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Success rate and resource consumption from project interdependencies

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Abstract

Purpose – The purpose of this paper is to show how interdependencies are used to make the project selection and review more effective in project portfolio management. Managers need to make appropriate pre-evaluation of disciplines before taking them into use, therefore it is useful to know how much interdependencies can increase the success rate of projects and how big is the resource reduction from the use of interdependencies. This paper is an excerpt of a larger interdependency survey.

Design/methodology/approach – A large-scale survey is carried out in two countries – Estonia and Finland. A total of 288 responses were received.

Findings – People see only positive aspects in interdependencies, but this paper proves that it is not always so. It is found that companies which take the phenomenon into account are more successful. Contrary to the respondents' perception and prior literature, a higher need for resources is noticed among the users of interdependency. The results indicate homogeneity between managerial issues of interdependencies in small-to-large companies.

Research limitations/implications – The main limitation comes from the sample, as findings from the sample countries and industries may limit generalizability.

Practical implications – Practitioners can expect a higher success rate and resource consumption from interdependencies. Managers from small-to-large companies can find size-related peculiarities and practices for their daily managerial actions.

Originality/value – This paper provides empirical evidence for a less investigated, but emerging field of interdependencies. So far, mostly components of interdependency have been investigated in isolation. The paper highlights the behavior of success rate and resource consumption among the users/non-users of interdependency, which to the author's knowledge has not been provided so far.

Keywords Project management, Project evaluation, Estonia, Finland

Paper type Research paper

1. Introduction

"Projects are temporary endeavors undertaken to create a unique product, service, or result" (SPM, 2006, p. 4). A project portfolio "is a collection of projects" (SPM, 2006, p. 4). Project portfolio management (PPM) is meant for managing projects in companies that run many projects simultaneously. It consists of project selection and portfolio review. PPM is an emerging field in project management (PM). PPM has been popular in large companies with big portfolios, but PPM is becoming more popular and practical in small and medium size enterprises (SME)[1] as well.

A survey (Archer and Ghasemzadeh, 2004, p. 239) indicates that 50-60 percent of new product development (NPD) projects fail. If the project selection is done with care, the success rate of the project portfolio is higher (Cooper, 1997) and the wastage lower

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(Wideman, 2006). Cooper *et al.* (1999) emphasize that project selection is one of the most important strategic issues, as poor selection "may make decision makers select wrong projects for the project portfolio" (Guo *et al.*, 2008, p. 994), which in turn may "produce additional useless work, which slows up other projects, and decreases the productivity and effectiveness of R&D" (Piippo *et al.*, 1999). Many aspects are recommended to be considered during project selection and portfolio review, interdependency being one of them (Archer and Ghasemzadeh, 1999). Since "no project is an island" (Engwall, 2003, p. 790), they have relationships with each other in the portfolio and with the outer context. Interdependency is defined as a relationship between projects[2]. Based on the definition, the terms "interdependency" and "relationship" are used interchangeably in this paper.

There can be many types of interdependencies (e.g. task, objectives, projects, and alliances). Some of these types are related. One of the most widely researched types is task interdependencies. However, this research does not deal with task interdependencies, but with interdependencies between projects, concentrating on resource, technological and market-related relationships. These types of interdependencies cover such issues as resource availability on time, resource conflicts, modularity, knowledge diffusion across projects, and substituting/abandoning existing products, to mention some.

Interdependencies are part of the emerging PPM field, and they are not just a short-term phenomenon, as they have roots in the 1960s (Thompson, 2003). Interdependencies have generally not been a primary research subject, they have been a side product of larger research, and mostly components of interdependency have been investigated, but isolated from each other. According to Schmidt (1993), there is a gap in the interdependency literature. This paper provides empirical evidence for this less investigated, but emerging field of interdependency. The research questions of this study are:

RQ1. How does interdependency management relate to project success?

RQ2. How does interdependency management relate to resource reduction?

The unit of analysis in this study is bi-level: company and project portfolio level, and the portfolio owners' perspective is mostly taken into account.

A survey was prepared, pre-tested and sent out to companies. The target group comprised Estonian (one of the Baltic states) and Finnish companies. In total, 288 companies participated in the survey. Roughly two-third of the responses were from small, one-fourth from medium, and the rest from large companies (32 respondents). SMEs were included, because portfolio management is found to be relevant in SMEs and they are under-investigated (van Witteloostuijn, 2008). Also, attention was paid to differences between SMEs and large companies, to provide more focused results. The survey was first performed in Estonia (94 responses), where the target group was not limited, to achieve a broad pre-understanding of the phenomenon, and later in Finland (194 responses), where the focus of interest was on certain industries to limit environmental variety. In Finland, to get an idea of mature and/or innovative industries, the construction and engineering industries were chosen as historical representatives of PM, information and communication technology (ICT) as a modern and emerging industry, and machinery as one of the leading industries in Finland.

