing the new product development process varies across firms and markets, and is being considered as an important decision to realize the strategic objectives of the firm (Dussauge *et al.*, 1992; Shehabuddeen *et al.*, 2006; Tushman and Rosenkopf, 1992). However, the emergence of wide array of technological options available today for NPD that a firm can exercise and the shrinking technology life cycles have increased the complexity of technology acquisition for new product development processes (Iansiti and West, 1997; Saji *et al.*, 2005). In case of new high-tech product development (hereafter referred to as NPD) process, complexity of technology selection is further augmented as these products function in conjunction with other complementary products as part of a network system, rather than as stand-alone products (Cohan, 1997). Therefore the network environment, in which a high-tech firm operates, exerts significant influence on managerial decisions like technology acquisition for NPD process.

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Journal of Product & Brand Management
22/1 (2013) 18–29

[DOI 10.1108/10610421311298641]

Market side view of technology evolution suggests that demand related factors motivate technological changes and the decision to acquire a new technology depends on customer driven standards, diversity in preferences, and benefits derived from the presence of other customers in the network (Adner and Levinthal, 2001; Cohen and Levinthal, 1990). Surprisingly, there is a dearth of empirical research that could have ascertained the influence of environmental variables on a firm's technology acquisition in the NPD process, which has been the primary motivation behind the present study. In order to address this critical research gap, a focused literature survey has been conducted to explore the relationships among the environmental variables, firm's technology acquisition intent (TAI), and its effect on NPD process. The literature review has lead to a comprehensive theoretical framework, which was then empirically tested by conducting a survey among the 215 high-tech firms. The results highlighted the variables that influence the firm's TAI and its effect on the NPD process.

2. Research problem and objectives

Cáñez *et al.* (2007) has recently reported the lack of extant literature that could address the need to link technology acquisition with the Stage-Gate system of NPD process in a structured manner. Although there are a few studies that have explored the influence of industry standards, network externalities and market structure on innovation, rarely any prior research has examined the strategic role of these extraneous variables on a firm's technology acquisition intent for pursuing the NPD process. Further, the extant organizational theory suggests that a firm's response to extraneous environment varies depending on its own contingencies and resources. Therefore, it has been decided to investigate the environmental variables that could influence a firm's TAI, and how this intent is related to the NPD process outcome in the context of high-tech industry. The specific objectives of the study include:

- to explore the possible relationships between extraneous environmental variables and a firm's TAI; and
- to understand the effect of TAI on the Stage-Gate system of NPD process.

In order to meet the objectives of the study, to start with, a focused literature review has been done that resulted in a theoretical framework, which is then taken for empirical validation through a carefully executed survey.

3. Theoretical framework and research hypotheses

In high-tech markets, the ability of a firm to develop new technologies and transform them as new differentiated products determines its market capitalization (Goyal and Menke, 2006). Prior researches have reported that the firms having their ability to introduce more new technologies in their new products succeed more than those who fail to do so (Nevens *et al.*, 1990; Saji and Nair, 2010). Typically NPD process necessitates acquisition and commercialization of new know-how through complex learning and relational skills (Eisenhardt and Martin, 2000). Successful firms acquire necessary know-how by optimal utilization of available internal and external resources to their favor (Smith *et al.*, 2005). Choice of the technology for NPD is influenced by organizational as well as environmental factors (Hemmert, 2004; Shehabuddeen *et al.*, 2006). At the beginning of competition, multiple technologies compete with each other and emergence of dominant design is considered as watershed event in high-tech markets (Tushman and Anderson, 1986; Dattee and Weil, 2007). Technologies that are considered as industry standards and more closely aligned to statutory norms are more readily accepted (Schilling, 2002). Prior studies have investigated the variation in demand of products in line with compatibility and availability of complementary products. The benefits derived by a customer from installed base can be an important determinant of technology selection and success of product in the market. In addition, variations in customer preferences have been attributed behind technological evolutions (Adner and Levinthal, 2001). However, according to the Resource Based View of the firm, the variation in firms' actions originates from the differences in their resources. The focused literature survey carried out has enabled us to identify the possible antecedents to a firm's TAI as well as their relationships with TAI and new product commercialization.

3.1 Technology acquisition intent (TAI)

Technology is the required know-how that together serves a functional need to the NPD setting (Das and Van De Ven, 2000). By deriving merits from this definition of technology, we define TAI as product development team's intent of making a new know-how fully available in place of a required or existing know-how prior to the prototype design stage in the NPD process. Being a technology-intensive process, the NPD necessiates bridging the knowledge gap so as to realize a new product. A firm has to first search, identify, and evaluate an alternative technology from available sources. Once the potentially useful technology is identified, the firm must attain that know-how from the source and modify it to suit the firm's internal environment (Saji and Jain, 2006). The technology should then be utilized so as to get transformed as specific product designs that constitute product innovation (Carlile, 2004; Smith *et al.*, 2005). Prior researches have asserted that in order to meet the performance requirements of product design in the NPD process, a relatively high level of technical creativity is required (Nieto and Quevedo, 2005; Nyström, 1985).

