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The performance of innovation networks in transition economies: An empirical study of Slovenia

Abstract

The paper presents first findings on innovative behaviour and co-operations in the transition context based on a recent industrial innovation survey in Slovenia. The share of innovating and co-operating firms is much higher than commonly assumed. Segmentation analysis focuses on characteristics of innovating firms whereas probit modelling reveals important determinants of innovation. Besides internal R&D capacities, the empirical analysis shows vertical linkages between firms as most important factor for the innovative performance, as was assumed according to the network paradigm. Structural characteristics of the firm and the transformation proved to be of minor direct influence. Horizontal networks between firms and research institutes seem to be not fully explored.

1 The concept of innovation networks and the relevance to economies in transition

The discussion of industrial competitiveness in advanced market economies increasingly focuses on a new type of economic actor which is no longer the multinational or unitary firm but networks of innovative companies. The network paradigm is based on the success stories of several European and North-American regions which experienced above-average growth rates in the 1970s and 1980s, such as Silicon Valley in California, the Third Italy, Cambridge in England and Baden-Württemberg in Germany, to name only a few (Pyke/Sengenberger 1990; Storper 1992; Aydalot 1986; Cooke 1996; Zeitlin 1992). Regionally embedded networks of mostly small manufacturing enterprises foster flexibility and learning capabilities and thus lead to innovation and competitiveness. These are often complemented by service firms, research institutes, universities and intermediary institutions. Network-based strategies are promoted to solve the restructuring of old industrial areas not only in Western Europe but also in the Central and Eastern European transition countries.

Macro-economic stabilisation marked the completion of the first transition phases in most Central and Eastern European Countries (CEECs). Still, they have not completed the transformation of their industrial sectors, which would be the indispensable precondition for international competitiveness. Across countries, governments pursued heterogeneous strategies: They range from a rapid and centralised approach of privatisation with an early involvement of foreign investors to a more bottom-up and decentralised restructuring policy which relied on the participation of the country's citizens and firms' employees (for an overview of the Visegrad Countries see e.g. Borish/Noel 1996). However, the corporate governance as well as type of firms in transition countries still differ very much from their counterparts in Western market economies. While the restructuring of large industrial complexes has not been completed yet, a huge percentage of newly founded firms are micro-enterprises and too small to foster economic growth (e.g. OECD 1994a). After the typical underdevelopment of the service sector in the soviet economic order, there is now a high growth in services, mostly with a huge share of activities like trade and tourism. While in some CEECs, like in the former Yugoslavia or in Hungary, private small firms existed, in others, such as the Czech Republic, private entrepreneurship and small businesses were not an element of the former economic order (OECD 1994b; Neumann 1993). Furthermore, it was often not achieved to preserve and re-orientate industrial R&D capabilities during the transformation. On the one hand, the soviet science and technology system with its concept of science push in the linear innovation model, which often hampered innovations, had to be transformed profoundly (Dyker/Perrin 1997). On the other hand, besides their inappropriateness for market conditions, especially industrial R&D capacities shrunk considerably in most CEECs (Meske et al. 1998).

After the fragmentation of the former industrial relations in the planned economy networks can be a way to consolidate industrial and technological potentials (Grabher/Stark 1997; Radosevic 1997). They include newly emerging networks as well as linkages relying on former relations. The success of the network model depends on the ability of the actors in CEECs to transform and use the linkages to enhance their flexibility and learning capabilities. The case of spin-offs from companies or the research sector maintaining close interaction with their former environment could be an example (Balazs 1996). On the contrary, the obligation of enterprises under the socialist regime to invest in R&D at research institutes, which often did not result in innovation, led to a rather sceptical attitude towards co-operation.

Innovation networks and similar phenomenon have been analysed by heterogeneous schools under the title of industrial districts, innovation networks, regional innovation systems and innovative milieu. Without emphasising the nuances in the theoretical background and focus, all approaches underline the embeddedness and reciprocity of relationships (cf. Granovetter 1973). The social fabric creates trust relationships and constitutes a shared culture. These weak ties facilitate the open exchange of information leading to interactive learning capabilities, the reduction of uncertainty and increase in flexibility to adopt to market changes (Grabher 1993; Camagni 1991). This rationale is based on the understanding of innovation as an interactive, chain-linked-process with many feedback loops between different stages and actors of the innovation process (Kline/Rosenberg 1986). Out of this perspective, networks can be seen as a basic institutional arrangement and not just an intermediate stage between market and hierarchy, since they are able to cope with systemic innovation (Imai/Baba 1991; Grabher 1993).

Many schools (cf. Hakansson 1987 and 1989) focus on industrial networks constituted through vertical linkages between supplier and user firms in industry, although they do not exclude horizontal linkages with other types of actors, among them research institutes and universities. Networks mostly rely on interpersonal contact and informal linkages, but they sometimes manifest and also include more formal agreements. These types of network relationships bear diverse opportunities for learning and innovation.

Close interactions between suppliers and users are especially effective for product innovations in manufacturing (Andersen/Lundvall 1988; Lundvall 1992). In the case of more traditional industries like in the Third Italy, e.g. textiles, leather products and tiles, the clustering of small firms is more effective to react to market changes and use buffer capacities and the creativity of the network of a heterogeneous lot of firms on different stages in the production process (Pyke/Sengenberger 1992; Pyke/Beccatini/Sengenberger 1990).

