Multiple Levels in the Organization of Innovation: Project Organization in Single-firm Projects and Multi-firm Projects

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Abstract Studies about how the organization of new product (and new service) development projects (NPD) projects influences project performance typically investigate this in Single-firm projects, i.e. projects with high ownership integration. However, NPD projects are often performed by two or more partnering firms. In this paper we investigate whether specific project-level organizational mechanisms, such as free flow of information between team members, project leader autonomy, external search for information, and decentralization, have different performance outcomes in Single-firm projects than in Multi-firm projects. Using data on web application development projects we find that project-level integration mechanisms, i.e. mechanisms that align and coordinate the interests and activities of team members, contribute comparatively stronger to the speed of problem solving in alliance projects than in Single-firm projects. This shows that the performance effects of a project's organizational form are determined by the interplay of firm-level organizational choices and project-level mechanisms.
Key words NPD, multiple levels, project organization, Multi-firm, project performance

1 Introduction

The management and organization of innovation is a complex and a multi-level phenomenon (Gerwin and Ferris, 2004; Gupta et al., 2007; Tiwana, 2008). In this paper we aim to increase our understanding of the performance of NPD projects and processes by explicitly studying the complementarities between a project's firm-level organizational form and its project-level organizational form. At the level of the firm, a project's organizational form for instance relates to the number of firms that are involved in the project, how investments are divided, and how tasks are allocated to the partnering firms and suppliers. Within a particular firm-level setup (e.g. a single innovator with multiple suppliers or a fifty-fifty alliance project with no supplier involvement) the NPD process is subsequently executed in a way that is managed and structured based on the project-level differentiation and integration mechanisms, such as free flow of information, project manager influence, and decentralization (Sheremata, 2000; Atuahene-Gima, 2003).

In this paper we investigate the interplay of a project's firm-level organizational characteristics and its project-level organizational form. In other words, this chapter centers on the research question whether, and if so how and to what extent, a project's firm-level organizational form interacts with project-level organizational characteristics in its effect on the team's problem-solving proficiency as well as on project performance. Such multi-level innovation research is scarce and important opportunities therefore exist to generate a more comprehensive understanding of the management of innovation (Gerwin and Ferris, 2004; Gupta et al., 2007; Tiwana, 2008).

In terms of the firm-level organizational variable this paper focuses on the degree of ownership integration (Robertson and Langlois, 1995). In this paper we define ownership integration as the number of firms that invests in a project. In general, ownership integration increases if fewer firms invest in a new product development project, i.e. ownership integration is high for Single-firm projects and it is considered to be low for Multi-firm/alliance projects. Below we first of all formulate hypotheses. After that we present the methodology that will be used to test these hypotheses, which is followed by our results. We end this paper with a discussion and conclusions.

2 Theory

Innovation is a phenomenon that is influenced by factors that operate at many levels of analysis, such as the level of individuals, the level of groups or teams, the level of organizations, and the level of industries (Gopalakrishnan and Damanpour, 1997; Gupta et al., 2007). Most innovation studies focus on just one level of analysis, whereas multilevel theory has the potential to explain a phenomenon more precisely by generating a better understanding of the ways in which different levels of analysis are

related (Klein et al., 1994; Gupta et al., 2007). Recently some innovation studies have explicitly taken into account multiple levels of analysis, but mostly these studies aim to explain firm-level performance, i.e. in terms of patenting, rather than project performance (Rothaermel and Hess, 2007; Somaya et al., 2007).

The literature about new product development success factors (Brown and Eisenhardt, 1995) has mostly proceeded without taking into account multiple levels of analysis. For instance, this literature typically considers projects that are financed and executed by individual firms on their own. As a result, most of the literature about success factors related to issues of project management falls into this category. Shenhar and Dvir (1996) recognized that research is needed that explicitly consider the role of organizational boundaries.

Gerwin and Ferris (2004) met this call as they investigated theoretically the costs and benefits of alternative ways to organize NPD projects in strategic alliances (as opposed to projects in single firms). For instance, one or both of the partners in an alliance project might actually perform project tasks, i.e. 'single participation projects' or 'dual participation projects'. If both firms choose to perform part of the workload, then several project-level organizational decisions have to be made about whether and how to perform tasks separately or in an integrated approach with collaborating team members from both firms, i.e. 'dual separate' or 'dual integrated'. In addition, for dual integrated alliance projects, project management can be organized in different ways, such as by means of a single project manager or by means of a team that takes decisions based on consensus.

In a recent empirical study Tiwana (2008) aimed to explain the performance of alliance projects by means of 'bridging ties' and 'strong ties'. Alliances involve a bridging mechanism to bring together the expertise and capabilities of different firms (i.e. structural holes). In order to fully realize the potential that is created by this differentiation at the level of the firm, projects need to be structured in such a way that they are able to effectively integrate and combine the capabilities from the different firms, i.e. strong ties. In other words, Tiwana (2008) argues and also finds empirical support that differentiation brought about by alliances of diverse partners (bridging ties) complements integration mechanisms at the project level (strong ties) in the explanation of alliance project performance. This shows that multiple levels of analysis interact in their effect on the outcome, i.e. cross-level moderators (Klein et al., 1994; Gupta et al., 2007).

