Impact of Government and Corporate Strategy on the Performance of Technology Projects in Road Construction

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Abstract: In this study, we focus on road construction and analyze technology development projects. Based on the business strategy literature and literature on technology policy, we test the relative importance of a firm's strategies and government as a buyer and champion. Our empirical findings stress the value of government championing behavior. Our results show that in road construction, championing behavior is more important than public technology procurement for project performance. The results even suggest that government championship is more important than a firm's strategic orientation.

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Introduction

Most research on technology development has focused on high-technology industries, such as the biotechnology, semiconductors, and electronics industries. Yet, low- and medium-technology industries represent over 80% of gross domestic product (GDP) and account for more than 55% of total business research and development (R&D) expenditures (European Economic and Social Committee 2005). Despite the importance of low and medium-technology industries, these have been neglected in technology development literature. However, these technology industries have a considerable impact on both high-tech industries and the economy as a whole (Bender 2006). Process innovations in these sectors are a key driver for sustainable economic growth and industry survival. Furthermore, low and medium-technology industries are important as suppliers to high-tech industries, therefore advancements in low and medium-tech industries are a necessity for developments in high-tech industries to be made. Low and medium-technology sectors account for more than 85% of value added (Von Tunzelmann and Acha 2005), thereby, most of economic activity and employment (Bender 2006).

This study focuses on technology development within a low-technology industry road infrastructure. We consider road infrastructure because road infrastructure is an important sector both in terms of GDP and employment (European Union Road Federation 2007). Furthermore, a well-established transportation infrastructure is seen as an important precondition for economic growth (Démurger 2001). Finally, government has an important role as a buyer and first user of new technology in road infrastructure (Dalpé et al. 1992; Caerteling et al. 2008).

This paper contributes to the literature on technology development in two ways. First, we focus on the effect of government behavior on technology development. Although many studies emphasize the importance of government support in technology development and diffusion (Morris and Hough 1987; Rosenberg 1994), previous research on the role of government in technology development has primarily focused on macrolevel analysis (Dalpé et al. 1992; Greer and Liao 1986). A systematic empirical investigation at project level is lacking. Furthermore, most studies have been limited to the effect of regulations or funding on technology development (Lerner 1999; Ring et al. 2005; Shapiro 2001), yet government buys a significant part of new technology in low-technology industries (Dalpé et al. 1992).

Second, we focus on the strategic orientation of firms. Most research on technology development has concentrated on high-technology industries. Little knowledge has been gained about the strategies that firms in low-tech industries use to develop and commercialize new technology. Therefore, we incorporated the firm's strategic orientation in assessing the performance of technology development projects (Baker and Sinkula 2005; Gatignon and Xuereb 1997; Han et al. 1998; Narver et al. 2004).

This research is designed as a first step in filling the aforementioned gaps. Based on a literature review and prior case studies we built and tested a theoretical model to answer the following research questions:

- How important is government behavior with regard to the performance of technology development projects in low-tech industries?
- What type of strategic orientation leads to the higher perfor-

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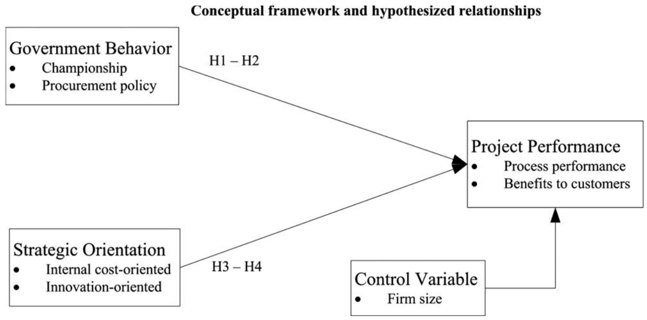

Fig. 1. Conceptual framework and hypothesized relationships

mance of technology development projects in low-tech industries?

In this study, the term "technology" refers to the physical artifact as well as the proprietary design knowledge or "capability" that can be used in different applications (Das and Van de Ven 2000). In mature industries, most technologies are incremental improvements of existing products and processes (Christensen and Bower 1996). Product technology refers to the design knowledge incorporated in a product. Process technology embodies the design knowledge required to manufacture a finished product (Capon and Glazer 1987).

We define road infrastructure as a large technical system consisting of physical components such as roads, bridges, and traffic monitoring equipment. Analogous to other large technical systems, such as telecommunications and railways, these components form a structured network (Hughes 1983; Geyer and Davies 2000). In road infrastructure this network hierarchically links roads of various classes (Mom 2005). Furthermore, all large technical systems have a control component for system performance and efficiency (Geyer and Davies 2000). Road infrastructure is controlled by the use of signs, regulations, and dynamic route information, which are organized to optimize traffic flow.

This paper has the following outline. In "Theory and research hypotheses," we develop the conceptual framework and research hypotheses. In "Methodology," we discuss the methodology used and in "Results," we will describe the results. In the final section, we will discuss the findings and conclude the paper with managerial and policy implications.

Theory and Research Hypotheses

In this section, we develop a conceptual framework and hypotheses to explain the performance of technology development projects in road infrastructure. Our conceptual framework is shown in Fig. 1.

Recent studies show that low-technology industries are relevant sources of innovative activities and vital for growth and employment (Bender 2006; Von Tunzelmann and Acha 2005). Although innovation research has primarily focused on high-tech industries and major technological advancements, these are not necessarily the economically or socially most important (Fagerberg 2004). More relevant are so-called user-producer innovations that occur throughout low-, medium-, and high-tech industries. In road infrastructure, like in other large technical systems, user-producer innovations are common because the interoperability and compatibility of new technology is vital for its successful adoption (Hughes 1983; Geyer and Davies 2000; Markard and Truffer 2006). In large technical systems, two dimensions are important in addressing technology development. The first dimension refers to the system builder. This actor is financially, politically, or technically so powerful that it can direct technological change in the system (Jacobsson and Bergek 2004). In road infrastructure, government performs this role of system builder. Government as an owner, operator, and regulator is the key actor in the system's design and operation. Therefore, we include government behavior in our conceptual framework. The second dimension is the nature of technical change. In large technical systems, technological advancements occur along technological paths (Markard and Truffer 2006). This path dependent nature has to ensure the interoperability and compatibility. As such, technology development is a process of improvement, incremental innovation, and differentiation rather than radical change. Therefore, the relevant business strategies refer to operational efficiency and differentiation. These strategies are incorporated in our framework.

