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Non-technological and Technological Innovation: Strange Bedfellows?

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Non-technical Summary

The traditional concept of innovation in firms distinguishes product and process innovation. Since both are typically associated with the development or application of new technologies, these innovations are often called technological innovations. The technological view on innovation has been criticised for not fully capturing innovation in services and for ignoring important elements of innovative activities of firms, e.g. adopting new and re-organise existing business routines, external relations and marketing. The critics conclude that a broader concept of innovation which includes non-technological innovation is needed. The OECD and Eurostat have recently adopted this view by introducing organisational and marketing innovation into the guidelines for collecting and interpreting innovation data ("Oslo-Manual") and by incorporating respective questions into the fourth Community Innovation Survey (CIS 4) conducted in 2005.

This paper analyses the determinants and effects of non-technological innovations (i.e. organisational and marketing innovations) and compares them with those of technological innovations, using the German CIS 4 data. The analyses show that technological and non-technological innovations are closely linked to each other. Marketing innovation often coincide with product innovations while firms with organisational innovations often introduce new technological processes, too. However, there is also a significant share of firms introducing only non-technological innovations (24%), which is clearly above the share of firms only introducing technological but no non-technological innovations (13%). Consequently the share of non-technological innovators (59%) is above the one of technological innovators (48%).

Looking at the determinants of both types of innovations, these are by and large the same, i.e. the decision to innovate is mainly driven by the same factors regardless of the type of innovation. This reinforces the descriptive results of a rather close link between technological and non-technological innovation.

Technological innovators who combine their product and process innovations with marketing and organisational innovations perform better in terms of sales with market novelties and process innovation driven cost reductions. This positive effect only applies, however, if technological innovators implement both types of non-technological at the same time. A combination of technological with non-technological innovations also has a positive impact on the profit margin of firms. Surprisingly enough, this effect can be solely attributed to the combination of organisational with product innovation. What is more, the highest innovation effects on profit margins are to be found for firms introducing technological innovations without non-technological ones, indicating that comprehensive innovation activities involving both types are likely to raise costs stronger than returns.

Non-technological and technological innovation: Strange Bedfellows?

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Abstract

Non-technological innovation is an important element of firms' innovation activities that both supplement and complement technological innovation, i.e. the introduction of new products and new processes. We analyse the spread of non-technological innovation in firms, their relation to technological innovation, and their effects to firm performance and success with product and process innovation, using data from the German Community Innovation Survey conducted in 2005 (German CIS 4). Non-technological innovation is defined as the introduction of new organisational methods or the introduction of new marketing methods. We find that the determinants of a firm's propensity to introduce technological and non-technological innovations are very similar and that both types are closely related. There are only small effects of non-technological innovation on a firm' profit margin, which contrasts the strong effects to be found from technological innovation. However, non-technological innovation spurs success with product and process innovation terms of sales with market novelties and cost reductions from new processes.

Keywords: organisational innovation, marketing innovation, effects of innovation, CIS 4

JEL-Codes: O 31, O 30, L 25

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1 Introduction

Innovation activities of firms are traditionally perceived to comprise product and process innovation. Both types of innovation are often associated with the development or application of new technologies. New products typically contain new technical features that offer new functionalities, increase product quality or allow for totally new areas of application. New processes basically rest on the use of new technologies to increase the efficiency or quality of production. This view on innovation was reflected by the first and second edition of the "Oslo Manual" – the OECD's handbook for innovation surveys (OECD, 1993; OECD and Eurostat, 1997) -, which directly linked product and process innovation with technological innovation.

The technological view on innovation has been criticised for different reasons. First, it is said to be biased towards innovation in manufacturing and not able to fully capture innovation in services (see e.g. Hipp and Grupp, 2005; Hipp et al., 2000). Secondly, innovation in firms is not just about developing and applying new technologies but also to adopt and re-organise business routines, internal organisation, external relations and marketing (see Baranano, 2003; Boer and During 2001). Thirdly, innovation management literature stresses the importance of integrating product, process and organisational innovation for successfully transferring new ideas and new business opportunities into market success (see Tidd et al., 2001; Cozzarin and Perzival 2006) and emphasises the crucial role of linking R&D, technological innovation and new marketing approaches (see Griffin and Hauser 2001). The critics conclude that for getting a complete picture of innovative efforts of firms across all economic sectors, the concept of innovation should be extended to non-technological innovation.

The third edition of the Oslo Manual, published in 2005, adopted this view and introduced two new types of innovation, organisational innovation and marketing innovation, which complement the standard concepts of product and process innovations. Organisational innovation refers to the implementation of new organisational methods not used in the firm before, while a marketing innovation is the implementation of a new marketing method (OECD and Eurostat, 2005). In connection to this change, the fourth Community Innovation Survey (CIS 4) conducted in the member states of the European Union in 2005, contained some questions on non-technological innovations, i.e. on changes in marketing strategies and business organisation, which came close the Oslo Manual's definitions of organisational and marketing innovation.

Having information on both "technological"[1] and "non-technological" innovation from a large scale questionnaire such as the CIS 4 at hand offers an excellent opportunity to analyse the interaction of technological and non-technological innovation. In particular, four research questions will guide the analysis:

(1) To which extent are technological and non-technological innovations complementary, in particular with respect to product and marketing innovations on the one hand, and process and organisational on the other?
(2) To which extent do determinants of marketing and organisational innovations differ from those of product and process innovation?
(3) Do non-technological innovations contribute to the success of product and process innovation, i.e. does a combination of technological with non-technological innovations yield higher returns of technological innovations?
(4) Do non-technological innovations generate extra-returns, i.e. is there an innovation rent for this type of innovation, similar to innovation rents from product and process innovations?

In this paper we use of the German part of the CIS 4 since this survey - in contrast to most other national CIS - also contains information on the success with process innovation and measures of firm performance, including the level of profit margins which allows for a detailed analysis of our research questions.

First, we will discuss some basic concepts and definitions of non-technological innovation (Section 2) and provide a short description of the data base used, the German CIS 4 (Section 3). In the empirical part of the paper, we first present descriptive results, based on weighted data, on the prevalence of non-technological innovations by industry groups, including service industries (Section 4). Moreover, we take a look on the degree to which non-technological and technological innovation occur simultaneously or separately. This will be followed by multivariate analysis of the determinants of non-technological innovations for all firms and the subset of technological innovators (Section 5). Finally we estimate the effects of non-technological innovation on firm performance as well as on innovation success with technological innovations (Section 6).

1 In the remainder of this paper, we call product and process innovations "technological" innovations as opposed to non-technological innovations, i.e. marketing and organisational innovations, despite the fact that the questions on product and process innovations in the CIS 3 and CIS 4 and the definition of these two types of innovation in the 3rd edition of the Oslo Manual are not only focusing on technological innovations but include some non-technological changes as well.

2 Nature of Non-technological Innovation

Our research questions basically deal with the issue whether non-technological innovation are different in nature compared to technological ones, or whether they are just another dimension of innovation activities of firms, demanding similar capabilities to develop and implement them, and producing similar results in terms of firm performance effects. The main starting point for separating between the two types is of course the different role of technology. While technological innovations are typically characterised by developing or using new technologies, i.e. new technical knowledge and technical inventions, non-technological innovation need not necessarily involve a change in technology, or the adoption of new technology, but may solely rest on the use of new business methods, new organisational concepts or other immaterial ways of changing business activities.

This non-technological character is reflected in the definition of the two new types of innovation introduced to the definition of innovation in the third (i.e. 2005) edition of the Oslo Manual. They are defined as follows:

*"A **marketing innovation** is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing." (OECD and Eurostat, 2005: § 172)*

*"An **organisational innovation** is the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations." (OECD and Eurostat, 2005: § 180)*

Relating innovation to non-technological activities may alter some key assumptions about the determinants of innovative activities and their effects on firm performance which relate to the concepts of uncertainty, investment, knowledge spillovers and limited appropriability, and temporary market power:

a) Innovation is generally associated with *uncertainty* (in Knight's, 1920 sense) over the outcome of innovative activities. Uncertainty implies that the probability of the later success of innovation activities is typically not known when starting the activity, which restricts external financing (see Hall, 2002) and insurance against the costs of potential failure. While uncertainty is common for developing and implementing new technologies, the case is less clear for organisational or marketing innovation since the latter often rests on the adoption of established business methods or marketing practices, supported by specialised consultants who can substantially limit the risk of failure.

b) Innovation involves *investment*, i.e. costs that occur in the current period with potential returns occurring in later periods. The amount of investment may often be substantial and involve both the purchase of fixed and intangible assets as well as to certain types of current expenditures such as R&D. Innovation thus typically requires pre-financing. Organisational and marketing innovations are likely to differ in this respect since costs for implementing them may be significantly lower and rarely involve fixed investment or long periods between expenditure and return. A special case is marketing expenditure for advertising and implementing corporate brand strategies which own investment characteristics, though these expenditures will constitute marketing innovations only when related to newly introduced market methods.
c) Innovation is associated with the creation and use of new knowledge, which is subject to *spillovers*. Consequently, the benefits of innovative activities may only partially be appropriated by the innovating firm while other firms may benefit from these innovative efforts through learning, imitating and adopting. Since costs of learning and adopting are typically lower than costs of innovating, the result of innovation activities must be applicable to some type of protection measure in order to provide an incentive to innovate. For non-technological innovations, spillovers are less likely to occur: organisational innovations are mostly specific to a firm and difficult to observe externally, though consultants involved in implementing this type of innovation, or employees moving to competitors may transfer experiences on organisational innovations. Marketing innovations may more likely be subject to spillovers, e.g. through the imitation of a new design concept, pricing policy or brand strategy. Similar to new technologies that may be protected by patents, trade marks may serve to some extent as a protection mechanism for marketing innovations.
d) Innovation aims at gaining a competitive advantage by either shifting the demand curve of the firm’s products (e.g. through increasing product quality, offering new products or opening up new markets) or a firm's cost curve (e.g. through reducing unit costs of production, purchasing, distribution or transaction). In both cases, firms will be able to obtain short term extra profits, either through a temporary monopoly (product innovations) or through temporary marginal costs below the market price. Organisational and marketing innovations can potentially act in a similar way. New methods for organising the business may reduce unit costs and exert the same effect on profits as cost-reducing process innovation. The more original and complex these organisational strategies are, the more difficult it will be for competitors to imitate them, thus producing a competitive advantage for the organisational innovator (see Rivkin 2000). New marketing methods which contribute to an increased perceived product quality or address new groups of customers not

served by the respective type of product so far may generate a temporary monopoly.