Especially if innovation networks constitute a whole regional or national innovation system, the important role not only of firms of different size but of knowledge generators and intermediary organisations is emphasised (Cooke 1996). Regional services and network organisers such as co-operatives or development centres can even stimulate the development of an innovative milieu and the innovation-oriented transformation of a region (Zeitlin 1992; Schmitz/Mysick 1994).

Only recently, networks in Central and Eastern Europe have been investigated theoretically and empirically (e.g. Grabher/Stark 1997; for a brief overview see Radosevic 1997). While especially production networks, such as observed in the Hungarian automobile industry (Havas 1997) are easier to trace, there has been less published evidence – case studies or extensive surveys – on innovation networks yet, e.g. in the environment of science and technology parks or research centres in CEECs. Therefore, the present analysis aims at a broad survey in a transition country to analyse the preconditions of the network model and to identify existing innovation-supporting linkages between actors. This is performed for the case of Slovenia.

2 Political and economic situation of Slovenia

The Republic of Slovenia has declared her independence in 1991. Slovenia has 2 mill inhabitants and covers a surface of 20,256 km^2. The overall economic starting point for transformation was relatively good, since Slovenia was the strongest developed region in the former Yugoslavia. The economic situation during the transformation, especially during its early stage, was – as typically observed in CEECs – accompanied by economic deterioration. In 1991, the inflation rate increased to 117.7 %, Gross Domestic Product (GDP) declined about –9.3 % in 1991 (World Bank 1996), unemployment rose from 4.7 % in 1990 to its peak of 14.4 % in 1993 and 1994 (EBRD 1997). As a specific external factor to Slovenian development the war within Yugoslavia interrupted former trade linkages with the neighbouring regions which led to an aggravation of economic decline.

After macro-economic stabilisation during the early transition phase, Slovenia has the highest GDP per capita among the Central European economies which in 1996 amounted to 9,279 $ compared to Poland (3,459 $), Hungary (4,357 $) and the Czech Republic (5,340 $) (EBRD 1997). However, other indicators look less promising: GDP growth is moderate between 3.1 % (1996) and 3.8 % (1998, estimated) (EBRD 1997; IMAD 1998; Raiser/Sanfey 1998), with a relatively high unemployment level of 14.4 % in 1997 (Raiser/Sanfey 1998). This is partly caused by the austerity policy of the Slovenian central bank aiming to control the inflation rate which is at 9.1 % (annual average) in 1997 (BCE 1997; Raiser/Sanfey 1998). Due to the traditional openness of the Slovene economy, the economic performance is strongly dependent on trends in the business cycle in Europe as a whole.

While Slovenia as a Republic of the former Yugoslavia has in common many features of the socialist legacy with other Central European transition economies, her situation was specific. Actually, the Yugoslavian constitution of 1974 introduced a kind of decentralisation of the state organisation leading to the creation of own administrative bodies in the republics and the transfer of power though without democratisation (Vejvoda 1996). In contrast to the other transition economies, elements of the market economy have a much longer tradition in the former Yugoslav model: Although partly cancelled in 1974, in 1965 a market socialist and self-managed economy was launched (Bojicic 1966). The social ownership of assets, which during transition turned out to hamper privatisation, originates from this policy experiment.

The production system inherited from former socialist times was characterised by the following enterprise structure: In Slovenia, large enterprises shaped especially the metal working industry and steel production, vehicles, electronics and household appliances sectors. Medium to large enterprises dominated the chemical industry. In addition, small workshops were already widespread in former Yugoslavia as a special case among CEECs. In Slovenia, there is a strong bias towards service industries (e.g. trading businesses, restaurants and other business related to tourism). However, the so-called "SME-gap" prevails, it describes the absence of economically successful and growing enterprises in this sector which are a motor of economic growth in many Western economies (Komac 1996). The transformation of the corporate structure has not led to the creation of innovative industries yet. Most of the traditional heavy industries were not able to compete against western products both in terms of price and quality. There are only very few examples of successful continued businesses which could split out of former combines. The first phase of privatisation relied mainly on the employees and management as well as on various funds, foreign investors were only accepted in the second phase (Vrecar 1998). Privatisation was mainly carried out in the form of management buy-out. Consequently, only minor changes in the practices of self-management took place. As a result, the transformation has only proceeded hesitantly and privatisation has not fully been concluded yet.

3 Innovation networks in Slovenia

3.1 Analytic design

The following analysis presents first findings on innovative and co-operative behaviour of enterprises in the transition context, based on an industrial innovation survey carried out in Slovenia from October 1997 to February 1998. As extensive surveys so far have been rare in the transition context, the data will reveal first results concerning innovation characteristics of enterprises and network behaviour.

The study has been performed in two steps. The first more descriptive part aims at distinguishing innovating from non-innovating firms on the basis of segmentation analysis (cf. Chapter 3.3.2). Additionally, important determinants of the innovative behaviour of Slovenian firms are investigated with the help of maximum-likelihood probit modelling (cf. Chapter 3.3.3). The theoretical framework and the specific transformation context in Slovenia (cf. Chapters 1 and 2) guide the hypotheses of the empirical research: The network approach and the modern innovation concept emphasise the importance of co-operative linkages for innovation (Hypothesis 4). However, the actors' ability to explore their network opportunities and to innovate depends on internal innovation capabilities in terms of quantity and quality (Hypothesis 3). The co-existence of recently founded and older firms leads to a great diversity of companies with different prerequisites and propensities to innovate (Hypotheses 1 and 2).