In the remainder of this section, we will discuss these two dimensions of our conceptual framework and develop our hypotheses. To assess the impact of those two dimensions on performance, we define project performance at the end of this section. In the last part of this section, we also discuss why we add firm size as a relevant control variable.

Government Behavior

Previous studies on government behavior and technology development have been mainly limited to the role of government as a regulator and sponsor (Lerner 1999; Ring et al. 2005; Shapiro 2001). Government as a regulator provides the conditions for competition (Dobbin and Dowd 1997) and affects the development and commercialization of new technologies (Nelson 1995; Norberg-Bohm 2000). Government as a sponsor has concentrated on funding of basic research and private R&D, based on technology push (Von Tunzelmann and Acha 2005). The rationale for these instruments is that the social benefits of R&D are greater than the private returns. Therefore, regulation and funding is necessary to prevent underinvestment in technology development (Klette et al. 2000; Wallsten 2000).

However, in low-tech industries, such as road infrastructure, stimulating diffusion and demand pull are often more important mechanisms than technology push (Jacobsson and Bergek 2004; Von Tunzelmann and Acha 2005). Championing behavior can be an important instrument to encourage demand and diffusion. Analogous to the championing behavior in new product development (NPD) literature, the government can act as a champion too (Morris and Hough 1987). Championing behavior is an important way of stimulating the development of specific technologies. Championing behavior is defined as making a decisive contribution to any innovation by actively and enthusiastically promoting its progress through the critical development stages (Howell and Shea 2001). Examples of championing behavior are—the support for alternative energy sources, the semiconductor industry, and the rise of Silicon Valley (Adams 2005; Mowery 1998; Rosenberg 1994). In large technical systems, the relevance of championing behavior increases when government is the system builder or when there is no obvious beneficiary of the new technology (Morris and Hough 1987). As a system builder, government is the primary actor to champion new developments. When government is not the system builder, the partially nonrival nature of large technical systems requires a champion to encourage investments (Jacobsson and Bergek 2004).

Championing behavior has a positive effect on technology de-

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velopment. This behavior accelerates development projects by speeding up approvals and by involving key decision makers (Morris and Hough 1987). This behavior can also accelerate the first commercial application of a new technology because it actively promotes the technology's advantages among targeted users. In addition, this behavior can knock down regulatory barriers that block the development or application of the new technology. These arguments suggest:

- H1: government championing behavior has a positive effect on the performance of technology development projects.

Closely related to champion behavior is procurement policy, as public technology procurement can be used to create demand pull. Dalpé et al. (1992) have shown that government buys a substantial part of the new technology developed in manufacturing industries, including low and medium-technology sectors. In low and medium-technology industries, firms concentrate on solving their main customers' needs and their product range is tailored toward a few large customers (Slater and Mohr 2006). Therefore, their main customers, including government, strongly affect their technology development activities and commercial success (Christensen and Bower 1996; Norberg-Bohm 2000).

Furthermore, public technology procurement can be a powerful instrument to direct technological developments in an industry (Rothwell and Zegveld 1981). As a buyer government has several ways of affecting technology development. First, government as owner and user can provide opportunities for experimentation and the demonstration of new technology (Rothwell and Zegveld 1981; Seaden and Manseau 2001). Providing these opportunities can include offering technical support for prototype development or technical assistance during the final test stage (Dalpé et al. 1992). Even when government is not the targeted user, experimentation can show the advantages of the new technology. This facilitates the diffusion process. Furthermore, experimentation and technical support can accelerate design iterations, thereby, improving quality and reducing development time (Eisenhardt and Tabrizi 1995). Second, government methods of awarding contracts have an effect on technology development. The most common method is competitive bidding. Research in the defense industry has shown that competitive contracting for new technologies induces greater private R&D investment than noncompetitive R&D contracting (Lichtenberg 1988). This suggests that government procurement has a positive effect on the private R&D resources spend. *An increase in resources is likely to improve the performance in terms of adherence to quality, time, and budget* (Gatignon and Xuereb 1997). Furthermore, demand specification affects the technologies that can be used. Method-based specifications specify in detail how the supplier should provide the technology and which components or materials to use. Performance specifications describe how the finished technology should perform over time without specifying how it should achieve the performance objectives. Performance specifications offer more opportunities for improvement and *the development of technologies with significant benefits to customers.*

• H2: public technology procurement has a positive effect on the performance of technology development projects.

Strategic Orientation

The management literature argues that a firm's performance depends on how well business strategy is implemented in its strategic orientation (Walker and Ruekert 1987; Olson et al. 2005). The most dominant frameworks on business strategy are Porter's typology and the Miles and Snow typology (Olson et al. 2005). Porter's typology differentiates between the cost and the perceived benefits for customers and whether the strategy is used in a particular market or on industrywide basis (Porter 1980). Porter's typology is based on observed competitive actions, whereas the typology of Miles and Snow (1978) focuses on the firm's projected strategy (Walker and Ruekert 1987). The primary dimension of Miles and Snow's typology is the intended rate of product-market change (Olson et al. 2005). Most research on the implementation of business strategy focuses on the Miles and Snow typology (Olson et al. 2005; Slater and Mohr 2006). However, both typologies have their flaws. Porter's typology neglects the organizational processes to implement each strategy. The Miles and Snow typology is rather broadly defined and combines different strategies in one category (Walker and Ruekert 1987). To overcome these limitations, Walker and Ruekert (1987) have defined a hybrid model in which the underlying dimensions of both typologies are incorporated. These dimensions are (1) the basis for competing, i.e., the cost or differentiation, and (2) the intended intensity of product-market change. Their hybrid model proposes three business strategies archetypes: prospectors, low-cost defenders, and differentiated defenders. In low-tech industries, operational cost and differentiation are the main strategic drivers (Hambrick 1983; Von Tunzelmann and Acha 2005). Consequently, the internal/cost orientation and the innovation orientation are likely to be dominant in these industries. The first allows firms to defend their existing market share. The second enables firms to differentiate their technology base and improve performance.

