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Abstract:
This research investigates the mutual and diverging factors for successful and less successful innovations in software and manufacturing of machine tools in Central and Eastern Europe (CEE). We apply univariate and multivariate analyses on 115 indicators by revisiting the seminal SAPPHO project based on the analysis of pairs of innovations and conducted at SPRU – Science and Technology Policy Research during the 1970s. We aim to identify principal factors influencing firm success in innovation in the context of CEE and compare our results to those of SAPPHO and see whether any changes took place during the last 40 years in this context after several decades of globalization. Our initial findings from a database of 90 innovations and 45 pairs of innovations – introduced onto the market during the period 2007-2010 - from 51 CEE enterprises demonstrate that, in particular, user and market-driven factors differentiate successful innovations from less successful ones. Our results fully confirm the continuing relevance of SAPPHO results and methodology. Successful innovators have stronger user orientation and better understanding of market demand. Although, CEECs are catching up economies, continuous and strategic R&D and innovation collaboration is essential to generation of greater commercial success from innovation activities. Given the catching-up character of the CEECs this is surprising result which may reflect knowledge-intensive nature of two sectors which form the basis of our sample. Results of this research clearly demonstrate that orientation of the CEEC innovation policies is inconsistent with the characteristics and behaviour of successful innovators.

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1. INTRODUCTION

The sources of successful innovations have been the object of debate for quite some time in innovation studies (Schmookler, 1966; Mowery and Rosenberg, 1979). The Project SAPPHO[1] (SPRU, 1972; 1974; Rothwell et al., 1974) represent clear milestone in this debate as it has clearly demonstrated that innovation is coupling of new technology with a market (Freeman and Soete, 1997, chapter 8). Either technology push or demand pull explanations of innovation process are one sided and successful innovators are distinguished by coupling of innovations with market demand and users needs. This important insight in the nature of innovation process is the major rationale why in this paper we have re-applied SAPPHO methodology in the case of knowledge intensive enterprises (KIE) in Central and Eastern Europe (CEE).

Why revisiting SAPPHO? First, we firmly believe that this methodology is insufficiently exploited in innovation studies which have become dominated by hypothesis testing and deduction based research with comparatively little exploratory research. Second, forty years after original SAPPHO we want to explore whether there are major changes in the nature of innovation process, especially in view of increased importance of innovation networks in the last 40 years. As science and technology interfaces have intensified so has increased the importance of external networks for success in innovation (see Dodgson and Rothwell, 1994, p. 82 for references on this). Moreover, the latest trend towards open innovation model has further reinforced the role of users in innovation process (von Hippel, 1988; Chesbrough, 2003). Third, we are interested whether there are specific features of successful and less successful innovations in firms and countries that operate behind technology frontier.

Why do we explore these issues in the catching up countries of CEE? First, we may expect that the role of R&D in innovation is reduced in these economies as their overall business expenditures on R&D are comparatively quite low but the role of users and markets should be important. If innovation is coupling between technology push and demand pull factors it is very interesting to explore whether and how this coupling takes place. Equally, the role of networks should be very important especially in view of openness of these economies. We explore factors of innovation success in the most knowledge intensive enterprises (KIE) in these economies. Hence, we would expect even more that the knowledge networks would play an important role.

This research aims to understand the common and diverging factors for commercially successful innovation in knowledge-intensive enterprises (KIE) in three Central and Eastern European Countries (CEECs), namely Hungary, Poland and Croatia. We focus on all the major factors driving innovation at firm level: technology, R&D, firm interactions, users and market demand. In doing so, we explore discriminating factors between successful and less successful innovations.

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[1] SAPPHO stands for Scientific Activity Predictor from Patterns with Heuristic Origins.

In this research, KIEs are defined as firms that are innovative, have significant knowledge intensity in their activity, and which explore and exploit innovative opportunities (Malerba and McKelvey, 2011). By definition KIE should have internal management, business model and organization that enable them to transform knowledge into innovation. KIE operates based on new products and processes (innovations) which are knowledge intensive and, hence both use and generation of knowledge are essential part of KIE.

In the next section we review literature which is based on or related to SAPPHO perspective. Section three explains methodology (criteria for selection of firms and sectors, brief information on sectors in the CEE context, definitions of success in pairs of innovations, indicators and methods of analysis). Section four presents results in overall and by sectors (software and machine tools). Conclusions generalise based on empirical results from previous section.

Our results fully confirm the continuing relevance of SAPPHO results and methodology. Forty years after and tested in different socio-economic context successful innovation is still about good coupling between technology and market. Successful innovators have stronger user orientation and better understanding of market demand. However, our results also point to interesting differences.

2. SAPPHO FOCUSED LITERATURE: A REVIEW

2.1. What is Project SAPPHO?[2]

Project SAPPHO is a study of industrial innovation, more specifically *management of innovation* (Rothwell et al., 1977: 415), in two science-based industries, chemicals and scientific instruments. It was conceived as a systematic attempt to identify and evaluate the factors which distinguish innovations that achieved commercial success from those that have not. In SAPPHO, successful innovations are those that managed to establish a worthwhile market or profit. Less successful innovations are those that failed to establish a worthwhile market or profit even though technically they have been successes. SAPPHO, which has been a landmark study, showed how much a commercially successful innovation depends on non-technological factors – i.e. understanding of user needs, marketing, organisation, use of external knowledge sources and leadership (SPRU, 1972; Rothwell et al., 1974; Freeman, 1994). In essence, SAPPHO demonstrated that successful innovation is largely the case of coupling technology and market needs.

Project SAPPHO refers to successful innovations as those that managed to establish a worthwhile market or profit as well as being technically successful. Griffin and Page (1996) also found market share as the most useful measure for assessing success in projects involving new-to-the-company products. Successful technology commercialization is defined as the whole process of acquiring ideas, developing and manufacturing saleable

[2] This section draws on SPRU (1972; 1974).

goods, and selling the goods in a market (Mitchell and Singh, 1996:170; Cooper, 1993; 2000).

The originality and uniqueness of SAPPHO lie not only in its ambition to explore factors which distinguish between successful innovations from failures but also in its methodology – i.e. especially in the way that the data is arranged. The SAPPHO technique involved detailed comparison of 'paired' successful and unsuccessful innovations, where comparison between pairs was made using a large number of 'project execution' variables (Rothwell et al., 1977). It analysed 29 such pairs, 17 in chemicals and 12 in scientific instruments.

The data were gathered by in-depth interviews in firms. From these interviews, 201 measures were attempted. Most of these were comparative measurements which were designed to throw light on hypotheses previously advanced to explain innovation success, such as size of organisation, management techniques, characteristics of individuals, speed of development, structure of firm, communications environment of firm and relationship with the market. In the outcome, much of the statistical analyses were based not on 201 measures but on 122 which proved to be statistically significant in binomial tests. Since the number of variables (122) largely exceeded the available number of observations (29 pairs), they have used multivariate techniques such as factor analyses and compound variable analysis to overcome this limitation.

SAPPHO's results yielded five underlying factors to discriminate between successful and failed innovations. These can be very briefly listed as follows (emphasis ours):

1. Successful innovators were seen to have a much better *understanding of user needs*.
2. Successful innovators pay much more *attention to marketing*.
3. Successful innovators *perform their development work more efficiently* than failures, but not necessarily more quickly.
4. Successful innovators make more effective *use of outside technology and scientific advice*, even though they perform more of the work in-house.
5. The *responsible individuals* in the successful attempts are usually *more senior* and have greater authority than their counterparts who fail.

2.3 Importance of SAPPHO: Attention on user needs and markets

SAPPHO was not confined to itself, it did not remain as a one-off research and paved the way for other studies that highlighted crucial aspects in innovation studies. Whereas SAPPHO found non-technological factors such as user needs and markets more influential on innovation success; several studies extended SAPPHO further by using SAPPHO data. For instance, Von Hippel's (1976) key finding – by examining scientific instrument innovations only, since these were mostly significant product innovations in the SAPPHO data whereas chemical industry's innovations were mostly incremental process innovations – was that almost 80% of the successful innovations involved substantial user collaboration whether at the stage of invention, prototyping or field testing. Moreover, von Hippel (1976: 222) observes that the user-dominated pattern of innovating is not necessarily accompanied by the manufacturer-dominated innovation process, implying the firm-internal efforts for R&D. The importance of user/customer involvement in innovation has been the primary feature in von Hippel (1978, 1986, 1988), Baldwin and von Hippel (2011) and Lundvall (1985, 1988, 1992) as well as its primary role in the learning economy (Lundvall and Vining, 2005; Hyysalo, 2009; Johnson, 2011).