H1:	Innovative performance is influenced by general firm characteristics

H2:	Organisational and transformation related aspects affect firms' innovative performance
H3:	Internal innovation capabilities are important preconditions for innovation
H4:	Firms with co-operative linkages are more innovative

In comparison to regularly carried out innovation surveys in the EU and even some CEECs, the written questionnaires employ an extended methodology. In addition to basic data on the enterprise – such as type of activity, employees, turnover, foundation – two sections deal in detail with innovation activities and co-operations with supplier, users, other companies, research institutes, universities and intermediaries. The questions aim at covering not only quantitative indicators but also at collecting information on qualitative aspects such as attitudes and behavioural determinants. While the methodology has also been applied to other regions in advanced market economies (Koschatzky 1997; Muller 1997; Koschatzky/Muller 1997), it has been considerably modified in order to consider transition specific aspects.

3.2 Sample description

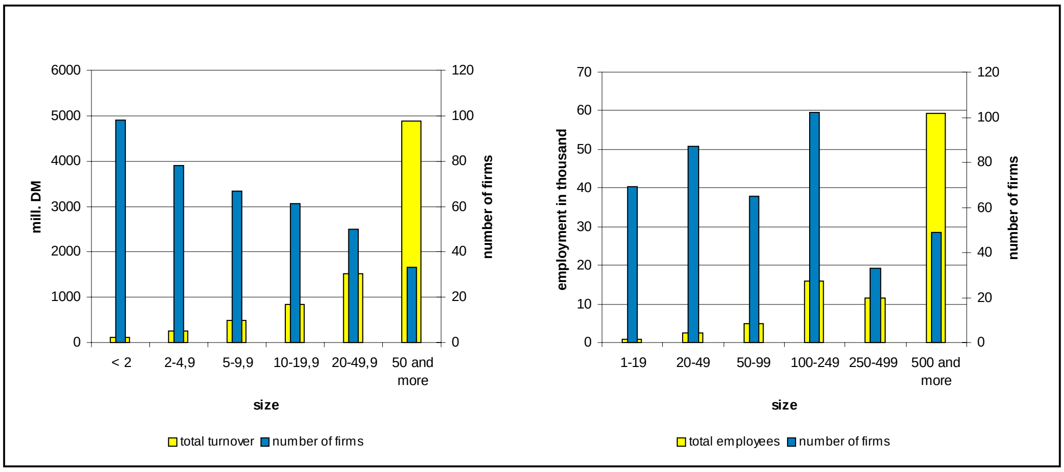
The unit of analysis is the individual firm. The list of firms was compiled by the Slovene statistical office in autumn 1997. The total population of Slovene manufacturing firms with ten or more employees amounted to 1,336 firms of which 416 or 31.1 % responded to the questionnaires. As can be seen from Table 1, the sample represents the sectoral composition of the total population.

Table 1: Composition of the population and the sample according to industry

No.	**NACE**	**Type**	**Total population**		**Sample**	
			Number	**Percentage**	**Number**	**Percentage**
1	15, 16	Food products, beverages and tobacco	118	8.8	33	7.9
2	17 - 19	Textiles, clothing	160	12.0	46	11.1
3	20 – 22, 36	Wood, paper and printing	293	21.9	79	19.0
4	23 – 26	Chemical products and plastics	194	14.5	54	13.0
5	27, 28	Metal processing	200	15.0	77	18.5
6	29, 34, 35, 37	Mechanical engineering, vehicles	203	15.2	63	15.1
7	30 - 33	Electrical and optical equipment	168	12.6	64	15.4
Σ	-	-	1,336	100.0	416	100.0

To characterise the sample of 416 manufacturing firms, their average turnover amounted to 20.7 mill DM in 1996 and the average number of employees was 235 in the same year. However, the median for both was much less, with 5.8 mill DM turnover and 87 employees. This shows that the sample is characterised by a high number of firms with a turnover below the average and few enterprises with high turnover; 79.8 % of firms have up to 250 employees (Fig. 1).

Fig. 1: Turnover (mill DM) Employment (1996)



Nevertheless, from 340 firms of which turnover of both years 1994 and 1996 is known, 74.4 % reported an increase and only 24.6 % a decline in turnover, measured in mill DM. This does not necessarily correspond to developments in employment, since half of the enterprises (50.9 %) decreased employment, while 40 % increased their staff and 9.1 % reported no changes. The traditional openness of the Slovene economy is confirmed by the high export share: 49.6 % of the enterprises export half or even more of their turnover. This differs significantly across industries: The highest export shares can be found in the electrical and optical equipment industries (71.2 % of firms have 50 % or a higher export rate) and the textile and clothing producing industries (64.7 %) which have been traditionally strong in Slovenia; to less extent this applies also to the metal processing as well as mechanical engineering and vehicles manufacturing industries.

In Slovenia, more than three quarters (76.4 %) of the firms in the sample innovate which means that they have undertaken product or process innovations or both during the period from 1994 to 1997. As could be expected, 70.0 % of innovating firms undertake both process and product innovation, while the shares of only process innovations with 8.2 % and only product innovations with 22.0 % of innovators are much smaller. Although the Slovenian percentage of innovating firms in the sample is almost ten percent higher than was observed in an earlier industrial innovation survey in Baden, Germany, where 66.8 % of firms innovated (Koschatzky 1997), the greater need for new processes and products is clear in the context of market disruptions and overall economic transformation.