The ever increasing pace of technological development and widening availability of technological options from external sources have given more choices to acquire the required technologies for NPD and in turn contributed to higher rate of new technology acquisition during the NPD process (Iansiti and West, 1997). Technology can be acquired in two broad ways, namely:

1 internal development; and
2 external sourcing (Durrani *et al.*, 1998).

Either of these two basic routes of technology sourcing have several possible variations within themselves – for, e.g. technology transfer could take place in the form of licensing, joint venture, foreign direct investment, franchising etc. (Contractor, 1993). However, each mode of technology acquisition has its own advantages and limitations (Saji *et al.*, 2005). Technology inherits value from its source(s) and is not neutral in nature. Hence the acquisition of the technology requires thoughtful examination of its sources and careful preparedness of the organization that gets involved in the NPD process (Zhou and Wu, 2010).

3.2 Firm resources

Firm resources have been considered as one of most the important determinants of managerial action and widely investigated in relation to the firm's output (Acs and Audretsch, 1988; Dougherty and Hardy, 1996). There is a visible lack of consensus among researchers on what all constitute the firm resources. However mostly available slack tangible and intangible resources are said to constitute firm resources (Saji and Nair, 2010). According to the neoclassical view, firm resources are measured in terms of number of full-time year-round employees, land and financial assets (Hunt and Morgan, 1995).

Most of the prior studies in organizational theory and economics have asserted that the firms possessing slack resources are more likely to adopt innovations earlier than those with lack of resources (Ettlie and Rubenstein, 1987; Damanpour, 1991; Lee and Grewal, 2004). Access to slack resources provides flexibility to firms for investing in riskier projects. On the other hand, smaller firms even struggle to provide resources for their on-going projects. It is argued that the large firms develop deep expertise in handling innovations from their past purchase experience, larger base of technological expertise, and greater product knowledge (Dholakia *et al.*, 1993; Saji and Jain, 2006). It is also easier for larger firms to access financial and human resources owing to their favourable reputation. The large firms are better off with the availability of excess resources, which they can comfortably invest in new technologies (Lee and Grewal, 2004). In order to fuel their growth and hold their dominant positions in respective markets, larger size firms are more likely to incorporate new technologies in place of existing ones during the NPD process compared to smaller firms.

3.3 Dominant design

Dominant design is defined as design standards inherent to the industry evolved in line with the customer voice external to the firm, and considered to be an important concept related to innovation and NPD (Anderson and Tushman, 1990; Suárez and Utterback, 1995). Technologies that are accepted as dominant standards in their respective markets generate large profits; and the firms failing to invest in dominant designs bear severe economic losses and may even go out of business as well (Murmann and Frenken, 2006). Therefore firms compete among themselves to establish their architecture as dominant design in the product category to differentiate their products. Emergence of dominant design is the process by which products in a market converge on a design, or standards ensuring that all products are interoperable, or compatible (Koski and Kretschmer, 2004). The standardization could be market driven or design gets established by formal or coordinated efforts of stakeholders from the industry. According to Koski and Kretschmer (2007), the design may then be determined either by public bodies (e.g. by government bodies or regulators) or collaboratively within standardization consortia usually comprising of experts from standards organizations and industry participants.

Evolution of dominant design in a market changes the focus of firms from product innovation to process innovation until another disruption (Abernathy, 1978; Abernathy and Utterback, 1978). Prior research in both design theory and evolutionary biology suggests that the highly standardized components of a complex system are difficult to change successfully (Murmann and Frenken, 2006). Thus firms introduce their products based on technologies that have been accepted as industry standard or the one that are believed to emerge as dominant standard in future in place of the existing technology. Firms will exhibit greater tendency to align themselves in line with the accepted industry standard and customer voice by acquiring technologies that are considered to be of dominant design type. Further, after the emergence of dominant design, competition shifts from architectural technologies to numerous component technologies (Anderson and Tushman, 1990). Performance of technology on key parameters improves faster than before after the emergence of dominant design (Sood and Tellis, 2005). Reduced uncertainty about architectural design stimulates technological innovations at component level to improve performance (Christensen *et al.*, 1998). This should further increase the rate of technology acquisition in the NPD process. Hence:

H1. Emergence of dominant design increases a firm's technology acquisition intent.