This survey is part of a larger research, and it is based on and extends prior publications (Rungi, 2009b)[3].

This paper is structured as follows: first, Section 2 contains a short literature review, and Section 3 explains the research method. In Section 4, the results of the study are presented and analyzed, and finally, Section 5 contains concluding remarks.

2. Literature review

2.1 Interdependency from different perspectives

Interdependency is a rich and diverse topic, it has been found to be a "very difficult concept to define both theoretically and operationally" (Staudenmayer, 1997, p. 24). Even if interdependency management is not theoretically a well-established discipline, it is widely used in practice, 84 percent of companies claim to consider it (Reyck *et al.*, 2005). It is a rather interdisciplinary phenomenon, including sociology, psychology, and technology, among others. The interdependency issue can be explained by the contingency (Thompson, 2003), decision making (Saaty, 1982), strategy management (Mintzberg, 1983), system (von Bertalanffy, 1976), resource-based view (RBV) (Pfeffer and Salancik, 1978), network (Håkansson, 1987), and PPM (Levine, 2005) theories. Interdependencies are also interconnected with several other well-known terms, such as "coordination" (Dietrich, 2007) and "integration".

According to Artto and Dietrich (2004), the management of a single project is nowadays not enough. Multi-PM has become more important. In general, PPM is meant to meet the strategy through managing projects (Levine, 2005). Unfortunately, a portfolio is usually considered to be consisting of independent projects, as if the projects were islands (Engwall, 2003). Despite the importance and benefits provided by interdependencies (Cooper, 1997; Staudenmayer, 1997), a survey conducted by Elonen and Artto (2003, pp. 398-9) reveals that "the links between projects are usually not considered systematically," which is due to the complexity and lack of knowledge (Rungi, 2009b).

From the perspective of the contingency theory, the interdependency theory is used to find a fit between projects in a portfolio and their environmental context. RBV is about "examining [. . .] resource linkages among common units" (Staudenmayer, 1997, p. 51). The decision-making theory seeks ways of how to apply existing knowledge and environmental nuances to make good decisions. In the system theory, interdependency is characterized by how one system element causes change of state in another element (Sanchez and Worren, 2005).

2.2 Typology of interdependencies

There are different typologies and taxonomies available for relationships between projects. Some typologies are based on the roots/nature of relationships, such as resources, technology and markets (Verma and Sinha, 2002). Perhaps the best known typology has been presented by Thompson in 1967, who divided relationships on the basis on different structure of connection, e.g. sequential, parallel, and reciprocal (Thompson, 2003). There are other typologies available as well (Staudenmayer, 1997, pp. 35-36, 38, 82, 85; Sanchez and Worren, 2005). Although the existing typologies may seem to be different, many of them can be fully or partly mapped to each other, e.g. technological and resource interdependencies are drawn out from many typologies. This paper is based on the classification of Verma and Sinha (2002):

- Resource interdependency deals with the availability of human resources (HRs) and resource sharing. This is needed, because a limited amount of resources is usually available. Also, such issues as motivation (Verma and Sinha, 2002), conflicts, lack of knowledge diffusion, and geographic location-related problems are important (Newell *et al.*, 2008). Resource interdependencies "occur when the total cost of a portfolio is different from the sum of individual costs" (Schmidt, 1993, p. 404).
- Technology interdependency is about the ability to leverage existing technical knowledge, advantages achieved from modular development of components, and knowledge diffusion between projects (Verma and Sinha, 2002; Maurer *et al.*, 2007). It takes place when some projects have the effect "on the probability of success of another" (Schmidt, 1993, p. 404).
- Market interdependency emphasizes the interest of the business unit in its projects, utilization of existing market knowledge and diffusion of the knowledge in the project to others, and competition between projects/products with the same or similar objectives. A new mobile phone taking over the market of existing phones is an example here.

  Market interdependencies are included in the study, because they are considered important from the project point of view and make it possible to include the strategic dimension.

2.3 Other aspects of interdependency

The analysis of an interdependency survey (Rungi, 2009b) revealed that companies are aware of the interdependency issue in general, but they have lack of detailed knowledge. Also, they do not consider the interdependencies regularly, because they do not have enough time to implement the corresponding processes and evaluate the interdependencies *per se*. The main methods used to evaluate interdependencies are informal and visual methods, as well as the scoring model. The main drawbacks are seen to be delays when predecessor projects are not ready on time, substituting existing project resources, and conflicts from resource sharing.