The internal/cost orientation allows firms to lower cost or increase value. *Internal cost oriented firms* pursue efficiency in all parts of their value chain (Hambrick 1983; Olson et al. 2005; Porter 1980). They attempt to reduce costs in primary activities, such as logistics, operations, and sales and marketing. They also attempt to reduce costs in support activities, such as procurement, R&D, and administrative functions. These firms pursue operational excellence that they can translate into higher sales through lower prices or higher margins (Olson et al. 2005). Furthermore, in pursuing efficiency, these firms focus on cost and time dimensions. Therefore, they have well developed process capabilities to conduct technology development projects in accordance to time, budget and quality constraints. The downside of this internal focus on efficiency is that they are less receptive to changes in customer preferences and environmental developments (McKee et al. 1989). Furthermore, these firms focus on a narrow scope of activities with little variation in standard practices and procedures (Morgan and Strong 2003). Therefore, they will face difficulties in developing technologies with significant benefits to customers. From these arguments we derive

• H3a: high levels of the internal/cost orientation have a positive effect on the process performance of technology development projects.

• H3b: high levels of the internal/cost orientation have a negative effect on the benefits to customers.

The second important strategic orientation is innovation orientation that represents firms intended product-market development (Gatignon and Xuereb 1997; Han et al. 1998). *Innovation orientation* indicates that the firm is not only open to new ideas but also proactively pursues these ideas in both its technical and administrative domains. These firms seek state-of-the-art technologies, thereby, increasing the potential to differentiate from competitors and diversify into new markets (Gatignon and Xuereb 1997). An innovation orientation encourages risk taking and enhances the likelihood of developing radically new products

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(Olson et al. 2005). Furthermore, adopting this strategy entails having the drive to acquire a substantial technological background and to use this in the development of new technologies (Gatignon and Xuereb 1997). Consequently, these firms dedicate sizeable resources to R&D and have experience in conducting technology development projects (Pavitt et al. 1989). Furthermore, their focus on new technologies and ways to enter or create new markets enables them to mobilize first mover advantages (Morgan and Strong 2003). Being ahead of competition, these firms are the first to offer substantial benefits to customers. From this given discussion, we obtain

• H4a: high levels of the innovation orientation have a positive effect on the process performance of technology development projects.

• H4b: high levels of the innovation orientation have a positive effect on the benefits to customers.

Project Performance

In this research, we measure the performance of technology development projects in two ways. First, we assess the process performance of the development project in terms of meeting budget, quality, and development time objectives. These performance objectives are dominant in low and medium-tech projects (Shenhar et al. 2001). Second, we measure the performance of the technology in terms of significant benefits to the customer. Low and medium-technology development projects are usually designed to solve a customer's problem (Shenhar et al. 2001) and are aimed at improving operating efficiency, safety, or maintainability. The central question regarding the performance of these projects is: what are the benefits of the new technology to the customer compared to the previous generation of technology?

Control Variable

Firm size is added as a control variable as size can affect a firm's R&D expenditure. The strategic marketing literature emphasizes the importance of firm size because resource advantages can strongly affect new product performance (Gatignon and Xuereb 1997). In low-technology industries there is also a low R&D intensity, as a high rate would deplete technological opportunities more quickly than new ones are being created (Klevorick et al. 1995). Therefore, only some of the (probably larger) firms will have developed in-house technological capabilities (Pavitt et al. 1989).

Methodology

Data Collection

We used the membership database of the American Road and Transportation Builders Association (ARTBA), which contains 789 road infrastructure firms with complete contact information. According to the ARTBA their members are responsible for over 90% of the transportation construction industry.

To ensure that we would reach the intended respondents, we sent a pre-survey letter to all 789 firms. The pre-survey consisted of the following three questions. Did you develop any new technologies in the past 3 years? Are your company's main activities heavy construction and highway construction? Are you willing to participate in a study on the effect of the roles of government on the success of technology development? A total of 336 firms responded positively to all questions, 32 companies declined to participate, and 421 companies did not respond.

In administering the final survey, we followed the total design method for survey research (Dillman 1978). The first mailing packet included a personalized letter, the survey, a priority prepaid envelope with an individually typed return address label, and a list of research reports available for participants. The package was sent by priority mail to 336 firms, which agreed to participate. We asked the respondent to fill out the questionnaire with a specific technology development project in mind that was executed in the last 3 years. We emphasized that respondents should select a project that is representative of technology development within their firm. After three follow-up letters, we received completed questionnaires from 115 firms, representing a response rate of 34% (115/336).

Measures

The measures are shown in Appendix. For most measures we used existing scales or adapted existing scales for our objectives. We used a seven-point Likert scale throughout the survey.

For measuring strategic orientation we used the measures developed by Olson et al. (2005) and Narver et al. (2004). Government behavior is subdivided into championship and procurement policy. To measure championing, we took the measurement items on championing behavior used by Howell and Shea (2001) and adapted them to government. Our measurement consisted of eight items. We asked respondents to agree or disagree with the statements on championing behavior. The items referred to government support, conviction, and the willingness to solve problems and remove obstacles. No measurement was available at project level for public technology procurement, so we developed a five item measure. We asked respondents to agree or disagree with statements on how the contract was awarded, what specifications were used, who took the initiative, and whether government supported the project technically or financially.

Process performance was measured using three items on meeting budget, quality, and development time objectives. The first item asked respondents to assess process performance relative to the firms stated objectives, the second referred to the process performance relative to the firm's other new technologies and the third asked respondents to evaluate their project against competing technologies.

The benefits of the new technology are measured from the firm's perspective. Following, Chandy and Tellis (2000), we developed a measure to assess the benefits to customers relative to the previous generation of technology. These benefits resembled the themes in federal support for road infrastructure and performance specifications of government agencies (Federal Highway Administration 1998,2004).

Firm size was measured as the natural logarithm of the firm's total revenues over the last year. The amount of revenues is a standard measure of firm size (Finkelstein and D'Aveni 1994). We used the natural logarithm form to reduce heteroscedasticity (Kerlinger 1973).