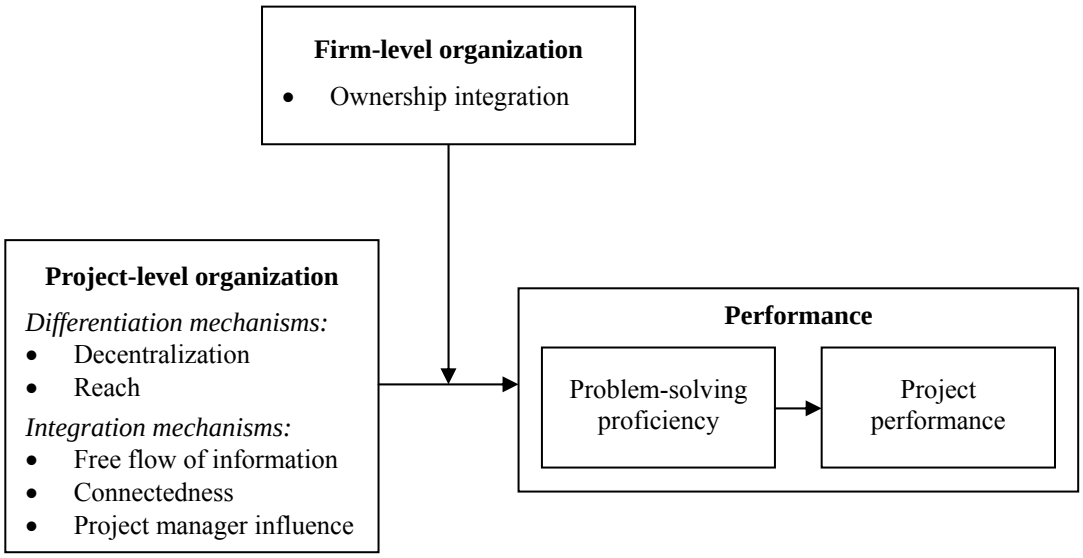

Figure 1 Conceptual framework

Like Tiwana we are also interested in the cross-level moderating effects of the project-level and the firm-level on project performance. Whereas Tiwana - at the firm-level - considers variation in terms of the type of alliances (i.e. the extent that partners have different capabilities, or bridging ties), we consider a different type of firm-level variation. We namely take into account that projects can be performed in alliances or not, i.e. alliance projects or Single-firm projects. At the project-level our study also differs from and complements Tiwana's study. Whereas Tiwana focuses on the extent that the

project's organizational structure provides integration mechanisms (the strength of ties), we not only focus on integration mechanisms, but also on project-level differentiation mechanisms (i.e. reach and decentralization). Figure 1 represents the theoretical relationships we are interested in. Next we formulate hypotheses.

3 Hypotheses

The extent of ownership integration and therefore the decision to finance a project alone or to ally with one or more external parties is an important decision for innovating firms. Partnering of course reduces the required financial resources and allows risks to be shared. At the same time, partnering could mean that different expertise and capabilities are allocated to the project, which is likely to increase the chance of success (Tiwana, 2008). As potential drawbacks, partnering is likely to result in reduced project control and decision-making power and in the risk that a partner acts opportunistically (Gulati et al., 2005). Next to these behavioral and appropriation uncertainties, information-exchange and coordination between partners might be problematic as a result of structural and cultural barriers (Li and Hambrick, 2005). Furthermore, partners might develop honest differences of opinion and conflicts (Gulati et al., 2005).

Hence, at the level of the firm, the fact that multiple firms are brought together in an alliance means that opportunities are generated for novel ideas and creativity. In terms of the project problem-solving, Multi-firm projects might for instance be comparatively faster, more efficient, and more effective if the partners possess complementary information and capabilities. At the same time, the fact that multiple routines, interests, and frames of reference are involved complicates the realization and exploitation of this potential (Tiwana, 2008). Hence, at the project-level, integration mechanisms are needed to facilitate communication, collaboration, and decision-making across the fault line that might exist between team members from different firms (Li and Hambrick, 2005).

In terms of a project's project-level organizational form we can distinguish between differentiation and integration mechanisms. Decentralization and reach, i.e. search for information in the teams environment, are differentiation mechanisms that provide the project team with a greater quantity and quality of specialized expertise (Sheremata, 2000). In contrast, free flow of information, connectedness, and project management influence help the project team to integrate knowledge and to align activities (Sheremata, 2000). Hence, these mechanisms provide the team with an integrative capability.

Also firm-level organizational decisions influence a project's integration and differentiation capabilities. Brusoni et al. (2001) for instance define different firm-level organizational forms (i.e. make, buy, and systems integration) as different combinations of differentiation and integration. In principle, Single-firm projects ('make') can be characterized as scoring high on integration and low on differentiation (e.g. Brusoni et al., 2001). The single investing firm has formal authority over the project and is able to exert extensive control if needed. At the same time, the differentiation benefits of this organizational form are limited, because there are no partnering firms that bring incentives and unique capabilities to the project. In contrast, Multi-firm projects typically indicate that decision-making and project control is executed by multiple firms. In principle, such projects are therefore less integrated than Single-firm projects. At the same time, Multi-firm projects have a larger potential to benefit from differentiation because of the involvement of multiple distinct and committed parties.

Based on the same logic as in Tiwana (2008) we argue project-level integration mechanisms are especially beneficial in Multi-firm projects to help realize their differentiation potential. These mechanisms can for instance help to achieve unity of effort among the multiple investing firms. In a similar vein, differentiation mechanisms might be less effective in Multi-firm projects than in Single-firm projects. For Single-firm projects it will comparatively easy to align incentives and to effectively coordinate because people will know each other and because they are likely to have the same routines and identical goals. At the same time, differentiation mechanisms, when compared to their potential in Multi-firm projects, can be expected to be particularly useful in Single-firm projects. Since these projects lack the diversity that often characterizes alliances, differentiation mechanisms might compensate for this by exploiting as much as possible the incentives, specialization, and diversity from within the firm. We expect that these moderating effects hold for project performance as well as for problem-solving proficiency. Hence, we can formulate the following general hypotheses:

Hypothesis 1a. *Project-level differentiation mechanisms* (decentralization and reach) *contribute more to project performance* (project speed, project cost-efficiency, and product quality) *in Single-firm projects (high ownership integration) than in Multi-firm projects (low ownership integration).*

Hypothesis 1b. *Project-level integration mechanisms* (free flow of information, connectedness, and project management influence) *contribute less to project performance* (project speed, project cost-efficiency, and product quality) *in Single-firm projects (high ownership integration) than in Multi-firm projects (low ownership integration).*

Hypothesis 2a. *Project-level differentiation mechanisms* (decentralization and reach) *contribute more to problem-solving proficiency* (problem-solving speed, problem-solving cost-efficiency, and solution quality) *in Single-firm projects (high ownership integration) than in Multi-firm projects (low ownership integration).*

Hypothesis 2b. *Project-level integration mechanisms* (free flow of information, connectedness, and project management influence) *contribute less to problem-solving proficiency* (problem-solving speed, problem-solving cost-efficiency, and solution quality) *in Single-firm projects (high ownership integration) than in Multi-firm projects (low ownership integration).*

4 Method

We tested our hypotheses using survey data on 92 development projects of web applications that were performed in the Netherlands. In the absence of an encompassing population of Dutch web application development projects, we established our target population as follows. First, we approached 74 projects that were performed as part of a government program called 'Kenniswijk' to promote the development of broadband services. We obtained data on 39 of these projects (53%). Secondly, we compiled a list of 43 Internet bureaus made up of members of an association of Dutch Internet bureaus and of Internet bureaus mentioned in a list of top ICT companies in 2005 (published by a leading Dutch ICT magazine). We asked a director of these firms to complete our survey for a recently finished project that was relatively complex for their firm. This increased the likely variation in our dataset in terms of the extent that problems are systemic rather than autonomous. In some cases the directors themselves were the project manager of these projects. In other cases the directors provided us with the name of the project manager. From this list 27 firms completed the survey (63%). Finally, we compiled a list of new applications mentioned on an ICT news site (Planet Multimedia) in 2006 and 2007. Of these 36 projects we got response on 26 projects (72%).