Cross-size comparison about interdependency management (Rungi, 2009b, p. 17) indicated:

> [. . .] only very few significant differences between companies with different size, and these significant differences were predictable, such as (1) relationship-related communication is easier in smaller companies, (2) smaller companies do not have enough time to evaluate interdependencies, or (3) smaller companies have difficulties to implement corresponding procedures. [. . .] These differences [stem] [. . .] from peculiarities of small companies (e.g. flat organizational structure/hierarchy, short communication chains).

Another "important conclusion is that portfolio management turned out to be very relevant for small companies (because they may have many simultaneous projects)" (Rungi, 2009b, p. 18). "Support was also received for many interdependency components [. . .] [Surprisingly, no] big support was received to the use of modularity" (Rungi, 2009b, p. 18).

2.4 Success of projects in the interdependency context

Interdependencies cause synergy for the company, which is typically positive (e.g. higher success rate (Cooper, 1997), additional value, cost and resource savings), but can also be

negative[4] (i.e. substituting the part of existing product "so that the overall benefit of both projects is less than the sum of individual projects" (Schmidt, 1993, p. 404)).

There are too many different definitions and measures available for "success" (Ojiako *et al.*, 2008), which leads to a difficulty to measure it (Cooke-Davies, 2004). As there is no "universal checklist of criteria suitable for all projects" (Ojiako *et al.*, 2008, p. 413), and the target group of this survey are practitioners, the decision was made to use a definition that is widely used among practitioners – "successful are all projects which are finished in time, within the budget, and produce their scope", even if this definition has certain limitations. This definition is understood more as PM success, not project success *per se* (Cooke-Davies, 2004). However, other definitions of "success" are much less familiar among practitioners and could cause difficulties in answering in the survey. For example, Ojiako *et al.* (2008) have raised some practicality issues of new concepts due to their conflicting nature. Also, Dalcher (2008) questions whether there is a real need to go beyond the practitioner definition of success, if many surveys about practitioner criteria have already indicated a very high failure rate (up to 98 percent). An additional justification for the used definition of "success" was retrieved from the fact that new concepts in measuring the success of projects goes hand in hand with traditional measures (Ojiako *et al.*, 2008).

"Success" is recommended to be measured years later, "after the termination of the project", and different stakeholder perspectives should be taken into account (Ojiako *et al.*, 2008, p. 406). The interest of the present study was to determine the average success rate of projects, i.e. including already finished projects.

A wide variety of means to increase the success rate has been pointed out by Cooke-Davies (2004), Ojiako *et al.* (2008), and other authors. Some of them are related to interdependencies, for instance, success rate influences technological interdependency, it reduces project/process management knowledge diffusion, but increases product/market knowledge diffusion (Maurer *et al.*, 2007). The paper of Ojiako *et al.* (2008) also shows the importance of knowledge diffusion for project success from the perspective of information availability. In addition, people perceive new technology as a source of success (Ojiako *et al.*, 2008), but managing interdependencies rather avoids taking new technologies into use, preferring modularity instead, which is not always usable in the case of NPD projects (Rungi, 2009b).

On the basis of literature sources, it can be predicted that efficient management of interdependencies results in a higher project success rate and resource reduction (Figure 1).

3. Methodology

3.1 Research method

The aim of this research is to find confirmation for the given theoretical model (Figure 1). In general, quantitative research is considered to be more appropriate for theory testing, and qualitative research for theory creation (Vafidis, 2007). Quantitative survey is suitable for testing prior theoretical ideas in situations where enough research literature (Daft, 1995) and not enough empirical evidence are available, as is the situation here.

Secondary data sources were cursorily inspected and pre-tested scales were searched, but PPM-related information was not found, and there was some critique reported in the address of existing measures (Staudenmayer, 1997), therefore the use of

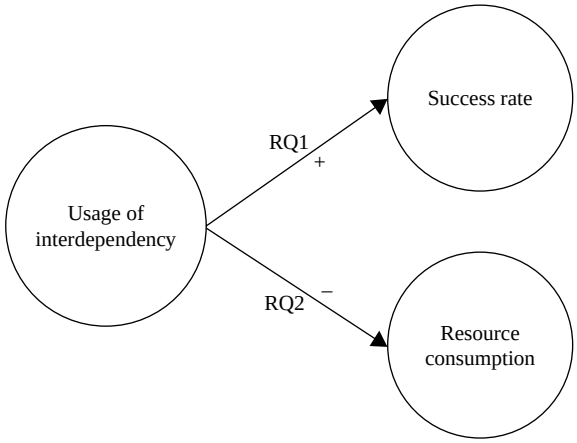

Figure 1.
Theoretical model

a self-prepared survey questionnaire was justified. An electronic questionnaire was prepared, based on examples and recommendations (Churchill, 1995), and then pre-tested. The research setting was meant to be symmetrical – to investigate both the benefits and drawbacks of the interdependencies. At first, the questionnaire was presented to researchers in five academic institutions, and then it was tested in three representatives of the industry. During the pre-testing, feedback and comments were collected, and the time needed to complete the questionnaire was measured. It took around 15 minutes, which may lead to a response rate around 47 percent (Churchill, 1995). The test respondents found the questionnaire not to concern sensitive issues, but the "I do not know" option was included to the five-step Likert scales nevertheless.

