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Key Success Factors of Innovation Projects of Vegetable Breeding Companies in China

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Abstract

The vegetable breeding industry is generally recognized as an innovation-driven industry. However, innovation is costly, time-consuming and uncertain. This study aims to identify the key success factors of innovation project performance of vegetable breeding companies (VBCs) in China. Based on empirical data that was collected from 53 innovation projects in 38 VBCs, it was found that integrative capabilities play an important role in the novelty and newness of the innovation to enhance product potential (superiority) and also in improving functional capabilities and in gaining market potential. Furthermore, market competition is a positive factor for inspiring innovation in the breeding industry.

Keywords: Key success factors, integrative capabilities, innovation project performance, vegetable breeding companies, China

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Introduction

As agricultural inputs, such as arable land, labor, fertilizer, crop protection, and irrigation grow increasingly scarce or more expensive, continuous improvements in crop production are expected in the quality of varieties used. This requires continuous innovation in the plant breeding industry in order to meet the challenges of food production and consumption through the development of new varieties with higher yields, resistance to biotic stresses, tolerance to abiotic stresses and better quality. This is especially true for the vegetable breeding industry in a country like China, which accounts for nearly half of the world's vegetable production and consumption, yet its average yield is 1/3 lower than in western European countries (FAO 2012). Vegetable breeding companies (VBCs) in China are embedded in a competitive environment and this industry has been experiencing restructuring since 2001. Old companies have merged and new players have entered the market. Companies from various backgrounds such as traditional seed companies, vegetable research institutes, foreign seed companies, new biotechnology and agrochemical companies, food processors and wholesalers/retailers now compete and/or collaborate in supplying seed to the market. Their performance is increasingly dependent on continuous improvement of breeding processes and the fast introduction of innovative products (new varieties). The vegetable breeding industry is recognized as an innovation-driven industry, which invests intensively in research and development (R&D). It requires large financial resources to apply innovative technologies for the development of new varieties (Dons and Bino 2008).

In a survey conducted by the American Management Association (AMA) (Jamrog 2006), innovation was identified by more than 90% of 1,400 top executives from large-multinational companies as important to a company's long-term survival. However, innovation is also costly, risky, time-consuming and uncertain. For example, Cooper and Edgett (2009) found that 44% of all innovation projects fail to achieve their profit target, only one out of seven concepts for new products becomes a new product winner and half of all new product launches are late to market. In our research on the vegetable breeding industry, senior managers of all prospector companies indicated that innovation is essential to their business. They set up strategies to fight for product leadership, position the R&D department as the core functional unit, and organize the R&D activities on innovation project base. The duration of innovation projects in the breeding sector is long, it takes about 6-8 years to develop a new variety and this might even be longer for specific crops. The new variety needs to combine good traits to ensure optimal performance under a variety of conditions including: resistance against pests and diseases, tolerance to extreme climate conditions such as drought, flood, salty conditions, etc. and; catering to consumers' demand for better taste, improved nutrition and longer shelf time. In China, for instance, the plant breeding industry has to innovate quickly in response to the changing Chinese customer demands, which are highly affected by changing lifestyles. In addition, crop production can be highly influenced by the unpredictability of nature, such as the frequency and intensity of extreme weather events (de'Donato and Michelozzi 2014).

Previous studies of innovation in the seed industry were either about seed policies or the seed business in general. These were studies about intellectual property rights (Srinivasan 2004; Lence et al. 2005; Louwaars et al. 2005; Dons and Louwaars 2009; Hu et al. 2009; Moschini

2010), the impact of seed industry concentration (Schimmelpfennig et al. 2004; Howard 2009; Schenkelaars et al. 2011), production, trade and related institutions (Kamphuis 2005), entrepreneurial processes (Kumar and Ali 2010), industry structure (Huang et al. 2001; Gadwal 2003), marketing (Larson and Mbowa 2004), and the supply chain (Burer et al. 2008). However, few studies focused on the innovation project level. In this research, we aim to find the key success factors and mechanisms that affect innovation project performance in the vegetable breeding industry, using empirical data from on-going R&D projects of VBCs in China.

The next section provides an overview of the theoretical background and conceptual framework. It addresses definitions and previous research conducted on innovation and innovation management. Key success factors in previous innovation projects are reviewed. A conceptual framework and hypotheses concerning the relationship between innovation-related factors, integrative capabilities, organizational capabilities, innovation potential and project performance are introduced. The methodology section describes the method of data collection, the measurements, as well as the method of analysis. In the results section, the results based on PLS modelling are presented, and discussed again in the last section with general conclusions and managerial recommendations for the vegetable breeding industry in China.

Theoretical Background

Innovation

Innovation is highly recognized as one of the major drivers of business success and economic development in the knowledge-driven economy nowadays. Researchers have found that innovation makes a significant contribution to economic growth, as it is the basis for increasing productivity, both through incremental improvements and breakthrough change (Pavitt 1969). Innovation is also widely recognized as playing a central role in creating value and sustaining competitive advantage (Jamrog 2006).The concept of innovation was initially defined by the economist Schumpeter as a process of creative destruction, where the quest for profits pushes innovation by constantly breaking old rules to establish new ones (1934). It implies introduction of new products, new processes, the opening of new markets or the introduction of new organizational forms. Since then, innovation is of interest to researchers and practitioners across a range of business and management disciplines. Based on the review of 60 definitions of innovation collected from the various disciplinary literatures, a generic definition of innovation, given by (Baregheh et al. 2009), is "*the multi-stage process whereby organizations transform ideas into new or improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace*".

Innovation Project Management

Management of innovations projects is challenging, as innovation is a broad-ranging, complex and difficult issue. Starting with the SAPHHO study (Rothwell 1972) and Cooper's pivotal work developing the NewProd assessment tool (Cooper 1979; Cooper and Kleinschmidt 1987; Cooper 1999), numerous empirical studies have been conducted in order to disclose the key success factors of innovation projects. Various groups can be recognized within these studies. One group focused on factors related to planning and execution of the innovation process, such as select the right project, clearly define the role of the project, organize true cross-functional projects teams, build tough go/kill decision points into process, etc. (Cooper 1978; Cooper and Kleinschmidt 1987; Johne and Snelson 1988). Another group of studies focused on in-depth aspects of information-processing, such as communication, knowledge sharing, selection of new ideas, etc. (Cooper 1999; Lievens and Moenaert 2000; Fortuin et al. 2007; Aramburu and Saenz 2010; Oke and Idiagbon-Oke 2010; Tranekjer and Søndergaard 2013). The third group focused on tangible resources, such as physical and finance assets, and intangible resources, such as human capital and reputation, as strengths from which the company distinguishes itself from competitors and ensures its competitive advantage (Grant 1991; Balachandra and Friar 1997; Barney et al. 2001; Belout and Gauvreau 2004; Blindenbach-Driessen and van den Ende 2006; Lu and Yuan 2010). From resource-based view, both resources and capabilities to develop resources are important, because innovation requires creative and innovative re-combination of resources and skills (Grant 1991; Teece et al. 1997) to develop superior new products and introduce them quicker in the market. The different groups of studies aligned to the research results from Harmancioglu et al. (2009) suggest that successful management of innovation projects is often related either to the proficiency of the project execution or to the fit between the resources and capabilities with the requirements of the project.