A comparison of the three subpopulations in terms of our variables of interest as well as several control variables (see below) revealed that these three groups are very similar[40]. In sum, our overall population consists of 153 projects and our dataset consists of 92 projects, which is a response rate of sixty percent. With respect to all of the variables that we included in our analysis, we compared the group of responses that we obtained after the first contact (63 respondents) and the group of responses that we obtained after sending out a reminder e-mail (29 respondents). We found no significant differences between these two groups (Oneway ANOVA), which is typically seen as evidence for the absence of nonresponse bias (Wright and Overton, 2008).

The average project duration from start to completion was nine months. In general, the web applications were considerably new (3.8 on a five-point scale ranging from not new at all to very new) and they were developed under considerable time pressure (with an average value of 3.7 on a five-point scale ranging from minimal to huge time pressure). In general, the teams in our dataset were small. For instance, 54% of the project teams consisted of 2-5 full-time project members. Another thirty percent of the teams consisted of 6-25 full-time team members. In terms of firm size the number of employees in about one third of the firms was in the range of 1 to 5. Another one third of the firms had more than one hundred employees. Finally, about one third of the firms existed for more than twenty years, while another one third of the firms existed five years or less.

5 Data collection and measurement

To collect data we used an on-line questionnaire. We pretested our questionnaire with colleagues and the self-completion of the on-line questionnaire was pretested in on-site think-aloud interviews with two managers of web application development projects (Hak et al., 2004). With our questionnaire we targeted project managers as single informants, because they are generally the most knowledgeable actors. For most cases we found the names of project managers or company directors and their telephone numbers on the Internet. We first approached respondents by phone and invited them to participate. If they agreed we sent them an e-mail with a link to the questionnaire. If multiple firms were

[40] Of the variables included in our analysis One-way ANOVA revealed different means for team size, connectedness, and reach. Subsequent Tukey tests revealed only two significant mean differences ($p<0.05$), i.e. Kenniswijk projects are smaller-sized than Planet Multimedia projects and Kenniswijk projects on average reach out more to their environment than the projects performed by Internet bureaus.

involved in the project, our respondent was typically the project manager from the leading firm in the project.

Our approach of single respondents might have introduced a common variance problem (Podsakoff et al., 2003). We think that this threat is limited in our case, since it is unlikely that the ratings of respondents were structured by implicit theories they might have had that resembled our moderation hypotheses (e.g. Doty et al., 1993; Podsakoff et al., 2003). Further evidence for the absence of common method bias is provided by the Harman's single-factor test (Podsakoff et al., 2003). Principal component analyses on the variables included in the regression models reported in Table 4 and 5 revealed multiple factors. We would expect one factor to emerge should strong common method bias exist. In the case of multiple factors we would expect the largest factor to account for a large degree of the covariation among the variables. The explained variation of the largest variable is limited however (less than 24 percent), which reduces concerns of common method bias.

We measured most of our concepts using (5-point Likert) scales that were validated in prior research. Some items were adapted to reflect the characteristics of our particular empirical context. Appendix A provides a detailed overview of the measures used and their sources. It is important to stress that we asked respondents to complete these questions for all the project members working on the project from all the firms involved. Although the principal project manager might for instance not know the details of the way that a partner organizes its separate workload, we expect that this actor is the most knowledge single respondent regarding these matters. Table 2 presents a correlation matrix together with descriptive statistics. This table not just includes the ownership integration dummy, but also (and both of them reverse-scored) the absolute number of investing firms and the absolute number of investing firms for all Multi-firm projects.

In the Appendix we also provide the results from the exploratory factor analysis (Varimax rotated principal axis factoring) we used to validate the scales. All scales point to a one-factor model. They all have an eigenvalue greater than 1 and all but one explain more than 70% of the variance in the data. Appendix A also presents the Cronbach's alpha values. One of these coefficient reliabilities (connectedness) is slightly below the common threshold value of 0.70. All other scales are (well) above this value. Table 2 presents descriptive statistics (mean, standard deviation, and correlations).

Ownership integration is not included in Appendix A. This measure is discussed here. It is operationalized in two different ways. First of all we use a dummy variable. A value of 1 indicates development projects that were financed by a single firm. This reflects a high (maximum) value of ownership integration. A value of 0 indicates that two or more firms financed the total expenses to complete the development project, indicating a low degree of ownership integration. Secondly, we consider ownership integration in terms of the absolute number of investing firms. Table 1 provides an overview of the frequency of the number of investing firms. It appears that 43 projects were financed by a single firm and 49 projects were financed by two or more firms. Most of the alliances involved two or three investing partners (seventeen projects and sixteen projects respectively). Eight projects were financed by four firms and the remaining eight projects had five or more investing firms. Ownership integration is high if a single firm invests in the project and ownership integration will in general decrease as the number of investing firms increases. Note however that this treatment of ownership integration in terms of the number of investing firms includes no data about the actual division of investments between the investing firms.

Table 1 Frequency of the number of investing firms

	Frequency (no. of projects)
1 investing firm	43
2 investing firms	17
3 investing firms	16
4 investing firms	8
5 investing firms or more	8
Total	*92*

To test our hypotheses we use hierarchical regression analysis. Multicollinearity was of no concern in these analyses. We used mean-centered variables (except for the ownership integration dummy) and the VIF values were below 2.5 for most factors. The maximum VIF value was still very limited with a value of 3.6. This also suggests that there is no particular direct effect of ownership integration on the way projects are organized. This is also the picture that emerges if we investigate the correlation coefficients in Table 2 between the five organizational project characteristics and the absolute number of investing firms (both in the dataset as a whole and in the Multi-firm subset, i.e. variables 15 and 16 in Table 2).