Higher levels of uncertainty and volatility in high-tech markets reduce the larger resourced firm's willingness to invest in new technologies (Burns and Stalker, 1961; Warner and Caliskan-Demirag, 2011). This is because new technologies remains unattractive to large investment as it is difficult for them to qualify on standard practices of financial evaluation of new investment (Leiblein and Madsen, 2009). Therefore in the absence of dominant standards, these firms abstain from acquiring new technologies for NPD. Hence:

H2. In the presence of dominant design, the firms with larger resources will exhibit greater propensity to acquire a new technology, compared to firms with fewer resources.

3.4 Market heterogeneity

A wide spread notion among marketing scholars is that demand is not homogeneous and varies within a market because of differences among individual consumers leading to market segments (Smith, 1956). The presence of this inherent heterogeneity in the market has far reaching implications for a firm's marketing strategy (Sheth, 2011). Market heterogeneity has also been attributed to the motivation behind continuous technology evolution (Adner and Levinthal, 2001). Smith (1956) defines market heterogeneity as differences in customer preference structure and the relative value placed on different product attributes by the customer. Besides this, customers may also differ in their desired performance level on these preference structures, willingness to pay for products, and access to the products for satisfying their needs (Sheth, 2011). Therefore customer's net utility is a function of their preference structure, performance level of product attributes, relative value placed on different product attributes, and price (Adner and Levinthal, 2001). Variation in any of these factors cause differing net utility derived by consumers from the same product. Differences in utility perceived by consumers for the same product lead to a heterogeneous market with different segments and niches.

Market heterogeneity also offers an alternative explanation to the supply side depiction of technology evolution, which is based on notions of investment risk, appropriability regimes, and declining opportunity to innovation (Abernathy and

Utterback, 1978; Utterback, 1994). In a contrasting view to that of sociologists', the common assumption in economics is that the technological developments are endogenous outcome of market dynamics. Technology evolution proceeds with a close interaction between technological development and demand environment in which technology is ultimately evaluated (Adner and Levinthal, 2001). Variation in selection criteria among customers in a market lead to heterogeneity in demand. Serving such heterogeneous market-needs with single product technology is limited by technological developments. Also, variation in the requirements of different market segments can better be served with customization in functionality and attributes by incorporating technologies that suit the specific requirements of targeted segments. According to the market based view of technology evolution, heterogeneous demand is the primary motivation behind development of different technologies (Adner and Levinthal, 2001). Therefore heterogeneity in market motivates firms to incorporate new product technologies to suit targeted customers and increases the chances of technology substitution. Hence:

H3. Increasing market heterogeneity increases a firm's technology acquisition intent.

In general, firms with large resources have presence in multiple markets and serve relatively larger customer base (Samiee and Walters, 1990; Šuštar, 2005). Larges resources allow the firms to invest in multiple projects and acquire new technologies, which the firms can utilize to develop products for serving various market segments. This is not possible for firms with resource constraints, which remain focused to specific market segments (Scherer, 1965). Hence:

H4. Firms possessing large resources will exhibit greater propensity to acquire new technology as market heterogeneity increases, compared to firms with fewer resources.

3.5 Network externalities

Network externalities is said to exist in those product categories wherein the perceived customer utility of a product depends not only on its attributes, but also on the installed customer base of product, compatibility with complementary products, and availability of these complementary products (Varian, 1992; Basu *et al.*, 2003; Song *et al.*, 2009). In these products, the utility that a user derives from the consumption of a good increases (or decreases) with the number of other users consuming the good depending on the nature of network externalities (Katz and Shapiro, 1985). Often it is observed that large installed customer base can influence an innovation's perceived value by stimulating the availability of complementary products and services (Song *et al.*, 2009). In addition, large customer base and compatibility with complementary products signal the ease with which information and usage about the product can be obtained from the installed customer base (Shurmer, 1993; Westland, 1992). All in all, the dissemination of information and learning about products depend heavily on the physical and virtual networks of installed customer base. Therefore, larger installed customer bases reduce customer's perceived financial and psychological risks as number of adopters signifies their trust in product quality. This effect may assume significant value in the presence of competing technologies, and thus favour the one with larger installed base (Katz and Shapiro, 1985).

Prior research has stressed the importance of network effects in the context of high-tech products as a determinant of firm's technology strategy (Farrell and Saloner, 1986; Katz and Shapiro, 1986). Firms incorporate and commercialize those technologies in their new products for which they expect the market to grow in future and garner large installed base (Frels, 1999; Padmanabhan *et al.*, 1997). High-tech products are part of a system, consisting of different components that are inter-dependent and integrated to function together as a unit. Fundamental changes, like new technology acquisition in the presence of such interdependencies, are possible only when there are clear and significant economic incentives to the firm adopting the change (Majumdar and Venkataraman, 1998). The ability to exploit increasing returns is a primary economic incentive for firms to adopt new technologies in network industries (Arthur, 1996). As the size of installed base grows larger, the initial technological and administrative cost of technology acquisition can be spread over a large installed base (Antonelli, 1992; Arthur, 1996). Hence unit cost of acquisition remains low and promotes technology acquisition (Majumdar and Venkataraman, 1998). Hence:

H5. Higher network externalities increases a firm's technology acquisition intent.