Based on these studies, Tepic et al. (2013) summarized the factors that influence innovation performance into three categories:1) innovation-related factors, i.e. product novelty and newness of innovation project to the company; 2) organizational capabilities, including functional capabilities that are related to specific knowledge of the different functional units of the company, e.g. R&D, manufacturing, marketing, distribution, sales and financing, etc., and integrative capabilities that refer to communication, team interaction, knowledge sharing; and 3) innovation potential (i.e. product and market potential).

Innovativeness and Newness

Innovation can vary from incremental innovations, which reproduce existing products with marginal improvements to current practice (Amasona et al. 2006), to radical innovations, which are completely novel and totally different from existing practices. Innovativeness and newness are two dimensions that both affect management and outcome of innovation projects, because these two aspects are considered as uncertainty enhancing factors in innovation processes (Tepic et al. 2013). Innovativeness is positively linked to product advantage, which refers to customer-perceived superiority (quality, benefit, functionality) and has been noted as a strategic factor that drives new product performance (Montoya-Weiss and Calantone 1994, Subramanian and Nilakanta 1996, Zhou 2006).

Innovation newness to the company is determined by the extent to which the customers, competitors, customer needs, market, product are new to the company (Danneels and Kleinschmidtb 2001). Although newness of an innovation might enhance product potential (superiority), it could also have a negative effect on the innovation process itself. Speed of market introduction could be decreased because of the task-related uncertainty and high complexity. Or there could be inadequate functional capabilities at hand to execute innovative projects that are new to a company (Cooper and Kleinschmidt 1987).

Functional Capabilities and Integrative Capabilities

From the resource-based view of innovation management, adequate resources and the capabilities to develop those resources are important. Innovation requires a creative and innovative re-combination of resources and skills to develop superior new products and introduce them quickly into the market (Grant 1991; Teece et al. 1997). Two capabilities are considered especially important within the context of innovation (Tepic 2012). One is functional capabilities, which are related to deep and specific functional knowledge, e.g. R&D, manufacturing, marketing, distribution, sales and financing. These different kinds of knowledge enable the company to execute innovation projects adequately, to develop novel products in a timely fashion, to screen, use and disseminate market information properly, and to capture customer needs and preferences precisely, as well as to ensure sales, distributions and services. The second factor is the integrative capabilities, e.g. communication, team interaction and knowledge sharing. These capabilities are important for the combination and assimilation of the different competencies present in various company departments (Grant 1991,1996, 2009).

Product and Market Potential

Based on integrative and functional capabilities, the innovation team works with the novelty, complexity and newness of innovation, and then the transformation into product potential (superiority). Product potential refers to the superiority of a new product in terms of better quality, unique features or attributes, reduced costs, high technology, etc., compared to current or competing products. The market potential refers to the market demand for new product in terms of large volume, quickly grow, great need, etc. These will be further described in the following section.

Conceptual Model and Research Hypotheses

Conceptual Model

To understand the dynamics of innovation processes, we propose a conceptual model (Figure 1), based on the three essential key factors in innovation project performance and further investigate the interactions of these factors. Firstly, integrative capabilities play an important role as they are the basis to acquire external information and identify new opportunities, which could be assimilated into developing novel products. Functional capabilities present in the company could facilitate the transformation of innovative ideas into novelty products. However, if the innovation project is too new to the company, it could be a challenge to have adequate functional capabilities to deal with. Novel products could have big potential and eventually a good market potential. Finally, the functional capabilities together with market and product potential will affect the innovation project performance, which could be also influenced by external environment such as market competition.

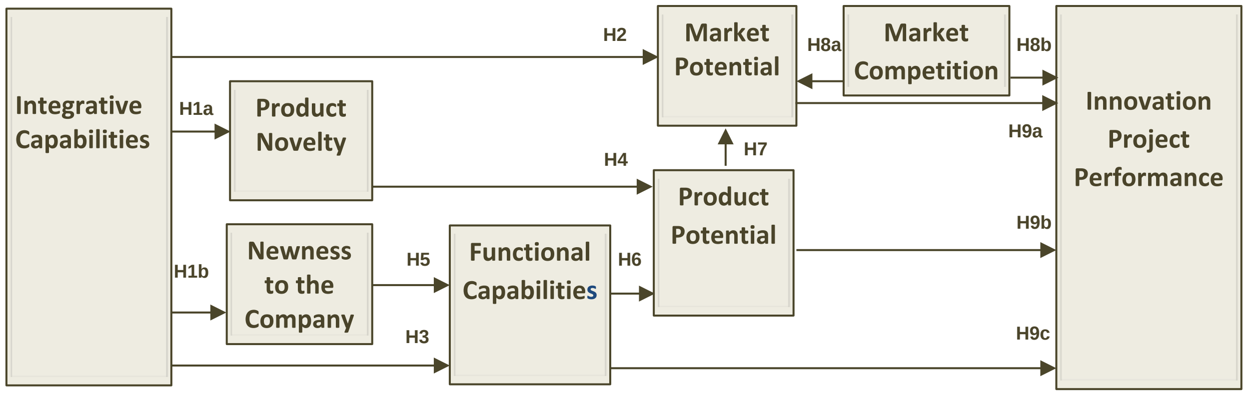

Figure 1. Conceptual model, the interaction of key factors in innovation project performance.