Results of Project SAPPHO did not only explain what factors explain successful innovation, but they were also shedding light on what factors explain unsuccessful innovations. The latter has been largely overlooked even today. Spiller and Teubal (1977) analyzed innovation failures and found that failing to understand the precise structure of user needs and low level of market determinateness in the firm causes failures in innovation. Especially these extensions to SAPPHO on external market environment involved the 'demand-pull' approaches to the execution of innovation process (see Mowery and Rosenberg, 1979 for a critical review). The major lesson is that innovations should be conceived and developed with a careful regard to the differential customer benefits they offer which requires close links with the potential customers throughout different stages of development process (Littler, 1994). ICT has further enhanced the role of users in innovation process. For example, Von Hippel (2002) shows why firms would need to develop 'user toolkits' to involve users in the innovation process. This has been followed by recognition of strategic importance of open innovation models at both micro (Chesbrough, 2003) and at macro-levels (De Backer et al, 2008) where users' considerations are not only influencing but driving innovation process.

SAPPHO approach oriented literature is largely focused on better understanding of factors that discriminate between successful and less successful innovators or failures. Since the original SAPPHO publications a rich stream of literature has tried to answer on similar questions but in different contexts. The focus of SAPPHO inspired research is to explore whether successful innovations originate largely from own or external R&D, whether firms innovate by interacting with external actors, observing the market, answering the user needs, etc. We investigate factors such as firm interactions (Hakansson, 1989; Hagedoorn and Schakenraad, 1990; Gelsing, 1992; Laursen and Salter, 2004), R&D conduct –both external and internal to firm- (Cohen and Levinthal, 1990; Kim, 1997a, 1997, 1998, 1999; Tether and Tajar, 2008), user involvement (von Hippel, 1988; Lundvall, 1992) and market effects on successful and less successful innovations.

This research re-visits Project SAPPHO (SPRU, 1972; 1974; Rothwell et al., 1974) in the context of Central and Eastern Europe (CEE) to evaluate the factors which distinguish successful innovations from less successful ones. Many factors that affect innovation are external factors and thus may impinge on firms' innovation success. We are interested if there are specific environmental factors which affect innovation process and which are shared by other economies that operate behind technology frontier. Interestingly SAPPHO 'pair comparison' technique was applied to the investigation of twelve success-failure pairs in the Hungarian electronics industry in 1974 (Szakasits, 1974). Rothwell (1974) in reviewing this study comments that 'considering the differences which exist between the centralized Hungarian communist system and the Western capitalist free enterprise system, the results of the SPRU and Hungarian studies are remarkably similar, both of them highlighting the importance of need satisfaction, the importance of good communications, (both internal and external), the necessity for efficient development, the advantages of a market orientation, and the crucial role played by certain key individuals in bringing about success. It is reassuring to see that, despite political and cultural differences, innovators are, beneath the skin, much the same everywhere!' (p38). In revisiting SAPPHO our interests are to explore whether differences still exist and whether they are systemic or largely developmental.

3. METHODOLOGY

This research focuses on pairs of successful and less successful innovations in knowledge-intensive enterprises (KIEs). We will be able to find out which are the discriminating factors at the level of innovation that influence commercial success. We aim to uncover the characteristics of factors which both types of innovations (successful and less successful) *share* and in which respect they *diverge.*[3]

As a first requirement of the research design, the implementation of SAPPHO methodology relies on strict criteria/rules with regard to selection of sectors, firms, innovations and their pairings. We describe these below staying within the boundaries of our research, from which this section draws.

3.1. Selection of sectors: Sector characteristics in CEE[4]

We have first selected two sectors, namely software and manufacturing of machine tools. These two sectors are quite relevant for the CEECs as the new member states of the European Union for two reasons. First, they have inherited good competencies in mechanical technologies from the socialist period. Second, they are being integrated into global value chains in new areas like ICT and software.

Companies operating in the software sector in the CEE are largely oriented towards local markets (Radosevic, 2006). Demand-side problems continue to be significant barriers for the development of knowledge intensive entrepreneurship (KIE) due to the relatively low purchasing power in the CEE markets. A low level of knowledge-intensive services indicates low degree of sophistication of demand, which is largely confined on customization. The industry in the developed EU (i.e. Germany, UK, Sweden, Denmark) is also oriented towards local markets but its share of global orientation is significantly more present than in the CEE and requirements from local firms are more demanding. There is a thin layer of companies in CEE countries which are either fully export-oriented or are among

[3] In this respect, our methodology differs from SAPPHO which has been able to identify outright failures and successes. We expect that our focus on relative, not absolute, success will influence robustness of our results. Nevertheless, we think that good research design based on SAPPHO will enable us to generate even more relevant research results. This approach was initially applied in PhD dissertation of George Tsekouras (SPRU PhD) on the best practices of knowledge integration of firms in Greece who was initially supervised by Roy Rothwell.

[4] This section draws on Project AEGIS Work Package 4.2 primary reports by Gable, J. et al. (2012) and Radosevic and Yoruk (2012).

technology leaders in their market niches. Technological opportunities for companies in the CEE are limited due to low R&D intensity, lower productivity and smaller size of their firms when compared to the developed EU. This leads to limited organisational capabilities and below minimum economies of scale for export-led growth. Developed EU countries have visible regional ICT clusters while they have not yet emerged in the CEECs. They also have difficulties in attracting skilled software labour though to different degrees. Institutional opportunities seem to be the area with the smallest gap between developed EU and the CEE. For example, Sweden and Croatia have both low level of co-operation in ICT between industry and academy. However, in Sweden it is a sector composed of public research institutes and consultancies that compensates for this gap, while there is no such compensatory mechanism in Croatia. Software industry does not operate based on specific sectoral regulatory regime and hence national regulatory framework largely applies to this industry.

In the machine tools sector, market opportunities in Poland and Czech Republic seem promising when compared to the developed EU countries. For instance, machine tool sector in the UK, where demand has been largely oriented towards standardized (general purpose) goods of medium quality range corresponding to less demanding and less sophisticated buyers, has been witnessing negative growth in its market value (-32% between 2000 and 2007). CEEC, on the other hand, have experienced positive, and in case of the Czech machine tools sector, very significant growth. However, technological and productivity level of industry in the CEECs is much lower when compared to the developed EU. CEE technology-wise lags behind as indicated in the low productivity rate in the sector and lower R&D intensity. Links between technology, productivity and growth of industry seem to be mutually dissociated largely due to globalisation and impact of value chains. For example, the Czech industry fares very well in terms of average turnover per employee but is far behind in terms of gross value added per employee. This suggests that the Czech industry is well integrated internationally in global supply chains but in terms of technological level falls behind developed EU. Moreover, the R&D intensity of the Czech industry is falling. Yet, co-operation in both the Czech and Croatian machine tools industries seems to be not less present than in developed EU countries. In machine tools industry, as in software, there is no strong sectoral regulatory regime and hence national regulations are quite relevant. There is interesting difference between Poland and other countries as Poland does not have associations representing machine tool producers, who tend to belong rather to associations of the industries they produce for.

The selection of sectors does not automatically ensure that any firm within these sectors should be considered a KIE. In order to select true KIE we apply the following main and auxiliary criteria.

3.2. Selection of firms: Two major criteria

In this research, KIEs are defined as firms that are innovative, have significant knowledge intensity in their activity, and which explore and exploit innovative opportunities. KIE have internal management, business model and organization that enable them to transform knowledge into innovation. KIE operates based on new products and processes (innovations) which are knowledge intensive and, hence both use and generation of knowledge are essential part of KIE.

We apply two major criteria for selection of firms to be included in the sample:

1. The firm should be registered that its major activity is in sectors: software and machine tools.
2. The firm should be innovative. It should have introduced new products, processes or services onto the market during the last three years.

Apart from the main criteria above, a selected firm should also meet at least one of the auxiliary criteria below:

1. It is employing highly skilled personnel (MSc, PhDs) in engineering sciences, or
2. It is continuously (not intermittently) investing in R&D, or
3. It has registered patents.