3.3 Empirical analysis

3.3.1 Description of the variables

Four groups of independent variables have been selected to identify the main determinants of firms' innovative performance in Slovenia. They relate to general characteristics of the company (first group), to organisational and transition specific influences (second group), to firms' innovation input (third group) and networking behaviour (fourth group), as presented below. The dependent variable is dichotomic and describes the innovation output in terms of performance of innovations.

First group	**Variables related to general characteristics of the firms**
•	Production mode: *Share of mass production*
•	Sector of activity*: Food products, beverages, tobacco; textiles, clothing; wood, paper, printing; chemical products, plastics; metal processing; mechanical engineering, vehicles; Electrical and optical equipment*
•	Size: *Number of employees*
•	Export rate: *Share of turnover outside Slovenia (1996)*

Second group	**Variables related to organisational and transformation aspects**
•	Restructuring*: Company restructured since 1990*
•	Ownership: *Private owners, foreign owners, social ownership, state property*
•	Firm type: *Independent firm, headquarters, independent subsidiary, branch*

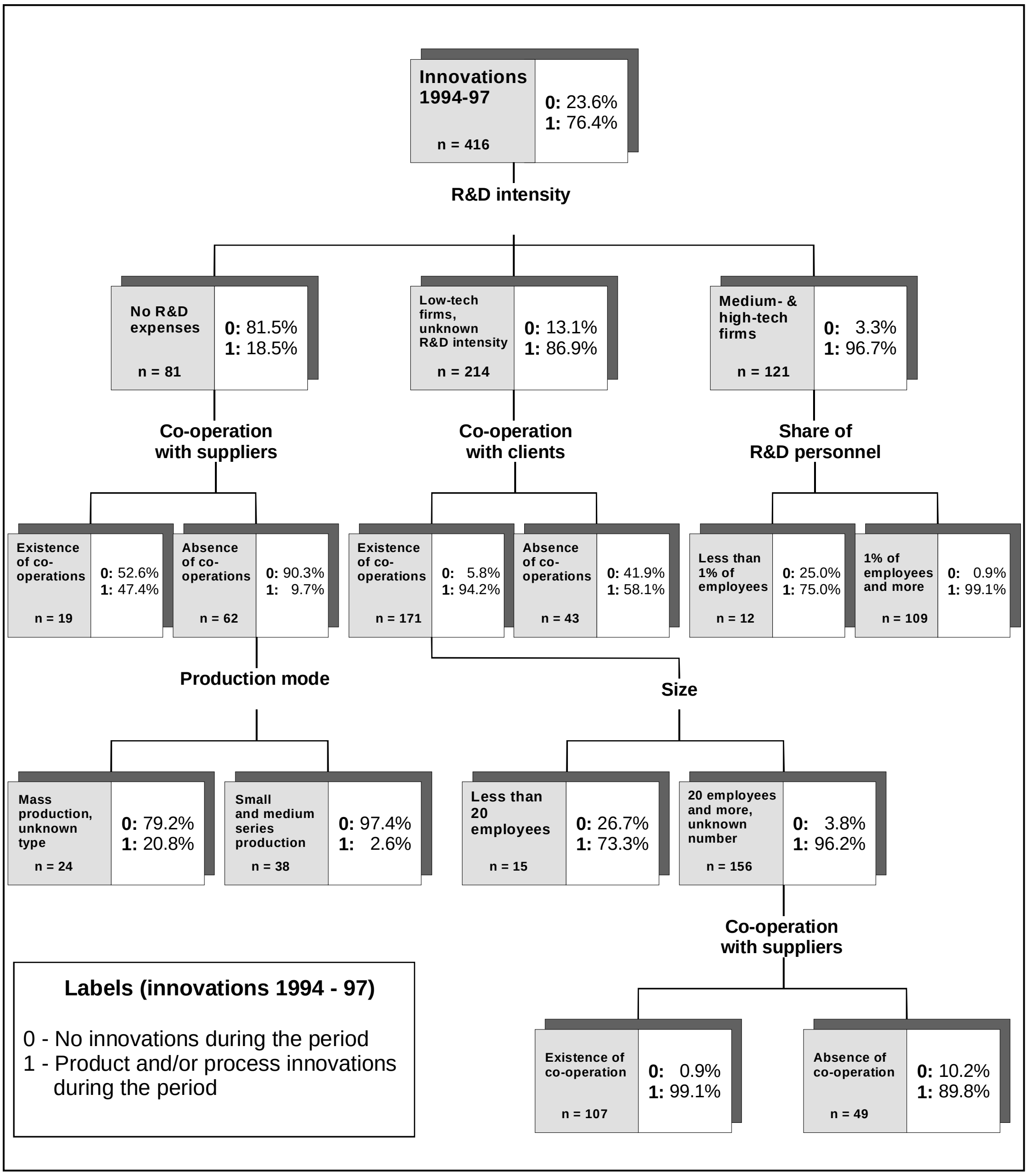
Third group	**Variables related to innovation input**
•	Continuity of research: *Permanent, occasional, no research*
•	Continuity of development: *Permanent, occasional, no development*
•	R&D intensity: *Share of R&D expenses of total turnover (1996)*
•	R&D personnel: *Share of R&D personnel of total number of employees (1996)*