Research Hypotheses

Novelty is highly emphasized as important by many researchers in studies on innovation (Amara et al. 2008; Therrien et al. 2011). However, determination of the value of new products is mainly based on existing knowledge and that might create barriers to innovation (Carlile and Lakhani 2011). Integrative capabilities, e.g. communication, team interaction and knowledge sharing are important to overcome such barriers, because it creates clarity and understanding of the value of new knowledge, and to acquire a shared understanding of complex, inter-related activities. Previous research about new product development found that the qualities of communication, team interaction, and knowledge sharing have a positive effect on the innovation process(Kivimaki et al. 2000; Moenaert et al. 2000; Aramburu and Saenz 2010; Kyriazis et al. 2012; Liu et al. 2012a). There are two kinds of communication: one is team communication, which refers to the communication among innovation project team members. Another is cross-functional communication, which refers to the communication between the innovation project team and the other functional units in the company and the collection of information from outside the company. The openness of communication, which is defined as the degree to which team members are willing to exchange their ideas and knowledge within the project team, as well as with the functional units within the company, plays an important role in knowledge implementation (Lin 2011). The openness to acquire internal and external information and exchange information with team members and other functional units will help identify the most advanced technology and latest market trends, and then implement and develop this knowledge in innovation projects. Cross-functional communication can help the company to develop its functional capabilities to support product development (Lievens and Moenaert 2000; Lawson et al. 2009; Kyriazis et al. 2012). Cross-functional communication has been identified as a key driver of new product success, by helping to build and maintain a productive interface between the functional units. It assures that integration takes place among the separate capabilities delivered by engineering, production, and marketing departments (Pinto and Pinto 1990; Griffin and Hauser 1992; Thamhain 2003; Sarin and O'Connor 2009). This leads to the following hypotheses concerning integrative capabilities:

> *Hypothesis H1: Integrative capabilities will be positively related to product novelty (H1a) and to newness to the company (H1b).*

Hypothesis H2: Integrative capabilities will be positively related to identifying the market potential of an innovation.

Hypothesis H3: Integrative capabilities will be positively related to the development of the functional capabilities.

Innovative projects usually need the application of advanced technology to solve complex problems and offer solutions to customers that existing products are not able to offer. From the customer's perspective, product novelty is regarded as levels of change in product attributes and consumer's behavior patterns (Danneels and Kleinschmidt 2001). The degree of novelty is likely to affect the dynamics of disclosure and the speed of new product development (Rindova and Petkova 2007), and would entail a less open discussion with competitors (Cooper 1978; Oakey and Cooper 1991). Furthermore, advanced innovative technologies are not easy for competitors to imitate, because they need to invest heavily to accumulate relevant knowledge and technologies. The more novel the innovation project is, the greater the opportunities for the company to develop outstanding products to meet potential market demand (Im and Workman Jr 2004). Support from a company's different functional capabilities is indispensable in developing successful commercial products. It is also key in acquiring insight into the specific needs of the customer during the design phase, and subsequently developing the adequate production, marketing and sales skills necessary to successfully launch the new product into the market (Cooper and Kleinschmidt 1987). However, Cooper (1979) also found that the newness of an innovation project to the company was negatively related to the success of the project, because it leads to a high level of uncertainty as it might require new engineering skills, new distribution channels or stresses coming from new customers and/or competitors. Therefore, new areas of activities may lead to difficulties and uncertainties when adapting current functional capabilities to these new requirements. This leads to the following hypotheses:

Hypothesis H4: Product novelty will be positively related to product potential.

Hypothesis H5: Newness to the company will be negatively related to the company's existing functional capabilities.

Hypothesis H6: Functional capabilities of the company will be positively related to product potential.

Market potential is defined as the potential demand for a new product in the target market. When a new product shows unique benefits to customers, such as high quality, attractive cost or innovative features, there could be a strong market demand (Mahajan et al. 1979; Im and Workman Jr 2004; Tepic 2012, Flipse et al. 2013). So a positive relationship is expected between product potential and market potential, but highly competitive environments may bring greater uncertainty to an innovation project, as competitors may launch similar products on the market earlier or with a lower price. This could affect innovation performance negatively (Mikkola 2001). It is expected that in case of high market competition, it is more difficult to introduce a new product for which the market is growing very quickly. Therefore, market competition could limit market potential of a new product and negatively influence the innovation project performance (Prajogo and Ahmed 2007). With the support of functional capabilities, companies can introduce new products, which bring unique benefits to customers and potentially big market opportunities. This leads to the following hypotheses:

> *Hypothesis H7: Product potential will be positively related to market potential.*
>
> *Hypothesis H8: Market competition will be negatively related to market potential (H8a) and to innovation project performance (H8b).*
>
> *Hypothesis H9: Market potential (H9a), product potential (H9b) and functional capabilities (H9c) will all be positively related to innovation project performance.*

Research Context and Methodology

The Chinese Vegetable Breeding Industry

The Chinese seed market, second after that of the USA (ISF 2011), has been experiencing a transformation from a centrally controlled industry into an open and active market since the enforcement of the new Seed Law in 2000 (Huang et al. 2001). Recently, the threshold for participation in the seed industry has been increased based on the *Guiding Opinions on Accelerating the Development of the Modern Crop Seed Industry*, released by the State Council in April 2011, and its enforcement regulation – the *Crop Seeds Production & Operation Licensing Rules* (MoA 2010b). This has led to an increase in mergers and acquisitions in this industry, aimed at improving the innovative power and the production of novel products by breeding (crop varieties).

At the end of 2010, there were over 8,700 licensed seed companies in China, but most of them were seed producers, processers, or trading companies. When the threshold for taking part in the seed industry was raised by these new regulations, the number of seed companies decreased to less than 6,500 in March 2013 (MoA 2013). However, the seed industry is still fragmented and integrated breeding companies, who are really active in breeding (and seed production and sales), are still a small group within in the seed industry. There are about 200 integrated breeding companies that operate nation-wide (MoA 2010a). For the vegetable subsector, we estimated that in China only 112 VBCs could meet the following three criteria: 1) the company should be active in breeding; 2) seed production and sales, should focus on vegetables; and 3) have more than 10 employees (Liu et al. 2012b).

The VBCs in China can be divided into three groups: 1) public companies, which are the so-called state-owned companies, often originating from vegetable research institutes; 2) domestic private companies; and 3) foreign private companies, including wholly owned subsidiaries and joint ventures. The public VBCs have had a monopoly in the seed industry in China for a long time. Most state-owned companies went bankrupt or were privatized after 2000 (Tong 2010), whereas vegetable research institutes were encouraged by the government to separate their research and commercial activities, though some are still active in commercializing their cultivars. The number of private VBCs has increased rapidly since 2000, often founded by former plant breeders from research institutes or employees of state-owned companies. The large market opportunities and economic reform in China also attracted foreign VBCs (Liu et al.