Data Analysis

In the factor analysis we examined the loadings of the items of government behavior, strategic orientation, and project performance. The factor analysis resulted in six factors: we retained all

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Table 1. Results of Exploratory Factor Analysis

Construct	Item	Factor loading[a]
Government championship	CHAM1	***0.684***
	CHAM2	***0.819***
	CHAM3	***0.631***
	CHAM4	***0.935***
	CHAM5	***0.926***
	CHAM6	***0.925***
	CHAM7	***0.936***
	CHAM8	***0.917***
Public technology procurement	PROC1	***0.954***
	PROC2	***0.709***
	PROC3	***0.947***
	PROC4	***0.952***
	PROC5	***0.956***
Internal/cost orientation	INT1	***0.732***
	INT2	***0.836***
	INT3	***0.746***
Innovation orientation	INN1	***0.698***
	INN3	***0.669***
	INN4	***0.750***
Process performance	BUD1	***0.894***
	QUAL1	***0.862***
	TIME1	***0.876***
	BUD2	***0.849***
	QUAL2	***0.857***
	TIME2	***0.866***
	BUD3	***0.907***
	QUAL3	***0.888***
	TIME3	***0.868***
Benefits to customers	TPRF1	***0.843***
	TPRF2	***0.856***
	TPRF3	***0.749***
	TPRF4	***0.724***
	TPRF5	***0.666***

[a]Factor loadings are based on exploratory factor analysis with Varimax rotation.

those items that loaded on the correct factor over the 0.40 mark and had no cross loadings over the 0.40 mark. Table 1 shows the factor loadings of the items that were retained.

Following the factor analysis we performed a two-sided Pearson correlations test of the different variables including firm size. The outcomes of the correlations are shown in Table 2. Table 2 also includes the Cronbach Alpha's of the variables. The results suggest that the construct reliabilities are high, except for the innovation orientation construct, which is acceptable.

The hypotheses were examined in two regression models using ordinary least squares (OLS) estimation. In Model 1, we analyzed the effect of strategic orientation, government behavior, and firm size as independent variables on process performance as the dependent variable. In Model 2, we used the same independent variables, but benefits to customers are the dependent variable. To reduce multicollinearity, we used mean-centered variables, as suggested by Jaccard et al. (1990). The variance inflation factors shown in Table 2 are below harmful levels (Mason and Perreault 1991), suggesting that collinearity has not affected the results.

Results

Table 3 summarizes the results of the regression analysis. The results show that the two models are significant: process performance ($R^2=0.162$, $F_{(5,109)}=5.398$, $p=0.000\,1$) and benefits to customers ($R^2=0.218$, $F_{(5,109)}=7.349$, $p=.000\,1$).

Government Behavior and Project Performance

The hypotheses on government behavior, H_1 and H_2, predict a positive relationship between government championship and project performance and positive relationship between public technology procurement and project performance. The results support the positive relationship between government championship and project performance: process ($b=0.387$, $t=2.506$) and benefits to customer ($b=0.395$, $t=3.547$). Consistent with H_2, there is a positive relationship between public technology procurement and process performance, although the result is not significant ($b=0.031$, $t=0.245$). Countering our hypothesis, the predicted positive relationship between public technology procurement and the benefits to customers is contradicted by the

Table 2. Descriptive Statistics and Pearson Correlations[a]

Variable	Mean	standard deviation	VIF[d]	1	2	3	4	5	6	7
Championship[b]	4.81	1.16	1.416	*0.96*						
Public technology procurement [b]	4.34	1.35	1.316	0.37[e]	*0.97*					
Internal/cost orientation[b]	4.30	1.47	1.397	0.33[e]	0.41[e]	*0.83*				
Innovation orientation[b]	5.08	1.09	1.361	0.41[e]	0.21[f]	0.41[e]	*0.69*			
Firm size[c]	13.02	2.56	1.068	0.14	−0.09	−0.09	−0.08			
Process performance[b]	3.72	1.76		0.38[e]	0.21[f]	0.31[e]	0.32[e]	0.02	*0.98*	
Benefits to customers[b]	5.07	1.31		0.39[e]	0.02	0.34[e]	0.26[e]	0.08	0.56[e]	*0.91*

[a]$N=115$.

[b]We used a seven-point scale.

[c]We used the natural logarithm on total firm revenues to control for heteroscedasticity.

[d]VIF=variance inflation factor.

[e]Correlation is significant at the 0.01 level (2 tailed tests).

[f]Correlation is significant at the 0.05 level (2 tailed tests).

Note: The coefficient α for each measure is on the diagonal (and in italics) and the intercorrelations among the measures are on the off-diagonal.

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Table 3. Regression Results for Hypotheses[a]

	Dependent variables							
	Process performance				Benefits to customers			
Independent variables	Hypothesis	Unstandardized parameter estimate	Standard error	Standardized parameter estimate	Hypothesis	Unstandardized parameter estimate	Standard error	Standardized parameter estimate
Championship	$(H_1,+)$	0.387[b]	(0.154)	0.256	$(H_1,+)$	0.395[c]	(0.111)	0.350
Public technology procurement	$(H_2,+)$	0.031	(0.128)	0.024	$(H_2,+)$	−0.236[b]	(0.092)	−0.244
Internal/cost orientation	$(H_{3a},+)$	0.196	(0.121)	0.164	$(H_{3b},-)$	0.280[c]	(0.087)	0.313
Innovation orientation	$(H_{4a},+)$	0.229	(0.162)	0.142	$(H_{4b},+)$	0.053	(0.117)	0.044
Firm size		0.011	(0.061)	0.016		0.022	(0.044)	0.042
Adjusted R^2		0.162				0.218		
F-statistic		5.398[c]				7.349[c]		

[a]We used mean-centered variables to reduce multicollinearity, as suggested by Jaccard et al. (1990).

[b]$p<0.05$.

[c]$p<0.01$.

results. The results suggest a significant *negative* relationship ($b=-0.236$, $t=-2.566$).

Strategic Orientation and Project Performance

The third and fourth hypotheses consider the effect of strategic orientation on process performance and benefits to customers. H_{3a} predicts that higher levels of internal/cost orientation increase process performance. Although in the expected direction, the results suggest a nonsignificant relationship between internal/cost orientation and process performance ($b=0.196$, $t=1.615$). Countering hypothesis H_{3b}, the outcomes indicate that the relationship between internal/cost orientation and the benefits to customers is positive and significant ($b=0.280$, $t=3.198$). H_{4a} and H_{4b} predict a positive effect for innovation orientation on process performance and benefits to customers. Although the results show that the relationships are in the expected, positive direction, the outcomes are not significant (process performance: $b=0.229$, $t=1.416$; benefits to customers: $b=0.053$, $t=0.450$).