Fourth group	**Variables related to networking activities**
•	Co-operation with clients: *Existence of co-operations with clients*
•	Co-operation with suppliers: *Existence of co-operations with suppliers*
•	Co-operation with research: *Existence of co-operations with research and transfer institutions*

3.3.2 Segmentation analysis

The first step of the empirical analysis characterises innovating firms according to the variables described above. For this purpose, the analysis starts with a segmentation procedure using the CHAID (Chi-squared Automatic Interaction Detector) algorithm. The principle of a CHAID analysis is the division of a population into different groups based on categories of the "best predictor" of a dependent variable. In the next step, CHAID splits each of these groups into smaller subgroups in relation to predictor variables that are now "best predictors" for the first level. This splitting process which is based on χ^2 continues until no more statistically significant predictors are available. Additionally, CHAID merges categories of variables whose response rates are statistically indistinguishable. As the segmentation algorithm is based on the best-predictor principle on every level, CHAID produces a hierarchical "segmentation tree". The segmentation procedure requires categorical or classified data and has been performed using Pearson's χ^2 on the 5 % significance level.

Fig. 2: Segmentation of innovating firms in Slovenia



The segmentation analysis (Fig. 2) shows that R&D intensity is the main distinguishing characteristic of firms' innovation performance. Accordingly, three groups are formed: first firms without R&D expenses, second low-tech firms with a R&D intensity below 3.5 % (and firms with an unknown R&D intensity) and third medium- and high-tech firms with an R&D intensity of 3.5 % to 8.5 % and more than 8.5 % respectively. Of the medium- and high-tech firms, 96.7 % have performed product or process innovations or both. The share of innovative firms declines in the other two groups: 86.9 % of low-tech firms innovate and only 18.5 % of companies without R&D expenditure.

On the second level, supplier-user linkages and internal R&D input are best predictors for further segmentation. As 47.4 % of no-tech companies co-operating with suppliers innovate, in contrast to only 9.7 % of no-tech firms without such linkages, co-operation can be identified as major characteristic for innovations in this group. The same is true for co-operations with clients in the group of low-tech firms: The share of innovators in the subgroup with linkages amounts to 94.2 % compared to 58.1 % of low-tech firms without client linkages. Among low-tech companies maintaining co-operation with clients, a significant size effect can be observed: Companies with less than 20 employees display a distinctive innovation pattern and seem to be less innovative than companies belonging to the other size classes.

For the group of medium- and high-tech firms, the share of R&D personnel is the best predictor for segmentation on the second level. Here, contrary to the no-tech and low-tech firms, the in-house R&D capacities seem to exceed the relevance of networks as distinguishing characteristic. Medium- and high-tech firms with more than 1 % R&D personnel are more innovative than the other companies in the segment (99.1 % versus 75.0 %).

Surprisingly, the variables related to the organisational and transformation specific situation did not prove to be significant for differentiating the respondents in relation to their innovation behaviour. However, they may have an impact on innovations which cannot be identified at this level of analysis. Summarising, innovating firms are mainly characterised by their networking activities and innovation input.

The CHAID segmentation procedure reports 9 final segments (Table 2). The highest number of innovative firms can be found in segments 5 and 9. These are on the one hand, low-tech firms with more than 20 employees co-operating with clients and suppliers and on the other hand, medium- and high-tech firms with a share of R&D personnel of more than 1 %.

The aim of this first part of the analysis was to emphasise the characteristics of innovating firms in Slovenia. However, CHAID does not allow for conclusions concerning the causal relationship between the dependent and the independent variables, the segmentation tree (Fig. 2) exclusively shows the frequency of innovations by firms with different characteristics.

Table 2: Description of final segments

Characteristics of firm segments	Size of the segment	Innovating firms
1. No R&D expenses, co-operation with suppliers	n = 19	47.4 % (n = 9)
2. No R&D expenses, no co-operation with suppliers, mass production (or unknown production mode)	n = 24	20.8 % (n = 5)
3. No R&D expenses, no co-operation with suppliers, small and medium series production	n = 38	2.6 % (n = 1)
4. Low-tech firms (or unknown R&D intensity), co-operation with clients, less than 20 employees	n = 15	73.3 % (n = 11)
5. Low-tech firms (or unknown R&D intensity), co-operation with clients, 20 employees and more, co-operation with suppliers	n = 107	99.1 % (n = 106)
6. Low-tech firms (or unknown R&D intensity), co-operation with clients, 20 employees and more, no co-operation with suppliers	n = 49	89.8 % (n = 44)
7. Low-tech firms (or unknown R&D intensity), no co-operation with clients	n = 43	58.1 % (n = 25)
8. Medium- and high-tech firms, less than 1 % share of R&D personnel	n = 12	75.0 % (n = 9)
9. Medium- and high-tech firms, 1 % and more share of R&D personnel	n = 109	99.1 % (n = 108)

3.3.3 Probit modelling

Further information about the dependencies between the general characteristics of the firms, organisational and transformation specific factors, R&D input and the vertical networking behaviour of the companies have been gained by probit analysis using the performance of innovations as dependent variable and the variables of the four different groups as independent or explanatory ones. In order to detect probability patterns, bi- and multivariate probit models have been used. The model to be estimated is:

$$\text{Prob}(\text{innovations}) = \varphi(\beta_0 + \beta_1 A + \beta_2 B + ... + \beta_n X)$$

with φ being the cumulative normal distribution, A, B and X being the explanatory variables. β_0 is the constant, β_1, β_2 and β_n are the coefficients of the independent variables in the equation.