2012c). Competition is growing more intense, requiring the VBCs to innovate in order to introduce better performing new products to the market.

Sample

This study focused only on VBCs that are active in innovation and are continuously working on the development of new cultivars for vegetable crops. The target group is the 112 VBCs mentioned above. The list of these 112 VBCs was verified and by several interviewed vegetable seed business experts, in order to ensure they still met the three criteria mentioned above.

In 2009, we conducted an in-depth case study of three Chinese VBCs (one per group) for pre-testing purposes. We interviewed senior managers about their innovation strategy and the organization of innovation in their company, and then asked project managers to complete a questionnaire prior to an in-depth semi-structured interview. Based on their comments, we improved the questionnaire. In 2010 and 2011, we randomly visited 70 of the 112 VBCs to interview the senior managers to gain more insight about innovation management in their companies. These VBCs are located in ten provinces and three municipalities (Beijing, Shanghai and Tianjin), representing the major locations for VBCs and the primary regions of vegetable production in China (Figure 2).

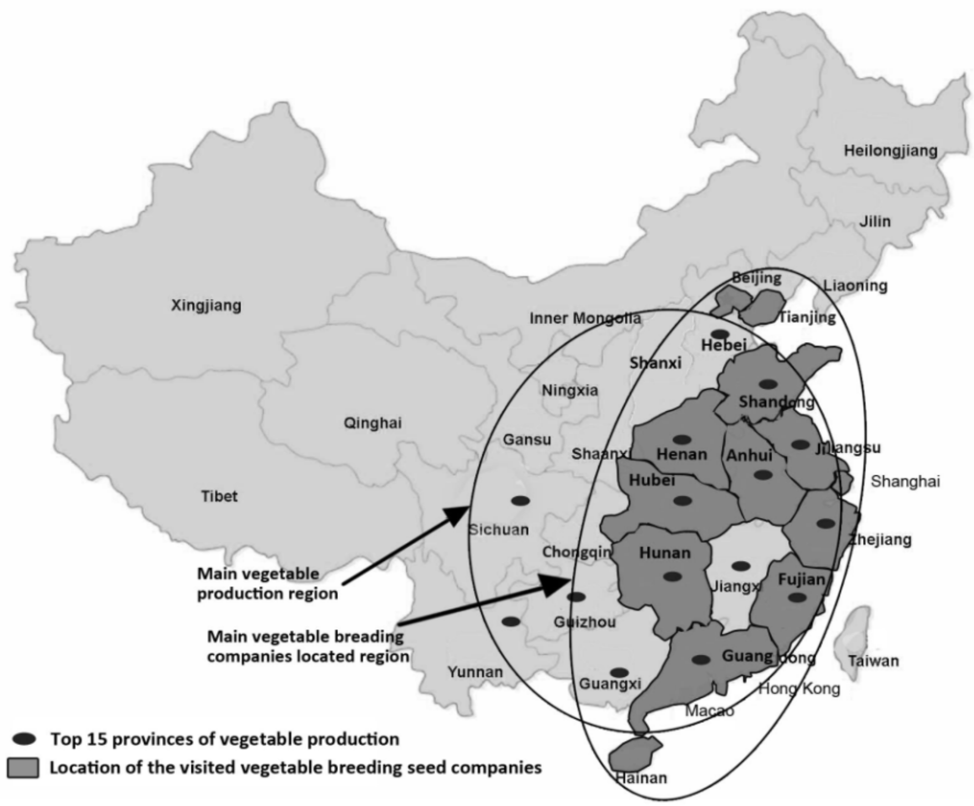

Figure 2. Location of vegetable breeding companies in China, visited for the research and the 15 main provinces known for the production of vegetables.

In 36 of the VBCs, innovation managers filled out a questionnaire about one or two of the most important innovation projects (a respond rate of 51.4%). In total, 53 valid questionnaires were filled out. The questionnaire contained 58 ten-point Likert scale questions about the perception of the respondents on a number of constructs. These were: integrative capabilities, product novelty, project newness to the company, functional capabilities, product and market potential, market competition and innovation project performance. The respondents were asked to indicate to what extent they agreed with the statement using a ten Likert scale going from completely disagree (1) or completely agree (10). The questionnaire was built on the NewProd innovation assessment tool (Cooper 1979), and was combined with questions about the communication capabilities of the innovation team, as developed by Hollander (2002) and was used in Wageningen Innovation Assessment Toolkit (WIAT) (Im and Workman Jr 2004; Fortuin et al. 2007; Batterink 2009).

Construct Measurement and Data Analysis

SPSS was used to select the most relevant items for all constructs by applying exploratory factor analysis with oblique rotation. Thirty-nine items were identified and valid to measures those described constructs (Table 2, see Appendix). A structural equation modeling (SEM) was used to analyze the cause-effect relations between latent constructs, which has become a quasi-standard method in marketing and management research. For many researchers, SEM is equivalent to carrying out covariance-based SEM (CB‑SEM) analyses using software such as Amos, EQS, LISREL, Mplus, and others (Hair et al. 2011a). CB-SEM's statistical objective is to estimate a covariance matrix that matches that of the observed sample data as closely as possible. So the focus is largely on achieving model "fit" assuming valid and reliable constructs.

In this research, Wold's (1980) PLS model was used to test the conceptual model and the nine hypotheses. Besides emphasizing prediction, PLS-SEM offers other advantages. The target of present study was to find key success factors of innovation projects of VBCs, so the use of partial least squares (PLS)-SEM path modeling was chosen, as its overriding objectives predict the dependent (endogenous) variables (constructs) (Hair et al. 2011b). Our sample size was relatively small (53). PLS path modeling has an advantage that it can avoid small sample size problems, and can, therefore, be applied in situations where other methods (e.g. LISREL) cannot be used (Götz et al. 2010). Furthermore, PLS path modeling has several advantages over covariance structure analysis and is generally preferred when: 1) requirements of multivariate normality and interval scaled data cannot definitely be met; 2) the primary concern of the analysis lies in the prediction accuracy when estimating a complex model with many variables and parameters; 3) the observations are not truly independent from each other; or 4) the model contains formative indicators (Sarstedt 2008, Henseler et al. 2009).