Firm Size and Project Performance

The effect of firm size on performance is not significant for both process performance ($b=0.011$, $t=0.177$) and for the benefits to customer ($b=0.022$, $t=0.494$), but has the expected positive effect.

Discussion

Low-technology industries are relevant sources of innovative activities and important for growth and employment (Bender 2006). However, only a small amount of empirical research on the relevance of government behavior and how low-technology firms manage their development activities has been conducted. This study is among the first to provide empirical findings about the relevance of government behavior on development project performance. Second, we extend the strategy implementation literature to low-technology industries.

Link between Government Behavior and Technology Development Outcomes

Our major contribution is the empirical investigation of the effect of government behavior on technology development projects. Our study shows that government championship is an important factor for both process performance and creating benefits to customers. In previous empirical research the importance of government championship was identified (Caerteling et al. 2008; Morris and Hough 1987), but the importance was not empirically tested. Howell and Shea (2001) have shown that championing behavior can make a decisive contribution to project performance within manufacturing firms. We have shown that government championship is crucial to project performance in road infrastructure.

A second key contribution to literature is the empirical research on public technology procurement. Previous research on government procurement primarily addressed contract awarding methods: bidding systems, contests, and reward systems (e.g., Anton and Yao 1990). The importance of public technology procurement was downplayed (Edler and Georghiou 2007). This research focused on public technology procurement, which government used to offer opportunities for experimentation and the demonstration of new technology (Rothwell and Zegveld 1981; Seaden and Manseau 2001). We have measured the relevance of contract specification (use of performance specifications), and technical and financial support. The predicted positive relationship between public technology procurement and project performance was not supported by the results. This finding contradicts earlier research on public technology procurement that suggests that this type of procurement can induce substantial private R&D investment (Lichtenberg 1988). Yet, most research on public technology procurement is based on defense contracts specified by government. But most of the technologies in our study were developed on the firm's own initiative. Our results indicate that for those technologies, public technology procurement has a negative effect on how the benefits of the new technology to the customer are perceived. This suggests two options. First, lowest bid selection favors existing technologies with minor improvements because new technologies with significant improvements are more costly than existing technologies. Second,

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public technology procurement rarely asks for significant improvements compared to existing technologies, as this might exclude too many firms.

Impact of Strategic Orientation on Technology Development Outcomes

Our second main contribution is the analysis of strategic orientation in a low-technology industry. Although the literature argues that strategic orientation is important to all firms, little effort has been made to examine low-technology industries. In this study, we used literature to analyze and predict the relevant strategic orientations for firms involved in road infrastructure. Based on this specification, we considered two types of strategic orientation: internal/cost orientation and innovation orientation. We expected both of these orientations to be present, given the dominance of low-cost and differentiated defenders in road infrastructure. Based on our hypotheses we predicted that innovation orientation would have the highest performance as it has a positive effect on both process performance and benefits to customers. We hypothesized that a focus on cost reduction of primary activities and support activities, such as logistics, operations, and administrative functions would have a negative effect on benefits to customers. However, counter to our hypothesis this study showed that pursuing operational excellence has a significant, positive effect in creating benefits to customers. Firms emphasizing operational excellence even outperform their rivals who stress an innovation orientation. This outcome suggests that internal/cost oriented firms have acquired ingrained marketplace knowledge of customer preferences because they focus on a narrow market segment (Morgan and Strong 2003). This knowledge gives them an edge over less domain-focused firms in providing benefits to their customers. Furthermore, the use of cost-based selection criteria by their main customers is likely to stimulate an internal/cost orientation within road construction firms.

Firm Size and Project Performance

The insignificant relationship between firm size and project performance can be attributed to industry characteristics. According to Malerba and Orsenigo (1997), traditional sectors have low levels of opportunity, appropriability, and cumulativeness. Consequently, they expect these sectors to have many geographically dispersed innovators. Breschi et al. (2000) showed that most low-technology industries have a widening pattern of innovation. A widening pattern of innovation refers to "an innovative base which is continuously enlarging through the entry of new innovators and to the erosion of the competitive and technological advantages of the established firms" (Breschi et al. 2000, p. 389). These conditions erode the potential advantage of larger firms.

Managerial and Policy Implications

The implications of this study for managers are threefold. First, this study reconfirms the importance of aligning strategic orientations with the environment. In mature low-technology industries, an internal/cost orientation seems more important to improve the competitive position than innovation-oriented efforts. Second, incremental improvements in existing technologies are more likely to succeed under competitive bidding than significant improvements. Government customers have difficulties in prizing the added value of significant improvements because of cost-based selection criteria. Third, firms should invest in relationships with champions within government. Existing studies of corporate political strategies focus on lobbying and reporting to affect policy and gain access to relevant information (e.g., Baysinger 1984). Yet, professional ties between firms and government are more likely to have a positive effect on firm performance (Hillman et al. 1999).

From a policy perspective, we can derive several implications from the results. First, government should extend technology policies to include its role as champion. In previous discussions on technology policy this dimension has been neglected. Most efforts have been directed at providing capital, facilitating technology transfer and supporting universities and public research institutes (Feldman and Kelley 2006; Martin and Scott 2000; Klette et al. 2000). Although public funding of university research is crucial, Feldman and Kelley (2006) argued that government has to find ways to convince firms to use university research for commercial applications. Government championship is a key element in stimulating commercial applications. Government should develop long-term policies to help firms in their efforts ranging from R&D, prototype development, and testing to market launch. For firms to engage in technology development, continuity in technology policy is necessary (Falk 2007). More important than providing opportunities for demonstration projects and financial support, government officials should

- Secure the support of top level policy makers.
- Remove regulatory barriers to new technologies that support policy objectives.
- Involve the key officials who decide on the procurement of new technologies.
- Promote the advantages of the new technology throughout the different government levels.

The aforementioned aspects of government championship are more likely to result in a market for new technology than demonstration projects and financial support. Supporting commercialization and the emergence of a market are crucial in low and medium-technology industries where government is a large buyer and first user of new technology.