The analysis first examines the relation between innovations and the explanatory variables calculating bivariate tests. The aim is to identify significant dependencies for each group of determinants

– general firm characteristics, transformational aspects, innovation input and co-operation – separately, which are then included in a multivariate model. On the one hand, this procedure permits to focus on the most important factors on later stages of the analysis. On the other hand, significant results of the bivariate models which could be overlaid in a multivariate analysis can be detected. In general, the independent variables have been integrated in the models in the most detailed form available: Variables which have been measured on the numerical level, have been used in a continuous form. This distinguishes probit modelling from the CHAID analysis, since the segmentation procedure requires categorical variables.

3.3.3.1 Firm characteristics

The general firm characteristics which are expected to have a significant impact on innovations are sector, size in terms of employees, production mode and export rate. In Western market economies, size strongly affects the conditions for innovations, such as flexibility or financial resources (Rothwell 1984), especially SMEs are often attributed with innovative creativity. Sector and production mode are likely to differ in need and potential of innovations. The export rate is included as indicator for firms' competitiveness although high export shares might have different reasons: not only internationally competitive products, but also a tight relationship between subcontractors and their foreign mother companies.

Table 3: Results of bivariate probit models for variables related to general firm characteristics

Independent variable	**Coefficient**	**t-value**	**Significance of the variable**
Sector			
Textiles, clothing	-0.267791	-0.829	0.407
Wood, paper, printing	-0.358398	-1.216	0.224
Chemical products, plastics	-0.143748	-0.453	0.651
Metal processing	-0.342509	-1.157	0.247
Mechanical engineering, vehicles	-0.196015	-0.637	0.524
Electrical and optical equipment	0.241892	0.747	0.455
Constant		3.573	0.000
Ref.: Food products, beverages			
Size			
Number of employees (log)	0.217641	4.019	0.000
Constant		-0.847	0.397
Production mode			
Share of mass production	0.002723	1.406	0.160
Constant		7.810	0.000
Export rate			
Share of turnover outside Slovenia	0.007006	3.245	0.001
Constant		3.718	0.000

Obviously, there are significant positive size and export effects on the performance of innovations. The production mode and the sector of activity do not show significant effects on the innovative performance of Slovenian firms. However, the negative coefficient of most sector variables is surprising because it indicates that all sectors except electrical and optical equipment are less innovative than food production and beverages (81.8 % of firms in this sector innovated). Concluding, hypothesis 1 can partly be confirmed.

3.3.3.2 Organisational and transformation aspects

Organisational and transformation related aspects are expected to influence innovations, since they determine the interest of the management, the communication and decision processes, their implementation as well as financial and mental constraints for successful innovation. As a considerable share of Slovenian industry is still socially owned or state property, with hesitant restructuring, this could result in less innovations.

Table 4: Results of bivariate probit models for organisational and transformation aspects

Independent variable	Coefficient	t-value	Significance of the variable
Firm type			
Independent firm	0.214903	0.489	0.625
Headquarters	0.776687	1.558	0.119
Independent subsidiary	0.364933	0.779	0.436
Constant		0.997	0.319
Ref.: Branch			
Restructuring			
Company restructured	0.168349	1.236	0.216
Constant		6.187	0.000
Ownership			
Private owners	0.134328	0.368	0.713
Foreign owners	0.275672	0.682	0.495
Social ownership	0.120694	0.307	0.759
Constant		1.593	0.111
Ref.: State property			

As already indicated in the segmentation analysis, the transformation related variables have no significant direct impact on innovative performance which leads to the rejection of hypothesis 2. Nevertheless, they may have indirect effects that need further investigation.

3.3.3.3 Innovation input

As already indicated by the segmentation analysis, internal innovation input plays a major role for innovative performance. The variables have to be understood as prerequisites for innovation, since they mainly refer to in-house R&D capacities from which the effectiveness of the innovation process cannot be estimated. While the continuity of R&D reflects the routinisation of the search for innovation, the other two variables are quantitative input indicators reflecting R&D expenses and R&D personnel.

Table 5: Results of bivariate probit models for innovation input

Independent variable	Coefficient	t-value	Significance of the variable
Continuity of research			
Permanent	1.049436	4.196	0.000
Occasional	0.408694	2.804	0.005
Constant		3.814	0.000
Ref.: No research			
Continuity of development			
Permanent	2.221736	9.534	0.000
Occasional	1.264897	5.554	0.000
Constant		-3.903	0.000
Ref.: No development			
R&D personnel			
Share of R&D personnel	0.139067	5.632	0.000
Constant		2.431	0.015
R&D intensity			
Share of R&D expenses	0.161408	6.429	0.000
Constant		3.202	0.001

Not surprisingly, all four variables show significant positive influences on firms' innovative performance. This supports hypothesis 3 concerning the importance of internal R&D capabilities.