Generally, surveys provide good external validity. However, validity was improved on the basis of literature recommendations (Maula, 2001). In addition to the examination of prior theory and pre-testing the questionnaire, the convergent validity was checked as well. It remained low, because the correlation values were mostly at the low ($r < 0.30$) or medium ($0.29 < r < 0.50$) level.

Before starting the survey, several steps were taken to improve the reliability of the data and the construct (Maula, 2001). First, the survey was sent to key informants. Only those were asked to respond who were responsible for PPM. Hoffmann (2005) emphasizes the specialists' role in portfolio management, so specialists' responses (4.3 percent) were accepted as well. Overall, reliability was guaranteed, as 81 percent of the informants were from the top or middle management, and 10 percent were from PM. The survey demonstrated good construct reliability, the Cronbach's Alpha values on all the scales ranged from 0.70 to 0.80 concerning the different item groups surveyed.

There was a small number of missing values. The missing values were not replaced by calculated ones, pairwise deletion was used instead, as it is found to be "generally preferable" (Olinsky *et al.*, 2003, p. 56). Owing to the pairwise deletion, the sample size may differ test by test.

χ^2 and ANOVA tests were employed to test the research questions and analyze the differences between groups, like small-to-large companies and different project types. The χ^2-test was used, because the relationship between categorical variables was

examined (Pallant, 2001);, e.g. industries and usage of interdependency (Table I). The ANOVA test was used, because continuous variables from three different groups were compared (Pallant, 2001), e.g. how the mean of continuous dependent variable "success" differs between small-to-large companies (Table V). These tests are general and robust enough. Correlation and regression analysis were performed as well.

3.2 Sample and data

The target population of this research were all the project-oriented companies in the Estonian and Finnish area. According to statistics, there are 64,789 active companies (ones which declare turnover) in Estonia (Estonian Tax and Customs Board, 2008) and 38,226 active companies in Finland (Finnish Tax Administration, 2008), which together formed the target population. Unfortunately, there was no statistics of how many of them are project-oriented. However, SMEs "spend on average roughly one third of their turnover on projects" (Turner *et al.*, 2008, p. 1221). In addition, PM is very widely spread in these countries, for instance in Finland there is a strong local branch office of the International Project Management Association (IPMA) with nearly 3,000 members in 2008 (IPMA Finland, 2009). In Estonia, there is no local branch office of any worldwide PM association (IPMA, Project Management Institute) or any country specific PM association. However, as Estonian companies are mostly small, flexible and service oriented, there is good ground for running companies through projects.

As SMEs have a huge impact on the economy (Turner *et al.*, 2008), PPM is very relevant for SMEs, and there is claimed to be size bias in management research (mostly large companies are under focus) (van Witteloostuijn, 2008), special focus was put on SMEs. The target group involves individuals in these companies, who are responsible for project selection, e.g. top management and those in a position responsible for the company's project portfolio or project development (e.g. project portfolio manager, head of the development department). It has been argued that is it enough to involve only one executive officer from a company (Venkatraman and Grant, 1986). More than one respondent per company was allowed to take part in the case of large companies, but this opportunity was not used by the recruiters.

In Estonia, students from a management class gathered the data. Working in pairs, the students performed the survey in February-March 2008. The students contacted

Industry	Frequency	%	Usage of interdependency (%) Yes	No
ICT	71	25.2	88.7	11.3
Mechanical equipment	33	11.7	90.9	9.1
Construction	27	9.6	85.2	14.8
Food industry	23	8.2	87.0	13.0
Electrical equipment	18	6.4	94.4	5.6
Tourism	12	4.3	100.0	0.0
Other industries	98	34.8	93.9	6.1
Total	282	100.0	91.1	8.9

Note: $\chi^2 = 4.513$

Table I. Industry and usage of interdependency (χ^2 for independence, all respondents)

120 companies, 94 of which replied (response rate 78 percent). The number of reminders varied respondent by respondent. In Finland, due to initial difficulties to find respondents through associations, the data-gathering task was given to a company, one of the main business lines of which is to carry out surveys. They performed the survey in April-May 2008. During this period, they contacted 582 companies, 194 of which replied (response rate 33 percent). Invitation was sent out to different industries by two separate mailings. Two reminders were sent. Particular importance was put on obtaining companies from industries: ICT, construction and machinery, but around 54 percent of the sample contained replies from other industries as well (Table I). Engineering companies were also included in the target group, but these companies mostly categorized themselves as part of some other industry, and therefore no specific frequency figure was calculated for them. In total, 702 companies were contacted, and 288 of those answered the questionnaire (resulting in a response rate of 41 percent).