Summing up, there are some arguments for considering non-technological innovations as being similar in their economic effects to technological ones, e.g. the effects on temporary extra profits, or the occurrence of spillovers in case of marketing innovation. In some other respects, such as the level of uncertainty involved or the investment nature, non-technological innovations seem to differ substantially.

Regarding non-technological innovation as an integrative element of a firm's innovative activities is in line with one of the earliest works on systematising innovation activities of firms: Schumpeter (1934) distinguishes five types of innovations, two referring to technological innovations (introducing new products and introducing new processes) while three are linked to some extent to the concept of technological of non-technological innovation (opening of new markets, developing new sources of supply, and creation of new market structures). For all five types, Schumpeter assumes similar effects on market structures and firm performance. This also raises the question of likely interactions between the various types of innovation. In case of similar effects technological and non-technological innovation may just represent different aspects of one innovative strategy of a firm, and measuring both types may provide little additional information on whether a firm is pursuing an innovation strategy.

With respect to organisational innovation, a close link to process innovation is likely, since introducing new technologies in production or distribution may demand reorganising business routines, which may trigger the introduction of new business practices or new organisational models. Organisational innovation may also occur in the course of product innovations, however, for instance when new products induce the establishment of new production or sales divisions and call for re-organisation of work flows, knowledge management or external relations. Marketing innovations may be closely connected to product innovation. New products may demand new ways of marketing and urge for introducing new marketing methods. In practice, new marketing concepts for product innovations may represent an integral part of the innovative effort, both types of innovation constituting one single innovation project. There is also a case for marketing innovation interacting with process innovation. New production technologies may result in increased production capacities or in improved quality characteristics of products. In order to market this increased capacity or improved quality, new marketing approaches may be required.

3 The German CIS 4

For our empirical analysis, we use data from the fourth Community Innovation Survey (CIS 4) conducted in 2005 under the co-ordination of the Statistical Office of the European Commission (Eurostat). The CIS 4 covers innovation activities of firms in the reference period 2002-2004 and is based on a harmonised methodology and questionnaire agreed upon by the member states of the European Union. It is largely based on the 2nd edition of the Oslo Manual in order to ensure comparability with CIS 3 conducted in 2001. However, the CIS 4 survey also contains a set of questions on non-technological innovation that comes very close to the definition of organisational and marketing innovation in the 3rd edition of the Oslo Manual. Each firm, regardless of having introduced technological innovations, was asked whether it has introduced within a three year period (2002 to 2004)

- new or significantly improved knowledge management systems to better use or exchange information, knowledge and skills within your enterprise;
- a major change to the organisation of work within your enterprise, such as changes in the management structure or integrating different departments or activities;
- new or significant changes in your relations with other firms or public institutions, such as through alliances, partnerships, outsourcing or sub-contracting;
- significant changes to the design or packaging of a good or service (exclude routine/seasonal changes such as clothing fashions).
- New or significantly changed sales or distribution methods, such as internet sales, franchising, direct sales or distribution licenses.

The first three items refer to organisational innovations, while the forth and fifth attempt to capture marketing innovation. For organisational innovations, their effects on reducing response time to customer or supplier needs, improving product or service quality, reducing costs per unit of output, and improving employee satisfaction have been measured through a Likert scale.

The CIS 4 was conducted in all EU member states. We restrict our analysis to the German CIS 4 data since these contain a number of questions that are not part of the harmonised CIS 4 questionnaire developed by Eurostat, but are highly useful to address our research questions:

– A set of questions refer to the market situation of a firm, containing questions on the number of main competitors and their the relative size, on the relevance of various competitive factors (such as price, product quality, technology, service, advertising etc.), on the significance of different market environments (such as high rate of market entries, rapid technological change, short product cycles, high

uncertainty of behaviour of market actors, high substitution potential), and the sales share with the three largest customers.

– For process innovators, the magnitude of unit cost reduction achieved by the implementation of new process is queried as a key indicator of process innovation success.

– Firm performance is measured by the profit margin, complemented by some key financial figures (personnel costs, material costs, gross fixed investment, tangible fixed assets, exports).

The German CIS 4 is part of an annual innovation survey, called "Mannheim Innovation Panel (MIP)" (see Janz et al., 2001; Rammer et al., 2005 for more details) and goes beyond the minimum requirements of the harmonised methodology with respect to sector and size coverage. While most EU member states cover firms with 10 or more employees, the MIP also includes firms with 5 to 9 employees. The MIP also covers a broader set of sectors, including construction, retail trade, real estate, renting, R&D services, consulting, advertising, producer services, refuse disposal, motion picture and broadcasting. This means that the service sector is covered much more complete, which is a particular advantage when it comes to analysing the relevance of non-technological innovation in the service sector

The MIP, and thus the German CIS 4, is conducted by the Centre for European Economic Research (ZEW) in co-operation with infas (Institute for Applied Social Sciences) and the Fraunhofer-Institute for Systems and Innovation Research (ISI) on behalf of the German Federal Ministry of Education and Research (BMBF).[2] The sampling technique used is stratified random sampling. The sample is stratified by size class (7 to 8, depending on the sector group), region (East/West Germany) and industry (basically 2-digits, in services partially also 3-digits). The gross sample (net of neutral unit non-response due to firm closure etc.) was about 27,900 firms. Filled in questionnaires were received from 5,476 firms, resulting in a response rate of 20%. A comprehensive non-response analysis with a net sample of more than 4,230 firms (= 19% of non-responding firms) was performed to control for a potential bias in the non-responding firms. Weighting factors which consider this potential bias have been calculated in order to derive weighted figures which will be presented in Section 3.

4 Prevalence of Non-technological Innovations

Organisational and marketing innovation activities of firms were registered for all firms, i.e. also for firms with no technological innovations. In accordance to

2 For a more detailed description of the Mannheim Innovation Panel see Janz et al. (2001) or Rammer et al. (2005).

the CIS methodology, firms have been asked whether they have introduced organisational or marketing innovations during the last three years, i.e. from 2002 to 2004. The introduction of product and process innovations was measured for the same reference period 2002-2004. This allows us to calculate the share of non-technological innovators in the same way as the share of firms with product and process innovations, and to calculate the share of firms with only non-technological, with only technological and with both types of innovation, as well as to analyse the relation between the four types of innovation. In order to identify main differences between manufacturing and services, we distinguish three broad sector groups: manufacturing (including mining and quarrying: NACE 10-37), knowledge intensive services (NACE 64.3, 65-67, 72-73, 74.1-74.4) and other services (NACE 51, 60-63, 64.1, 74.5-74.8, 90).[3]

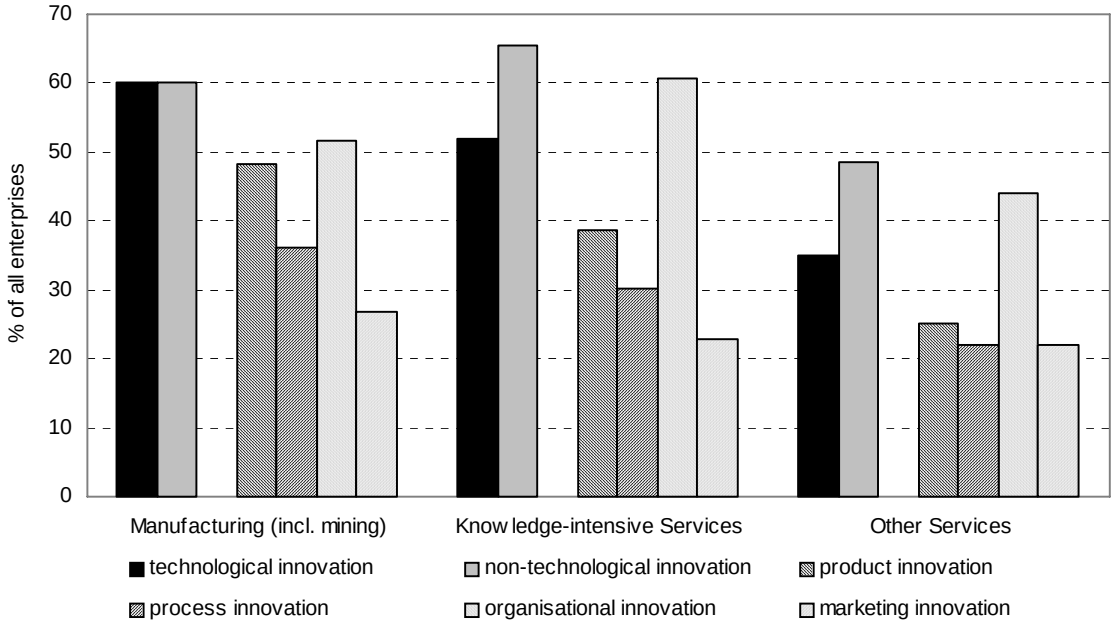
Figure 4-1 shows that the share of firms with technological innovations equals that with non-technological innovations in the manufacturing, while the share of non-technological innovators exceeds the share of technological innovators in the service sectors. In manufacturing, 60% of all firms introduced technological innovations between 2002 and 2004, and also 60% of all firms introduced non-technological innovations. For knowledge intensive services the corresponding figures are 52% and 66%, and for other services 37% and 48%. This clearly shows that service industries are more focused on marketing and organisational innovations than on product and process innovations.