Table 2 Correlations and descriptive statistics

	mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Project speed	2.90	1.14																	
2. Product quality	3.61	0.95	0.35***																
3. Project cost efficiency	3.22	1.08	0.54***	0.28**															
4. Problem-solving speed	3.67	0.93	0.32**	0.24*	0.30**														
5. Solution quality	3.65	0.90	0.13	0.19	0.09	0.16													
6. Problem-solving efficiency	3.49	1.04	0.42***	0.34***	0.55***	0.56***	0.17												
7. Decentralization	3.31	0.95	0.25*	0.03	0.44***	0.14	0.30**	0.25*											
8. Free flow of information	3.57	0.90	0.25*	0.20	0.36***	0.39***	0.42***	0.26*	0.35***										
9. Reach	3.64	0.93	0.05	0.14	0.07	-0.06	0.11	-0.09	-0.04	0.06									
10. Connectedness	3.39	0.77	-0.09	-0.03	-0.04	-0.01	0.02	-0.12	0.09	0.41***	-0.02								
11. Project management influence	3.53	0.84	0.08	0.11	0.15	0.08	0.21	-0.04	0.13	0.26*	0.15	0.04							
12. Application novelty	3.98	1.11	-0.09	-0.02	0.14	-0.07	-0.05	-0.20	0.16	-0.01	0.12	-0.10	0.10						
13. Team size	3.47	1.24	-0.25*	-0.08	-0.39***	-0.21	0.05	-0.17	-0.22*	-0.07	-0.06	0.27*	-0.17	-0.05					
14. Ownership integration dummy	0.53	0.50	-0.09	0.02	-0.07	0.01	-0.04	-0.11	-0.01	0.05	-0.20	0.04	0.17	0.14	-0.12				
15. Number of investing firms (R)	2.39	2.11	0.00	0.11	-0.01	0.21*	-0.14	0.00	0.06	0.04	-0.13	-0.01	0.14	-0.06	-0.28**	0.62**			
16. If > 1, no. of investing firms (R)[a]	3.61	2.27	0.11	0.19	0.07	0.34**	-0.20	0.13	0.12	0.01	0.00	-0.06	0.06	-0.06	-0.36**	NA	-1.00***		
17. Problem frequency	2.76	1.29	-0.39***	-0.17	-0.38***	-0.63***	-0.14	-0.53***	-0.19	-0.24*	0.17	0.12	-0.03	0.24*	0.30**	-0.04	0.12	0.24	
18. Extent problems are systemic	2.88	1.13	-0.16	-0.05	-0.20	-0.18	-0.25*	-0.20	0.02	-0.17	0.06	0.08	-0.13	0.18	0.14	-0.14	0.06	-0.05	0.31**

* p<0.05; ** p<0.01; *** p<0.001; N=92; [a]N=49; (R) Reversed-scored.

Table 3 Means in the Two Sub Groups of High and Low Ownership Integration

	Ownership integration	Mean (on a 1-5 scale)
Decentralization	High (one investing firm)	3.29
	Low (two or more investing firms)	3.32
Reach*	High (one investing firm)	3.44
	Low (two or more investing firms)	3.82
Free flow of information	High (one investing firm)	3.62
	Low (two or more investing firms)	3.52
Connectedness	High (one investing firm)	3.42
	Low (two or more investing firms)	3.36
Project management influence	High (one investing firm)	3.68
	Low (two or more investing firms)	3.40

* Statistically significant one-sided t-test (p<0.05).

Neither do we find much differences if we compare the average values of the differentiation and integration mechanisms across the two sub groups of the ownership integration dummy (i.e. Single-firm projects and alliance/Multi-firm projects). The results from a one-sided t-test indicate that in our dataset only one factor substantially differs across the two groups. Reach is on average higher for alliance projects than for Single-firm projects. This mean difference is 0.38 on a five-point scale ($p<0.05$). The other four project-level organizational factors do not differ significantly for the two types of ownership integration (see Table 3).

6 Results

6.1 Do the moderating effects contribute to the explanation of project performance?

Table 4 presents the results from regression analyses for project speed, product quality, and project cost efficiency. In each of these three analyses, Model 1 includes two control variables, the five project-level characteristics and the ownership integration dummy. In absolute sense the largest standardized regression coefficient for the ownership integration dummy in these six models is -0.12. This suggests that projects with high ownership integration (one investing firm) are in general somewhat less successful than projects with low ownership integration (two or more investing firms). This is however a small effect size (and statistically not significant). Furthermore, the effect of the ownership integration dummy variable as reported in Table 4 (Model 1) remains limited if we run these same regression models without the five project-level organizational factors. The largest regression coefficient in these models is still -0.12 (this result also holds for the regression analyses reported in Table 5, which we discuss below). The absence of a strong direct effect in these limited regression models allows us to rule out the possibility that ownership integration does have an effect on one or more of the performance indicators, but that this effect is (at least partially) mediated by one or more of the project-level organizational factors (Baron and Kenny, 1986).

Table 4 Results of Regression Analyses – Project Performance

	Product Quality		Project Cost Efficiency		Project Speed	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Team size	-0.02	-0.03	-0.30**	-0.27**	-0.17	-0.10
Application novelty	-0.05	-0.04	0.08	0.06	-0.13	-0.19*
Decentralization	-0.04	-0.04	0.28**	0.32*	0.16	0.33*
Reach	0.13	0.16	0.01	-0.05	0.02	-0.15
Free flow of information	0.25*	0.33*	0.28**	0.32*	0.25*	0.27*
Connectedness	-0.12	-0.29*	-0.08	-0.12	-0.17	-0.17
Project manager influence	0.03	-0.11	0.04	-0.07	-0.04	0.01
Ownership integration (OI)	0.03	0.13	-0.12	-0.01	-0.09	0.03
Decentralization * OI		0.03		0.02		0.20
Reach * OI		0.01		-0.14		-0.31*
Free flow of information * OI		0.21		0.08		0.03
Connectedness * OI		-0.32		-0.06		-0.04
Project manager influence * OI		-0.18		-0.12		-0.02
Incremental R^2		0.04		0.02		0.05
Partial F		0.72		0.36		1.03
R^2	0.08	0.12	0.36	0.37	0.17	0.23
Adjusted R^2	-0.02	-0.04	0.29	0.26	0.09	0.09
F	0.82	0.77	5.58***	3.43***	2.08*	1.68*
n	92	92	92	92	92	92

* $p<0.05$; ** $p<0.01$; *** $p<0.001$; standardized coefficients are reported for a 1-sided test.