4. Results and discussion

In total, 91 percent of companies consider relationships, which exceeds an earlier finding – 84 percent by Reyck *et al.* (2005). As such, big support was received, the conclusion can be drawn that the people in the sample do not see projects as islands, i.e. the issue raised by Engwall (2003).

Interestingly, the usage of interdependency does not differ significantly when industry (Table I) or size-based characteristic are used as indicators (e.g. turnover (Table II) and the number of projects). Larger significant differences were expected,

Turnover	Frequency	%	Usage of interdependency (%) Yes	No
Less than €2 million				
Small	68	37.78	88.24	11.76
Medium	4	6.15	100.00	0.00
Large	–	–	–	–
Total	72	25.90	88.89	11.11
€2-9 million				
Small	84	46.67	88.10	11.90
Medium	22	33.85	95.45	4.55
Large	1	3.23	100.00	0.00
Total	107	38.49	89.72	10.28
€10-50 million				
Small	19	10.56	89.47	10.53
Medium	28	43.08	96.43	3.57
Large	5	16.13	100.00	0.00
Total	53	19.06	94.34	5.66
More than €50 million				
Small	9	5.00	88.89	11.11
Medium	11	16.92	100.00	0.00
Large	25	80.65	96.00	4.00
Total	46	16.55	95.65	4.35

Notes: χ^2 total = 2.593; χ^2 Small = 0.032; χ^2 Medium = 0.658; χ^2 Large = 0.248; small company: $<$50 employees, medium: 50-250 employees, large: $>$250 employees

Table II.
Annual turnover and usage of interdependency (χ^2 for independence, all respondents)

because industries differ much in the extent to which they deal with the components of interdependency, e.g. in resource sharing and modularity. The number of employees was also used as an indicator, and it proved that larger companies consider interdependency more than small and medium ones (Table III).

Some sources (Ojiako *et al.*, 2008) indicate a different perception of the success/failure of projects by different stakeholder groups, and it was an interesting finding that despite of having a chance to define an own definition of success in this questionnaire, almost nobody did it. It is especially interesting, as 36 percent of the respondents were from top management and 45 percent from middle management, and the top management is known to focus on strategic success criteria, rather than the objectives of project managers (Ojiako *et al.*, 2008).

Companies that use interdependencies in their portfolio selection have higher project success rate in total, and this tendency was also seen in small companies (Table IV), as there was a significant difference in the success rate between the users and non-users in these groups. Interestingly, the case was the opposite in medium and large companies, that is, the non-users' success rate was much higher. However, due to the small sample of non-users, the difference was statistically non-significant for medium companies. The ANOVA test could not be done for large companies because of the sample size. These unexpected exceptions in the case of medium and large companies could be caused by some non-included independent or moderator variable (for instance, the regression analysis explained only 10 percent of the variance in the success rate). This phenomenon needs further investigation to exclude a possible bias. The literature predicts higher advantages from interdependencies for companies which are bigger, not the opposite. Also, analyzing the users of interdependency, the

Number of employees	Frequency	%	Usage of interdependency (%) Yes	No
Less than 10 employees	53	18.9	83.0	17.0
10-49	129	46.1	89.9	10.1
50-250	66	23.6	97.0	3.0
More than 250 employees	32	11.4	96.9	3.1
Total	280	100.0	91.1	8.9

Note: $\chi^2 = 8.585^{*}$ ($^{*}p < 0.05$)

Table III.
Number of employees and usage of interdependency (χ^2 for independence, all respondents)

		Usage of interdependency				
		Yes			No	
Success rate (%)	Frequency	Mean	SD	Frequency	Mean	SD
Small	157	68.94^{**}	23.305	22	53.64^{**}	29.968
Medium	64	67.77	20.252	2	75.00	35.355
Large	31	59.11	24.053	1	70.00	–
Total	252	67.43^{*}	22.796	25	56.00^{*}	29.686

Notes: Significance at: $^{*}p < 0.05$; $^{**}p < 0.05$ (homogeneity violated); small company: <50 employees, medium: 50-250 employees, large: >250 employees

Table IV.
The influence of interdependency on the success rate (one-way between-group ANOVA, all respondents)

difference in absolute values of success rate among small, medium and large companies was ten. The indicator for non-users was 18, but neither of these differences was significant.