Continuity of research and development activities

Most firms (55.5 %) are permanently engaged in development activities while one third 32.5 % carry out development from time to time and 12 % never. Still, 16.4 % of the firms carry out research continuously, almost half (47.2 %) only from time to time and above one third (36.4 %) never. Remarkably, 40.9 % of the firms plan to expand their R&D activities in contrast to only 2.8 % which foresee a decline in R&D, 56.4 % of the firms do not expect any future changes in the level of their R&D activities. While the share of firms with permanent or occasional development activities is almost the same in Slovenia and Baden, the percentage of enterprises with research activities is much higher than in the German region, with 64 % compared to 49 % (Koschatzky 1997; Koschatzky/Muller 1997).

R&D personnel

Only 23.8 % of firms in the sample have reduced their R&D personnel from 1991 to 1994 (increase: 28.7 % of firms, no changes: 47.5 %); from 1994 to 1996, 32.3 % of firms increased and 17.5 % reduced their R&D staff (no changes reported 50.2 %). While in the sample as a whole, a decrease from 3,235 to 3,000 employees in R&D took place between 1991 and 1994, there can be observed a considerable increase to a number of 3,988 in 1996. While most studies on R&D systems in transition (Meske et al. 1998; Stanovnik 1998), assume a sharp decrease in R&D personnel in industry especially until 1994, this at least cannot be confirmed by the data. On the one hand, firms, which terminated their business, could account for a loss of R&D employment. On the other hand, R&D personnel could be involved in maintenance and service activities instead of research but this cannot be detected from the responses.

R&D intensity

According to R&D intensity the sample contains 12.5 % high-tech and 20.4 % medium-tech firms. The mean of R&D expenditure as share of turnover is with 2.0 % much less than in Baden (7.9 %) or Alsace (3.7 %) (Koschatzky 1997).

3.3.3.4 Networking activities

The network paradigm emphasises interactions between firms in the innovation process as well as with research and supporting institutions. These are sensors for clients' needs and channels to access relevant scientific results; following the concept of the interactive innovation model (Kline/Rosenberg 1986), this allows various feed-back mechanisms to improve products and processes continuously. Usually co-operative linkages are expected to complement in-house R&D capabilities.

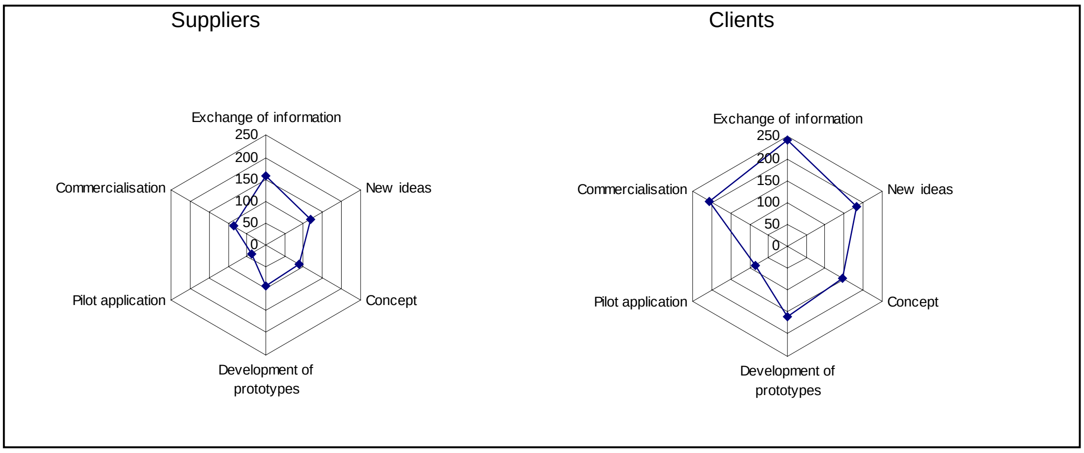
Table 6: Results of bivariate probit models for co-operations

Independent variable	**Coefficient**	**t-value**	**Significance of the variable**
Co-operation with clients			
Existence of co-operations	1.609990	10.359	0.000
Constant		-2.309	0.021

Co-operation with suppliers			
Existence of co-operations	1.172596	7.838	0.000
Constant		2.063	0.039
Co-operation with research institutes and universities			
Existence of co-operations	0.946604	5.600	0.000
Constant		5.741	0.000

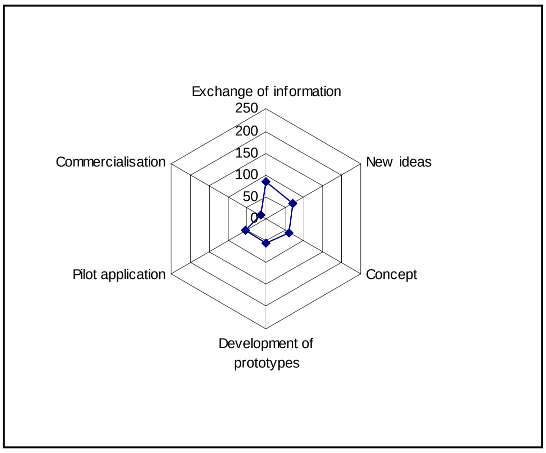
The bivariate probits show significant results for all three kinds of co-operations, even though the linkages with clients seem to play the most important role. Thus, hypothesis 4 is confirmed. However, the model does not consider the quality and intensity of linkages which would allow assumptions on learning processes in the network. Figure 3 is a first representation of the quality of vertical linkages.