In Table 4 for each of the dependent variables the shift from Model 1 to Model 2 involves the inclusion of the five moderating effects. We find that the three steps add very little to the explanation of the three dimensions of project performance. We did find one significant moderating effect however (β=-0.31): reach appears to contribute comparatively less to project speed in Single-firm projects than in alliance projects. This is the opposite of what we would expect based on Hypothesis 1a. Also

noteworthy is the joint effect of connectedness and ownership integration on product quality (β=-0.32; n.s.). This substantial effect suggests that connectedness (a project-level integration mechanism) complements Multi-firm projects by contributing to (greater satisfaction with) product quality. This is in line with our hypothesis.

In additional analyses we used the absolute number of investing firms (reverse-scored and as a standardized variable) as the moderator instead of the dummy variable. Also in these analyses we found no significant steps from Model 1 to Model 2. Similar to the results with the ownership integration dummy (Table 4) we found a strong moderating effect involving reach in its effect on project speed (β=-0.27; p<0.05; one-sided test). Additionally, we found in this model that ownership integration positively moderates the relationship between decentralization and project speed if ownership integration increases (β=0.25; p<0.05; one-sided test). This positive moderating effect is in line with what we would expect based on Hypothesis 1a. Just like for Model 1 in Table 4 we found no particular direct effect of ownership integration on project performance.

Finally, we also performed the regression analyses in the subset of Multi-firm projects with the absolute number of investing firms (i.e. two or more) as a proxy for ownership integration. This was to investigate whether it matters whether one allies with one or more partners. In this small dataset (N=49; see Table 1) we found no strong predictors of any of the three project performance indicators. Overall, we find little support for the claim that ownership integration and project-level differentiation and integration mechanisms interact in their effect on project performance. The steps have little explanatory power and the moderating effect involving reach disconfirms our hypothesis. The findings involving connectedness and decentralization do provide some support for our hypothesis however.

6.2 Do the moderating effects contribute to problem-solving proficiency?

Unlike the results for project performance, the inclusion of the moderating effects results in a substantially improved explanation of problem-solving proficiency (see Table 5). For all three dimensions of problem-solving proficiency the step from Model 1 to Model 2 explains about ten percent additional variation (and is statistically significant; p<0.05). We find strong (negative) regression coefficients for the interaction effects involving the three integration mechanisms (free flow of information, connectedness, and project management influence). This is in line with what we would expect based on Hypothesis 2b. Particularly connectedness and project management influence appear to be negatively moderated by the ownership integration dummy in their effect on problem-solving speed (p<0.05).

Table 5 Results of Regression Analyses – Problem-Solving Proficiency

	Solution Quality		Problem-solving Efficiency		Problem-solving Speed	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Team size	0.21*	0.17	-0.09	-0.06	-0.17	-0.20*
Application novelty	-0.13	-0.07	-0.23*	-0.25**	-0.07	-0.03
Decentralization	0.21*	0.10	0.18	0.21	-0.05	-0.07
Reach	0.10	0.24*	-0.09	-0.15	-0.09	0.04
Free flow of information	0.42***	0.28*	0.33**	0.25*	0.46***	0.39**
Connectedness	-0.23*	-0.43**	-0.25*	-0.42**	-0.13	-0.36**
Project management influence	0.11	-0.10	-0.11	-0.30*	-0.04	-0.32*
Ownership integration (OI)	-0.02	0.18	-0.08	0.26*	-0.02	0.20
Decentralization * OI		-0.07		0.02		0.04
Reach * OI		0.18		-0.21		0.14
Free flow of information * OI		-0.21		-0.10		-0.06
Connectedness * OI		-0.24		-0.22		-0.36*
Project management influence * OI		-0.21		-0.27		-0.31*
Incremental R^2		0.09		0.09		0.10
Partial F		1.97*		2.00*		2.09*
R^2	0.28	0.37	0.24	0.33	0.22	0.31
Adjusted R^2	0.21	0.26	0.16	0.21	0.13	0.19
F	3.76***	3.22***	3.09**	2.79**	2.66**	2.56**
n	92	92	92	92	92	92

* p<0.05; ** p<0.01; *** p<0.001; standardized coefficients are reported for a 1-sided test.

We should note however that the results in Table 5 also indicate that the inclusion of the moderating effects substantially reduces the main effects of the integration mechanisms. For illustrative

purposes we plotted the overall effects of connectedness and project management influence on problem-solving speed in Figure 2. For both factors the effects are almost identical. That is why we report only one figure. In general low values of these integration mechanisms seem to work best for both Single-firm projects and alliance projects. If these mechanisms are extensively applied however, then it appears that they work much better (in terms of problem-solving speed) in alliance projects than in Single-firm projects.

Another result from the inclusion of the moderating effects in Model 2 is the increase in the regression coefficient for the ownership integration dummy for each dependent variable. This indicates that problems on average are solved more proficiently in Single-firm projects than in Multi-firm projects. This especially holds for problem-solving efficiency (β=0.26; $p<0.05$). However, if judged by Figure 2 (which also incorporates the main effect of the ownership integration dummy), then alliance projects on average tend to perform better than Single-firm projects. This supports the view that it is better to interpret the results from Model 1 regarding the direct effects of the interacting variables (Carte and Russell, 2003). Hence, ownership integration does not have a direct effect on problem-solving proficiency.