3.3. Pairs of innovations and definition of success

The pairing technique has already being used for a long while in natural sciences; especially biology and chemistry (see MacKay and Bernal (1966) but its use in innovation studies is not very common. It allows for discerning patterns of strict dichotomies – i.e. in this research, success and less success. For the purposes of this research, pairs are not identical twins. Their similarity is defined in terms of product similarity aiming at similar markets – i.e. they may adapt different technical solutions. The technology fields of the innovations in the sample are presented in Table 1.

Table 1. Fields of technology related to pairs of innovations.

Machine Tools sector	**Software sector**
Tool making	IT security
Pasting machines	Knowledge management
Welding, cutting and bending machines	Language technology
High speed motor spindles	ERP-Enterprise resource planning
CNC Lathes	Financial management
CNC Milling machines	Internet portals
CNC Milling machine parts	Operating systems
CNC Drilling machines	
CNC Grinding machines	
Hydraulic presses	
Machine parts	

We do not consider failed innovations since all the innovations in our sample have been in the market. Yet, some innovations are much more successful than others in commercial terms, i.e. greater growth in sales. Indeed, *degree of success* was brought into attention in Rothwell et al. (1974: 269) when attempting to measure the overall success identified by

(1) Net direct monetary gain, accruing from the sale and/or licensing of the innovation and from the sale of technical know-how generated through the innovation.
(2) Market share, in terms of the number of units sold and the average sales price per unit.

(3) Alignment with company strategy.

We search for factors underpinning differences in successful and less successful innovations based on the definitions below.

Definition*:* Successful innovations are those that managed to establish a worthwhile market or profit. Less successful innovations are those that failed to establish a worthwhile market or profit even though technically they have been successes.

The difficulty is that success is not always self-evident. We differentiated between successful and less successful innovations by directly asking the interviewees about the growth of sales figure related to the innovation after its launch – i.e. whether it has been increasing very fast (more than 20%), fast (between 10 to 20%), slow (between 3 to 10%) or whether it has been static (between -3 and 3%) or declining (less than -3%). If the sales growth figure for the innovation was very fast or fast, we considered it to be a successful innovation. If it was slow, static or declining, we considered it to be a less successful innovation. In order to make sure that we received reliable answers for growth rates of innovations, we also asked about the amount of turnover for the innovation (one year after its launch and current). We used the latter to double-check the former; though the indicator has considerable number of missing values, since the firms are reluctant to reveal their fiscal measures in the CEECs due to tax-related issues.

Table 2 below shows the distribution of innovations, by country, sector and success vs. less success. We must note that we indeed have information about 118 innovations, however only 90 of these provided reliable information to be able to be paired reliably.

Table 2. Distribution of innovations, by country, sector and success.

	Software		Machine Tools		Total	
	Success	Less Success	Success	Less Success	Success	Less Success
Czech Republic	-	-	10	13	10	13
Croatia	6	12	1	1	7	13
Poland	15	8	10	5	23	15
Hungary	3	4	0	2	3	6
Total	24	24	21	21	45	45

3.4. Data Collection

Face-to-face interviews were conducted with managers in 51 firms in Czech Republic, Hungary, Poland and Croatia during April-May 2011. The managers have been asked structured questions related to the market conditions, their networks, research activities and institutional structure in connection with each of their innovations that they have introduced onto the market between 2007 and 2010. Information was also sought about the founders and establishment stage of the firm.

3.5. Coding the Pairs and the Dataset

Pairing of similar innovations – one successful, the other less successful – allows comparisons to be made avoiding the problem of absolute scales. Depending on whether an individual measure, compared within a particular pair, is judged to weigh in favour of success (S > LS), in favour of less success (S < LS), or neither (S=LS), it is accorded a coding of + 1, - 1 or 0, respectively. Thus, a particular relation *i* on the successful and less successful innovations defines vectors respectively S_i and LS_i of dimension 45, made up of 1s and 0s.

3.6. Operationalization of Concepts

The research initially encompassed 114 individual indicators to assess for factors identifying successful from less successful innovations. 114 indicators have involved the details about firm interactions ranging from universities, research institutes, consultant and suppliers as well as the type of interactions ranging from strategic alliances to R&D agreement and subcontracting. They also included almost all possible details about the design activities in the firm and the external contributors (i.e. customers, suppliers, universities, etc.) to design activities at any level. The questionnaire sought detailed information about the conduct of R&D at firm level as well as any external contributor to R&D activity and systematic R&D in the firm for the specific innovation in the absence of a formal R&D unit. Among the indicators, there were also finance and market-related ones.[5] Table A1 in appendix presents all the indicators studied in this research.

3.7 Methods of Analysis

The ultimate aim of this research, albeit at this stage, is largely of an exploratory nature as we do not prefer to state priory hypotheses regarding factors that discriminate successful from less successful innovations. Our intention is to repeat SAPPHO and compare our findings with it.

The number of variables greatly exceeds the number of cases (observations or paired innovations). Hence, the initial method to summarise information is based on multivariate analysis:

- binomial tests on all variables,
- examine interdependencies and aggregate variables into small number of 'integrated factors' via factor analysis (index variables).

First, all 115 indicators have been subject to binomial tests which comprised of eliminating the indicators that showed no differences between successful and less successful innovations. A careful implementation of this procedure resulted in 17 indicators which showed statistically significant differences between successful and less successful innovations within acceptable limits as required by statistical tests.

[5] The survey questionnaire is available from the authors upon request.

4. THE RESULTS

Our measures of innovation success are measures of commercial success, especially relative commercial success within the pair of firms, and not their technical success. From economic perspective, innovation is relevant only as long as it is introduced and successfully commercialized on the market. We are interested in factors that discriminate successful from less successful innovations within pairs of firms that operate not only in identical sectors but also on similar or identical markets. Hence, our approach explores which factors discriminate between firms in their effort to ensure commercial success. These factors have to do not only with R&D results but also with recognition of user needs. Moreover, our measures differentiate between factors which may originate from better articulation of needs of specific user (needs) and better articulation of market demand (wants). As rightly pointed by Mowery and Rosenberg (1979) this is important distinction in understanding demand vs. supply determinants of innovations. By the same token, our measures take into account so called 'market determinateness' or 'the degree of specificity of the market signals received by the innovating firm and consequently the extent to which it anticipates (instead of responding to) demand' (Spiller and Teubal, 1977).

4.1 Both Industries

We started with univariate analysis –a binomial test- to select the subset of elementary measures which distinguish between successful and less successful innovations. The statistical significance of a distribution, using the binomial test, gives the probability of the observed pattern of +1's and -1's occurring naturally. The smaller this probability, the greater is the statistical significance of the measure for success (or less success). A full list of indicators examined in this research is provided in Appendix Table A1 illustrating the number of successful and less successful innovations and their binomial tests for both industries and by each industry separately. For both industries (N=45 pairs of innovations) 17 indicators emerge to be statistically significant ($p < 0.1$) and thus were found to show the greatest differences between successful and less successful innovations. The results of the binomial tests are given in Table 4 for these 17 significant variables, the measures being grouped in four emerging areas as user involvement and orientation, understanding markets, R&D management and collaboration, and innovation source and collaboration. These are derived originally from a series of principal component analyses. Table 3 presents the results of factor analysis for a 4 factor model which allows for a momentous interpretation of factor loadings.[6] This 4 factor model forms the basis for the categorization of statistically significant indicators into four major subgroups in Table 4.

Left hand columns in Table 4 list measures that explain success and less success irrespective of whether their contribution is a priory positive or negative. In order to get clear

[6] Several of the exercises with factor analysis (i.e. a 3 factor model and a 5 factor model) have been presented in Appendix Tables A2 and A3. We have also undertaken exploratory factor analysis jointly on all 17 indicators for which binomial tests were significant. This yielded 6 factor loadings and this is not much different from a 5 factor model in terms of statistical measures.

idea on contribution of different measures we give negative signs to measures whose presence actually reduces probability of greater success. This enables us to achieve comparable scores across all observations and calculate average score for each of the four groups of factors and create a compound indicator. This simple operation shows that presence of close interaction with users, market-led (as opposed to technology-led) innovation, and strategic and continuous but well implemented R&D and networking (even though limited to subcontracting type of relationships and collaborations with foreign firms for design activities) are closely associated with comparatively greater commercial success.