Firms, possessing large resources, can only reap the benefits derived from large installed bases of customers. Serving a large market or multiple market segments or combination of both will require proportionately higher amount of resources from a firm, which a resource constrained firm can not typically commit. Also, firms having presence in multiple markets and large product line can appropriate the investment in technology by its application in more than one market or multiple products. Hence:

H6. Firms possessing large resources will exhibit greater propensity to acquire new technology as network externalities increases, compared to firms with fewer resources.

3.6 New product commercialization

New product commercialization can be considered as the culmination of the NPD process wherein the product is introduced to the target market(s). During commercialization, firm develops a marketing plan, determines how the product will be supplied to the market, and anticipates barriers to its success (Hultink *et al.*, 1997). It consists of several important activities such as deciding the timeliness of the product introduction, the locations where the product should be introduced, the market segments to be targeted, promotional strategies for the product introduction, and the budget preparation. New product commercialization demands significant amount of firm's resources and top management commitment for its success (Urban and Hauser, 1993). Firms that can commercialize new products at the early stages of technology life cycle reap higher financial benefits; while launching distinctive new products do provide the firm the capability of expanding to new markets or penetrating in existing market (Nevens *et al.*, 1990; Sood and Tellis, 2011; Yoon and Lilien, 1985). The outcome of such commercialization will make possible new streams of revenue

or market power, which would lead to superior firm performance. In other words, increasing new product commercialization could help the firm to meet its strategic objectives, which in turn could improve the firm performance.

Existing technologies often fall short of fulfilling desired product design requirements to achieve highly competitive new high-tech products (Krishnan and Bhattacharya, 2002). The extant literature attributes this to dynamic customer needs and intense competition, which always make the firm follow upward trajectory on performance parameters (Bhattacharya *et al.*, 1998; Mohr, 2001). This is why much of the NPD is new technology based and allows the NPD project teams to meet specified design requirements by addressing all technology acquisition issues (Nyström, 1985). Nevens *et al.* (1990) have reported that the firms introducing higher number of new technologies in their NPD projects tend to be more successful in their new product commercialization efforts. Hence:

H7. Firm's increasing technology acquisition propensity enhances the success of new product commercialization.

By leveraging on the outcome of the focused review of extant literature, we propose a theoretical framework (Figure 1) depicting the relationships among the research variables that influence a firm's TAI, and the possible positive effect of firm's TAI on new product commercialization.