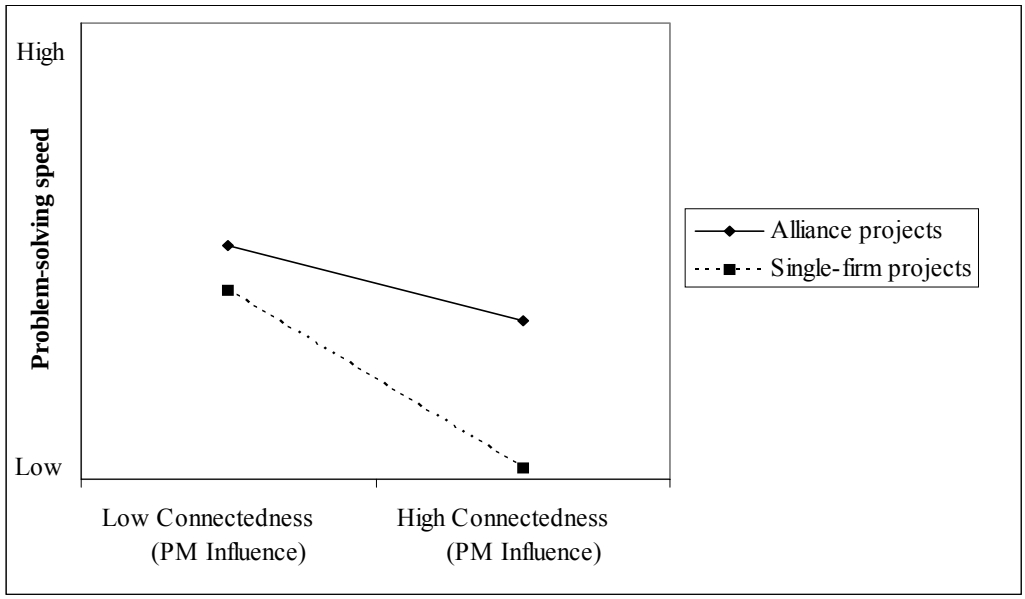

Figure 2 Contingent effects of connectedness and PM influence

Also for problem-solving proficiency we performed additional analyses with ownership integration as measured by the absolute number of investing firms. In neither of these analyses the step from Model 1 to Model 2 was significant. This indicates that especially the distinction between Single-firm projects or Multi-firm projects (as captured by our dummy variable) matters. We also performed the additional analyses with the absolute number of investing firms in the small subset of alliance projects. In these analyses again none of the steps from Model 1 to Model 2 was significant, although we did find one significant moderating effect in this subset: connectedness has a relatively weak effect on problem-solving speed if the number of investing firms increases (β=-0.30; $p<0.01$; one-sided). In these additional analyses we found no strong direct effects from the absolute number of investing firms on problem-solving proficiency (both in the entire dataset and in the Multi-firm subset). This also means that we found no particular effects on problem-solving speed, despite their strong bivariate correlations (respectively ρ=0.21; $p<0.05$ and ρ=0.34; $p<0.01$; see Table 7.2). In sum, we can conclude that we find strong support for Hypothesis 2b that ownership integration (Single-firm projects vs. Multi-firm projects) interacts with project-level integration mechanisms in the explanation of problem-solving proficiency.

7 Discussion and conclusions

In this paper we investigated how the multiple levels of a NPD project's organizational form influence problem-solving proficiency and ultimately project performance. More specifically we studied

five project-level organizational factors and ownership integration as the firm-level organizational factor. Our main findings are the following. First of all, we found that ownership integration hardly moderates the relationships between project-level mechanisms and project performance. A notable exception involves reach. In this respect, it is first of all important to note that the Single-firm projects in our dataset make less use of external sources of information than Multi-firm projects. In other words, projects that are closed at the firm-level (Single-firm) also tend to be closed at the project-level (limited external search). Conversely, Open Innovation tends to be applied both at the firm-level (partnerships) and at the project-level (extensive search for external information). In addition, we find that such extensive search tends to contribute substantially more to project speed in Multi-firm projects than in Single-firm projects. In terms of Open Innovation this finding suggests that firm-level Open Innovation contributes relatively strongly to project speed if it is complemented with project-level Open Innovation, i.e. if a NPD project is set-up by multiple partners then this openness appears to ensure strong compatibility with NPD processes that make use of intelligence from outside these firms.

This negative moderating effect of ownership integration on the relationship between reach and project speed is not in line with our expectation that project-level differentiation mechanisms complement a highly integrated firm-level organizational form (i.e. single firm projects). This indicates that firms are not always in need of a balance between differentiation and integration mechanisms. For instance, very uncertain and complex innovations might best be performed within a highly integrated organizational setting (Pisano, 2006; Hoetker, 2005).

The analyses with the absolute number of investing firms as a proxy for ownership integration also reported the negative moderating effect of ownership integration on the relationship between reach and project speed. In addition, and supporting our theory, we find that more integrated firm-level organizational forms (i.e. projects with less investing firms) complements decentralization in its effect on project speed.

Besides investigating as dependent variables project outcomes (e.g. project speed, project cost efficiency, and product quality), we also investigated how our models explained problem-solving proficiency (problem-solving speed, problem-solving cost efficiency, and solution quality). For these models we found that ownership integration (as measured by the dummy variable) and project-level mechanisms strongly interact. Hence, although the moderating effect does not influence project performance directly, it does tend to affect a team's problem-solving proficiency. An explanation might be that the projects' organizational set-up is much more closely related to the processes within projects, such as the problem-solving process, than to the eventual performance of the project. Project performance is likely to depend on a larger number of factors than the proficiency of project processes, which decreases the relative effect of the project's organizational form.

More specifically, and in line with our expectations, we find that project-level integration mechanisms complement differentiated firm-level organizational forms, i.e. alliance projects. This holds for problem-solving cost efficiency and for solution quality, but it especially holds for the speed of problem-solving. Two strong interaction effects in this regard involve the integration mechanisms connectedness and project management influence. This implies that the speed of problem-solving in alliance projects benefits relatively strongly from the integration of the team members from the different firms and their efforts. This is in line with the view that project-level integration is needed to realize the creative potential of alliances (Tiwana, 2008).

However, as indicated in Figure 2, irrespective of the extent of connectedness and the influence of the project's manager/management team, the speed of problem solving in general tends to be higher in alliance projects than in Single-firm projects. Reflecting the moderating effect, this difference in terms of problem-solving speed is especially strong if connectedness is used extensively and if the team's project manager or management team is highly influential. In Single-firm projects the application of these integration mechanisms appears to reduce the speed of problem solving. In these Single-firm projects the goals of project members tend to be more aligned and they tend to have a better mutual understanding. Hence, in Single-firm projects the effectiveness of team meetings and of influential project management tend to be limited, whereas in Multi-firm projects extensive connectedness, e.g. by means of cross-firm team meetings, and powerful project management is likely to be especially useful to define problems, to swiftly decide upon the solutions to implement, and to coordinate and manage the solution implementation process.