The differences in the success rate were tried to be explained by the type of project (Table V) and budget. Unfortunately, budget data were not available. The projects were categorized by the type of project, and this turned out to influence the success rate extensively. At first, a big difference was found between the users and non-users, interdependency seemed to be especially useful for increasing the success rate in the case of research, modification and internal projects, compared to non-users' results. The corresponding success rates were 76-30 percent, 72-54 percent and 71-53 percent, respectively. Predictably, the success rate remained closely the same in the case of NPD projects. NPD projects gain similar advantages as others from HR interdependencies, but they cannot gain as much advantage from technological (e.g. modularity) and market-related interdependencies, because the product is new, it may not be based on existing products and techniques. Unfortunately, due to the small number of non-users, only one statistically significant difference can be reported – the usage of interdependency significantly increases the success rate of product modification projects in small companies. However, significant differences were found within the users of interdependency categorized by the type of project, especially in SMEs.

Very surprisingly, certain resource reduction was noticed among those companies that did not use interdependency (Table VI). This difference was not statistically significant, however. This tendency is hard to explain from the perspective of

	Usage of interdependency					
		Yes			No	
Type of project	Frequency	Mean	SD	Frequency	Mean	SD
NPD projects						
Small	82	62.90**	25.022	9	56.67	25.125
Medium	33	66.82*	19.993	–	–	–
Large	16	56.88	26.763	–	–	–
Total	132	63.20*	23.987	12	60.83	25.121
Maintenance/line extensions/product modifications						
Small	32	78.53**	16.972	6	54.17**	36.526
Medium	15	58.00*	22.662	–	–	–
Large	5	70.00	15.811	–	–	–
Total	53	72.23*	20.555	6	54.17	36.526
Fundamental research/platform projects						
Small	7	77.86**	20.383	1	30.00	–
Medium	3	71.67*	2.887	–	–	–
Large	–	–	–	–	–	–
Total	10	76.00*	16.964	1	30.00	–
Development projects of own internal processes						
Small	36	72.42**	21.158	6	52.50	36.021
Medium	12	79.33*	13.446	–	–	–
Large	10	57.25	23.347	–	–	–
Total	58	71.23*	21.091	6	52.50	36.021

Notes: Significance at: $^{*}p < 0.05$; $^{**}p < 0.05$ (homogeneity violated); small company: <50 employees, medium: 50-250 employees, large: >250 employees

Table V.
The influence of the type of project on the success rate (one-way between-group ANOVA, all respondents)

technological interdependency, especially from the perspective of one of its components – modularity. However, it can be explained to some extent from the perspective of market-related interdependencies (e.g. substituting/abandoning existing products increases the need for additional resources) or from the perspective of HR interdependency, because negative aspects of HR relationships (e.g. conflicts, resource hacking between projects, taking advantage of the resources of a dependent project) may prevail on positive aspects (e.g. resource availability on time, resource sharing), especially if the company is not mature enough to manage them efficiently. One of the reasons may also stem from sample peculiarities, as a large part of the sample came from ICT, where many projects are not finished on time.

Interestingly, at the same time, the respondents perceived more benefits from resource reduction than from success rate (Table VII), contrary to the detailed results (Tables IV and VI).

In addition, the questionnaire contained several questions about different aspects of interdependency (e.g. benefits, drawbacks, and practices) (Table VII), but only a few significant differences between groups were discovered, which indicates homogeneity between small-to-large companies. This is surprising, because these issues were predicted to differ much in small, medium and large companies.

5. Conclusion

In conclusion, high usage of interdependencies was noticed in companies, especially HR interdependencies and in large companies. Companies of different size behave homogeneously in issues related to the phenomenon. Interdependencies help to increase the success rate (*RQ1*), but cause higher need for resources (*RQ2*). The mechanisms behind phenomenon need further investigation.

Managerial implications. Managing relationships between projects has a clear practical outcome: it was found to increase the success rate of projects (Table IV), and the price for this seems to be a greater need for resources (Table VI).

Controversially, at the same time, the respondents perceived that interdependency causes resource reduction. People even tended to believe that the usage of interdependency causes more resource reduction than success rate (Table VII). Managers should be aware of this false perception during the implementation of procedures and base the action on real facts.