Fig. 3: Share of firms with intensive co-operation with suppliers and clients



More than two thirds of companies (71.9 %) report co-operations with clients, more than half (55.8 %) maintain co-operations with suppliers in different phases of the innovation process. However, as could be expected, most firms prefer rather informal interactions such as exchange of information, generation of new ideas and concepts while the share of firms engaged in intensive co-operative in the development of prototypes or pilot applications is considerably less.

Fig. 4: Intensive co-operation with research institutes and universities



The co-operation pattern with research institutes, universities and transfer organisations differs considerably from vertical network relations. Only around 50 firms co-operate intensively in the development of prototypes and in pilot applications with these institutions. Since 1990, three times more firms report reduced co-operation with the research sector than with suppliers and users. This is significantly depending on the change of in-house R&D personnel. Intensified co-operation is mostly accompanied by an increase in in-house R&D capacity, substitution effects or outsourcing cannot be identified.

3.3.3.5 Synthesis: multivariate probit modelling

The final step of the probit modelling comprises those aspects of the bivariate modelling that have been proved to show significant influences on the performance of innovations.

Table 7: Results of the multivariate probit modelling

Independent variable	**Coefficient**	**t-value**	**Significance of the variable**
Size (log)	0.310073	2.670	0.008
Export rate	-0.001684	-0.501	0.617
Continuity of research			
- Permanent research	-0.195148	-0.481	0.630
- Occasional research	0.029617	0.125	0.901
Ref.: No research activities			
Continuity of development			
- Permanent development	1.317887	3.470	0.001
- Occasional development	1.055988	3.138	0.002
Ref.: No development activities			
R&D personnel	0.067554	2.015	0.044
R&D intensity	0.119354	3.707	0.000
Co-operation with clients	0.988844	4.308	0.000

Co-operation with suppliers	0.653680	2.867	0.004
Co-operation with research	0.076072	0.262	0.793
Constant	-2.936303	-5.249	0.000
Number of observations	333		
Significance level of the model	0.0000		
Pseudo R^2	0.5053		

Table 7 again emphasises the important effects of R&D input factors and of networks for the performance of innovations. Both permanent and occasional development activities within the firm prove to have a significant influence on innovative activities also in the multivariate model. In contrast to this positive significant impact, research activities do not prove to be significant any more. On the one hand, a possible reason could be that development activities have a higher impact compared to research work already in the short run. Research may have a positive significant impact in the medium and longer term. On the other hand, research capabilities, which have been formed before the transition, could be still not targeted enough towards commercial viable innovations or not inter-linked enough with the companies' development and marketing activities. The share of R&D personnel of total number of employees has a positive significant impact on the performance of innovations; but – as already shown in the segmentation analysis – R&D expenses have a higher impact on the success in terms of innovations.

The model shows a significant positive impact of vertical networks on innovations. Contrary to the bivariate models, co-operations with research and transfer institutions do not seem to be of crucial importance in the frame of the multivariate model. This means, while co-operations with the research sector do in fact have a (positive) impact on innovations (cf. Table 5), this effect is overlaid by others factors of higher importance in the multivariate model.

Concerning general firm characteristics, there is a considerable (positive) size effect on the performance of innovations, even if the probit model presented above does not allow to give further details. Finally, the share of firms' exports should be considered. Although this variable proved to be significant in the frame of bivariate tests, it does not belong to the group of significant ones in the final model and, additionally, indicates a negative sign of the coefficient: In the frame of the specific model presented above, the share of turnover realised outside Slovenia does not seem to be of crucial importance any more, but the positive effect of exports shown in the bivariate analysis is overlaid.

4 Conclusions

Based on a representative sample of Slovenian manufacturing firms, the analysis points out promising developments in firms' innovative behaviour: The overall share of co-operating firms and the innovative performance indicate a partly rehabilitation of the perception of firms' innovation performance in transition economies, at least for Slovenia.

Network relationships and internal innovation input factors proved to be the dominant explanatory variables for innovations in the segmentation analysis and probit models. The segmentation analysis reveals that co-operations with suppliers and users are an important factor for innovation, especially in no- and low-tech firms. Although this is conform with empirical network studies in traditional industrial districts, policy implications for Slovenia should consider these patterns. However, at this stage of analysis it is not possible to conclude whether the linkages contribute already to the consolidation of technological potentials in the transition context.

In contrast to the vertical networks in place, the lower share of firms interacting with research institutes is remarkable. Co-operations with the research sector and transfer institutions did not prove to be a significant determinant of innovation in the multivariate model even though a positive relationship was observed on the bivariate level of the analysis. While in-house development activities have a positive significant effect on innovations, research activities exert no significant impact. Both aspects support This reflects the often stressed assumption that the know-how transfer between a traditionally excellent science sector and the country's industry or even between different innovation-relevant functions within the firm itself is not fully working. Further research should focus on the barriers and stimulating factors for the emerging of network relations including the compatibility of firms' and institutions' technological strengths. Furthermore, the quality of interaction needs attention.

No clear and significant relations could be identified for most general firm characteristics and transformation specialities, except for positive size effects. This was not expected. As differences in innovative behaviour according to firms' size have been pointed out in the probit modelling and indicated in the segmentation analysis, detailed research could deliver conclusions for technology policy. Concerning organisational and transformation specific aspects, indirect effects should not be neglected and need further investigation.

To deliver a broader perspective, the findings of the Slovenian industrial innovation survey could be analysed in the context of inter-regional comparisons, e.g. with the region of Saxony (East Germany) – one of the regions being investigated with a similar methodology in 1995.

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