Next to the moderating effects for these integration mechanisms, it also appears for both Single-firm projects and alliance projects that problem-solving speed is generally highest if connectedness and project management influence are limited. In terms of connectedness this indicates

that meetings in general appear to delay the problem-solving process, which suggests that it is more important for team members to spend their time on figuring out the details of problems and on implementing solutions than to discuss problems with their peers. In terms of project manager influence, problems on average tend to be solved fastest in projects that are managed by a manager/management team that enjoys limited freedom vis-à-vis the management of the sponsoring firm(s). Hence, although strong project management is more important in alliances than in Single-firm projects, in general this appears to reduce problem-solving speed, possibly because it reduces the autonomy of team members to fully apply their expertise to solve problems fast. If unforeseen problems arise in projects that require the input from managers outside the project (i.e. limited project management influence), then project members might in the mean time take actions to solve problems. In sum, connectedness and project management influence both have a negative effect on problem-solving speed, but both contribute more to the speed of problem solving in Multi-firm projects than in Single-firm projects. This is especially true if these integration mechanisms are applied extensively.

In additional analyses we found that the two abovementioned moderating effects only hold for ownership integration in terms of the distinction between Single-firm projects and Multi-firm projects. These effects do not appear for ownership integration as judged by the number of investing firms. Hence, the decision to 'make' or to 'ally' for a NPD project is an important determinant of the way that project-level factors contribute to proficient problem solving. This also indicates that the decision to ally or not has more profound implications than decisions about the number of partners to innovate with.

7.1 Limitations and future research

This study has several limitations. First of all, we used single respondents. Hence we did not obtain data from multiple respondents and we therefore did no capture the view from partner firms if these were present in the project. Secondly, our measures of ownership integration do not include information about the actual division of investments among the partners in Multi-firm projects. Hence, we cannot control for the effect that different types of alliances may have, such as differences between fifty-fifty alliances and alliances with an unequal division of investments between the partners (e.g. 80%-20%). Fifty-fifty alliances might for instance require more project-level integration mechanisms to align partners than asymmetric alliances. In future research it would be valuable to take this division of investments into account.

As another limitation, we did not investigate however how our findings hold for different types of innovation. Future research is therefore needed first of all to replicate this finding and secondly to explore whether and how this finding is contingent upon other factors, such as the innovation's novelty or the type of problem. We suspect that integration between team-members from different firms contributes positively to the team's overall problem-solving capability if these problems also affect members from these different firms (i.e. systemic problems across firm boundaries), but we expect it to hardly improve, if at all, the proficiency with which problems are solved that are autonomously related to the activities and fields of expertise of members from individual firms. Future research is required in this regard.

Multi-level research in innovation management has only recently gained more attention (Gupta et al., 2007; Tiwana, 2008). Future research in this area is needed to improve our understanding of the way that firms organize innovation processes and how innovative performance is influenced. This paper has made a contribution to this field of research by showing how project-level integration mechanisms work differently in Single-firm projects than in alliance projects. These differential effects especially appear to hold for problem-solving proficiency. Additional insights might be obtained in future research by incorporating all four dimensions of integration instead of just ownership integration.

7.2 Managerial implications

For managers, an interesting finding involves reach, i.e. the extent that project teams search for information in their environment. Alliances tend to use this more extensively than Single-firm projects and rightly so. We find namely that extensive search for information contributes more to project speed in alliances than in Single-firm projects. This suggests that Open Innovation in the development phase, if applied, needs to be applied extensively, i.e. firms should not only partner in NPD projects (the firm-level), but the NPD process within these alliance projects needs to be open as well (the project-level).

This study also shows that a project's firm-level organizational form and its project-level organizational form are especially complementary in their effect on problem-solving proficiency.

Although limited integration on average appear to result in more proficient problem-solving, once applied extensively it results in comparatively more proficient problem-solving in alliances. Especially since extensive integration might be needed in alliances for other reasons than problem-solving, such as task alignment, monitoring, etc., this is an important finding for managers. In addition, we found that the comparative benefit of integration mechanisms for problem solving in alliance projects does not depend on the number of partnering firms. Hence, decisions of managers about how to structure and organize the NPD process should depend on whether the firm partners for the project or goes it alone.

References

[1] Atuahene-Gima, K. (2003). The effects of centrifugal and centripetal forces on product development speed and quality: how does problem solving matter? *The Academy of Management Journal*, 46 (3), 359-373.

[2] Ayers, D., Dahlstrom, R., and Skinner, S.J. (1997). An exploratory investigation of organizational antecendents to new product success. *Journal of Marketing Research*. 34, 107-116.

[3] Baron, R. M. and Kenny, D. A. (1986). The moderator-mediator distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51, 1173-1182.

[4] Brown, S.L. and Eisenhardt, K.M. (1995). Product development: Past research, present findings, and future directions. *Academy of Management Review*, 20 (2), 343-378.

[5] Brusoni, S., Prencipe, A. and Pavitt, K. (2001). Knowledge specialization, organizational coupling, and the boundaries of the firm: why do firms know more than they make? *Administrative Science Quarterly*, 46, 597-621.

[6] Carte, T.A. and Russell, C.J. (2003). In pursuit of moderation: Nine common errors and their solutions. *MIS Quarterly*, 27 (3), 479-501.

[7] Doty, D.H., Glick, W.H. and Huber, G.P. (1993). Multidimensional fit, equifinality, and organizational effectiveness: a test of two configurational theories. *Academy of Management Journal*, 36 (6), 1196–1250.

[8] Gerwin, D. and Ferris, J.S. (2004). Organizing New Product Development Projects in Strategic Alliances. *Organization Science*, 15 (1), 22-37.

[9] Gopalakrishnan, S. and Damanpour, F. (1997). A review of innovation research in economics, sociology and technology management. *Omega*, 25 (1), 25-28.

[10] Gulati, R. Lawrence, P.R. and Puranam, P. (2005). Adaptation in Vertical Relationships: Beyond incentive conflict. *Strategic Management Journal*, 26, 415-440.

[11] Gupta, A.K., Tesluk, P.E. and Taylor, M.S. (2007). Innovation at and across multiple levels of analysis. *Organization Science*, 18 (6), 885-897.

[12] Hoetker, G. (2005). How much you know versus how well I know you: Selecting a supplier for a technically innovative component. *Strategic Management Journal*, 26, 75-96.

[13] Hyatt, D.E. and Ruddy, T.H. (1997). An examination of the relationship between work group characteristics and performance: once more into the breech. *Personnel Psychology*. 50, 553-585.

[14] Klein, K.J., Dansereau, F., Hall, R.J. (1994). Levels issues in theory development, data collection, and analysis. *Academy of Management Review*, 19, 195-229.