The high shares of firms with non-technological innovations in particular in the service sectors are mainly driven by organisational innovations. Even in the manufacturing sector the share of firms with organisational innovations exceeds the share of the other three types of innovation.

The most striking differences between organisational innovations and other types of innovation can be found in the knowledge intensive service sector. In this sector the share of organisational innovators is 22 percentage points higher than the next highest share, i.e. that for firms with product innovations. The same difference is 19 percentage points for other services and just 2 percentage points for the manufacturing sector, again underscoring the assumption that the service sectors' innovation activities are more focused on non-technological than that of manufacturing. The finding that organisational innovations are more widespread in manufacturing than product innovations is evidence for the fact that non-technological innovations also play a role for industries and sectors that are technology oriented.

3 Some sectors which are covered in the MIP are not considered here. This refers to energy and water supply, construction, retail trade, real estate, renting, motion picture and broadcasting.

Figure 4-1: Share of firms with product, process, marketing and organisational innovations in Germany, 2002-2004 (in %)

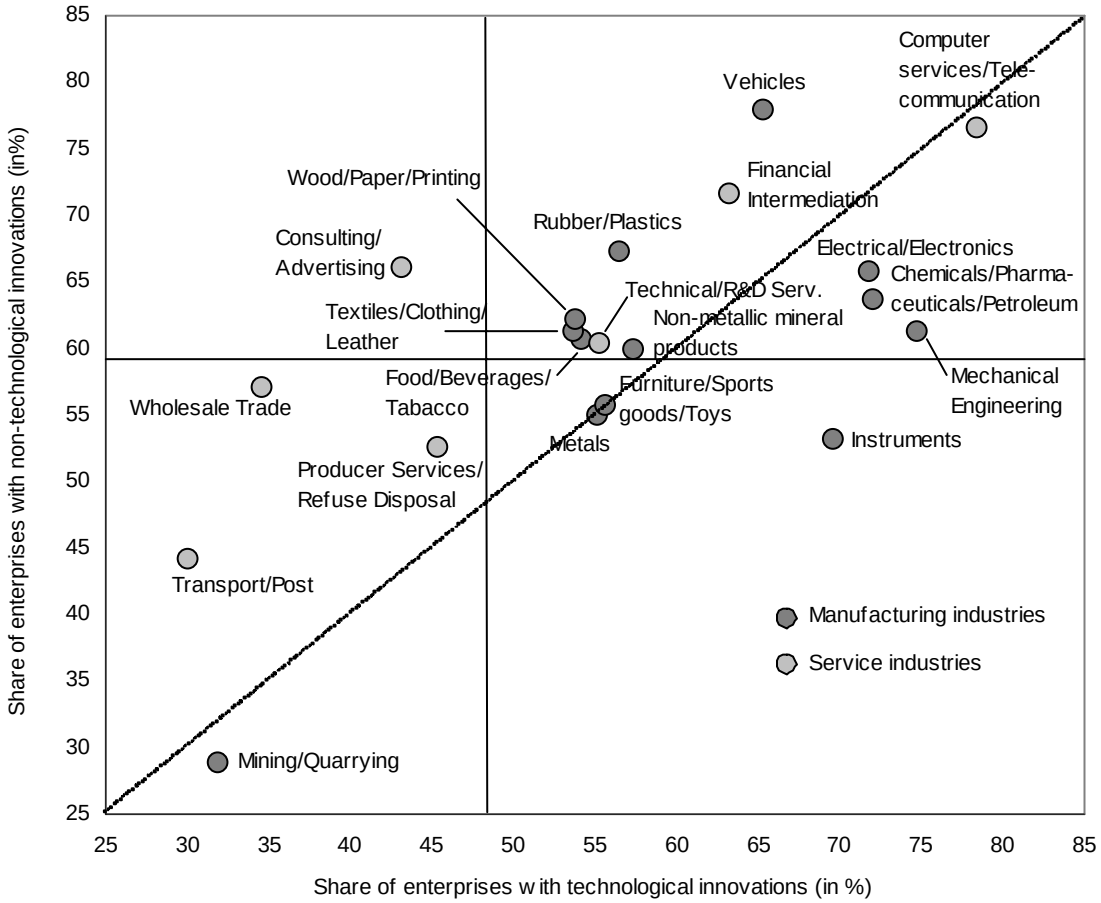


Source: ZEW (2005): Mannheim Innovation Panel; weighted data; firms with 5 or more employees.

Figure 4-2 provides further evidence that product and process innovations are linked to marketing and organisational innovations. In most industries in which the share of technological innovators is above average the share of non-technological innovators is also above average and vice versa. This statement is valid for almost all industries except for the metal producing and processing industry, the furniture, sporting goods, toys and recycling industry, the instruments industry, and the consulting and advertising business. In three first mentioned industries the share of non-technological innovators is slightly below average, whereas the share of technological innovators is clearly above average. In consulting and advertising, more firms than average conduct non-technological innovation, while a smaller than average share conduct technological innovations.

Figure 4-2 also shows that most manufacturing industries with a strong R&D orientation - electrical/electronics, chemicals/petroleum, mechanical engineering, instruments - have a higher share of technological than non-technological innovators. One exemption is the vehicles industry, where more than 75% of all firms have introduced non-technological innovations, compared to 65% technological innovators. Among the service industries, only computer and telecommunication services show a slightly higher share of technological than non-technological innovators.

Figure 4-2: Share of firms with product and/or process innovations and with marketing and/or organisational innovation in Germany, 2002-2004, by industry



Source: ZEW (2005): Mannheim Innovation Panel; weighted data; firms with 5 or more employees.

When considering both technological and non-technological innovators, the share of innovating firms is clearly increasing, and the ranking of industries by the share of innovating firms changes considerably as compared to a ranking solely based on technological innovations (see Table 4-1). While the computer and communication service industry ranks first with respect to both indicators, the manufacturer of vehicles move forward to position 2 (from 6) because of an extremely high share of non-technological innovators (80%). A similar change can be observed for consulting and advertising. This industries ranks below average with respect to technological innovation, but is among the most innovative industries when it comes to non-technological innovation. To the contrary, manufacturer of instruments show a low share of non-technological innovators, and only a small share of firms without technological innovations are active in non-technological innovation. As a consequence, this industry only ranks on place 12 (of 20 industries considered here) with respect to all types of

innovations, while it is among the most innovative industries in terms of technological innovation.

Table 4-1: Share of innovators by type of innovation in Germany, 2002-2004, by industry (% of all firms)

	All Innovators	**Technological Innovators**	**Non-technological Innovators**	**Only Technological Innovators**	**Both Technological and Non-technological Innovators**	**Only Non-technological Innovators**
Mining and Quarrying	40.2	31.5	28.8	11.3	20.2	8.6
Food/Beverages/Tobacco	77.1	54.1	60.7	16.4	37.7	23.0
Textiles/Clothing/Leather	75.6	53.7	61.4	14.2	39.4	21.9
Wood/Paper/Printing	73.0	53.8	62.2	10.8	43.1	19.2
Chemicals/Pharmac./Petrol.	84.1	72.0	63.7	20.5	51.5	12.1
Rubber/Plastics	79.2	56.4	67.2	12.0	44.4	22.8
Non-metallic Mineral Prod.	78.3	57.3	59.9	18.4	38.9	21.0
Metals	70.2	55.2	55.1	15.2	40.0	15.1
Mechanical Engineering	83.1	74.7	61.3	21.8	52.9	8.4
Electrical and Electronics	82.4	71.8	65.9	16.5	55.2	10.6
Instruments	76.6	69.6	53.2	23.4	46.1	7.1
Vehicles	85.9	65.3	77.9	8.0	57.4	20.5
Furniture/Sports Goods/Toys	77.1	55.6	55.8	21.3	34.3	21.5
Manufacturing (incl. mining)	*76.3*	*60.0*	*60.3*	*16.1*	*43.9*	*16.3*
Financial Intermediation	83.0	63.2	71.7	11.3	51.9	19.8
Computer/Telecom. Services	95.5	78.4	76.6	18.8	59.5	17.1
Technical/R&D Services	77.5	55.3	60.4	17.1	38.2	22.2
Consulting/Advertising	76.1	43.2	66.1	10.0	33.1	32.9
Knowledge-intens. Services	*79.2*	*51.7*	*66.3*	*13.0*	*38.7*	*27.5*
Wholesale Trade	64.8	34.5	57.2	7.6	26.9	30.3
Transport/Postal Services	54.7	30.0	44.2	10.5	19.5	24.7
Producer Serv./Refuse Disp.	71.5	45.3	52.6	19.0	26.3	26.2
Other Services	62.3	35.2	50.9	11.4	23.8	27.1
Total	*71.9*	*47.5*	*58.7*	*13.2*	*34.3*	*24.4*

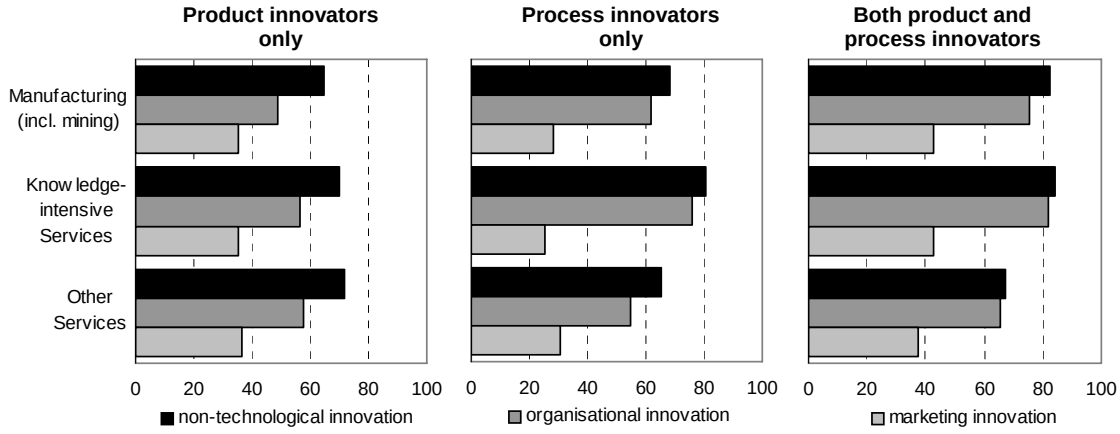
Source: ZEW (2005): Mannheim Innovation Panel; weighted data; firms with 5 or more employees.