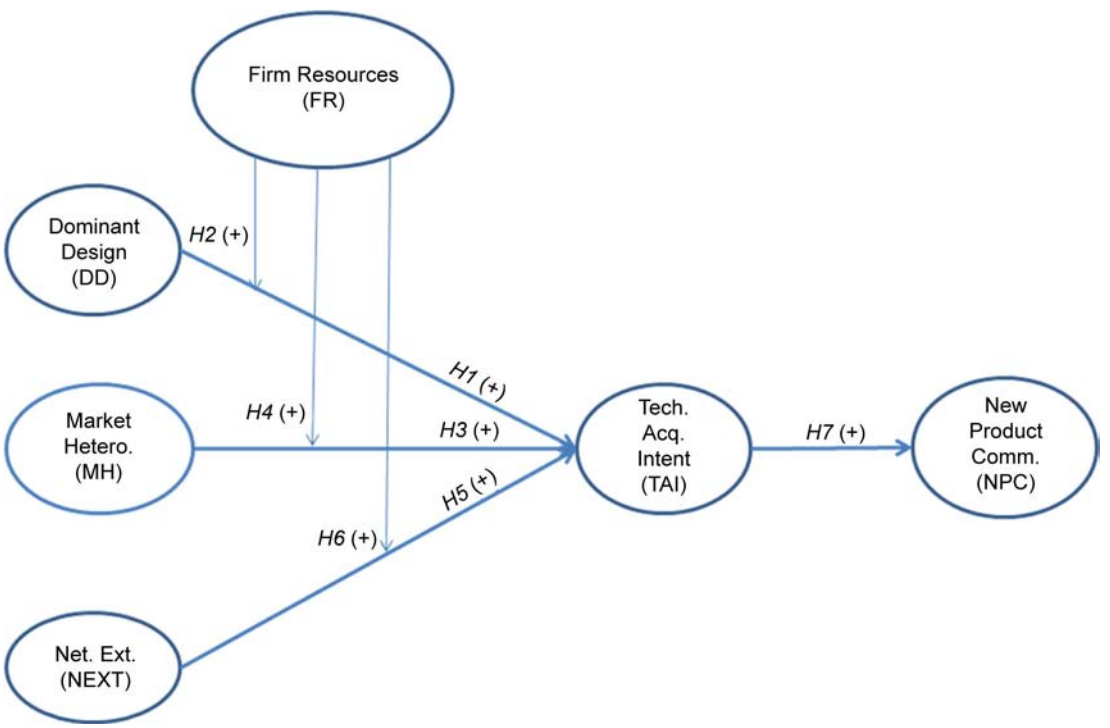
4. Research methodology

4.1 Sample and data collection

The theoretical framework evolved through the literature review has been taken for empirical testing. Survey method has been employed for the data collection purpose. Using a structured questionnaire, the responses to the suvey were collected from the product managers of high-tech firms spread across the globe. The sampling frame employed for the study consists of all the members of a professional networking community of high-tech product marketing firms. E-mails was sent to all the 1,729 community members with request to participate in our survey with an assurance to share the summary of research findings on completion of our study. A soft copy of the questionnaire was sent, set in MS Word format, along with a request to the members to participate in the survey. We received 477 positive reply e-mails from the members informing us about their acceptance to participate in our survey. All these 477 members were again sent the same MS Word formatted, pre-tested research questionnaire along with an internet link to directly participate in the online survey. Finally, we received 223 responses, a response rate of 12.89 per cent. A relatively low response rate in online survey method has been attributed to deletion of request even without reading (Dillman, 2000). After removing the missing data responses, we had 215 usable responses for data analysis.

The final sample constituted a diverse group of firms in terms of representation from different high-tech industry segments with median annual sales turnover of US$ 198.4 million, firm age of 23 years, and a median number of full time employee base of 1,000. Among the 215 usable responses, 110 were from North America, 68 from Asia, 34 from Europe, two from Africa and one from South America. In order to test for non-response bias, the differences between the firm characteristics of our respondents and non-respondents were examined. The resuts of two-independent-samples *t*-test showed no significant differences ($p < 0.05$) between the two groups based on the annual sales turnover, age of the firms, and number of full-time employees,

Figure 1 Theoretical framework



indicating that differences among respondents were not related to non-response bias.

4.2 Measures of study constructs

The construct measurements were done using five-point multi-item Likert-scales for all the six research variables of the present study. Though some items were developed specifically for this study, other measurement items were adapted from existing scales. The items specific to the context of the study were generated by resorting to the focused literature survey and in-depth interviews with academics and practitioners (Churchill, 1979). The resulting list of items that are employed for the present study are provided in the Appendix. Wherever existing scale was taken to develop the items, the same was modified in line with the operational definitions of the constructs used for the study. For meauring the dependent variable, new product commercialization (NPC), the required scale is developed by following Beard and Easingwood (1996) and Hartman and Lakatos (1998), which contains five items. TAI had four items, of which two items measure the newness of know-how (developed by following Das and Van De Ven (2000) and the remaining two measure the firm's propensity to acquire know-how for NPD (developed by following Johnson and Bhatia, 1997). Among independent variables, dominant design (DD) has a four-item scale developed by following Sahay (1996), Abernathy (1978), and Koski and Kretschmer (2007). Market heterogeneity (MH) has a three-item scale developed from Adner (1998); and network externalities (NEXT) has four items developed from Lee (1999) and Frels (1999). Firm resources (FR) has a three-item scale developed from Hunt and Morgan (1995). The descriptive statistics of measures used in the questionnaire are given in Table I.

4.3 Validation of measures

The measurement model is tested prior to examining structural model relationships as a two-step approach recommended by Anderson and Gerbing (1988). The confirmatory factor analysis (CFA) was performed in AMOS 7.0 to examine the reliability and validity of our constructs. The CFA results (given in Table II) indicate that measurement model showing an acceptable level of fit with a goodness of fit (GFI), incremental fit index (IFI), and comparative fit index (CFI) values of 0.87, 0.91 and 0.91 respectively. The root mean square error of approximation (RMSEA) of 0.066 and chi-square index of 1.91 ($p < 0.000$) show an acceptable level of measurement model fit.