[15] Li, J. and Hambrick, D.C. (2005). Factional groups: A new vantage on demographic faultlines, conflict, and disintegration in work teams. *Academy of Management Journal*, 48 (5), 794-813.

[16] Pisano, G.P. (2006). Can Science Be a Business? Lessons from Biotech. *Harvard Business Review*, October, p.114-125.

[17] Podsakoff, P. M., MacKenzie, S., Lee, J.-Y. and Podskoff, N. (2003). Common method biases in behavior research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology*. 88 (5), 879–903.

[18] Rothaermel, F. and Hess, A.M. (2007). Building dynamic capabilities: Innovation driven by individual-, firm-, and network-level effects. *Organization Science*, 18 (6), 898-921.

[19] Shenhar, A.J. and Dvir, D. (1996). Toward a typological theory of project management. *Research Policy*, 25, 607-632.

[20] Sheremata, W.A. (2000). Centrifugal and Centripetal Forces in Radical New Product Development under Time Pressure. *The Academy of Management Review*, 25 (2), 389-408.

[21] Sheremata, W.A. (2002). Finding and solving problems in software new product development. *Journal of Product Innovation Management*, 19, 144-158.

[22] Somaya, D. Williamson, I.O., and Zhang, X. (2007). Combining patent law expertise with R&D for performance. *Organization Science*, 18 (6), 922-937.
[23] Tatikonda, M.V. and Montoya-Weiss, M.M. (2001). Integrating operations and marketing perspectives of product innovation: The influence of organizational process factors and capabilities on development performance. *Management Science*, 47 (1), 151–172.
[24] Tiwana, A. (2008). Do bridging ties complement strong ties? An empirical examination of alliance ambidexterity. *Strategic Management Journal*, 29, 251-272.
[25] Van de Ven, A.H., Delbecq, A.L. and Koenig, Jr., R. (1976). Determinants of Coordination Modes within Organizations. *American Sociological Review*, 41 (2), 322-338.
[26] Wright, M. and Overton, J.S. (2008). The Ombudsman: Verification of citations: Fawlty towers of knowledge. *Interfaces*, 38 (2), 125-139.

APPENDIX A. Measures and Factor Analysis Results

Almost every development project faces technical or operational problems that threaten the goals of the project, for instance in terms of project costs, quality, or speed. To what extent do you agree or disagree with the following statements about the way problems were solved during this project? (1 = strongly disagree; 5 = strongly agree)

In italics: results from varimax rotated principal axis factoring and the Cronbach's Alpha reliability statistic.

Problem-solving speed; scale based on Atuahene-Gima (2003)

- Problem-solving took a lot of time during this project. (reverse-coded)
- Solutions found for problems we faced were not timely. (reverse-coded)
- The project team was very slow in finding and implementing solutions to the problems we encountered. (reverse-coded)
- Ideas for solving the problems encountered were discovered rather late to be implemented successfully. (reverse-coded)

Factor loadings are respectively 0.79; 0.92; 0.78; 0.68. Eigenvalue: 2.89. Variance explained: 72% . Cronbach's Alpha: 0.87.

Solution quality; new scale developed for this research

- The solutions found solved the problems effectively.
- The solutions found were of high quality.
- The solutions found were based on detailed knowledge of the nature of the problems.
- The solutions found did not result in new problems.

Factor loadings are respectively 0.83; 0.81; 0.77; 0.69. Eigenvalue: 2.81. Variance explained: 70% . Cronbach's Alpha: 0.85.

Problem-solving efficiency; new scale developed for this research

- Problem-solving in this project was very expensive. (reverse-coded)
- During this project a lot of financial resources were expended on problem-solving. (reverse-coded)
- The implementation of solutions found was very expensive. (reverse-coded)
- The costs of problem-solving formed a substantial part of the total development costs. (reverse-coded)

Factor loadings are respectively 0.88; 0.83; 0.88; 0.72. Eigenvalue: 3.05. Variance explained: 73% . Cronbach's Alpha: 0.89.

Indicate your agreement with these statements regarding the project team's product development activities:

Decentralization; Adapted from Atuahene-Gima (2003); Ayers, Dahlstrom, Skinner (1997)

- Project members had great freedom to make decisions of their own.
- Project members hardly had to ask permission of a higher manager to take action.
- Project members to a large extent determined how they realized their tasks.

Factor loadings are respectively 0.84; 0.86; 0.80. Eigenvalue: 2.38. Variance explained: 79% . Cronbach's Alpha: 0.87.

Free flow of information; Based on Atuahene-Gima (2003) and Hyatt and Rudy (1997).

- Access to information from team members was quick and easy.
- Project team members engaged in open and honest communication.
- Team members willingly kept each other informed at all times.

Factor loadings are respectively 0.76; 0.90; 0.82. Eigenvalue: 2.38. Variance explained: 79%. Cronbach's Alpha: 0.87.

Reach; Based on Atuahene-Gima (2003)

- The project team collected a lot of information about new market developments.
- Technological developments were monitored very closely by the project team.

The factor loadings for this two-item scale have a value of 0.82. Eigenvalue: 1.66. Variance explained:

83%; Cronbach's Alpha: 0.80.

Connectedness; Based on Sheremata (2002) and Van de Ven, Delbecq, Koenig (1976)
- Project members had frequent, informal interactions with other team members
- Project members frequently met in planned meetings
- Project members often met in informal meetings.
- Project members often collaborated in teams.

Factor loadings are respectively 0.47; 0.44; 0.71; 0.67. Eigenvalue: 2.22. Variance explained: 50%. Cronbach's Alpha: 0.66.

Project management influence; Adapted from Tatikonda and Montoya-Weiss (2001)
- Project management was free to determine interim schedule targets.
- Project management was free to adapt the technical design of the web application.
- Project management was free to adapt the functionality of the web application.
- Project management was free to choose the format of progress reviews.

Factor loadings are respectively 0.58; 0.78; 0.64; 0.55. Eigenvalue: 2.22. Variance explained: 55%. Cronbach's Alpha: 0.73.

The extent that problems are systemic rather than autonomous; New scale.
- Technical problems were often the result of problems with interfaces between components.
- Solving technical problems often involved the adjustment of multiple components.

The factor loadings for this two-item scale have a value of 0.81. Eigenvalue: 1.66. Variance explained: 83%; Cronbach's Alpha: 0.79.

Application novelty (1 = not new at all; 5 = very new)
- How new was the software code of this web application?