Considering both technological and non-technological innovators, the share of innovating firms increases to 72%, compared to 47.5% when referring to technological innovators only. In the computer and telecommunication services, almost all firms will become innovators when the broader concept of innovation is used. About half of all innovators (in a broad sense) conduct both

technological and non-technological innovation while about a third is conducting only non-technological innovations, and about a fifth only technological ones. The share of innovators with both technological and non-technological innovations is especially high in manufacturing (58%), in particular in industries such as vehicles, electrical/electronics, mechanical engineering and chemicals. Knowledge-intensive services show a similar distribution as the total of all industries, though financial intermediation and computer/telecommunication services report a particularly high share of innovating firms with both and non-technological innovations. In the other services, the share of innovating firms with only non-technological innovations clearly exceeds that of firms with both types of innovations. In this sector group, non-technological innovation seems to be rather complementary to technological innovation, while in manufacturing, non-technological innovations appears to play rather an ancillary role to technological innovation for most firms.

While Figure 4-2 and Table 4-1 indicate that there is no simple one-to-one relation between non-technological and technological innovations in the sense that each product innovation induces a marketing innovation or each process innovation induces a process innovation, it is without a doubt that there exists a relationship between the two. This also becomes evident in from Figure 4-3. The share of firms with non-technological innovations is higher for the group of firms with technological innovations than for all firms. In manufacturing and knowledge intensive services the share of technological innovators with non-technological innovations is above 80%, for other services it is at 67%.

Figure 4-3: Share of German firms with technological innovation that have introduced marketing and organisational innovations in 2002-2004 (% of all firms with product and/or process innovations)



Source: ZEW (2005): Mannheim Innovation Panel; weighted data; firms with 5 or more employees

Splitting up the technological innovators into innovators that introduced product innovations only and innovators that introduced process innovations only

allows us to investigate the relationship between the different types of innovation in more detail. For the product innovator only group the share of marketing innovations is higher than in the group of process innovators and in the process innovation group the share of firms with organisational innovations is higher in all sectors, but other services. These results point to a relationship between product and marketing innovations and process and organisational innovations. This is not surprising. A firm which introduces a product innovation can be expected to improve or at least change its marketing strategy for the introduction of this product. Similarly, the introduction of a new technological process may also make changes of other non-technological aspects of the whole production or distribution process necessary. We find that more than 50% of all innovators with product innovations only also significantly changed their organisation. A reason for this may be that the development and introduction of new products necessitates changes in the production processes and workflows which are not exclusively based on technologies. For the service sectors the relationship between product innovations and organisational innovations seems to particularly strong. This is not surprising given that the production process and the product are in general more closely related in service sectors than in manufacturing.

In summary, the descriptive analysis has shown that non-technological innovations, and in particular organisational innovations, are types of innovations introduced by many service and manufacturing firms. In manufacturing and services organisational innovations are introduced by more firms than the other types of innovation. We also find a link between technological and non-technological innovations. In the next section we will leave the industry level of analysis and look at the innovation behaviour of firms with respect to the determinants and effects of non-technological innovations.

5 Determinants of Non-Technological Innovations

In this section we will analyse the determinants of marketing and organisational innovation activities of German firms during the three year period 2002 to 2004 and compare them with those of technological innovations. We will also look at the effects of combinations of technological and non-technological innovations.

The determinants of introducing non-technological innovations

Several potential factors that influence a firm’s decision to undertake non-technological or technological innovation activities will be investigated (see Cohen, 1995; Brouwer and Kleinknecht, 1996; Love and Roper, 1999):

A first group of potential determinants is the competitive environment a firm faces. The type and intensity of competition on a firm’s market has certainly an

impact on its innovation behaviour. Which intensity of competition provides more incentives for innovations has been widely discussed in the economic literature. Schumpeter (1942) argues that the monopoly provides the highest incentives for innovations; while Arrow (1962) regards perfect competition as best for innovation incentives. The arguments brought forward by both authors are more related to technological innovations, they can be extended to non-technological innovations, however. Marketing innovations for example can be a reaction to intensified competition, in order to sustain higher prices. Regardless of which strand of literature one follows, competition certainly influences the innovation behaviour. In contrast to many other studies which measure the intensity of competition at the industry level, we use the assessment of firms on the type and intensity of competition in their product market. These variables include the number of main competitors and six dummy variables which represent the market environment:[4]

- Competitors' behaviour is hard to foresee
- General demand development is hard to foresee
- Threat of entry of new competitors
- Short technology cycles
- Short product-life cycles
- Own products are easily substitutable with those of competitors

A second group of potential determinants are firm characteristics. The distinction between the competitive environment and a firm's characteristics is not always clear cut, because some of the firm's decisions influence the competitive environment it faces. An example for this is the export activities of a firm. Whether a firm exports or not is certainly a decision of the firm and not a fixed framework condition. By deciding to be active on foreign markets it nonetheless changes the competitive environment it has to face, because it no longer only competes with firms in the home market but also those in the foreign market. It thus has to structure its innovation processes in a way that allows it to address the needs of the foreign customers as well as the home customers.

The industry a firm is operating in is even more of a borderline case than the export status. It certainly is an item that characterises a firm, but it also determines the framework a firm has to operate in and can only be changes very rarely. It can even be interpreted as another indicator of competition and the type of technological opportunities a firm has.

The degree of diversification is another characteristic that may influence the innovation activities of firms. It can be measured with respect to a firm's products (share of sales with the most important product) and to the number of

4 These indicators are constructed from a set of questions on the market environment of a firm. These questions were not included in the standard CIS 4 questionnaire, but only in the German CIS 4 survey and correspond to a similar set of questions used in the Swiss innovation survey (Arvanitis and von Arx, 2004; Arvanitis et al., 2007).

customers (share of turnover with the three most important customers). The more diversified a firm is with respect to its products, the more opportunities it has to improve its existing products. It also has a higher incentive to develop and use a new marketing method if this increases the sales with various products and not just for a single or very few products. For the diversification of customers the arguments is similar, marketing innovations for example will have "a larger audience" if the firm serves more customers. Consequently, the incentives to develop these innovations will increase.

If a firm belongs to an enterprise group its innovation strategy and behaviour might very well differ from firms which are not part of a group. A reason for this may be that the headquarters assigns a specific task to a given firm, for example to adapt new products and distribution processes to the peculiarities of a certain market or to generate knowledge in-flows. These special tasks are likely to have an impact on the type of innovation activities a firm conducts or is supposed to conduct.

Finally we include three measures which are related to a firm's employees as potential determinants of its innovation behaviour. A first determinant is the number of employees as a measure of size. The expected effect is that the larger a firm, the larger the impact of an innovation and the larger the incentive to invest resources for their development. A reduction in the average production costs through process innovations, should for example lead to a larger amount of cost savings for a firm that produces a high quantity of a good affected by the innovation than for a small firm. Large firms have also higher incentives to streamline their workflows and production processes than small firms simply because inefficiencies in their workflows would have a greater impact than in a small firm. As a result, large firms should have higher incentives for innovations than small firms.

But not only should the number of employees have an impact on their innovation behaviour but also the composition of their employees. In particular the share of high-skilled labour is seen as an important determinant of innovation behaviour of firms. The share is supposed to measure the absorptive capacity of a firm, i.e. its ability to use and exploit external knowledge (Cohen and Levinthal, 1989; 1990). The ever increasing complexity of innovations makes it necessary for firms to use external knowledge in their innovation processes (e.g. Tsang, 2000). Thus, firms that have the ability to source external knowledge and incorporate into their own innovation processes have much more possibilities for product, process, marketing and organisational innovations than firms with less absorptive capacity.

A third potential determinant related to the employees of a firm is the labour productivity, measured as the share of turnover per employee.

In order to be able to identify the determinants of technological and non-technological innovations and to formally test whether the decisions to introduce

these two types of innovation are related we use a bivariate probit model, which has the following form:

$$techno\_innovation^{*} = \beta_1' X + \varepsilon_1$$

$$\text{with } techno\_innovation_i = \begin{cases} 1 \ \ if \ techno\_innovation_i^{*} > 0 \\ 0 \ \ otherwise \end{cases}$$

$$non\_techno\_innovation^{*} = \beta_1' X + \varepsilon_1$$

$$\text{with } non\_techno\_innovation_i = \begin{cases} 1 \ \ if \ non\_techno\_innovation_i^{*} > 0 \\ 0 \ \ otherwise \end{cases}$$

where the correlation of the error terms is not equal to zero:

$$Cov(\varepsilon_1, \varepsilon_2) = \rho_1$$

If the covariance matrix of the two error terms (Rho) is significant the two decisions can be assumed not to be independent of each other.

Another advantage of the bivariate probit is that it allows us to calculated several different marginal effects, like conditional marginal effects for having non-technological innovations given that a firm has already introduced technological innovations or the marginal effect for the probability of having both technological and non-technological innovations.

The results of the bivariate probit model (see Table 5-1) show that the determinants of technological and non-technological innovations are quite similar. Only the size of the effects and the level of significance (1%, 5%, 10%) differ slightly. The significance of the Rho, the measures for the correlation of the error terms of the two equations, furthermore indicates that the decisions to introduce non-technological and technological innovations are not independent of each other. This supports the view that technological and non-technological innovations are rather complementing each other and represent two different aspects of one activity. This result goes in line with the findings of Cozzarin and Perzival (2006) based on Canadian data.