Table I Correlation matrix and descriptive statistics of measures

	RTD	TST	FR	DD	MHT	NEXT
RTD	1					
TST	0.70**	1				
FR	0.09	0.16*	1			
DD	0.21**	0.27**	0.07	1		
MHT	0.04	0.20**	0.03	0.05	1	
NEXT	0.16*	0.23**	0.04	0.13	−0.01	1
Mean	3.64	3.85	3.63	3.48	3.73	3.83
Std. Dev.	0.71	0.77	1.11	0.80	0.90	0.78

Notes: *Correlation is significant at the 0.05 level; ** Correlation is significant at the 0.01 level

For examining the internal consistency of developed measures, composite reliability and coefficient of alpha values are computed. Composite reliability was measured from CFA results by following Hair *et al.* (2006) formula. The coeffiecient of alpha was measured in SPSS 16.0. For all the six research variables, the value of composite reliability and coefficient of alpha values were more than the recommended limit of 0.7, which suggests that the measures used are internally consistent (Nunnally, 1978).

In order to test the convergent validity, the CFA results are examined to find whether the path coefficients from latent constructs to their corresponding manifest indicators are statistically significant or not. Results have shown that all items loaded significantly ($p < 0.000$) on their respective constructs with no cross-loadings. These results confirm the acceptable convergent validity of the measures of constructs.

Discriminant validity between the constructs (all independent, mediator, moderator and dependent variables) was examined by performing chi-square difference tests between a model in which correlation between the two variables was a priori fixed at 1.0 and the original (unrestricted) confirmatory factor analysis model (Anderson and Gerbing, 1988). When we compared the original unrestricted model with every restricted model, all the cases have shown a significantly poorer fit (i.e. $\Delta\chi 2\ (1) > 3.84$) and thus indicating acceptable discriminant validity of constructs.

5. Analysis and results

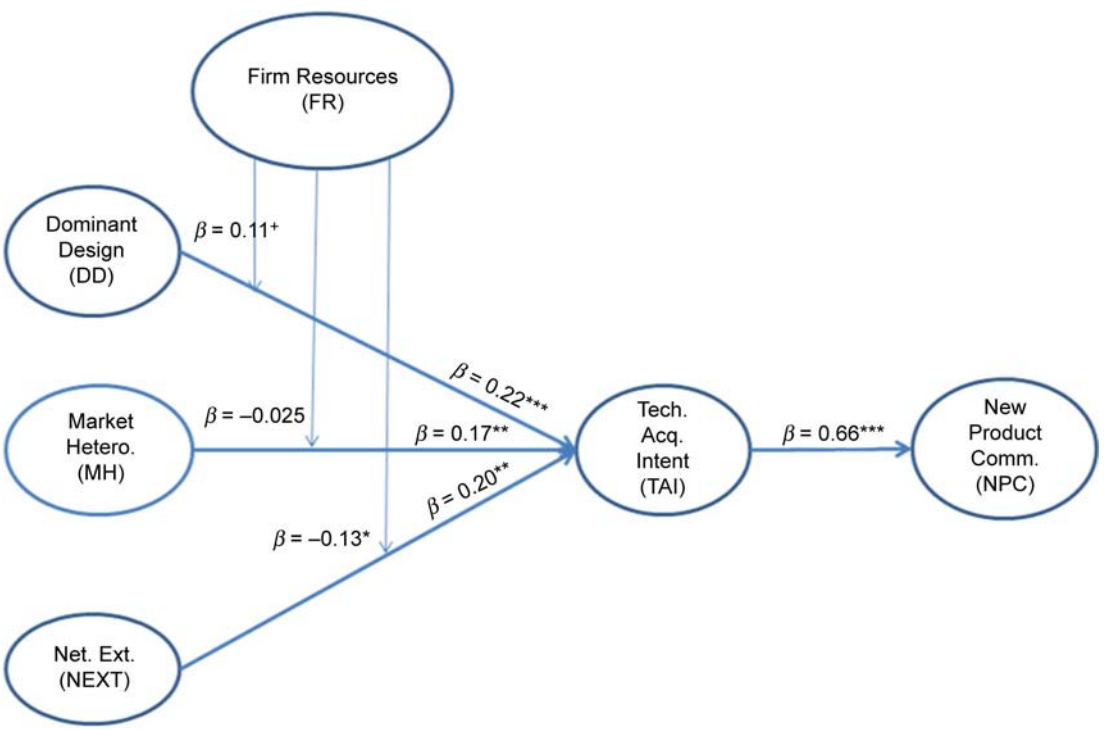
In this study, unit of analysis fixed is a recent New high-tech product development project. In order to validate the theoretical framework, path analysis and hierarchical regression analysis are perfomed to test the structural model and moderating effect of the firm resources. The results of the analysis and research model are given in Figure 2. Path analysis was performed to examine the relationship between independent variables, mediator variable and dependent variable. The output of path analysis (Table III) showed a good fit of the tested model (GFI = 0.99, CFI = 0.99, IFI = 0.99, RMSEA = 0.02, and $\Delta\chi 2/\mathrm{n} = 1.08$). Examination of individual hypotheses suggest that *H7* ($\beta = 0.66$, $t = 13.46$, $p < 0.000$) i.e. TAI to new product commercialization relationship, *H1* ($\beta = 0.22$, $t = 3.60$, $p < 0.000$) i.e. Dominant design to TAI, *H3* ($\beta = 0.17$, $t = 3.02$, $p < 0.00$) i.e. positive influence of market heterogeneity on firm's TAI, and *H5* ($\beta = 0.20$, $t = 3.14$, $p < 0.00$) i.e. network externalities to TAI are supported by the study results. Also, further examination of indirect effects of the independent variables revealed that effect of dominant design and network externalities on new product commercialization are found to be insignificant, indicating full mediating role of TAI in these relationships. However, market heterogeneity to new product commercialization relationship ($\beta = -0.08$, $t = -2.27$, $p < 0.05$) is also significant, and hence TAI only partially mediates the same relationship.