Subsequently, we have tested coherence of this grouping through confirmatory factor analysis (CFA) for each of these sub-groups. (Table 4 right hand side columns). As Table 4 shows the latent variables explain in between 23% to 53% variance in underlying measures. The findings from this exercise show that users' orientation is very important and indeed 'user involvement and orientation' component is statistically the most robust component significantly influenced by the involvement of users during the development stage of the innovation. A considerably higher number of more successful innovators had been more active in terms of involving users in development, educating them, and have identified problems immediately after launch of the product/process. On the other hand, in more number of less successful innovations, firms did not take steps to educate users or has not done modifications as result of users' experience. However, the findings also show that user – producer interaction vary in terms of modalities of interaction. Successful innovators have relied very much on users during development of innovation so that user problems could become apparent only after launch. Other successful innovators have taken a lot of steps to educate users or they identified potential users' problems in early stages of development or immediately after launch. In cases when users were involved in development there was not need to educate users or do modifications. In short, we see a variety of modalities in which interaction with users occur but whatever was the mode of involvement the presence or lack of interaction with users is strong discriminatory variable between successful and less successful innovators (see compound indicators 11.75 vs. 1.75 in Table 4).

Table 3. Confirmatory factor analyses results for a 4 factor model (N=45).

			Innovation management and collaboration	
Indicators	**user involvement and orientation**	**understanding market**	**R&D management and collaboration**	**innovation source and collaboration**
Potential users were involved a lot during the development stage of the innovation	**0.832**	-0.171	0.050	0.061
A lot of steps were taken to educate the users	**-0.524**	0.280	0.375	-0.435
If there were user problems, they became apparent after launch	**0.596**	0.178	-0.008	-0.234
The demand for the innovation was estimated by market research of the firm	-0.362	**-0.520**	0.208	0.186
The demand for the innovation was estimated by previous knowledge	-0.003	**0.793**	0.067	-0.077
There was a formal R&D department in the firm and it was the entire R&D department in the firm to carry out the research activities for the innovation	-0.067	-0.001	**0.484**	-0.361
There was/were external R&D unit(s) and the project manager for the innovation in your firm was the leading/responsible person for this R&D work in the external R&D department	0.115	-0.602	**0.347**	-0.164
There was/were external R&D unit(s) and number of qualified scientists and engineers in this external R&D department	0.210	0.018	**0.863**	0.184
There was a formal R&D department in the firm and it was part of the R&D department in the firm to carry out the research activities for the innovation	-0.151	-0.200	**0.613**	0.131
The kind of collaboration was subcontracting	-0.057	0.073	-0.049	**0.649**
Foreign firms contributed to design activities	-0.254	**0.474**	**0.373**	**0.335**
The innovation arose partly in the company	0.385	0.266	0.297	**0.549**
The demand for the innovation was estimated by customer's requests	-0.141	-0.168	0.149	**0.639**
Rotation: Varimax, Kaiser-Meyer-Olkin Measure of Sampling Adequacy: 0.302, Bartlett's Test of Sphericity is significant at 0.000, total variance explained (cum %): 55.40.				

Table 4. Statistically significant indicators for surveyed firms' pairs of innovations and results of confirmatory factor analyses (N=45).

			All firms (N=45)							
			Observations for			Confirmatory Factor Analysis results and tests				
		Significant indicators	successful innovations[1,3]	less successful innovations[2,3]	sig. (2-tailed)	CFA loadings	CFA loadings for Inn Mang& Collab. (grey shaded areas)	KMO	Bartlett's sphericity sig.	Total variance explained (Cum %)
	User involvement and orientation	Potential users were involved a lot during the development stage of the innovation	22	10	0.050	0.915		0.381	0.000	53.1
		A lot of steps were taken to educate the users	16	5	0.027	-0.741				
		No steps were taken at all to educate the users	-3	-12	0.035	_				
		If there were user problems, they became apparent after launch	12	4	0.077	0.453				
		Compound indicator (average)	**11.75**	**1.75**						
	Understanding markets	The demand for the innovation was estimated by market research of the firm	13	3	0.021	0.786		0.521	0.284	44.92
		The demand for the innovation was estimated by previous knowledge	16	5	0.027	-0.633				
		The innovation involved going into an unrelated market area	-1	-8	0.039	_				
		The demand for the innovation was estimated by customer's requests	18	7	0.043	0.575				
		Compound indicator (average)	**11.5**	**1.75**						
Innovation management and collaboration	**R&D management and collaboration**	There was a formal R&D department in the firm and it was the entire R&D department in the firm to carry out the research activities for the innovation	1	12	0.003	0.240	0.348	0.426	0.068	36.65
		There was/were external R&D unit(s) and the project manager for the innovation in your firm was the leading/responsible person for this R&D work in the external R&D department	6	0	0.031	0.578	0.337	0.366	0.035	23.62
		There was/were external R&D unit(s) and number of qualified scientists and engineers in this external R&D department	12	4	0.077	0.864	0.803			
		There was a formal R&D department in the firm and it was part of the R&D department in the firm to carry out the research activities for the innovation	15	6	0.078	0.572	0.216			
		Compound indicator (average)	**8.5**	**5.5**						
	Innovation source and collaboration	The kind of collaboration was subcontracting	9	2	0.065	0.817	0.373	0.488	0.125	45.61
		Foreign firms contributed to design activities	9	2	0.065	0.572	0.554			
		The innovation arose partly in the company	3	10	0.092	0.611	0.530			
		Compound indicator (average)	**7.00**	**4.67**						
	Degree of novelty	The innovation was new to the firm	-5	-19	0.007					
		The innovation was new to the country	14	5	0.064					
		Compound indicator (average)	**4.5**	**-7**						

1. Observations for success better than/more than less success. 2. Observations for success worse than/less than less success. 3. We have used inverted scores for some indicators (harmful effect negative) when calculating the compound indicators.

Successful innovators innovated with the view of market demand which was estimated in several ways. The most effective ways were by taking into account requests of customers - i.e. early identification of needs (customers' requests) or based on the previous knowledge or based on market research. So we see that 'market determinateness' or the capacity of the firm to anticipate needs is confounded with the explicit reception of the market signals. Probability of success was reduced when innovator was not involved in its core area, but the innovation ended up going into unrelated market area. There seems to be trade off between estimation of market demand based on the previous knowledge (experience based) or market research versus that of via explicit customers' requests (Table 3). Only one successful innovator has entered into unrelated market area which is clearly opposite to 16 successful entries based on the previous experience (Table 4). However, despite differences in modes of interaction with market the intensity of interaction of successful innovators is significantly higher when compared to less successful innovators (see compound indicators 11.5 vs. 1.75 in Table 4). One factor model CFA appears to be statistically not significant for this component. The greater relative significance of users (needs) rather than demand (wants) is confirmation of Mowery and Rosenberg (1979) point in their analysis of supply and demand factors in innovation process. The strong role of users in estimating demand is more associated with the 'innovation source and collaboration' component in 4 factor model CFA rather than with 'understanding market' component (see Table 3). This further supports and confirms the crucial and determining role of users in innovation which seem to be involved in a kind of collaborative innovation.

By being latecomers and operating in catching up context it could be expected that for KIEs in CEE R&D is not the major distinguishing factor in innovation successes. This is even more so if we look at national level and compare business expenditures on R&D in CEECs with more developed economies. Yet, our data indicate that some aspects of R&D management and collaboration do indeed discriminate successful innovations from less successful innovations in CEECs (Table 3). It is striking that one of the major distinguishing factors is the size of R&D team in the external R&D department whereas in SAPPHO project it was the size of R&D team in the firm (Freeman and Soete, 1997, p.216). These differences seem logical given that SAPPHO sample involved primarily large firms in the advanced countries while our sample consists largely of smaller enterprises in the CEECs where firms seek to exploit external R&D opportunities available to them. This may also suggest that official R&D statistics underestimate the R&D which is undertaken within KIEs and which does not conform to criteria of formalised R&D activity as defined in Frascati Manual. Additional to that, firm's project manager taking responsibility for the innovation research at the external R&D department led to success as further confirmation to strategic approach to R&D.