Managers from small to large companies can consider the presented size-related differences in their daily actions of interdependency management. Table V indicates that interdependency management is not so usable in the case of NPD projects as in other types of projects. Also, managers in medium and large companies should

	Usage of interdependency					
	Yes			No		
Length of project (months)	Frequency	Mean	SD	Frequency	Mean	SD
Small	154	8.78	14.077	22	6.42	5.043
Medium	62	9.38	10.109	2	2.50	0.707
Large	30	13.43	15.418	1	4.00	–
Total	246	9.50	13.399	25	6.01	4.861

Notes: Small company: <50 employees, medium: 50-250 employees, large: >250 employees

Table VI. The influence of interdependency on resource reduction (one-way between-group ANOVA, all respondents)

	n	Mean	SD
Evaluation of the benefit: achieved resource savings from sharing resources			
Small	159	3.95	1.054
Medium	63	4.13	0.813
Large	31	3.74	1.154
Total	254	3.97	1.015
Evaluation of the benefit: achieved higher project success rate			
Small	157	3.62	1.065
Medium	62	3.81	0.972
Large	31	3.58	1.177
Total	252	3.66	1.057
Evaluation of the drawback: delays caused when interdependent predecessor project is not ready on time			
Small	156	3.82	1.032
Medium	62	3.81	0.865
Large	29	3.86	0.875
Total	248	3.83	0.972
Evaluation of the drawback: project takes advantage of dependent project resources			
Small	152	3.65	1.129
Medium	63	3.37	0.989
Large	27	3.48	1.087
Total	243	3.56	1.091
Evaluation of the drawback: conflicts between interdependent projects due to shared resources			
Small	158	3.46	1.138
Medium	63	3.59	1.042
Large	29	3.86	0.833
Total	252	3.53	1.087
Evaluation of the drawback: shared HRs cause lack of motivation			
Small	158	2.47	1.115
Medium	63	2.78	1.170
Large	29	2.62	1.178
Total	252	2.56	1.136
Evaluation of the drawback: differences between cultures increase the complexity of relationships			
Small	147	2.55	1.200
Medium	60	2.85	1.219
Large	29	3.03	1.180
Total	238	2.69	1.209
Evaluation of the drawback: geographical dispersion or distance increase the complexity of relationships			
Small	149	2.67	1.270
Medium	61	2.70	1.308
Large	30	3.17	1.206
Total	242	2.75	1.275
Evaluation of the best practice: existence of well developed technologies helps to finish projects quicker and inexpensively			
Small	157	4.08	0.898
Medium	63	4.14	0.895
Large	30	4.10	0.995
Total	252	4.11	0.906

(*continued*)

Table VII.
Respondents' perceptions of success rate and resource reduction

	n	Mean	SD
Evaluation of the best practice: modular structure of the product helps to run projects concurrently and saves development time			
Small	150	4.01	0.890
Medium	62	4.13	0.859
Large	30	3.90	0.995
Total	244	4.03	0.895

Notes: Scale: 1 – totally disagree; 5 – totally agree (one-way between-group ANOVA, all respondents); small company: <50 employees, medium: 50-250 employees, large: >250 employees

Table VII.

consider the benefits with more precaution before taking the interdependency approach into use, as the advantages are less clear for them.

This descriptive survey has also given a list of the dominant problems to avoid (Table VII), and some best practices to increase the success rate and reduce resource consumption (Table VII), as well as information about which methods and techniques companies use (i.e. mostly informal methods and not much mathematical methods (Rungi, 2009b)).

Different stakeholders of the project, such as top management, middle – and project managers were found to use a practice-oriented definition of success, contrary to the literature.

The need for interdependency management increases when the economical situation becomes worse.

Limitations. The main limitation comes from the sample, as the focus was mostly on ICT, engineering, machinery and construction industries, and thus the findings may not be directly applicable to other industries, although some 54 percent of the responses were from other industries. Similarly, the findings from Estonia and Finland may limit generalizability to other countries. It has been argued that experience from a small country might not be interesting and relevant for advancing theoretical points in academic discussions (Tienari and Thomas, 2006), but it is definitely relevant for companies in countries of similar size round the world. The same countries have been compared earlier in international management journals (Ifinedo and Nahar, 2009). Also, the slightly varying data-collection methods in Estonia and Finland may have caused unintended bias. Finally, the sample was mostly limited to small and medium companies (182 and 66 respondents, respectively). There were not enough representatives of large companies (32 companies), which resulted in lack of evidence for the behavior of success rate and resource reduction in large companies in groups of users and non-users of interdependency. Several tests could not be performed properly due to the sample size.

Second, as there does not exist a good conceptual model for interdependency, and due to the choice of method (survey), the results rather indicate how the respondents perceived interdependency-related implications (e.g. advantages and problems), not exactly the real ones (in strictly theoretical terms). To get the real implications, data triangulation would be needed (e.g. data from project reports, interviews), and that is a matter of on-going in-depth research. Perceptional measures (not accurate/exact measures) in surveys are matter of self-reporting bias, which for example may result in giving socially desirable answers. Self-reporting bias takes mostly place when respondents need to answer sensitive questions, they have propensity do to that and there are situational characteristics

(Donaldson and Grant-Vallone, 2002, p. 248). Self-reporting bias was avoided here by non-sensitive questions, a symmetrical research setting (positive and negative aspects of the phenomenon were under focus), appropriate target group (managers with strong will), promised/guaranteed anonymity, avoiding questions concerning the phenomenon directly, and offering a chance to express "I do not know" if needed.