For testing the moderating effects of firm resources on the relationships between dominant deisgn and TAI, market heterogeneity and TAI, and network externalities and TAI, we performed a hierarchical moderated regression analysis. We mean-centered the independent and moderator variables before creating the interaction terms (Aiken and West, 1991). All the variables have VIF close to unity and Durbin-Watson

Table II Measures validation and reliability

				CFA ($\chi 2 = 414.24$, df = 215, $p = 0.000$; RMSEA = 0.066; GFI = .87; IFI = 0.91, CFI = 0.91)				
Variable	**Indicator**	**Mean**	**Std. Dev.**	**Factor loading**	***p*-value**	**Composite Reliability**	**AVE**	**Cronbach-Alpha**
NPC	NPC1	4.00	0.71	0.42	0.000	0.83	0.50	0.80
	NPC2	3.53	0.90	0.94	0.000			
	NPC3	3.65	1.06	0.55	0.000			
	NPC4	3.34	1.07	0.78	0.000			
	NPC5	3.70	0.99	0.76	0.000			
TAI	TAI1	4.02	0.97	0.77	0.000	0.80	0.51	0.80
	TAI2	4.10	0.88	0.71	0.000			
	TAI3	3.75	1.06	0.69	0.000			
	TAI4	3.51	0.98	0.68	0.000			
FR	FSZ1	3.63	1.25	0.88	0.000	0.90	0.74	0.90
	FSZ2	3.56	1.23	0.83	0.000			
	FSZ3	3.70	1.21	0.88	0.000			
DD	DD1	3.45	1.13	0.63	0.000	0.92	0.71	0.80
	DD2	3.52	1.06	0.66	0.000			
	DD3	3.58	1.01	0.72	0.000			
	DD4	3.37	0.82	0.89	0.000			
MH	MH1	3.71	1.02	0.81	0.000	0.82	0.61	0.83
	MH2	3.61	1.08	0.91	0.000			
	MH3	3.85	1.01	0.64	0.000			
NEXT	NEXT1	3.46	1.06	0.68	0.000	0.81	0.52	0.81
	NEXT2	3.77	1.01	0.79	0.000			
	NEXT3	4.16	0.87	0.69	0.000			
	NEXT4	3.94	0.99	0.71	0.000			

Figure 2 Research model



Note: Significance level: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$

Table III Results of path analysis

Hypothesis	Path Predictor → Criterion	Unstandardized estimates	*t*-value	*p*	Result
H1	DD → TAI	0.22***	3.60	0.000	Accepted
	DD → NPC	0.03	0.6	0.55	
H3	MH → TAI	0.17**	3.02	0.002	Accepted
	MH → NPC	−0.08*	−2.27	0.02	
H5	NEXT → TAI	0.20**	3.14	0.002	Accepted
	NEXT → NPC	−0.00	−0.07	0.95	
H7	TAI → NPC	0.66***	3.60	0.000	Accepted

Notes: Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; Fit statistics: $\chi 2 = 1.08$, df = 1, $p = 0.000$; RMSEA = 0.02; GFI = 0.99; IFI = 0.99, CFI = 0.99

static close to 2 (d = 1.85) indicating that multicollinearity is not a problem. The result of hierarchial regression (Table IV) indicates that the addition of the interaction variables adds 3.00 per cent ($\Delta F = 2.13$, $p = 0.097$) to the explained variance in TAI. Examination of individual interaction term reveals that results support *H2* ($\beta = -0.11$, $p = 0.094$) i.e. dominant design to TAI relationship, and *H6* ($\beta = -0.13$, $p = 0.04$) i.e. network externalities to TAI relationship, indicating that these relationships are significantly moderated by firm resources. However, *H4* ($\beta = -0.02$, $p = 0.696$ n.s.) is not supported, i.e. market heterogeneity to TAI relationship is not moderated by firm resources. Interestingly, the sign of regression coefficient is negative in case of firm resources moderating the network externalities to TAI relationship.