Less successful cases were associated with strategic approach to R&D when the entire R&D department was involved in innovation but that did not lead to comparatively greater success (Table 4). On the contrary, strategic approach to R&D when part of the R&D department was involved in innovation did lead to comparatively greater success. This may suggest careful division of labour in the R&D department in a strategic sense but also available resources of firms.

As for the sources of innovation, successful firms were more involved in collaborative subcontracting with foreign firms involved in design. When innovation did not arise entirely from the company but involved external innovation inputs, this was not associated with comparatively greater success (Table 4). This may point to difficulties that networking in innovation can generate and may explain our results on limited networking activities as discriminating factor between successful and less successful cases.

Networking has become one of the dominant features of innovation process. This is depicted in changing models of innovation process where interactivity, strategic and technology integration dominates (Dodgson et al, 2008) as well as in summaries of empirical evidence on the role of inter-organizational networks in innovation process (Powell and Grodal, 2005). The issue of networks of innovators is thought to be especially important for smaller firms as in our sample. However, our results show that this is only partially true in the context of the CEECs. Out of many network type measures used only two indicators – subcontracting kind of collaboration and foreign firms' contribution in design activities – discriminate between successful and less successful innovators. This is self-explanatory as CEECs are highly open economies very much dependent on trade and FDI. Vertical linkages with buyers are already taken into account in factors which group user and market oriented measures. Moreover, foreign firms contribution to design loads similarly to three factors (understanding markets, R&D management and collaboration, and innovation collaboration) but not in factor 'user involvement and orientation' (see 4 factor model CFA in Table 3). However, customer involvement is very strong in innovation collaboration factor. We should bear in mind that there is difference between users and customers. Foreign partners may be customers but not necessary users. We think that this largely explains why there is close involvement of foreign clients but not necessarily foreign users. CEE firms are involved in value chains only in production stages and rarely have direct access to users (McGowan et al, 2004).

In overall, average compound indicators, tests of significance and CFA show that the major discriminating factors are in areas of user involvement and orientation, and in understanding of markets. 'R&D management and collaboration' and 'Innovation sources and collaboration' groups are also differentiating between successful and less successful innovators power but with on average less statistical power and significance. Also, coherence of these two groups of factors is smaller as they can fit two factor as well as one factor solution 'innovation management and collaboration'. Partly, this may be due to our sample which involves two industries with somewhat different innovation models where R&D and innovation management factors are different.

Degree of novelty is an 'outcome' not 'input' variable and hence we do not include it in confirmatory FA (Table 4). By outcome we mean that degree of ambition of innovation is not necessarily a factor which distinguishes successful from less successful innovations/firms. In fact, factors which discriminate successful from less successful innovations/firms are those that *de facto* may raise degree of ambition of innovation – i.e. they could be endogenous to factors of success. Successful firm is more likely also to have more ambitious innovation. Finally, we are interested in differences between firms irrespective of degree of their ambition but largely based on whether they employ factors that based on our results indicate significantly higher probability of successful commercialization of their innovation.

4.2 Software Industry

The indicators that were found to show the greatest differences between successful and less successful innovations as a result of binomial tests are presented for both of the industries (Table 5). The results for the software sector separately are not substantially different from the pattern that we observed for the whole sample. User involvement and orientation and understanding of market needs are confirmed as two groups of factors which differentiate between successful and less successful Innovations. Market-led innovation process was enhanced by highly competitive market situation which increased probability of success when innovator was involved in its core area and has reduced probability of success when going into unrelated market area. Additional factors in ‘understanding markets’ group are competition factors, especially intensity of competition. Innovations that faced competitors in the same field and from the start of the innovation project were relatively more successful. We mentioned above that discriminating factors for R&D and innovation management variables are relatively less significant when compared to user and market factors. This is reinforced in software sector where based on compound indicators we do not get clear differentiation in R&D and innovation management factors although these factors are significantly loading on common underlying factor.

4.3. Machine Tools Industry

Factors that differentiate between successful and less successful cases in machine tools (MT) industry are much less present when compared to software industry. It seems that MT firms are much more homogenous in terms of user involvement and understanding of markets when compared to software firms. This is partly due to our sample which involves a large number of Czech firms that have emerged out of the large socialist-era machine tools producers and which are thus structurally quite similar. However, it is striking that the major discriminating factor between successful and less successful innovations is their strategic approach towards R&D collaboration. Firms that involved external R&D units with larger R&D teams, which involved research institutes based on R&D agreement were more likely to have more successful innovations. This strategic approach to R&D is reflected in the larger number of successful cases having innovation new to the country rather than new to the firm.

Table 5. Statistically significant indicators for surveyed firms' pairs of innovations by industry and results of confirmatory factor analyses.

		Software (N=24)			Machine Tools (N=21)						
		Observations for			Observations for			Confirmatory Factor Analysis results and tests			
	Significant indicators	successful innovations[1,3]	less successful innovations[2,3]	sig. (2-tailed)	successful innovations[1,3]	less successful innovations[2,3]	sig. (2-tailed)	CFA loadings[3]	KMO	Bartlett's sphericity sig.	Total variance explained (Cum %)
User involvement and orientation	No steps were taken at all to educate the users	0	-8	0.008	_	_	_	_	0.383	0.065	48.23
	Potential users were involved a lot during the development stage of the innovation	13	3	0.021	_	_	_	0.792			
	A lot of steps were taken to educate the users	12	3	0.035	_	_	_	0.539			
	Potential users were not involved at all during the development stage of the innovation	0	-5	0.063	_	_	_	_			
	If there were user problems, they became apparent after launch	9	2	0.065	_	_	_	0.116			
	Compound indicator (average)	**7**	**-1**								
Understanding markets	The demand for the innovation was estimated by market research of the firm	8	1	0.039	_	_	_	0.748	0.577	0.082	35.26
	The innovation involved going into an unrelated market area	0	-6	0.031	_	_	_	0.104			
	The demand for the innovation was estimated by previous knowledge	11	3	0.057	_	_	_	-0.726			
	The demand for the innovation was estimated by customer's requests	11	3	0.057	_	_	_	0.779			
	There were a little after sales problems	-9	-2	0.065	_	_	_	-0.041			
	There were competitors already at work in the same field when it was decided to pursue the innovation	12	4	0.077	_	_	_	0.522			
	The market situation confronting the firm in its regular product lines at the start of the innovation project was highly competitive	9	2	0.065	_	_	_	-0.699			
	Compound indicator (average)	**6**	**0.71**								
Innovation management and collaboration	There was a formal R&D department in the firm and it was the entire R&D department in the firm to carry out the research activities for the innovation	0	7	0.016	_	_	_	0.914	0.502	0.002	59.32
	The innovation arose partly in the company	0	6	0.031	_	_	_	0.434			
	The kind of collaboration was subcontracting	6	0	0.031	_	_	_	0.869			
	Amount of total R&D expenditure for the innovation	10	3	0.092	_	_	_	_			
	There was/were external R&D unit(s) and the project manager for the innovation in your firm was the leading/responsible person for this R&D work in the external R&D department	_	_	_	6	0	0.031	0.741	0.465	0.618	36.62
	There was/were external R&D unit(s) and number of qualified scientists and engineers in this external R&D department	_	_	_	10	2	0.039	0.763			
	If the firm had any outside collaboration, it collaborated with the research institute	_	_	_	6	0	0.031	0.004			
	The kind of collaboration was R&D agreement	_	_	_	10	2	0.039	0.577			
	Compound indicator (average)	**4**	**4**		**8**	**1**					
Degree of novelty	The innovation was new to the firm	-3	-12	0.039	_	_	_				
	The innovation was new to the country	9	2	0.065	_	_	_				
	Compound indicator (average)	**3**	**-5**		_	_	_				

1 Observations for success better than/more than less success. 2. Observations for success worse than/less than less success. 3. We have used inverted scores for some indicators (harmful effect negative) when calculating the compound indicators.