As expected one of the most important factors that influence firms' innovation behaviour is the competitive environment. If the competitive environment of a firm can be characterised by fast changing technologies and short product life cycles, then the likelihood increases significantly that this firm introduces technological and/or non-technological innovations. For both variables the effect is stronger for technological innovations than for marketing and organisational innovations. The opposite is true for the factor "own products are easily substitutable with those of competitors". Its influence on non-technological innovations is stronger and more significant than its impact on the likelihood to introduce technological innovations.

Table 5-1: Determinants of the propensity of German firms to introduce innovations in 2002 to 2004 by type of innovation: Marginal effects of a bivariate probit models

	Non-technological Innovation	**Technological Innovation**	**Non-technological innovation conditional on having technological innovation**	**Technological innovation conditional on having non-technological innovation**
Number of employees (log)	0.054 **	0.042 **	0.041 **	0.027
	(0.019)	(0.021)	(0.017)	(0.019)
Number of employees (log, squared)	0.0004	0.003	-0.0003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
Share of high-skilled labour (%)	0.002 ***	0.003 ***	0.001 **	0.003 ***
	(0.0004)	(0.0005)	(0.0004)	(0.0004)
Labour Productivity (turnover per employee)	-0.006	-0.0004	-0.005	0.001
	(0.007)	(0.007)	(0.006)	(0.006)
Export activity (Dummy)	0.066 ***	0.068 ***	0.046 **	0.049 **
	(0.019)	(0.020)	(0.017)	(0.018)
Turnover share of product with the highest turnover (in %)	-0.001 *	-0.002 ***	-0.0003	-0.001 ***
	(0.0004)	(0.0004)	(0.0003)	(0.0003)
Share of turnover with 3 most important customers >50% (Dummy)	0.019 *	0.023 **	0.012	0.017 *
	(0.010)	(0.010)	(0.009)	(0.009)
Part of an enterprise group (Dummy)	0.039 **	0.020	0.031 **	0.011
	(0.018)	(0.018)	(0.016)	(0.016)
Location in East Germany (Dummy)	-0.027	0.011	-0.027 *	0.016
	(0.018)	(0.011)	(0.016)	(0.017)

Table 5-1: Ctd.

	Non-technological Innovation	Technological Innovation	Non-technological innovation conditional on having technological innovation	Technological innovation conditional on having non-technological innovation
Number of main competitors <5 (Dummy)	0.007 (0.010)	-0.021 ** (0.011)	0.011 (0.009)	-0.021 ** (0.010)
High uncertainty about competitors behaviour (Dummy)	-0.002 (0.011)	-0.006 (0.011)	-0.0003 (0.009)	-0.005 (0.010)
Threat of market position by entry of new competitors(Dummy)	0.006 (0.010)	-0.006 (0.011)	0.007 (0.009)	-0.007 (0.010)
Rapid technology change (Dummy)	0.044 *** (0.012)	0.090 *** (0.013)	0.021 * (0.011)	0.074 *** (0.012)
Short product-life cycles (Dummy)	0.042 *** (0.013)	0.049 *** (0.013)	0.028 ** (0.011)	0.036 ** (0.012)
Own products easy to substitute by competitors' products (Dummy)	0.032 *** (0.009)	0.018 * (0.010)	0.025 ** (0.008)	0.010 (0.009)
High uncertainty about demand (Dummy)	-0.009 (0.012)	-0.009 (0.012)	-0.006 (0.010)	-0.006 (0.011)
24 industry dummies	Yes	Yes	Yes	Yes
Number of observations	3,606			
X^2	862.21			
Log-Likelihood	-4,039.320			
Rho	0.414 ***			

Level of significance: * 10%, ** 5%, *** 1%. Robust standard errors in parenthesis.

Industries covered: NACE 10-45, 50-52, 60-74, 90, 92.1-92.2.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

The more concentrate a firm's sales are on one specific product group (i.e. the lower the degree of product diversification), the lower the likelihood that a firm introduces an innovation. This signifies that less diversified firms are less likely to introduce innovations than diversified ones. This statement is valid for product, process and marketing innovations. The likelihood for organisational innovations is not significantly affected by the degree of diversification of the products and services a firm sells. This indicates that less diversified firms have the same incentives to improve their processes through streamlining their work flows and improve their knowledge management systems or engaging in new external relations, as their more diversified competitors. One reason that firms are less likely to introduce technological and marketing innovations if they are less diversified may be that they are producing the (few) products they have with optimal (technological) processes that leave little or no room for improvements. We also find support for the argument presented above, that fewer products provide less incentives to develop and use new marketing methods.

A low degree of diversification of the demand side also inhibits innovation activities. The likelihood to introduce technological or non-technological innovations is significantly lower for firms which get a lot of their turnover from their three most important customers. Splitting up the innovators into the four types of innovation, we find that this is only the case for product and marketing innovations. Organisational and process innovation activities are not significantly reduced by a low degree of diversification on the demand side. This is evidence that well functioning and technological new processes and modes of organisation are important regardless of the fact that a firm serves one or many customers.

Further commonalities between the determinants of product and process and marketing and organisational innovations, are found for the size of the company, the export status and the share of highly qualified labour. All three factors influence a firm's decision to introduce innovations of both types positively. For the export intensity the coefficient is similar for technological and non-technological innovations. The share of high skilled labour has a higher coefficient in the equation for technological innovations than non-technological innovations.

One of the few differences between the determinants of technological and non-technological innovation arises for the number of main competitors. The more competitors a firm has the lower the likelihood that it introduces product and process innovations. This finding is robust to taking into account that the firm in question also introduced marketing and organisational innovations. The likelihood to introduce non-technological innovations itself is not influenced by the number of main competitors, however. That more competition leads to less technological innovations supports the view of Schumpeter that the more concentrated markets are the more incentives for innovation activities exist.

We also find differences between the determinants of technological and non-technological innovations for the variable "belonging to a group". This variable

only influences the decision to introduce marketing and organisational innovations positively. The positive and significant impact on non-technological innovations is not surprising. Effective and coordinated work flows and organisational structures are essential for the functioning of large firms and in particular large enterprise groups.

The method chosen (bivariate probit) allows us to analyse the determinants of introducing both groups of innovations, i.e. to introduce both technological and non-technological innovations. Since the determinants for each type separately and the conditional marginal effects are quite similar, this exercise does not lead to any surprising result.[5] We find significant positive effects for the number of employees, the share of high-skilled labour, belonging to a group und three indicators of the competitive environment – short technology cycles, short product-life cycles and own products are easily substitutable with those of competitors. A significant negative effect can be found for the two degrees of diversification.

Relation between technological and non-technological innovation

The results of the bivariate probit above already show that technological and non-technological innovation activities are related to each other. To investigate this relationship in more detail, we analyse the effect of certain innovation activities related to technological innovation activities on the likelihood to introduce non-technological innovations.[6] In order to be able to do that we reduce the sample to firms that introduced at least one product or process innovation during the three year period 2002-2004. This leaves us with 1,952 observations of firms with five or more employees from manufacturing and service industries.

The set of potential determinants described above is supplemented by including variables for the following innovation activities related to technological innovations:

- Innovation expenditure on activities related to product and process innovations as a share of turnover
- Innovation co-operation with external partners (dummy)
- Intramural (in-house) R&D activities (dummy)
- External R&D activities (dummy)
- Acquisition of machinery, equipment and software (dummy)
- Acquisition of other external knowledge (dummy)

5 The marginal effects of the bivariate probit for the likelihood to introduce both types of innovation are calculated as the weighted average of the conditional marginal effects, i.e. the marginal effect to introduce technological innovations conditional on having introduced non-technological innovations and the marginal effect to introduce non-technological innovations conditional on having introduced technological innovations.

6 Note, we will only look at the impact of technological innovation activities on non-technological innovation activities and not vice versa.

- Training for product and process innovations (dummy)
- Market introduction of product innovations (dummy)
- Other preparations, e.g. procedures and technological preparation to implement new or significantly improved products and processes that are not covered elsewhere (dummy).

Again we will use a bivariate probit model to be able to test the independence of the decisions to introduce marketing or organisational innovations. Like in the estimations of the determinants of non-technological and technological innovations we obtain a significant Rho value, which indicates that the decisions for the two types of innovation are not independent.

The analysis shows that technological innovation activities induce marketing and organisational innovations (see Table 5-2). Organisational innovations are in particular affected by product and process innovation activities.

In more detail, the results show, that co-operating firms are more likely to introduce organisational innovations. The marginal effect of the relationship is estimated at 0.075, i.e. the likelihood to introduce organisational innovations is 7.5 percentage points higher for co-operating firms than for non-cooperating firms. One reason for this finding is, that significant changes in external relationships regardless of whether they occur as a result of innovation activities or not, are part of the definition of organisational innovations. This more technical explanation is not the only one, however. The relationship might also arise because innovation co-operation is usually linked to knowledge acquisition, which becomes more and more important as argued above (see also Cassiman and Veugelers, 2002; Abramovsky et al., 2005). To effectively use knowledge in-flows which result from co-operation activities and to prevent involuntary spillovers of valuable knowledge to the co-operation partner, firms need a well functioning knowledge management system and an adequate organisational structure. As a result, newly established and already existing relations with external partners provide an incentive to introduce organisational innovations.

An even stronger relationship between technological innovation activities and non-technological innovations can be found for the innovation activities other preparations, acquisition of machinery, and training. The marginal effects are above 10 percentage points for the two former items and 9.1 percentage points for training. The findings indicate that the development and introduction of product and process innovations are closely related to internal work flows and non-technological processes inside a firm. What is more, our results show that the organisation of a firm is innovatively modified in the course of the development and introduction of product and process innovations. The relationship between organisational and technological innovations is retained if we control for the fact that a firm has also introduced a marketing innovation between 2004 and 2006 only some of the marginal effects are smaller (see conditional marginal effects in Table 5-2).