6. Discussion and implications

Conceding the presence of pervasive technological and market turbulence in high-tech markets, prior researches have emphasized the importance of renewal of firm's existing know-how by acquiring new know-hows in order to continuously develop and introduce successful innovative products. However, our literature review highlighted scarcity of empirical research investigating the influece of environmental factors on the firm's TAI and the role of firm resources on these relationships. Addressing this critical research gap was the primary motivation behind the present study; and our focused literature review resulted in a well defined theoretical framework, which we tested empirically to ascertain the relationships of environmental variables on the firm's TAI.

Findings emanated out of the present study confirmed the hypothesized mediation of TAI between environment variables (namely, dominant design, market heterogeneity, and network externalities) and new product commercialization. The study results also confirmed that the roles of the three environmental variables (dominant design, market heterogeneity and network externalities) as antecedents to a firm's TAI. It can be infered from here that as dominant standards evolves in the industry, the firm's propensity to acquire the new technology increases. The increased propensity can also be attributed to the shift of technological development from architectural level to component level, and thus increases the chances of new technolgy acquisition as dominant design emerges (Sood and Tellis, 2005). The confirmation of relationship between

Table IV Results of hierarchical regression

Independent variables		TAI (TAI) Model 1 Standardized β	Model 2 Standardized β	Model 3 Standardized β
Main effects	Dominant design (DD)	0.23****	0.22***	0.22***
	Market heterogeneity (MH)	0.19****	0.19***	0.21***
	Network externality (NEXT)	0.20****	0.20***	0.18***
Moderator	Firm resources (FR)		0.13***	0.13**
Interaction terms	Dominant design x Firm resources (DD x FR)			0.11*
	Market heterogeneity x Firm resources (MH*FR)			−0.025
	Network externality x Firm resources (NEXT x FR)			−0.13**
R^2		0.15	0.16	0.19
Adjusted R^2		0.13	0.15	0.16
F		12.01****	10.17****	6.82****
ΔR^2		0.15	0.01	0.03
Partial *F*			4.11**	2.13*

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

market heterogeneity and firm's TAI suggest that the presence of diversity in customer demand promotes the acquisition of new technologies that can fulfill customer requirements, which is not possible by existing technologies. Support for the influence of network externalities on TAI suggest that the expected large installed base reduces the unit cost of new technology acquisition and makes acquisition more attractive option to a firm.

The moderation by firm resources on dominant design to TAI relationship suggests that the firm with higher resources prefer to wait until clear signal about dominant design emerges. In addition, the negative moderating effect of firm resources on network externalities to TAI relationship confirms that the availability of higher resources decreases the intent to acquire new technologies due to larger installed base. This could be because with large resources, firms possess the adequate strengths to afford higher technological investment that may not be posssible with a resource constraint firm. Further, no influece of firm resources on market herterogeneity to TAI relationship indicates that irrespective of firm resources, firms are compelled to acquire new technologies when heterogeneity in demand exists in the market.

7. Limitations and future research directions

By resorting to the resource based view of the firm, the present study has only investigated the influence of environmental variables and firm reseources on the firm's TAI. One important limitation of the study, therefore, could be the limited number of antecedent variables that have been considered for the present study, which could certainly be addressed by bringing in more feasible organizational variables as part of an improvised theoretical framework. Further, the sample drawn is generic in nature, and from across different high-tech industry sectors. There could be striking differences among the various high-tech industry sectors (for, e.g. in terms of technology life cycle). Also, the overall sample size used for the present study is bare minimum to perform the structural equation modeling. The future researches could therefore be thought of with specific reference to specific high-tech industry sectors with relatively larger sample size. Another important limitation of this study is the generic limitations associated with survey based methodology *viz*. internal validity, and the difference in self-reported NPD practices from the actual practices. Future researchers can utilize other research methods such as life cased-based research and experimental design to validate the findings of our study.

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Appendix. List of items employed

1 New product commercialization:
- product goals confirmed;
- technical capability demonstrated;
- new product adoption;
- residual problems addressed; and
- product life-cycle management.

2 Dominant design:
- technology standards;
- competing standards;
- industry standards; and
- institutional standards.

3 Technology acquisition intent:
- newness of know-how to the firm;
- newness of artifacts to the firm;
- perceived economic value and wealth; and
- perceived organizational value.

4 Market heterogeneity:
- preferred attributes structure;
- performance level; and
- willingness to pay.

5 Firm resources:
- number of full time employees;
- physical assets; and
- financial resources.

6 Network externalities:
- present size;
- compatibility;
- quality of network members; and
- accessibility.

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