4.4. A Discussion on Non-significant Indicators

Finally, we present Table 6 illustrating indicators which appear to be not significant (albeit at 10-20% level). Findings that are statistically not strongly significant sometimes are valuable as findings that are practically significant, especially in view of limited sample size (Goodman, 2008). Early detection of user problems was somewhat more present in successful than less successful cases. Also, non- involvement of users or later detection of their problems or no modifications as results of user experiences characterise more less successful innovators. In R&D management area successful innovators were more involved in R&D collaboration. Also, if they did not have formal R&D unit they had at least a systematic and periodic screening of R&D area. Successful innovators were more likely to collaborate with R&D institutes or to rely on innovation from outside. However, if source of innovation was external individual innovation was less successful as well as when collaboration was based on licence agreement. Finally, some inconsistent or difficult to explain results like design activities and leading person for innovation project reflect industry differences and small sample. However, it may be also argued that these findings show that some elementary issues with regard to successful innovations are lacking in the CEE context.

Table 6. Distribution of selected statistically not significant indicators within four major groups (0.1 < $p < 0.2$).

			All sample (N=45 pairs)			Software sector (N=24)			Machine tools sector (N=21)		
			Observations for innovations			Observations for innovations			Observations for innovations		
		statement - indicator	successful	less successful	sig.(2-tailed)	successful	less successful	sig.(2-tailed)	successful	less successful	sig.(2-tailed)
User involvement and orientation	46	Potential users were not involved at all during the development stage of the innovation	-1	-6	0.125	0	5	0.063	1	1	1.000
	48	If there were user problems, they became apparent early in development	14	7	0.189	8	4	0.388	6	3	0.508
	49	If there were user problems, they became apparent later in development	-2	-8	0.109	1	6	0.125	1	2	1.000
	56	No modifications were introduced as a result of user experience	-2	-7	0.180	0	3	0.250	2	4	0.500
R&D management and collaboration	28	The kind of collaboration was R&D agreement	11	4	0.118	1	2	1.000	10	2	0.039
	67	There was a formal R&D department in the firm and the chief engineer of the firm was the leading person in the R&D department	5	6	1.000	0	4	0.125	5	2	0.219
	69	There was a formal R&D department in the firm and project manager of the innovation was the leading/responsible person in the R&D department	1	6	0.125	1	2	1.000	0	4	0.125
	72	There was a formal R&D department in the firm and the staff in the R&D department worked in sections based on academic disciplines	2	4	0.688	0	4	0.125	2	0	0.500
	77	There was/were external R&D unit(s) and some of the development work was conducted at a university R&D department	8	4	0.388	0	2	0.500	8	2	0.109
	78	There was/were external R&D unit(s) and some of the development work was conducted at a research institute R&D department	4	1	0.375	0	1	1.000	4	0	0.125
	86	If there was no formal R&D unit in the firm, there was a systematic and periodically reconsidered R&D program	10	4	0.180	5	2	0.727	5	2	0.219
Innovation source and collaboration	8	The innovation arose solely from outside the company	4	0	0.125	3	0	0.250	1	0	_
	14	For the innovations which originated from outside, the individual(s) was the main source	0	4	0.125	0	4	0.125	0	0	_
	19	If the firm had any outside collaboration, it collaborated with the research institute	7	2	0.180	1	2	1.000	6	0	0.031
	30	The kind of collaboration was licensing agreement	0	4	0.125	0	4	0.125	0	0	_
Degree of novelty	1	The innovation was new to the firm	5	19	0.007	3	12	0.035	2	7	0.180
Other	34	Design activity was conducted re the innovation	6	13	0.167	5	7	0.774	1	6	0.125
	40	Fairs and exhibitions that firm's engineers have been to and seen new products/processes produced by other firms fontributed to design activities	15	10	0.454	11	4	0.118	4	6	0.754
	114	You havenoticed medium interest of the education sector/unis/local politics/labour market institutions after introducing the innovation	8	7	1.000	2	6	0.289	6	1	0.125

5. CONCLUSIONS

Our results fully confirm the continuing relevance of SAPPHO results and methodology (see Table 7). Forty years after and tested in different socio-economic context successful innovation is still about good coupling between technology and market. In this respect, the major message of SAPPHO remains equally relevant today. This applies especially to distinction between users' needs and market demand which both remains essential to coupling with R&D. Successful innovators have stronger user orientation and better understanding of market demand.

Although, CEECs are catching up economies continuous and strategic R&D is essential to generation of greater commercial success from innovation activities. However, rather than scale of own R&D budget or personnel what distinguishes successful from less successful innovators is their capacity to cooperate with external R&D organisations and resources employed or contracted in partner R&D organisation. Despite great importance of R&D collaboration innovation in successful cases originates from within the companies which are significantly more involved in collaborative innovation than less successful cases and which may include foreign firms and/or subcontracting partners.

When compared to SAPPHO which showed that the efficiency of the R&D process seems to matter we are surprised by the greater than expected importance of R&D collaboration. In fact, in machine tool industry this group of factors is the only one that distinguishes between successful and less successful cases. Still, the major two discriminating factors are user involvement and orientation with understanding of market. R&D and innovation collaboration are relatively less significant when compared to former two factors. It is very interesting that innovation policy in CEE countries is not concerned with users and demand side factors (see Edler, 2011) which based on our research seem to be the major differentiating factors in innovations in CEE. There is strong focus in CEE policies on science – industry linkages but largely upstream oriented – i.e. driven by technology push incentives and opportunities (Radosevic, 2011). However, our results demonstrate irrelevance of this perspective and much greater relevance of downstream R&D and innovation collaborations which are driven by firms with the view of enhancing market led innovation. We believe that our results give relevant empirical basis for re-examination of the current approaches.

In general terms, our results have reiterated the importance of users and user orientation for commercially successful innovations as well as have confirmed that innovation is largely market based process. This research has re-confirmed the irrelevance of entirely R&D-led models of innovation and policies, especially in catching up economies like CEECs. Our results have re-confirmed the importance of users and markets needs in innovation process when compared to technology-push or R&D driven innovations. The findings do not undermine the importance of R&D conduct, but they show that only policies that are able to enhance user/market – R&D interaction are relevant for KIEs.

Table 7. Characteristics of successful innovators when compared to less successful (this research) or failures (SAPPHO)

SAPPHO's findings	Our findings
Understanding of user needs	Understanding of user needs but also user involvement
Attention to marketing	Understanding of market
Perform their development work more efficiently	Successful R&D collaborations
Effective use of outside technology and scientific advice	Successful innovation collaborations
The responsible individuals in the successful attempts are usually more senior	

This research is limited by sample of innovation pairs which is relatively small (45). However, given information and labour intensive nature of case study research on which our results are based it is unlikely that this can be increased much in further research. In terms of methodology it is possible in future research to apply qualitative comparative analysis (QCA) (Ragin, 1987; 2000) in order to explore profiles of innovations (configurations) and try in alternative way to establish which profiles are associated with successful vs. less successful cases of knowledge intensive entrepreneurship.

Appendix

Table A1. Indicators used in the research, number of observations for successful and less successful innovation by industry and results of binomial tests.