This research further suggests that public technology procurement does not have a positive impact on the way technologies with significant improvements are valued. Government favors cost-based criteria, but seems unable to price the increased benefits of new technology compared to existing technologies. New technologies are often more expensive and risky than existing ones. We advise government to develop a pricing scheme that weighs the increased performance of new technology against the higher cost and risks. The weighed price of the new technology provides a more realistic comparison with existing technologies.

Limitations and Future Research

This paper has concentrated on a low-technology industry. The lack of understanding about technology development in these industries and the importance of the government as a buyer and user justified this choice. Future research could extend the dimensions of championship and public technology procurement to defense and other high-technology industries to compare findings. This research could enrich the discussion on the relevance of government championship and the value of differentiating between low and high-technology industries (Rush et al. 2007).

In this study we have excluded market orientation as the behavioral implementation of business strategy. We have argued that an internal/cost orientation and innovation orientation match the relevant dimensions of business strategy. Furthermore, existing

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studies on market orientation have shown mixed results that question the hegemony of market orientation (Noble et al. 2002). However, future research could study strategic orientation in more detail and incorporate market orientation in the framework. This would allow researchers to assess the importance of internal/cost orientation in low-technology industries compared to a customer and competitor orientation.

Further research could also examine the differences in strategic orientation between high and low-technology industries. In high-technology industries with a high level of R&D intensity, there is a strong relationship between advances in basic science and technology development performance. Advances in basic science provide a high degree of technological opportunity and thus a high R&D intensity can be sustained (Klevorick et al. 1995). Consequently, firms in high-technology industries are likely to have more technological opportunities allowing more innovation-oriented strategies.

Conclusions

In this paper we addressed the effect of government behavior and firms' strategic orientations on the performance of technology development projects in a low-technology industry. This study is among the first empirical research on the effect of government behavior to be conducted at project level. In previous research, government championship has been identified as an important contributing factor in technology success, but empirical grounding was lacking. Our empirical findings underscore the value of championing behavior and show that, in the industry studied, this behavior is more important than public technology procurement. The results even suggest that government championship is more important than a firm's strategic orientation.

Appendix. Study Measures

Government Behavior

Please indicate how much you disagree or agree with each statement. 1=strongly disagree; 7=strongly agree; the numbers between 1 and 7 represent the differing degree of your agreement.

Government championship								
In this selected project, …	ITEM	Strongly disagree						Strongly agree
… government officials enthusiastically promoted the technology's advantages.	CHAM1	1	2	3	4	5	6	7
… government officials got the key decision-makers involved.	CHAM2	1	2	3	4	5	6	7
… government officials expressed strong conviction about the technology.	CHAM3	1	2	3	4	5	6	7
… government officials got problems in the hands of those who could solve them.	CHAM4	1	2	3	4	5	6	7
… government officials persisted their support in the face of adversity.	CHAM5	1	2	3	4	5	6	7
… government officials secured the top level support required.	CHAM6	1	2	3	4	5	6	7
… government officials showed optimism about the success of the technology.	CHAM7	1	2	3	4	5	6	7
… government officials knocked down barriers to the technology.	CHAM8	1	2	3	4	5	6	7
Government procurement policy								
In this selected project,…	ITEM	Strongly disagree						Strongly agree
The technology was developed for a contract awarded through competitive bidding.	PROC1	1	2	3	4	5	6	7
The technology was developed on your company's own initiative.	PROC2	1	2	3	4	5	6	7
The technology was developed with technical support of government.	PROC3	1	2	3	4	5	6	7
The technology was developed using performance specifications.	PROC4	1	2	3	4	5	6	7
The technology was developed with financial support of government.	PROC5	1	2	3	4	5	6	7

Strategic Orientation

Please indicate how much you disagree or agree with each statement. 1=strongly disagree; 7=strongly agree; the numbers between 1 and 7 represent the differing degree of your agreement.

Internal/cost orientation								
In this selected project, …	ITEM	Strongly disagree						Strongly agree
… improving the operating efficiency of business was a top priority.	INT1	1	2	3	4	5	6	7

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… we had a continuing overriding concern for operating cost reduction.	INT2	1	2	3	4	5	6	7
… we continuously sought to improve production processes so we could lower costs.	INT3	1	2	3	4	5	6	7
… achievement of economies of scale or scope were important elements of our strategy.	INT4*	1	2	3	4	5	6	7
… we closely monitored the effectiveness of key business processes.	INT5*	1	2	3	4	5	6	7
Innovation orientation								
In this selected project, …	ITEM	Strongly disagree						Strongly agree
… management actively sought innovative ideas.	INN1	1	2	3	4	5	6	7
… competitors recognized us as innovation leaders.	INN2*	1	2	3	4	5	6	7
… we were first to market with this technology.	INN3	1	2	3	4	5	6	7
… we were recognized as being at the leading edge of technological innovation.	INN4	1	2	3	4	5	6	7
… innovation was perceived as too risky and was resisted.	INN5*	1	2	3	4	5	6	7

Items in asterisk were removed due to exploratory factor analysis.

Project Performance

Process performance

Please indicate, with what you know today, how successful this selected project was or has been using the following criteria.

Relative to your firm's stated objectives at the beginning of the project, how successful was this project in terms of:	ITEM	Far less than our stated objectives						Far exceeded our stated objectives
Budget	BUD1	1	2	3	4	5	6	7
Quality	QUAL1	1	2	3	4	5	6	7
Development time	TIME1	1	2	3	4	5	6	7
Relative to your firm's other new technologies, how successful was this project in terms of:	ITEM	Far less than our other technologies						Far exceeded our other technologies
Budget	BUD2	1	2	3	4	5	6	7
Quality	QUAL2	1	2	3	4	5	6	7
Development time	TIME2	1	2	3	4	5	6	7
Relative to competing technologies, how successful was this project in terms of:	ITEM	Far less than competing technologies						Far exceeded competing technologies
Budget	BUD3	1	2	3	4	5	6	7
Quality	QUAL3	1	2	3	4	5	6	7
Development time	TIME3	1	2	3	4	5	6	7
Benefits to customers								
Relative to the previous technology generation, this technology provides significantly higher benefits to the customer in terms of:	ITEM	Strongly disagree						Strongly agree
Increased reliability standard	TPRF1	1	2	3	4	5	6	7
Decreased production costs	TPRF2	1	2	3	4	5	6	7
Shortened production time	TPRF3	1	2	3	4	5	6	7
Increased safety standard	TPRF4	1	2	3	4	5	6	7
Reduced environmental impact	TPRF5	1	2	3	4	5	6	7
Reduced maintenance costs	TPRF6*	1	2	3	4	5	6	7
Broadened the applicability	TPRF7*	1	2	3	4	5	6	7

Items in asterisk were removed due to exploratory factor analysis.