For this analysis, the SmartPLS 2.0 software developed by Ringle et al. (2005) was used. Then factor loadings (item reliability), composite reliability, and average variance extracted (AVE) were obtained for each measurement separately, and for the structural model as a whole. Following Chin (1998), we ran a 500 resampling bootstrap with replacement. PLS, bootstrapping is a resampling procedure used to examine the stability of estimates for each parameter in the PLS model. The bootstrap procedure utilizes a confidence estimation procedure other than the normal approximation (Efron and Tibshirani 1993), which helped us to judge whether the proposed relationships were significant or not.

Results

In this section, the comparative assessment of the three types of VBCs and the innovation activities in the Chinese vegetable breeding industry are presented. Then the relationships among the factors that might affect the performance and success of an innovation project are analyzed.

Comparative Assessment of the Three Types of VBCs

Table 1 shows the baseline description of the VBCs in China we visited. The VBCs are characterized as small-sized in terms of the number of employees and the turnover, 75% of the VBCs has less than 60 employees and a turnover of less than 30 million RMB (approximately 3 million Euros). The VBCs invest intensively in R&D (14.2% of turnover) and in R&D human resources (R&D personnel accounts for 1/3 of the total personnel of the VBCs). However, please note that the public VBCs, especially the research institutes that are active in the breeding business, received a large amount of R&D subsidies from the Chinese government. The cultivars sold by public VBCs all stem from the research institutes they are affiliated with; which explains why the percentage of R&D compared to turnover could rise to 60% of the turnover.

The size of public and domestic private VBCs is similar both in number of employees and turnover, but much smaller than foreign ones, especially taking into account that they only represent 1-10% of their mother company. The R&D budget of public and foreign VBCs is at the same level (18% of turnover), and nearly double that of private ones. But it should be noted that the public VBCs gain substantial governmental funding, while the foreign VBCs are strongly supported by their mother companies.

Table 1. Basic information of three types of vegetable breeding companies in China

					Mean		
	Min.	**Max.**	**Mean**	**S.D**	**Public(26)**	**Private(32)**	**Foreign(12)**
Number of employees	12	167	44	33	40	41	74
Turnover 2010 (million RMB)	1	90	23	22	20	20	69
Number of R&D employees	2	80	15	16	19	9	28
R&D budget (% of turnover)	2	60	13	11	18	10	18
Age of company (years)	3	52	15	9	15	14	16

[a] This high percentage is due to the public VBCs that are affiliated with the research institutes, that receive large amounts of R&D subsidies and are functioning as R&D departments of the public VBCs.
[b] The age of the R&D department is higher than the age of the oldest company. This is due to the fact that the vegetable research institutes were founded much earlier than their affiliated seed companies (public VBCs), which use the former as R&D functional unit.

Innovation Activities in the Chinese Vegetable Breeding Industry

In the interviews with the 70 VBCs senior managers in China, we also asked for a priority list of the most important innovation activities within their company. As expected all put plant breeding on top of their list. Figure 2 presents the other main research activities. The most important activities are germplasm collection and seed technology. This aligns to the fact that the core innovation activity in a breeding company is the development of competitive new varieties and provides high quality seeds to their clients. In general, the public VBCs are more active in almost all activities than the private and foreign VBCs— especially in basic research. This might be due to the fact that research activities are heavily subsidized for public VBCs, up to 60% of their turnover. Since public VBCs have easy access to listed germplasms kept in the National Crop Gene Bank and the National Medium-term Storage, the necessity to collect germplasm is not so crucial for public VBC's as for private VBCs (Liu et al. 2012b). The germplasm collection is even much lower for foreign companies. There might be two explanations for this. Firstly, mother companies of foreign VBCs in China may already have a large germplasm collection based on their global operations and long-term development. Secondly, the restrictions for foreign VBCs to access to National Crop Gene Bank and National Medium-term Storage are much tighter. Furthermore, Figure 2 also shows that the vegetable breeding industry very rarely applies modern technologies. Less than one third of public VBCs are using modern technologies, such as plant tissue culture, molecular markers assistant breeding, genetic modification, genomics and bioinformatics. So, traditional breeding is the main innovation activity.

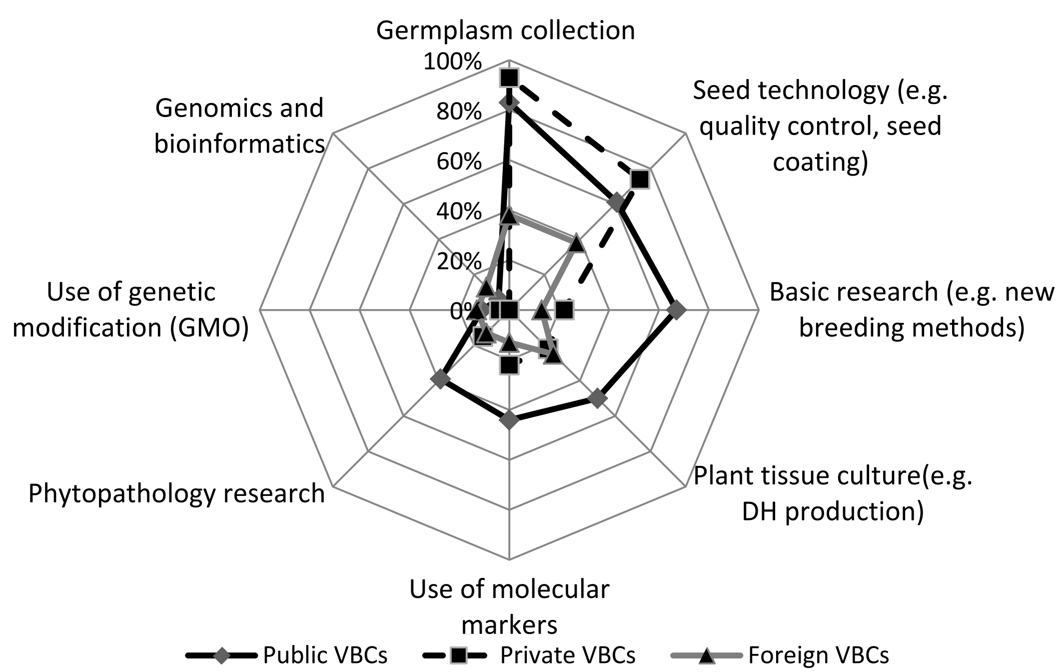

Figure 2. Percentage of innovation activities conducted by companies in each type of vegetable breeding companies in China

Reliability, Model Validity, Explanatory Power and Effect Size of Constructs

Table 2 (see Appendix) presents the mean, standard deviation (S.D.) and factor loading of all the indicators of different constructs. The individual item reliability (factor loading), internal consistency (composite reliability) and discriminant validity for each construct by the criteria given by Fornell and Larcker (1981) was examined. Factor loadings for most individual items were higher than 0.7 (Table 2), and shows good reliability for the individual items. A few items showed a factor loading a bit less than the cut-off point of 0.7 still indicating an acceptable individual reliability (Götz et al. 2010). The composite reliability (CR) and Cronsbach alpha for all constructs exceeded 0.75 (see Table 2), indicating a robust internal consistency of the constructs (Hair et al. 2011a).