Table 5-2: Effects of technological innovation activities on the introduction of non-technological innovations by German firms 2002 to 2004: Marginal effects of bivariate probit models

Technological innovation activities	**Marketing Innovation**	**Organisational Innovation**	**Marketing Innovation conditional on having Organisational Innovation**	**Organisational Innovation conditional on having Marketing Innovation**
Innovation-intensity (%)	-0.177	0.014	-0.190	0.040
	(0.126)	(0.121)	(0.133)	(0.100)
Innovation-intensity, squared	0.077	0.011	0.080	-0.003
	(0.062)	(0.061)	(0.080)	(0.050)
Co-operation with external partners	0.003	0.075**	-0.009	0.061**
(Dummy)	(0.030)	(0.028)	(0.032)	(0.022)
In-house R&D (Dummy)	-0.026	-0.002	-0.028	0.003
	(0.031)	(0.029)	(0.033)	(0.024)
Extramural R&D (Dummy)	0.025	0.060**	0.017	0.045**
	(0.029)	(0.027)	(0.030)	(0.022)
Acquisition of machinery, equipment,	0.036	0.104***	0.023	0.083***
software (Dummy)	(0.030)	(0.030)	(0.032)	(0.026)
Acquisition of other external knowledge	0.095***	0.060**	0.090***	0.035*
(Dummy)	(0.028)	(0.026)	(0.028)	(0.021)
Training for technological innovation	0.005	0.091***	-0.009	0.076***
(Dummy)	(0.07)	(0.026)	(0.029)	(0.022)
Market introduction of product	0.122***	0.027	0.126***	0.003
innovations (Dummy)	(0.026)	(0.025)	(0.027)	(0.021)
Other preparation for technological	0.177***	0.102***	0.176***	0.054**
innovation (Dummy)	(0.026)	(0.028)	(0.028)	(0.024)

Table 5-2: Ctd.

Number of Observations	1,952
X^2	463.79
Log-likelihood	-2,220.96
Rho	0.278 ***

Level of significance: * 10%, ** 5%, *** 1%. Robust standard errors in parenthesis.

The model includes all the other variables included in the empirical model above (see Table 5-1 for details): Correlation tables are available from the authors upon request.

Industries covered: NACE 10-45, 50-52, 60-74, 90, 92.1-92.2.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

Product and process innovation activities do not just influence the decision to introduce organisational innovations but also the decision to introduce marketing innovations. There exist some differences in the determinants of the two types of innovation, however. Cooperation with external partners, extramural R&D, training and the acquisition of machinery, equipment and software all have a significantly positive effect on the likelihood that a firm introduces organisational innovations, but not on the likelihood that it introduces marketing innovations. These are all areas of product and process innovation activities that are not closely related to marketing activities, but closely related to external relations and internal knowledge and work flows. The technological innovation activities more closely related to marketing – market introduction of innovations and other preparations for the introduction of innovations - have a highly significant impact on the likelihood that a firm introduces marketing innovations, as expected. The market introduction of an innovative product also induces marketing innovations. This indicates that firms do not use their established sales, distribution and marketing methods or designs and packaging to promote the sale of new products but innovative ones.

It is surprising that the innovation intensity and in-house R&D activities have no effect on the likelihood that a firm introduces marketing and/or organisational innovations. However, because innovation activities related to technological activities for which the innovation expenditure is spend have a positive effect on the likelihood of introducing non-technological innovations, these expenditures have an indirect effect on marketing and organisational innovations.

In summary, the bivariate probit analysis provides further evidence on a link between technological and non-technological innovation activities, in the sense that product and process innovations induce marketing and organisational innovations. Future research on the direction of these effects is necessary, in order to determine whether technological innovations induce non-technological ones or vice versa. It is also conceivable that effects in both directions are at work at the same time.

6 Effects of Non-Technological Innovations

In this section, we analyse the effects that result from marketing and organisational. Effects of innovations can be evaluated along several dimensions, e.g. the direct effects on immediate objectives associated with an innovation (e.g. increasing sales with new products or reducing costs) or indirect effects on firm performance. In this section of the paper we consider three types of effects: Direct effects of organisational innovation can be analysed through a respective question in the CIS IV questionnaire. For marketing innovations, no such question was included, however. Indirect effects are measured by estimating the

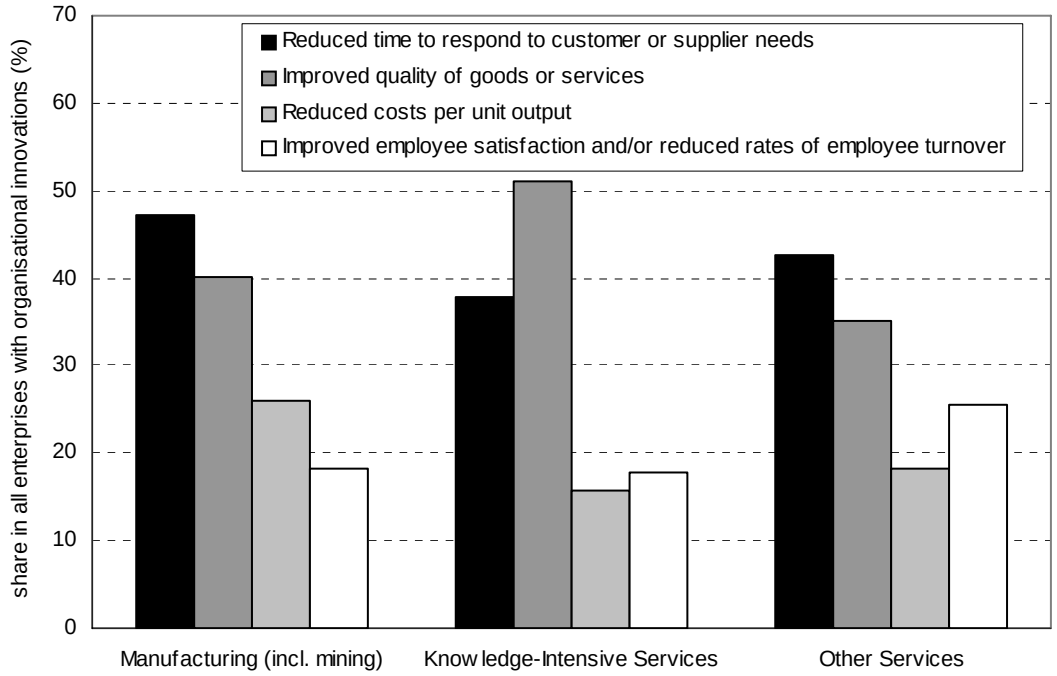
marginal effect of marketing and organisational effects on a firm's profit margin, while controlling for several other determinants of firm profitability, including technological innovation activities. Finally, we also investigate the effects of non-technological innovation on the success with product and process innovation. Product innovation success is measured by the sales share of new products while process innovation success refers to the unit cost reduction achieved by them. The basic research question here is whether firms that conduct non-technological innovations in addition to product or process innovation are more successful with the latter compared to firms with solely technological innovation activities.

Direct effects of organisational innovations

Direct effects of organisational innovations are measured by an evaluation of the relevance of four types of potential effects by those firms that have introduced an organisational innovation during 2002 and 2004. These four potential effects are a reduction of response time with respect to customer and supplier needs, an increase in product quality, a reduction of unit costs, and an improvement of employee satisfaction. The relevance of these effects was evaluated on a four-point Likert scale, ranging from high to not relevant. We focus on those effects that were ranked "high" by the responding firms. Firm answers were weighted in order to derive representative results.

Organisational innovations had a strong impact on the time it takes to respond to customers' and suppliers' needs. 47% of all organisational innovators in manufacturing, and 42% in other services report this effect as highly important (Figure 6-1). For knowledge intensive service firms the most common impact of organisational innovations is an improvement in the quality of the services they offer (51%), while 38% report reduced response times. Cost reductions, which is typically the most important effect of process innovations, is of rather limited relevance as an outcome of organisational innovation. 26% of all organisational innovators in manufacturing say that they could decrease their unit costs through changes in organisational routines or structures.

Figure 6-1: Share of firms with organisational innovations between 2002 and 2004 for which organisational innovations had the following strong impact (%)



Source: ZEW (2005): Mannheim Innovation Panel; weighted data; firms with 5 or more employees.

In the service sector, this share is even lower (16% in knowledge-intensive services and 19% in other services). Improving employee satisfaction or reducing the rate of employee turnover is also of subordinated importance: 18% of organisational innovators in manufacturing and in knowledge-intensive services, and 26% in other services report this effect as highly important.

Indirect effects on profit margin

In order to assess the indirect effects of organisational and marketing innovations, we estimate the impact of non-technological innovations introduced between 2002 and 2004 on a firm's profit margin in 2004. The profit margin is defined as profits before taxes as a share of total sales and is measured on an ordinal level, distinguishing seven classes (<0%, 0 to <2%, 2 to <4%, 4 to <7%, 7 to <10%, 10 to <15%, 15% and more). We run interval regressions, i.e. ordered probit models with known thresholds, to estimate both the separate impact of organisational and marketing innovations as well as the impact when these two types of innovations occur in combination with product and process innovations.

A fundamental issue when assessing the impact of innovation activities on firm performance is the lag between innovation and performance (see e.g. Belderbos et al., 2004b). Since no panel data on non-technological innovations exist, it is not possible to control for or test different lag structures. The estimated impacts

of marketing and organisation innovations on firm performance are thus the immediate effects or the effects that are attributable to innovations introduced no longer than three years ago. It is also possible, however, that the measures of marketing and organisational innovations for the period 2002 to 2004 measure a general tendency of a given firm to introduce non-technological innovations. In that case we will not only measure the immediate impact, but an average of immediate impacts and impacts of past innovations. Table 6-1 shows the main results with respect to the marginal effects of various innovation activities (in terms of a successful introduction of product, process, marketing or organisational innovation) and the combination among them on the profit margin. The reference group for the interval regressions are firms without any successfully introduced innovations.