Firm Size

What was your firm's last year's total revenues? $_____________,000

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References

Anton, J. J., and Yao, D. A. (1990). "Measuring the effectiveness of competition in defense procurement: A survey of the empirical literature." *J. Policy Anal. Manage.*, 9(1), 60–79.

Baker, W. E., and Sinkula, J. M. (2005). "Market orientation and the new product paradox." *J. Prod. Innovation Manage.*, 22, 483–502.

Baysinger, B. D. (1984). "Domain maintenance as an objective of business political activity: An expanded typology." *Acad. Manage. Rev.*, 9(2), 248–258.

Bender, G. (2006). "Peculiarities and relevance of non-research intensive industries in the knowledge-based economy." *Final Rep. Prepared for Research Project Policy and Innovation in Low-Tech-Knowledge Formation, Employment & Growth Contributions of the "Old Economy" Industries in Europe—PILOT*, European Commission's 5th Framework Program, Dortmund University, ⟨www.pilot-project.org⟩ (last accessed April 2007).

Breschi, S., Malerba, F., and Orsenigo, L. (2000). "Technological regimes and Schumpeterian patterns of innovation." *Econom. J.*, 110, 388–410.

Caerteling, J. S., Halman, J. I. M., and Doree, A. G. (2008). "Technology commercialization in road infrastructure: How government affects the variation and appropriability of technology." *J. Prod. Innovation Manage.*, 25(2), 143–161.

Capon, N., and Glazer, R. (1987). "Marketing and technology: A strategic coalignment." *J. Marketing*, 51, 1–14.

Chandy, R. K., and Tellis, G. J. (2000). "The incumbent's curse? Incumbency, size, and radical product innovation." *J. Marketing*, 64, 1–17.

Christensen, C. M., and Bower, J. L. (1996). "Customer power, strategic investment, and the failure of leading firms." *Strategic Manage. J.*, 17, 197–218.

Dalpé, R., DeBresson, C., and Xiaoping, H. (1992). "The public sector as first user of innovations." *Res. Policy*, 21, 251–263.

Das, S. S., and Van de Ven, A. H. (2000). "Competing with new product technologies: A process model of strategy." *Manage. Sci.*, 46(10), 1300–1316.

Démurger, S. (2001). "Infrastructure development and economic growth: An explanation for regional disparities in China?" *J. Comp. Econ*, 29, 95–117.

Dillman, D. A. (1978). *Mail and telephone surveys: The total design method*, Wiley, New York.

Dobbin, F., and Dowd, T. J. (1997). "How policy shapes competition: Early railroad foundings in Massachusetts." *Adm. Sci. Q.*, 42(3), 501–529.

Edler, J., and Georghiou, L. (2007). "Public procurement and innovation—Resurrecting the demand side." *Res. Policy*, 36, 949–963.

Eisenhardt, K. M., and Tabrizi, B. N. (1995). "Accelerating adaptive processes: Product innovation in the global computer industry." *Adm. Sci. Q.*, 40, 84–110.

European Economic and Social Committee. (2005). "Modern industrial policy—Supplementary opinion of the Consultative Commission on Industrial Change." *Rep. No. CCMI/032-CESE 1140/2005*, European Economic and Social Committee, Brussels, Belgium.

European Union Road Federation. (2007). *European road statistics 2007*, European Union Road Federation, Brussels, Belgium.

Fagerberg, J. (2004). "What do we know about innovation? Lessons from the TEARI project." *Rep. Prepared for TEARI Project*, European Commission and Norweigian Research Council, University of Oslo, ⟨http://folk.uio.no/janf/downloadable_papers.html⟩ (last accessed April 2007).

Falk, R. (2007). "Measuring the effects of public support schemes on firms' innovation activities: Survey evidence from Austria." *Res. Policy*, 36, 665–679.

Federal Highway Administration. (1998). "Transportation Equity Act for the 21st century—Fact sheet." *Rep. Prepared for Federal Highway Administration*, Washington, D.C (last accessed April 2007).

Federal Highway Administration. (2004). "Performance specifications—Strategic roadmap." *Rep. Prepared for Federal Highway Administration, Report No. FHWA-IF-04-023*, Washington, D.C. (last accessed April 2007).

Feldman, M. P., and Kelley, M. R. (2006). "The ex ante assessment of knowledge spillovers: Government R&D policy, economic incentives, and private firm behavior." *Res. Policy*, 35, 1509–1521.

Finkelstein, S., and D'Aveni, R. A. (1994). "CEO duality as a double-edged sword: How boards of directors balance entrenchment avoidance and unity of command." *Acad. Manage J.*, 37(5), 1079–1108.

Gatignon, H., and Xuereb, J.-M. (1997). "Strategic orientation of the firm and new product performance." *J. Mark. Res.*, 34, 77–90.

Geyer, A., and Davies, A. (2000). "Managing project-system interfaces: Case studies of railway projects in restructured U.K. and German markets." *Res. Policy*, 29, 991–1013.

Greer, W. R., and Liao, S. S. (1986). "An analysis of risk and return in the defense market: Its impact on weapon system competition." *Manage. Sci.*, 32(10), 1259–1273.

Hambrick, D. C. (1983). "High profit strategies in mature capital goods industries: A contingency approach." *Acad. Manage J.*, 26(4), 687–707.

Han, J. K., Kim, N., and Srivastava, R. K. (1998). "Market orientation and organizational performance: Is innovation a missing link?" *J. Marketing*, 62, 30–45.

Hillman, A. J., Zardkoohi, A., and Bierman, L. (1999). "Corporate political strategies and firm performance: Indicators of firm-specific benefits from personal service in U.S. government." *Strategic Manage. J.*, 20, 67–81.