The discriminant validity was accessed in two ways. First, the square root of the average variance extracted (AVE) should be greater than all construct correlations. Second, all items should load higher to their associated construct than to the other constructs. Both criteria for discriminant validity were met (see Table 3, in Appendix).The average variance explained (R^2) was used to evaluate the explanatory power of the structural model, the path Coefficients, t-value and the effect size were used to evaluate the correlation of constructs, their significant level and effect size. Table 4 gives a visual overview of the relations among the constructs. For product novelty (0.13), newness to the company (0.12), and functional capabilities (0.33) show an acceptable explanatory power significant at t 0.05 level (Eisenhauer 2009). Furthermore, R^2 of product potential (0.49), market potential (0.61), and innovation project performance (0.58) indicate robust explanatory power.

Structural Model

The results of the structural model are provided in Table 4 (see Appendix). Below we describe the result of confirmed, not confirmed and rejected hypotheses in more detail in Table 5.

As expected, integrative capabilities are significant and positively related to product novelty (β=0.34), newness to the company (β=0.34) and market potential (β=0.23). This shows the importance of integrative capabilities to identify new opportunities and to implement new knowledge into an innovation project. With more open communication, intensive team interaction and more knowledge sharing, VBCs can better recognize and make better use of the valuable external resources such as: the introduction of advanced technologies, seize new market demand, develop novel distribution channels, and maybe also target different market segments. Meanwhile, strong integrative capabilities might also stimulate the project team and the company to develop new functional capabilities such as R&D ability, production processes, and distribution systems.

Innovation projects aim to develop novel products that could bring extra benefit to clients, reduce the cost, and improve the efficiency, etc. It was found that product novelty is significantly and positively related to product potential (β=0.48), with a medium effect size (f^2=0.28). Furthermore, in order to be able to develop novel products with high potential, a company needs specific capabilities, such as R&D, engineering and processing, marketing and sales, etc. Indeed, a significant positive relationship was found between functional capabilities and product potential (β=0.37), with a medium effect size (f^2=0.19).

Table 5. Overview of the confirmed, not confirmed and rejected hypotheses

Hypotheses	Result
Hypothesis 1	
a. Integrative capabilities will be positively related to product novelty.	Confirmed
b. Integrative capabilities will be positively related to newness to the company.	Confirmed
Hypothesis 2	
Integrative capabilities will be positively related to identifying the market potential of an innovation.	Confirmed
Hypothesis 3	
Integrative capabilities will be positively related to the development of the functional capabilities.	Not confirmed
Hypothesis 4	
Product novelty will be positively related to product potential.	Confirmed
Hypothesis 5	
Newness to the company will be negatively related to the company's existing functional capabilities.	Rejected
Hypothesis 6	
Functional capabilities of the company will be positively related to product potential.	Confirmed
Hypothesis7	
Product potential will be positively related to market potential.	Confirmed
Hypothesis 8	
a. Market competition will be negatively related to market potential.	Rejected
b. Market competition will be negatively related to innovation project performance.	Not confirmed
Hypothesis 9	
a. Market potential will be positively related to the innovation project performance.	Confirmed
b. Product potential will be positively related to the innovation project performance.	Not confirmed
c. Functional capabilities will be positively related to the innovation project performance.	Not confirmed

The structural model also shows that newness of the company is not negatively related to the company's existing functional capabilities, but shows a medium positive effect (β=0.49, f^2=0.23). Interestingly, this is different from our expectation that newness could bring uncertainty and the company's functional capabilities would be inadequate to execute successfully an innovation project. However, we also found that newness to company had a mediated effect on integrative capabilities and functional capabilities. This means that integrative capabilities can only partially contribute to the improvement of functional capabilities. In order to enhance functional capabilities, newness to the company is needed.

An innovation project that leads to a high product potential also proved to gain higher market potential (β=0.66), because new products with unique benefits to customers can lead to a strong market position. The effect of product potential on market potential is large (f^2=0.45). Meanwhile, market potential also shows a significant positive effect on innovation project performance (β=0.60), with a medium effect size (f^2=0.29). Product potential was not found to have significant effect on innovation project performance directly, but more than half of the effect of product potential onto innovation project performance is mediated by market potential. This means that product potential can only partially be considered a substitute for the success of an innovation project. In order to achieve better innovation project performance, the innovation project should lead to both high product potential and high market potential. Furthermore, market competition, which was supposed to hamper successful introduction of new products, is positively related to market potential (β=0.25). This indicates that intensive competition can help innovation projects achieve a better performance, because it stimulates both the team members and the company as a whole to really come up with an innovative product in time.

Discussion and Conclusions

The Importance of Integrative Capabilities: Direct and Indirect Effects

From the resource-based view it is well known that knowledge and learning are key determinants of innovation, and the interaction between proprietary and external knowledge is important (Malerba 2002). This study further extends the essential role of integrative capabilities and shows that communication, team interaction, and knowledge sharing indeed increases the innovativeness of innovation projects. The exchange of information and interactions between individuals of the project team can create novel ideas through brainstorming and identifying new opportunities. Good cross-functional communication and knowledge sharing make the innovation project team aware of existing capabilities of various functional units available, whereas the functional units will most likely be informed of missing skills, routines and processes that are needed to support the development of a new products and launching them into the market. A good understanding of these missing requirements might be the starting point for adjustment and improvement. So, with a higher level of product novelty and newness to the company, integrative capabilities will contribute to improve functional capabilities and market potential indirectly.