The results obtained with the interval regression underscore the importance of technological innovations for the economic success of a firm. This positive effect is found both in case a firm introduced only technological innovations as well as in case it combined technological with organisational and marketing innovations. What is more, product and process innovations have separately identifiable positive and significant effects. This effect is slightly higher for product innovations than for process innovations.

A surprising result is that firms that only introduce technological innovations and no non-technological ones perform better in terms of profit margin than firms that introduce combinations of the two types. The difference between the two coefficients is quite small and insignificant, however. Only introducing non-technological has no significant impact on profit margins. The analysis in the next section will show that firms which combine technological with non-technological innovations have higher sales with market novelties and higher cost reductions with process innovations than firms that introduce technological innovations only. Because the innovative success of firms should translate into economic success over time, the small difference in the coefficient could be the result of a lag between the innovative success of firms and its impact on the economic success in 2004.

Splitting up the combinations of non-technological and technological innovations into two groups, technological innovations with marketing innovations and technological innovations with organisational innovations yields that product and process innovations without non-technological innovations have the same significantly positive effect on profit margins as the combination of technological innovations with organisational innovations. Another regression shows that the combination of process innovations with organisational innovations does not significantly influence the level of profit margins, but product innovations in combination with organisational innovations do so. Technological innovations in combination with marketing innovations do not affect profit margins significantly.

Table 6-1: Impact of different types of innovations introduced between 2002 and 2004 on the profit margin of German firms in 2004: results of interval regressions

	Model				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
At least one marketing or organisational innovation	-0.242				
At least one product or process innovation	0.888 **				
At least one marketing innovation		-0.268			
At least one organisational innovation		0.008			
At least one product innovation		0.725 **			
At least one process innovation		0.704 **			
Technological innovations only			0.846 **	0.905 **	0.972 **
Non-technological innovations only			0.410	-0.229	-0.199
Technological and non-technological innovations			0.639 **		
Technological and marketing innovations				-0.071	
Technological and organisational innovations				0.855***	
Marketing and product innovations					-0.263
Marketing and process innovations					0.322
Organisational and product innovations					0.873***
Organisational and process innovations					0.314
Number of observations	2,962	2,962	2,962	2,962	2,962
X^2	219.45	230.63	219.68	223.91	231.70
Log Likelihood	-5,783	-5,779	-5,783	-5,782	-5,779

Level of significance: * 10%, ** 5%, *** 1%.

The full regression results for each regression are presented in the Annex. Correlation tables are available from the authors upon request.

Industries covered: NACE 10-45, 50-52, 60-74, 90, 92.1-92.2.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

Indirect effects on product and process innovation success

Innovation management literature suggests that direct economic success of product and process innovation (such as sales with new products and cost reductions resulting from new processes) not only depends upon the product and process innovation itself, but also on accompanying adjustment in the organisation of a firm and - with respect to product innovation - in adjustments in marketing methods. In the following we test whether firms that combine technological innovation with non-technological innovation perform better in terms of product and process innovation success indicators. For this purpose we use the sales share from all new products as well as the sales share from new-to-the-market products ("market novelties", i.e. new products that have not been offered to the market by any other firm before) as product innovations success, and the share of unit costs that could be saved through the implementation of new processes as process innovation success. Both indicators are measured for the year 2004 and refer to product and process innovations that have been introduced in the three year period 2002 to 2004. We estimate three models: the first model measures the aggregate effect of introducing non-technological innovations on the success with product and process innovations. In a second step, we differentiate by the type of non-technological innovation. Finally, we distinguish whether a firm has introduced only marketing, only organisational or both types jointly with product or process innovations.

The success of firms with product and process innovations is only partially influenced by non-technological innovation activities, as the results of our tobit estimations show (see Table 6-2). The share of turnover that can be attributed to market novelties is the only output measure for technological innovations that is influenced by non-technological innovation. Cost reduction through process innovation and the sales share from all types of new products are not influenced by the introduction of non-technological innovations in general. However, some combinations of product and process innovation with marketing and organisational innovation have a positive impact on the innovation success. For the share of sales with product innovations, however, no combination with any of the two types of non-technological innovation has a significant impact.[7]

If a firm introduces marketing innovations in addition to novel product innovations its share of turnover with these market novelties increases significantly. The introduction of market novelties, which are typically more complex than regular product innovations and usually require more explanation than other products, seem to benefit from the usage of innovative marketing methods, including new packaging or design. Only introducing marketing and product innovations does, however, not increase the share of turnover with market novelties. The positive effect can only be found for a combination of

7 Note that the reference group for these estimations are those enterprises that have only introduced product innovations, but no non-technological innovation.

marketing, organisational and product innovation. This indicates that in addition to innovative marketing, the internal work and knowledge flows have to be changed in order to be successful with completely new products.

Table 6-2: Impact of different types of innovations on the success of German firms with product and process innovations: Marginal Effects of tobit models

Model		Share of turnover from product innovations[1)]	Share of turnover from market novelties[2)]	Cost reduction share as a result of process innovation[3)]
(1)	At least one marketing or organisational innovation	0.994	1.787 **	1.077
(2)	At least one marketing innovation	0.807	1.704 **	0.613
	At least one organisational innovation	0.470	1.075	1.071 *
(3)	Marketing innovation but no organisational innovation	1.276	1.619	0.067
	Organisational innovation but no marketing innovation	0.681	1.036	0.867
	Both organisational and marketing innovation	1.310	2.771 ***	1.616 **

Level of significance: * 10%, ** 5%, *** 1%.
1) Models estimated for product innovators, only.
2) Models estimated for firms with market novelties, only.
3) Models estimated for process innovators, only.

The full regression results for each regression are presented in the Annex. Correlation tables are available from the authors upon request.

Industries covered: NACE 10-45, 50-52, 60-74, 90, 92.1-92.2.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

The findings on cost reductions through process innovations are similar. We find a positive impact of organisational innovations on the cost reduction effects of process innovation. This is due to the fact that firms that introduce both types of non-technological innovations in addition to process innovations outperform those firms that have introduced a new process without any organisational or marketing innovation.

7 Conclusion

In this paper we have shown that technological and non-technological innovations are linked to each other both at the sector level and at the firm level. We could also show that no one-to-one relationship between the two types of innovation exists, in the sense that each product innovation is related to a marketing innovation. The results show that firms have an incentive to undertake non-technological innovation activities if they introduce technological innovations. This indicates that determinants of product and process innovations also affect the propensity to introduce non-technological innovations.

In the second part of the study we find that technological innovators that combine their product and process innovations with both marketing and organisational innovations perform better in terms of sales with market novelties and cost reductions as a result of process innovations than those focusing only on technological innovations. No significantly positive effect can be found, however, when combining product innovations only with marketing innovations (but not with organisational innovations at the same time), and process innovations only with organisational innovations.

A combination of technological with non-technological innovations also has a positive impact on the profit margin of firms. Surprisingly enough this effect can be solely attributed to the combination of organisational and product innovation. No other combination of technological and non-technological innovations leads to a significant higher firm performance. What is more, the highest coefficients in all regression on a firm's profit margin can be found for firms that introduced technological innovations without non-technological ones.

Future studies will have to address several caveats of our analysis. A first issue is to investigate the direction of the link between technological and non-technological innovations. We only established that there is an effect of product and process innovations on non-technological innovation activities, but did not investigate the opposite direction. Secondly, the intensity of the link should be investigated. Does a single technological innovation lead to a single non-technological innovation or many? The answer to this question would require data beyond that what is gathered through the CIS today. Finally, the lag structure between the introduction of a non-technological innovation and its impact on firm performance or innovation success with new products or processes needs to be investigated. This will be possible if a question on non-technological innovations is retained in future community innovation surveys so that longitudinal data is available.

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9 Appendix

Table A1: Effects of technological innovation activities on the introduction of non-technological innovations by German firms 2002 to 2004: Parameter estimates, standard errors and z values of bivariate probit models

	Marketing Innovation				**Organisational Innovation**			
	Coef.	Std. Err.	z value		Coef.	Std. Err.	z value	
Innovation Intensity	-0.478	0.341	-1.40		0.039	0.345	0.11	
Innovation Intensity, squared	0.207	0.168	1.23		0.031	0.175	0.18	
Co-operation with external partners	0.008	0.081	0.09		0.221	0.084	2.62	***
Innovation Activity: in-house R&D	-0.071	0.084	-0.85		-0.005	0.082	-0.06	
Innovation Activity: external R&D	0.066	0.078	0.85		0.173	0.081	2.15	**
Innovation Activity: aquisition of machinery, software	0.100	0.083	1.20		0.288	0.080	3.62	***
Innovation Activity: aquisition of external knowledge	0.251	0.072	3.50	***	0.175	0.077	2.27	**
Innovation Activity: training	0.014	0.073	0.19		0.257	0.071	3.61	***
Innovation Activity: market introduction	0.331	0.071	4.66	***	0.077	0.073	1.06	
Innovation Activity: other preparation activity	0.505	0.080	6.34	***	0.285	0.076	3.76	***
No. of employees (log)	-0.140	0.067	-2.11	**	0.021	0.080	0.26	
No. of employees (log), squared	0.009	0.006	1.41		0.007	0.009	0.80	
Share of high-skilled labour	-0.001	0.002	-0.40		-0.001	0.002	-0.35	
Turnover per employee	0.039	0.051	0.77		-0.015	0.056	-0.27	
Export activity	0.183	0.082	2.21	**	0.025	0.082	0.30	
Turnover share with main product	-0.001	0.001	-0.88		0.002	0.001	1.68	*
Share of sales with 3 most important customers >50%	0.093	0.039	2.35	**	-0.030	0.040	-0.76	
Part of an enterprise group	0.141	0.069	2.03	**	0.129	0.069	1.89	*
No. of main competitors <5	-0.082	0.040	-2.06	**	0.050	0.040	1.23	
High uncertainty about competitors' actions	-0.027	0.041	-0.65		-0.016	0.042	-0.39	
Threat by entry of new competitors	0.081	0.040	2.02	**	-0.043	0.040	-1.06	
Rapid changes in technology	-0.058	0.046	-1.28		0.054	0.047	1.16	
Short product life cycles	0.092	0.046	1.99	**	0.040	0.048	0.84	
Own products easy to substitute by competitors' products	0.071	0.039	1.83	*	-0.003	0.039	-0.08	
High uncertainty about development of demand	0.023	0.044	0.51		-0.010	0.045	-0.23	
Location in East Germany	0.005	0.071	0.08		-0.174	0.071	-2.46	**
Food/Beverages/Tobacco	0.995	0.404	2.46	**	-0.740	0.441	-1.68	*
Textiles/Clothing/Leather	0.432	0.410	1.06		-0.397	0.451	-0.88	

Table A1: Ctd.