		All sample (N=45 pairs)			Software sector (N=24)			Machine tools sector (N=21)		
		Observations for innovations			Observations for innovations			Observations for innovations		
	statement - indicator	successful	less successful	sig.(2-tailed)	successful	less successful	sig.(2-tailed)	successful	less successful	sig.(2-tailed)
1	The innovation was new to the firm	5	19	0.007	3	12	0.035	2	7	0.180
2	The innovation was new to the country	14	5	0.064	9	2	0.065	5	3	0.727
3	The innovation was new to the world	12	7	0.359	6	4	0.754	6	3	0.508
4	The firm took out patent for the innovation	5	4	1.000	1	2	1.000	4	2	0.688
5	Firm'semployees published in scientific papers related to the innovation	4	8	0.388	3	4	1.000	1	4	0.375
6	The innovation was awarded prize(s)	14	7	0.189	9	6	0.607	5	1	0.219
7	The innovation arose solely in the company	9	6	0.617	5	2	0.453	4	4	1.000
8	The innovation arose solely from outside the company	4	0	0.125	3	0	0.250	1	0	_
9	The innovation arose partly in the company	3	10	0.092	0	6	0.031	3	4	1.000
10	For the innovations which originated from outside, the university was the main source	0	4	0.125	0	1	_	0	3	0.250
11	For the innovations which originated from outside, the research institute was the main source	1	1	1.000	0	1	_	1	0	_
12	For the innovations which originated from outside, the government was the main source	0	1	_	0	1	_	0	0	_
13	For the innovations which originated from outside, the customer was the main source	2	2	1.000	2	2	1.000	0	0	_
14	For the innovations which originated from outside, the individual(s) was the main source	0	4	0.125	0	4	0.125	0	0	_
15	For the innovations which originated from outside, the parent firm was the main source	0	0	_	0	0	_	0	0	_
16	For the innovations which originated from outside, the supplier was the main source	1	1	1.000	0	0	_	1	1	1.000
17	For the innovations which originated from outside, the competitor was the main source	0	0	_	0	0	_	0	0	_
18	If the firm had any outside collaboration, it collaborated with the university	5	5	1.000	1	2	1.000	4	3	1.000
19	If the firm had any outside collaboration, it collaborated with the research institute	7	2	0.180	1	2	1.000	6	0	0.031
20	If the firm had any outside collaboration, it collaborated with the government	0	1	_	0	1	_	0	0	_
21	If the firm had any outside collaboration, it collaborated with another firm	3	4	1.000	2	3	1.000	1	1	1.000
22	If the firm had any outside collaboration, it collaborated with the customer	8	9	1.000	7	6	1.000	1	3	0.625
23	If the firm had any outside collaboration, it collaborated with the individual (s)	3	2	1.000	3	2	1.000	0	0	_
24	If the firm had any outside collaboration, it collaborated with the parent firm	1	3	0.625	1	1	1.000	0	2	0.500
25	If the firm had any outside collaboration, it collaborated with the supplier	8	3	0.227	2	0	0.500	6	3	0.508
26	If the firm had any outside collaboration, it collaborated with the consultant(s)	5	3	0.727	3	2	1.000	2	1	1.000
27	The kind of collaboration was strategic alliance	1	1	1.000	1	1	1.000	0	0	_
28	The kind of collaboration was R&D agreement	11	4	0.118	1	2	1.000	10	2	0.039
29	The kind of collaboration was technical cooperation agreement	9	5	0.424	3	3	1.000	6	2	0.289
30	The kind of collaboration was licensing agreement	0	4	0.125	0	4	0.125	0	0	_
31	The kind of collaboration was subcontracting	9	2	0.065	6	0	0.031	3	2	1.000
32	The kind of collaboration was marketing/export promotion	0	2	0.500	0	1	_	0	1	_
33	The kind of collaboration was research contract-out	1	0	_	0	0	_	1	0	_
34	Design activity was conducted re the innovation	6	13	0.167	5	7	0.774	1	6	0.125
35	Customers' design was the source of design activity conducted	2	2	1.000	2	0	0.500	0	2	0.500
36	Other firms' designs were the source of design activity conducted	1	5	0.219	0	2	0.500	1	3	0.625
37	The firm's own design was the source of design activity conducted	7	13	0.263	5	8	0.581	2	5	0.453
38	Research institutes/universities contributed to design activities	4	6	0.754	0	2	0.500	4	4	1.000
39	Foreign firms contributed to design activities	9	2	0.065	6	2	0.289	3	0	0.250
40	Fairs and exhibitions that firm's engineers have been to and seen new products/processes produced by other firms fontributed to design activities	15	10	0.454	11	4	0.118	4	6	0.754
41	Personal contacts established at the conferences contribute to design activities	3	6	0.508	3	4	1.000	0	2	0.500
42	News about new products in the magazines and journals of your field contributed to design	5	5	1.000	4	5	1.000	1	0	_
43	Firm's own researchers in its own labs contributed to design activities	8	10	0.815	6	5	1.000	2	5	0.453
44	Potential users were involved a lot during the development stage of the innovation	22	10	0.050	13	3	0.021	9	7	0.804
45	Potential users were involved a little during the development stage of the innovation	11	17	0.345	5	10	0.302	6	7	1.000
46	Potential users were not involved at all during the development stage of the innovation	1	6	0.125	0	5	0.063	1	1	1.000
47	The users found the innovation technologically problematic or difficult to use	13	8	0.383	9	8	1.000	4	0	0.125
48	If there were user problems, they became apparent early in development	14	7	0.189	8	4	0.388	6	3	0.508
49	If there were user problems, they became apparent later in development	2	8	0.109	1	6	0.125	1	2	1.000
50	If there were user problems, they became apparent after launch	12	4	0.077	9	2	0.065	3	2	1.000
51	A lot of steps were taken to educate the users	16	5	0.027	12	3	0.035	4	2	0.500
52	A little number of steps were taken to educate the users	8	9	1.000	4	5	1.000	4	4	1.000
53	No steps were taken at all to educate the users	3	12	0.035	0	8	0.008	3	4	1.000
54	A lot of modifications were introduced as a result of user experience	10	6	0.454	7	3	0.344	3	3	1.000
55	A few modifications were introduced as a result of user experience	11	8	0.648	4	4	1.000	7	4	0.549
56	No modifications were introduced as a result of user experience	2	7	0.180	0	3	0.250	2	4	0.500
57	There were competitors already at work in the same field when it was decided to pursue the innovation	13	9	0.523	12	4	0.077	1	5	0.219
58	The innovation was developed in the light of what competitors were doing or apparently	11	8	0.648	7	3	0.344	4	5	1.000
59	There were a lot of after sales problems	2	1	1.000	2	1	1.000	0	0	_
60	There were a little after sales problems	14	8	0.286	9	2	0.065	5	6	1.000
61	There were NO after sales problems at all	8	9	1.000	1	5	0.219	7	4	0.549
62	Amount of total R&D expenditure for the innovation	17	11	0.345	10	3	0.092	7	8	1.000
63	There was a formal R&D department in the firm to carry out the research activities for the	8	10	0.815	5	7	0.774	3	3	1.000
64	There was a formal R&D department in the firm and it was the entire R&D department in the firm to carry out the research activities for the innovation	1	12	0.003	0	7	0.016	1	5	0.219
65	There was a formal R&D department in the firm and it was part of the R&D department in the firm to carry out the research activities for the innovation	15	6	0.078	8	3	0.227	7	3	0.344