In this research we introduced three types of VBCs in China: public, private and foreign VBCs. Although the sample size is limited to really test the differences on the basis of the conceptual model, we have seen differences based on interviews conducted with the project managers. It was found that in foreign VBCs a form of matrix organization is widely applied and innovation project teams are organized with members from different functional units, but share the same crop/topic focus. Furthermore, these foreign VBCs heavily encourage their project team members to communicate intensively and effectively. In contrast to this, and for historical reasons, in public VBCs, which are affiliated to vegetable research institutes, participation of members from different functional units is rather limited, especially the interaction between R&D and M&S. This can be explained by the fact that the original goal of such companies was to bring varieties developed by the affiliated research institute to the market. The new Chinese policy (MoA 2010b) requires further separation of the two functional units (R&D and M&S). We expect that this will lead to further reduction in innovative varieties from public VBCs. Take as example Shouguang, the most famous vegetable production area, has become .more and more specialized vegetable farmers are demanding more innovative and high-quality seeds. With their innovative and high quality products, foreign VBCs are now already dominating the market.

Constrained integrative capabilities in public VBCs limit product innovativeness and also reduce market potential since the functional capabilities are not only less developed, they are not able to respond to new market demand quickly. Private sector VBCs are doing somewhat better, but there is still much need for improvement. For example, a senior manager from a large private VBC, who was building a new biotechnology center, complained that it was difficult for breeders and biotechnologists to share information. Breeders hesitate to share information because it has been their competitive strength for many years'— accumulated know-how and experience. They did not want to give up their own benefits. Moreover they had the impression that the contributions of biotechnologists were limited.

Newness to the Company: A Challenge but also an Opportunity

Innovation projects that are closer to existing products, markets and technologies of the firm are more successful (Zirger and Maidique 1990) because the greater the extent of newness to the company, the higher the chance that the company's functional capabilities are insufficient to execute the innovation project. This was further proved by Tepic (2012), who studied innovation projects from nine large multinational companies representing different industries. In contrast to these studies, we found a positive effect of newness to the company on functional capabilities and also a positive effect from integrative capabilities on functional capabilities, mediated by newness to the company. So newness to the company in innovation projects could be a challenge because a company needs a higher level of flexibility and adaption when it engages in a completely new innovation. However, newness to the company might also stimulate the need for adaption and improvement of functional capabilities in order to execute a new innovation project. This could be related to a specific type of innovation in plant breeding. In most cases the VBCs projects include the development of novel varieties, a time consuming process, which normally takes up to 10 years or even longer. In general VBCs are small and communication lines are short, while cross-functional teams are widely used for innovation projects. So during the long period phase of new product development, the company is able to gradually develop the functional capabilities needed to support innovation. Furthermore, we found that "newness to the company" category of innovation projects scored lower than five on a ten-point Likert scale. This could mean that the production process, distribution, advertising and promotion for the innovation projects of VBCs are in general not totally new, so the flexibility and adaption of functional capabilities needed for innovation projects are not too radical.

Market Competition: A Positive Factor for Innovation in the Breeding Industry

Market competition stimulates innovation project performance because such competition urges companies to develop unique new products faster, as shown by Tepic (2012) in her research on large European agri-food companies. We made the same observation in our research of Chinese VBCs indicating that market economy is important for innovation. This form of "healthy tension" or "good competition" is a stimulus for innovation and was mentioned by several CEOs of outstanding breeding companies. Foreign VBCs have brought intensive competition into the

Chinese vegetable breeding industry but foreign VBCs also bring new technologies and forms of management, that are widely shared with domestic VBCs so can learn from them and can improve their innovation. Increased competition is good for innovation. However, within the vegetable breeding industry there is no free competition. There are political reasons for the Chinese government to stimulate domestic VBCs in order to avoid allowing this industry to be controlled by foreign VBCs. However, limited competition, could constrain innovation. Furthermore, improving intellectual property rights such as with plant breeders' is essential to fair competition. Although legislation and regulation of property rights have improved considerably as government as well as the private sector recognizes its importance, poor intellectual property protection is still a very large constrain for VBCs to invest in innovation.

Product and Market Potential: Two Pillars for Innovation Project Success

Product potential has a positive effect on innovation project performance, but it is mediated by market potential. This means that even if the new product is novel, (such as novel traits in crop plants or novel breeding technologies), if there is no need for it, the innovation project would not be successful. Innovation projects of public VBCs are subsidized by government, with a requirement of scientific contribution, so product potential such as new traits or new technologies are highly emphasized and widely applied. However, without the target to fill a market request, it would be difficult to gain market success. Public VBCs had been the dominant players in the vegetable seed sector for historical reasons. However, this gradually changed about ten year ago. Private and foreign VBCs are taking the lead because their innovation is more focused on market demand rather than technology advancement.

Recommendations and Further Research

This study identifies the importance and interaction of integrative capabilities and functional capabilities, product novelty and newness to the company, as well as product potential and market potential for innovation project performance. In order to improve innovation performance, vegetable breeding companies need to improve their integrative capabilities, which can be stimulated by open communication, knowledge orientation and sharing, teamwork, training, and their functional capabilities, which are the skillsets needed in order to introduce novel products into the market successfully. Furthermore, market competition also plays a positive role to stimulate innovation in the vegetable breeding industry. It needs to be further improved by reducing governmental interaction with the market activities in the breeding industries. Instead of playing multiple functions in this industry e.g. legislation and regulation, supporting breeding activities in governmental research institutes and even supporting stat-owned breeding companies, it would be more effective for government to take measures to ensure a free and fair market, with good intellectual property protection.

The present study identifies direct and indirect effects coming from integrative capabilities, which also link access to external information and knowledge. The diversity and scope of team members' personal networks could facilitate access to non-redundant sources of knowledge that could expand the innovation possibilities of the project (Uzzi and Lancaster 2003; Kao et al. 2009). Therefore, it could be valuable to include the social networks of team members in further studies on the innovation process. Furthermore, this research is based on empirical data collected in the Chinese vegetable breeding industry, which might be quite different from other agri-food sectors, so further study is needed to verify generalization of this conceptual model.