Howell, J. M., and Shea, C. M. (2001). "Individual differences, environmental scanning, innovation framing and champion behavior: Key predictors of project performance." *J. Prod. Innovation Manage.*, 18, 15–27.

Hughes, T. P. (1983). *Networks of power*, The John Hopkins University Press, Baltimore.

Jaccard, J., Turrisi, R., and Wan, C. K. (1990). *Interaction effects in multiple regression*, Sage, Newbury Park, Calif.

Jacobsson, S., and Bergek, A. (2004). "Transforming the energy sector: The evolution of technological systems in renewable energy technology." *Ind. Corp. Change*, 13(5), 815–849.

Kerlinger, F. N. (1973). *Foundations of behavioral research*, Holt, Rinehart, and Winston, London.

Klette, T. J., Møen, J., and Griliches, Z. (2000). "Do subsidies to commercial R&D reduce market failures? Microeconometric evaluation studies." *Res. Policy*, 29, 471–495.

Klevorick, A. K., Levin, R. C., Nelson, R. R., and Winter, S. G. (1995). "On the sources and significance of interindustry differences in technological opportunities." *Res. Policy*, 24, 185–205.

Lerner, J. (1999). "The government as venture capitalist: The long-run impact of the SBIR program." *J. Business*, 72(3), 285–318.

Lichtenberg, F. R. (1988). "The private R&D investment response to federal design and technical competitions." *Am. Econ. Rev.*, 78(3), 550–559.

Malerba, F., and Orsenigo, L. (1997). "Technological regimes and sectoral patterns of innovative activities." *Ind. Corp. Change*, 6(1), 83–117.

Markard, J., and Truffer, B. (2006). "Innovation processes in large technical systems: Market liberalization as a driver for radical change?" *Res. Policy*, 35, 609–625.

Martin, S., and Scott, J. T. (2000). "The nature of innovation market failure and the design of public support for private innovation." *Res. Policy*, 29, 437–447.

Mason, C. H., and Perreault, W. D. (1991). "Collinearity, power, and interpretation of multiple regression analysis." *J. Mark. Res.*, 28, 268–280.

McKee, D. O., Varadarajan, P. R., and Pride, W. M. (1989). "Strategic adaptability and firm performance: A market contingent perspective." *J. Marketing*, 53, 21–35.

Miles, R. E., and Snow, C. C. (1978). *Organizational strategy, structure, and processes*, McGraw-Hill, New York.

J. Constr. Eng. Manage., 2009, 135(11): 1211-1221

Mom, G. (2005). "Roads without rails." *Technol. Cult.*, 46(4), 745–772.

Morgan, R. E., and Strong, C. A. (2003). "Business performance and dimensions of strategic orientation." *J. Bus. Res.*, 56, 163–176.

Morris, P. W. G., and Hough, G. H. (1987). *The anatomy of major projects*, Wiley, New York.

Mowery, D. C. (1998). "The changing structure of the US national innovation system: Implications for international conflict and cooperation in R&D policy." *Res. Policy*, 27, 639–654.

Narver, J. C., Slater, S. F., and MacLachlan, D. L. (2004). "Responsive and proactive market orientation and new-product success." *J. Prod. Innovation Manage.*, 21, 334–347.

Nelson, R. R. (1995). "Why should managers be thinking about technology policy?" *Strategic Manage. J.*, 16(8), 581–588.

Noble, C. N., Sinha, R. K., and Kumar, A. (2002). "Market orientation and alternative strategic orientations: A longitudinal assessment of performance implications." *J. Marketing*, 66, 25–39.

Norberg-Bohm, V. (2000). "Creating incentives for environmentally enhancing technological change: Lessons from 30 years of U.S. energy technology policy." *Technol. Forecast. Soc. Change*, 65, 125–148.

Olson, E. M., Slater, S. F., and Hult, T. M. (2005). "The performance implications of fit among business strategy, marketing organization structure and strategic behavior." *J. Marketing*, 69, 49–65.

Pavitt, K., Robson, M., and Townsend, J. (1989). "Technological accumulation, diversification, and organization in U.K. companies, 1945–1983." *Manage. Sci.*, 35(1), 81–99.

Porter, M. (1980). *Competitive strategy*, Free Press, New York.

Ring, P. S., Bigley, G. A., D'Aunno Insead, T., and Khanna, T. (2005). "Perspectives on how governments matter." *Acad. Manage. Rev.*, 30(2), 308–320.

Rosenberg, N. (1994). *Exploring the black box: Technology, economics and history*, Cambridge University Press, Cambridge, U.K.

Rothwell, R., and Zegveld, W. (1981). *Industrial innovation and public policy*, Francis Pinter, London.

Rush, H., Bessant, J., and Hobday, M. (2007). "Assessing the technological capabilities of firms: Developing a policy tool." *R & D Manage.*, 37(3), 221–236.

Seaden, G., and Manseau, A. (2001). "Public policy and construction innovation." *Build. Res. Inf.*, 29(3), 182–196.

Shapiro, C. (2001). "Setting compatibility standards: Cooperation or collusion?" *Proc., Conf. of the Engelberg Center on Innovation Law and Policy*.

Shenhar, A. J., Dvir, D., Levy, O., and Maltz, A. C. (2001). "Project success: A multidimensional strategic concept." *Long Range Plann.*, 34, 699–725.

Slater, S. F., and Mohr, J. J. (2006). "Successful development and commercialization of technological innovation: Insights based on strategy type." *J. Prod. Innovation Manage.*, 23, 26–33.

Von Tunzelmann, N., and Acha, V. (2005). "Innovation in 'low-tech' industries." *The Oxford handbook of innovation*, J. Fagerberg, D. C. Mowery, and R. R. Nelson, eds., Oxford University Press, New York, 407–432.

Walker, O. C., and Ruekert, R. W. (1987). "Marketing's role in the implementation of business strategies: A critical review and conceptual framework." *J. Marketing*, 51, 15–33.

Wallsten, S. J. (2000). "The effects of government-industry R&D programs on private R&D: The case of the Small Business Innovation Research program." *Rand J. Econ.*, 31(1), 82–100.

J. Constr. Eng. Manage., 2009, 135(11): 1211-1221