Table A1 continued

		All sample (N=45 pairs)			Software sector (N=24)			Machine tools sector (N=21)		
		Observations for innovations			Observations for innovations			Observations for innovations		
	statement - indicator	successful	less successful	sig.(2-tailed)	successful	less successful	sig.(2-tailed)	successful	less successful	sig.(2-tailed)
66	There was a formal R&D department in the firm and the manager of the firm was also the leading person in the R&D department	7	7	1.000	6	7	1.000	1	0	_
67	There was a formal R&D department in the firm and the chief engineer of the firm was the leading person in the R&D department	5	6	1.000	0	4	0.125	5	2	0.219
68	There was a formal R&D department in the firm and the manager of the R&D department was the leading person in the R&D department	5	5	1.000	3	3	1.000	2	2	1.000
69	There was a formal R&D department in the firm and project manager of the innovation was the leading/responsible person in the R&D department	1	6	0.125	1	2	1.000	0	4	0.125
70	Percentage of the existing manpower in the R&D department of the firm allocated for the R&D work regarding the innovation	18	17	1.000	10	10	1.000	8	7	1.000
71	There was a formal R&D department in the firm and the staff in the R&D department worked in an unstructured basis	4	4	1.000	0	0	_	4	4	1.000
72	There was a formal R&D department in the firm and the staff in the R&D department worked in sections based on academic disciplines	2	4	0.688	0	4	0.125	2	0	0.500
73	There was a formal R&D department in the firm and the staff in the R&D department worked in sections based on product/process group	8	5	0.581	5	5	1.000	3	0	0.250
74	There was a formal R&D department in the firm and the staff in the R&D department worked in project teams	6	8	0.791	5	3	0.727	1	5	0.219
75	There was an external R&D department involved in the innovations	11	7	0.481	2	2	1.000	9	5	0.424
76	Number of external R&D departments that were concerned with the innovation	12	7	0.359	2	2	1.000	10	5	0.302
77	There was/were external R&D unit(s) and some of the development work was conducted at a university R&D department	8	4	0.388	0	2	0.500	8	2	0.109
78	There was/were external R&D unit(s) and some of the development work was conducted at a research institute R&D department	4	1	0.375	0	1	1.000	4	0	0.125
79	There was/were external R&D unit(s) and some of the development work was conducted at another company's R&D department	3	4	1.000	2	1	1.000	1	3	0.625
80	There was/were external R&D unit(s) and some of the development work was conducted at an R&D department abroad	1	1	1.000	0	1	_	1	0	_
81	There was/were external R&D unit(s) and number of qualified scientists and engineers in this external R&D department	12	4	0.077	2	2	1.000	10	2	0.039
82	There was/were external R&D unit(s) and the manager of the firm was also the leading person for this R&D work in the external R&D department	1	4	0.375	0	1	_	1	3	0.625
83	There was/were external R&D unit(s) and the chief engineer of the firm was the leading person for this R&D work in the external R&D department	0	1	_	0	1	_	0	0	_
84	There was/were external R&D unit(s) and the manager of the external R&D department was the leading person for this R&D work in the external R&D department	4	2	0.688	2	0	0.500	2	2	1.000
85	There was/were external R&D unit(s) and there was another person (i.e. project manager) in the firm as the leading person for this R&D work in the external R&D department	6	0	0.031	0	0	_	6	0	0.031
86	If there was no formal R&D unit in the firm, there was a systematic and periodically reconsidered R&D program	10	4	0.180	5	2	0.727	5	2	0.219
87	The percentage of existing R&D manpower allocated to the R&D work regarding the innovation within the systematic R&D program	11	9	0.824	6	6	1.000	5	3	0.727
88	The manager of the firm was also the leading person for this systematic R&D work	9	4	0.267	4	3	1.000	5	1	0.219
89	The chief engineer of the firm was the leading person for this systematic R&D work	6	6	1.000	6	3	0.508	0	3	0.250
90	The firm used financial assistance from the government/EU re the innovation	8	4	0.388	3	3	1.000	5	1	0.219
91	The firm used financial assistance from the parent firm re the innovation	1	0	_	1	0	_	0	0	_
92	The firm used financial assistance from private sources re the innovation	7	5	0.774	5	5	1.000	2	0	0.500
93	The demand for the innovation was estimated by R&D personnel	9	6	0.607	5	3	0.727	4	3	1.000
94	The demand for the innovation was estimated by market research of the firm	13	3	0.021	8	1	0.039	5	2	0.219
95	The demand for the innovation was estimated by commissioned market research	2	0	0.500	2	0	0.500	0	0	_
96	The demand for the innovation was estimated by previous knowledge	16	5	0.027	11	3	0.057	5	2	0.453
97	The demand for the innovation was estimated by customer's requests	18	7	0.043	11	3	0.057	7	4	0.549
98	Demand for the innovation was estimated by other sources in the firm	8	4	0.388	5	4	1.000	3	0	0.250
99	The demand for the innovation was estimated by published literature	3	1	0.625	2	1	1.000	1	0	_
100	The demand for the innovation was estimated by pure speculation	1	3	0.625	0	3	0.250	1	0	_
101	The demand for the innovation was estimated by single outside request	3	7	0.344	2	3	1.000	1	4	0.375
102	The market situation confronting the firm in its regular product lines at the start of the innovation project was highly competitive	13	9	0.523	9	2	0.065	4	7	0.549
103	The market situation confronting the firm in its regular product lines at the start of the innovation project was moderately competitive	10	10	1.000	4	6	0.754	6	4	0.754
104	The market situation confronting the firm in its regular product lines at the start of the innovation project was with little or no competition at all	1	3	0.625	1	3	0.625	0	0	_
105	The innovation was a marketing decision	15	13	0.851	8	5	0.581	7	8	1.000
106	The innovation was a production decision	13	9	0.523	7	5	0.774	6	4	0.754
107	The innovation involved going into an unrelated market area	1	8	0.039	0	6	0.031	1	2	1.000
108	The innovation involved a little concious resconstruction of the marketing organisation to accomodate the innovation	4	2	0.688	4	2	0.688	0	0	_
109	The innovations involved a lot of concious resconstruction of the marketing organisation to accomodate the innovation	2	1	1.000	1	1	1.000	1	0	_
110	The innovation was aimed at a preconcieved market but found a different outlet	3	2	1.000	1	1	1.000	2	1	1.000
111	Other local/national firms entered the market area of the innovation after introducing it by	12	9	0.664	6	3	0.508	6	6	1.000
112	Other international firms entered the market area of the innovation after introducing it by your company	3	0		0	0	_	3	0	0.250
113	You have noticed slight interest of the education sector/unis/local politics/labour market institutions after introducing the innovation	12	9	0.664	7	5	0.774	5	4	1.000
114	You havenoticed medium interest of the education sector/unis/local politics/labour market institutions after introducing the innovation	8	7	1.000	2	6	0.289	6	1	0.125
115	You have noticed large interest of the education sector/unis/local politics/labour market institutions after introducing the innovation	10	5	0.302	7	3	0.344	3	2	1.000

Table A2. Confirmatory factor analyses results for a 3 factor model (N=45).

Indicators	Factor 1	Factor 2	Factor 3
Potential users were involved a lot during the development stage of the innovation	0.194	**-0.723**	0.163
A lot of steps were taken to educate the users	-0.096	**0.755**	-0.176
If there were user problems, they became apparent after launch	-0.037	**-0.432**	-0.184
The demand for the innovation was estimated by market research of the firm	0.129	0.292	**0.558**
The demand for the innovation was estimated by previous knowledge	0.112	0.147	**-0.757**
There was a formal R&D department in the firm and it was the entire R&D department in the firm to carry out the research activities for the innovation	0.067	**0.362**	0.115
There was/were external R&D unit(s) and the project manager for the innovation in your firm was the leading/responsible person for this R&D work in the external R&D department	0.051	0.025	**0.664**
There was a formal R&D department in the firm and it was part of the R&D department in the firm to carry out the research activities for the innovation	**0.452**	0.344	0.336
There was/were external R&D unit(s) and number of qualified scientists and engineers in this external R&D department	**0.755**	0.161	0.175
The kind of collaboration was subcontracting	**0.419**	-0.126	-0.086
Foreign firms contributed to design activities	**0.515**	0.356	-0.374
The innovation arose partly in the company	**0.692**	-0.301	-0.201
The demand for the innovation was estimated by customer's requests	**0.496**	0.008	0.196
Rotation: Varimax, Kaiser-Meyer-Olkin Measure of Sampling Adequacy: 0.302, Bartlett's Test of Sphericity is significant at 0.000, total variance explained (cum %): 43.98.			

Table A3. Confirmatory factor analyses results for a 5 factor model (N=45).

Indicators	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Potential users were involved a lot during the development stage of the innovation	0.032	**0.835**	-0.162	0.113	0.043
A lot of steps were taken to educate the users	0.231	**-0.535**	0.246	-0.256	0.467
If there were user problems, they became apparent after launch	0.048	**0.597**	0.272	-0.327	-0.036
The demand for the innovation was estimated by market research of the firm	0.267	-0.342	**-0.519**	0.019	-0.158
The demand for the innovation was estimated by previous knowledge	0.111	-0.032	**0.833**	-0.095	0.001
The demand for the innovation was estimated by customer's requests	0.428	-0.134	-0.094	0.179	**-0.671**
There was a formal R&D department in the firm and it was the entire R&D department in the firm to carry out the research activities for the innovation	0.163	-0.081	-0.144	0.138	**0.825**
There was/were external R&D unit(s) and the project manager for the innovation in your firm was the leading/responsible person for this R&D work in the external R&D department	**0.726**	-0.143	-0.143	-0.136	-0.133
There was/were external R&D unit(s) and number of qualified scientists and engineers in this external R&D department	**0.852**	0.197	0.003	0.166	0.185
There was a formal R&D department in the firm and it was part of the R&D department in the firm to carry out the research activities for the innovation	**0.291**	0.138	**-0.600**	-0.167	0.184
The kind of collaboration was subcontracting	-0.117	-0.080	-0.079	**0.873**	-0.004
Foreign firms contributed to design activities	0.369	-0.285	0.413	**0.394**	0.051
The innovation arose partly in the company	0.314	0.358	0.204	**0.611**	-0.049
Rotation: Varimax, Kaiser-Meyer-Olkin Measure of Sampling Adequacy: 0.302, Bartlett's Test of Sphericity is significant at 0.000, total variance explained (cum %): 65.71.					

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