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Appendix

Table 2. Measurement and factor loadings for each construct of the model

Construct	Items	Mean	S.D.	Factor Loading
Integrative capabilities	1. I have enough communication with my team members to do my work efficiently and in an effective way.	7.85	1.61	0.81
	2. In this project, I am the one who most frequently provides information and support to other team members.	7.77	1.79	0.74
	3. We always give other departments (e.g. M&S, manufacturing, etc.) the information they ask for.	8.62	1.50	0.69
	4. We always get the information from other departments (e.g. M&S, manufacturing, etc.) we ask for.	8.32	1.53	0.78
	5. All our team members are focused on “collecting” knowledge for our project.	7.94	1.67	0.67
	6. The cooperation with marketing and sales is essential for the success of this project.	8.79	1.20	0.67
Product novelty	7. The product type is totally new for our company (e.g. new crops, etc.).			0.67
	8. We have never made or sold products to satisfy this type of customers need or use before (e.g. new disease-resistant, new shape, etc.).	6.70	2.02	0.79
	9. The potential customers for this product are totally new for the company (e.g. new area, new type of customers, etc.).	5.40	2.51	0.87
	10. The technology required to develop this product is totally new to our company.	5.53	2.79	0.73
	11. The competitors we face in the market for this product are totally new to our company.			0.66
Newness to the company	12. The nature of the production process is totally new for our company.	4.75	2.52	0.69
	13. The distribution system and/or type of sales-force for this product is totally new to our company.	4.91	2.58	0.91
	14. The type of advertising and promotion required is totally new to our company.	4.92	2.51	0.87
Functional capabilities	15. Our engineering skills and people are more than adequate for this project.	6.19	2.47	0.85
	16. Our marketing research skills and people are more than adequate for this project.	6.21	2.19	0.88
	17. Our advertising and promotion resources and skills are more than adequate for this project.	6.13	2.20	0.81
	18. Our sales and/or distribution resources and skills are more than adequate for this project.	6.28	2.26	0.92

Table 2. *Continued*

Construct	Items	Mean	S.D.	Factor Loading
Product potential	19. Our product will be of higher quality than competing products.	7.17	1.97	0.87
	20. Compared to competitive products, our product will offer a number of unique features or attributes to the customer.	7.64	1.77	0.86
	21. Our product will permit the customer to do a job or do something he/she cannot presently do with what is available.	7.08	2.00	0.89
	22. Our product will permit the customers to reduce their overall costs, when compared to what they use now.	7.00	2.06	0.78
	23. Our product is highly innovative totally new to the market.	6.34	2.12	0.86
	24. Our product is a very high technology one.	6.49	2.01	0.73
	25. Our product is mechanically and/or technically very complex.	6.36	2.03	0.84
Market potential	26. The market for this product is growing very quickly.	7.19	1.82	0.80
	27. Potential customers have a great need for this type of product.	7.57	1.58	0.77
	28. The customer will definitely use the product.	6.68	1.86	0.65
	29. This product has a high potential (i.e. can additional products, multiple styles, price ranges).	7.55	1.44	0.86
	30. This project will contribute to the competitive advantage of the company.	8.17	1.17	0.82
	31. This new product will surely meet the applicable laws (e.g. product liability, regulations, and product standards).	8.79	1.26	0.62
Market competition	32. The market is a highly competitive one.	8.51	1.49	0.94
	33. There are many competitors in this market.	8.55	1.61	0.95
Innovation project performance	34. What is the probability that this project will be completed within the original planning?	8.00	1.27	0.83
	35. What is the probability that this project will be completed within the original budget?	7.72	1.38	0.87
	36. What is the probability that this project fulfils all its objectives?	8.06	1.22	0.85
	37. What is the probability that this project will directly benefit the end-users (either through increasing efficiency or effectiveness)?	8.17	1.28	0.76
	38. What is the probability that this project will earn more money for the company than it costs?	8.21	1.56	0.76
	39. What is the probability that this project will improve customers' loyalty to the company?	8.11	1.44	0.76

Note. All items expect the items of "innovation project performance" were measured by ten-point Likert scale that respondents completely disagree (1) or completely agree (10) with the statements. The items of innovation project performance were measured by the expected probability by scale of 0-10.

Table 3. Discriminant validity of constructs

	Mean	S.D.	AVE	CR	a	1	2	3	4	5	6	7	8
1. Integrative capabilities	8.25	1.13	0.53	0.87	0.83	**0.73**							
2. Product novelty	6.21	1.97	0.75	0.92	0.89	0.34*	**0.87**						
3. Newness to the company	8.03	1.09	0.65	0.92	0.89	0.34*	0.49*	**0.81**					
4. Functional capabilities	8.53	1.47	0.90	0.95	0.89	0.34*	0.35*	0.55**	**0.95**				
5. Market potential	7.74	1.13	0.58	0.89	0.85	0.22	0.61**	0.35*	0.54**	**0.76**			
6. Product potential	4.87	2.12	0.69	0.87	0.77	0.53**	0.43**	0.08	0.34*	0.65**	**0.83**		
7. Market competition	5.89	1.77	0.55	0.86	0.79	0.65**	0.38**	0.13	0.16	0.02	0.41*	**0.74**	
8. Innovation performance	6.90	1.66	0.70	0.94	0.93	0.48**	0.30	0.09	0.23	0.54**	0.75**	0.31	**0.84**

Note. *Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed).
[a] The bold numbers on the diagonal are the square roots of the variance shared between the constructs and their measures (square root of average variance extracted, AVE). CR refers to composite reliability and Off-diagonal are the correlations among the constructs. α refers to Cronsbach alpha.
[b]all the constructs measured by ten-point Likert scale indicators

Table 4. Path coefficients, t-values and significant level of structural model

	Path Coefficients (β)[1]	**T-value**	**f^2-value**
Product novelty (R^2=0.12)			
Integrative capabilities	0.34	2.20**	0.12
Newness to the company (R^2=0.11)			
Integrative capabilities	0.34	2.62***	0.11
Functional capabilities (R^2=0.33)			
Integrative capabilities	0.17	1.22	0.04
Newness to the company	0.49	3.18***	0.23
Product potential (R^2=0.49)			
Product novelty	0.48	3.75***	0.28
Functional capabilities	0.37	3.28***	0.19
Market potential (R^2=0.61)			
Integrative capabilities	0.23	1.74*	0.06
Product potential	0.60	4.75***	0.45
Market competition	0.25	2.67***	0.07
Innovation project performance (R^2=0.58)			
Market potential	0.66	5.08***	0.29
Product potential	0.16	1.11	0.02
Functional capabilities	-0.09	0.85	0.01
Market competition	0.06	0.52	0.00

Note. [1]* Path coefficient is significant at 0.1 level (2-tailed); ** Path coefficient is significant at 0.05 level ng (2-tailed); *** Path coefficient is significant at 0.01 level (2-tailed).
[2]f^2-values of 0.02, 0.15 and 0.35 can be viewed as a gauge for whether a predictor latent variable has a week, medium or large effect at the structural level.