Third, this paper does not claim to constitute theory yet, because it presents only interim research results from a survey and will be continued by multiple case study, i.e. the research is still at an early stage and therefore rather descriptive. This research has focused more on "what" questions, not so much on "why" questions. According to Whetten (1989, pp. 490-1), "what", "how", and "why" are the main "building blocks of theory development", where "what" and "how" describe and "why" explains phenomena.

Further research. Interdependency is partly a phenomenon which cannot be fully observed (e.g. in parts where human motivation is involved), and therefore it also requires post-positivistic (e.g. qualitative) approaches. In addition, a complex phenomenon is under study (Staudenmayer, 1997), where quantitative approaches might be difficult to apply fully. This research situation causes the need to look at phenomenon from different perspectives and methods. In further research, the mixed method (method triangulation) will be used in the order: quantitative → qualitative (for good examples, see Hurmerinta-Peltomäki and Nummela, 2004). In the mixed method "the researcher seeks to elaborate or expand the findings of one method with another method" (Creswell, 2003, p. 16). After the current survey, a multiple-case study will be performed, its research design being based partly on the results of the survey. The survey will be used to test theories, find regularities and get broad empirical pre-understanding, and multiple-case study will help to provide in-depth material about the phenomenon *per se*. The mixed method increases also the validity of the whole research and makes it possible to gain a more comprehensive view.

Notes

1. According to EU categorization – small company: less than 50 employees, medium company: 50-250 employees, and large company: more than 250 employees.
2. There are many definitions available for interdependency, many use Thompson's definition, which sees "interdependency as a contingent relationship among tasks or activities" (Staudenmayer, 1997, p. 23). However, some definitions are based on the level of analysis (Staudenmayer, 1997), as the one here.
3. An earlier version of this paper was published in the proceedings of the 23rd IPMA World Congress (Rungi, 2009a). A series of papers addressing the same survey have been produced, as the aim is to analyze different aspects of the same phenomenon.
4. According to Liesiö *et al.* (2006) and Schmidt (1993), this is called "cannibalization".

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Appendix. Extracted questions from the interdependency survey

Relationships between projects

Part I: Profile of the company

Main field of business:

The classification is based on EU industry sectors.

- ○ Aerospace.
- ○ Automotive industry.

...

- ○ Anything else, please specify.

Company's turnover:

- ○ Less than €2 million.
- ○ €2-9 million.
- ○ €10-50 million.
- ○ More than €50 million.

Number of employees?

- ○ Less than 10 employees.
- ○ 10-49.
- ○ 50-250.
- ○ More than 250 employees.

Please specify which one do you focus on when you respond (choose one):

- ○ NPD projects.
- ○ maintenance/line extensions/product modifications.

○ fundamental research/platform projects.
○ development projects of own internal processes.

Success rate

Successful are all projects which finish in time, within the budget and produce their scope. What is the success rate of the projects (approximately)? (percent).

Please state whether your company/unit has different success criteria (for example some companies use more flexible criteria, such as successful are projects, which have not been killed, delayed (not more than 10 percent), over budgeted (not more than 20 percent) or they have the expected functionality (more than 85 percent)).

Size of average project in terms of time

Average length of projects? [months].

Part II: Questions about relationships between projects

Does the company/unit consider relationships between projects?

○ Yes ○ No

In your opinion, what are the main benefits of considering relationships between projects?

Using the scale below, please evaluate each row (1–totally disagree, 5–totally agree):

1	2	3	4	5	I do not know
○	○	○	○	○	○

Achieved resource savings from sharing resources.
Achieved higher project success rate.
. . .
Anything else, please specify.

In your opinion, what are the main drawbacks from considering relationships between projects?

Using the scale below, please evaluate each row (1–totally disagree, 5–totally agree):

1	2	3	4	5	I do not know
○	○	○	○	○	○

Project cannibalizes dependent project resources.
Delays caused when interdependent predecessor project is not ready on time.
Conflicts between interdependent projects due to shared resources.
Shared HRs cause lack of motivation.
Geographical dispersion or distance increase the complexity of relationships.
Differences between cultures increase the complexity of relationships.
. . .
Anything else, please specify.

Please evaluate in which way technological relationships between projects can help?

Using the scale below, please evaluate each row (1–totally disagree, 5–totally agree):

1	2	3	4	5	I do not know
○	○	○	○	○	○

Existence of well developed technologies helps to finish projects quicker and inexpensively
Modular structure of the product helps to run projects concurrently and saves development time.
. . .
Anything else, please specify.

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