	Marketing Innovation				Organisational Innovation			
	Coef.	Std. Err.	z value		Coef.	Std. Err.	z value	
Wood/Paper/Printing	0.790	0.379	2.09	**	-0.746	0.417	-1.79	*
Chemicals/Pharmaceuticals/Petroleum	0.174	0.381	0.46		-0.677	0.421	-1.61	
Rubber/Plastics	0.316	0.388	0.82		-0.437	0.426	-1.03	
Non-metallic Mineral Products	0.288	0.415	0.69		-1.082	0.452	-2.40	**
Metals	0.005	0.375	0.01		-0.651	0.413	-1.58	
Mechanical Engineering	0.009	0.376	0.02		-0.692	0.417	-1.66	*
Electrical and Electronics	0.015	0.381	0.04		-0.800	0.420	-1.91	*
Instruments	0.219	0.378	0.58		-1.106	0.417	-2.65	***
Vehicles	-0.090	0.408	-0.22		-0.472	0.449	-1.05	
Furniture/Sports Goods/Toys (incl. Recycling)	0.256	0.409	0.62		-0.575	0.447	-1.29	
Wholesale Trade	0.484	0.403	1.20		0.064	0.446	0.14	
Retail Trade/Repair of Vehicles	0.438	0.500	0.88		-0.091	0.569	-0.16	
Transport/Post	0.632	0.388	1.63		-0.194	0.429	-0.45	
Financial Intermediation	0.746	0.397	1.88	*	-0.219	0.441	-0.50	
Computer/Telecommunication Services	0.513	0.389	1.32		-0.647	0.429	-1.51	
Technical/R&D Services	-0.002	0.385	0.00		-0.476	0.421	-1.13	
Consulting/Advertising	0.302	0.403	0.75		-0.106	0.445	-0.24	
Producer Services/Refuse Disposal	0.482	0.396	1.22		-0.359	0.429	-0.83	
Real Estate/Renting	0.497	0.466	1.07		-0.681	0.489	-1.39	
Energy/Water Supply	0.007	0.423	0.02		-0.200	0.453	-0.44	
Construction	0.465	0.480	0.97		-0.599	0.510	-1.17	
Motion Picutre/Broadcasting	1.172	0.478	2.45	**	-0.603	0.502	-1.20	
Constant	-1.393	0.453	-3.07	***	-0.177	0.492	-0.36	
No. of observations					1,952			
Wald Chi^2					463.8			
Log Likelihood					-2,221.0			
Rho					0.278			

Level of significance: * 10%, ** 5%, *** 1%.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

Table A2a: Impact of non-technological and technological innovations introduced between 2002 and 2004 on the profit margin of German firms in 2004: Parameter estimates, standard errors and z values of interval regressions

	Coefficient	Standard Error	z value	
Non-technological Innovation	-0.242	0.242	-1.00	
Technological Innovation	0.888	0.260	3.41	***
No. of employees (log)	-1.014	0.260	-3.91	***
No. of employees (log), squared	0.096	0.026	3.72	***
R&D Intensity	-2.474	4.125	-0.60	
R&D Intensity, squared	-6.197	5.875	-1.05	
Export share	2.224	0.577	3.85	***
Share of high-skilled labour	-0.003	0.007	-0.38	
Co-operation with external partners	-0.628	0.353	-1.78	*
Part of an enterprise group	0.294	0.237	1.24	
Location in East Germany	-0.313	0.240	-1.31	
Food/Beverages/Tobacco	-2.377	1.093	-2.18	**
Textiles/Clothing/Leather	-2.752	1.159	-2.37	**
Wood/Paper/Printing	-2.419	1.062	-2.28	**
Chemicals/Pharmaceuticals/Petroleum	-0.923	1.126	-0.82	
Rubber/Plastics	-1.171	1.144	-1.02	
Non-metallic Mineral Products	-1.609	1.211	-1.33	
Metals	-2.252	1.032	-2.18	**
Mechanical Engineering	-1.874	1.069	-1.75	*
Electrical and Electronics	-1.481	1.094	-1.35	
Instruments	-0.059	1.155	-0.05	
Vehicles	-3.466	1.159	-2.99	***
Furniture/Sports Goods/Toys (incl. Recycling)	-3.005	1.202	-2.50	**
Wholesale Trade	-2.769	1.100	-2.52	**
Retail Trade/Repair of Vehicles	-3.822	1.137	-3.36	***
Transport/Post	-2.728	1.059	-2.58	***
Financial Intermediation	2.347	1.166	2.01	**
Computer/Telecommunication Services	-2.091	1.161	-1.80	*
Technical/R&D Services	-1.386	1.129	-1.23	
Consulting/Advertising	0.971	1.237	0.79	
Producer Services/Refuse Disposal	-0.579	1.079	-0.54	
Real Estate/Renting	-1.087	1.385	-0.78	
Energy/Water Supply	0.829	1.149	0.72	
Construction	-2.984	1.158	-2.58	***
Motion Picutre/Broadcasting	-0.737	1.512	-0.49	
Constant	8.065	1.139	7.08	***
Ln(sigma)	1.732	0.018	94.89	***
Sigma	5.652	0.103	5.45	***
No. of observations		2,962		
Wald Chi^2		219.5		
Log Likelihood		-5,783.5		

Level of significance: * 10%, ** 5%, *** 1%.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

Table A2b: Impact of marketing, organisational, product and process innovations introduced between 2002 and 2004 on the profit margin of German firms in 2004: Parameter estimates, standard errors and z values of interval regressions

	Coefficient	Standard Error	z value	
Marketing Innovation	-0.268	0.263	-1.02	
Organisational Innovation	0.008	0.238	0.03	
Product Innovation	0.725	0.265	2.74	***
Process Innovation	0.704	0.257	2.74	***
No. of employees (log)	-1.019	0.258	-3.94	***
No. of employees (log), squared	0.093	0.026	3.60	***
R&D Intensity	-3.083	4.106	-0.75	
R&D Intensity, squared	-5.499	5.843	-0.94	
Export share	2.187	0.577	3.79	***
Share of high-skilled labour	-0.002	0.007	-0.37	
Co-operation with external partners	-0.758	0.353	-2.15	**
Part of an enterprise group	0.288	0.237	1.22	
Location in East Germany	-0.311	0.240	-1.30	
Food/Beverages/Tobacco	-2.366	1.093	-2.16	**
Textiles/Clothing/Leather	-2.735	1.156	-2.37	**
Wood/Paper/Printing	-2.412	1.063	-2.27	**
Chemicals/Pharmaceuticals/Petroleum	-0.948	1.123	-0.84	
Rubber/Plastics	-1.256	1.144	-1.10	
Non-metallic Mineral Products	-1.635	1.207	-1.35	
Metals	-2.272	1.031	-2.20	**
Mechanical Engineering	-1.907	1.067	-1.79	*
Electrical and Electronics	-1.532	1.091	-1.40	
Instruments	-0.019	1.153	-0.02	
Vehicles	-3.528	1.156	-3.05	***
Furniture/Sports Goods/Toys (incl. Recycling)	-3.013	1.200	-2.51	**
Wholesale Trade	-2.735	1.098	-2.49	**
Retail Trade/Repair of Vehicles	-3.777	1.137	-3.32	***
Transport/Post	-2.745	1.057	-2.60	***
Financial Intermediation	2.265	1.167	1.94	*
Computer/Telecommunication Services	-2.118	1.158	-1.83	*
Technical/R&D Services	-1.444	1.127	-1.28	
Consulting/Advertising	0.903	1.237	0.73	
Producer Services/Refuse Disposal	-0.584	1.076	-0.54	
Real Estate/Renting	-1.102	1.385	-0.80	
Energy/Water Supply	0.783	1.148	0.68	
Construction	-3.005	1.156	-2.60	***
Motion Picutre/Broadcasting	-0.745	1.513	-0.49	
Constant	8.032	1.137	7.06	***
Ln(sigma)	1.731	0.018	94.85	***
Sigma	5.644	0.103	5.45	***
No. of observations		2,962		
Wald Chi^2		230.6		
Log Likelihood		-5,779.4		

Level of significance: * 10%, ** 5%, *** 1%.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

Table A2c: Impact of different combinations of non-technological and technological innovations introduced between 2002 and 2004 on the profit margin of German firms in 2004: Parameter estimates, standard errors and z values of interval regressions

	Coefficient	Standard Error	z value	
Technological and Non-technological Innovation	0.639	0.312	2.05	**
Technological Innovation only	0.846	0.390	2.17	**
Non-technological Innovation only	-0.275	0.335	-0.82	
No. of employees (log)	-1.013	0.259	-3.90	***
No. of employees (log), squared	0.096	0.026	3.72	***
R&D Intensity	-2.474	4.125	-0.60	
R&D Intensity, squared	-6.194	5.876	-1.05	
Export share	2.226	0.578	3.85	***
Share of high-skilled labour	-0.002	0.007	-0.37	
Co-operation with external partners	-0.632	0.355	-1.78	*
Part of an enterprise group	0.294	0.237	1.24	
Location in East Germany	-0.313	0.240	-1.30	
Food/Beverages/Tobacco	-2.375	1.093	-2.17	**
Textiles/Clothing/Leather	-2.746	1.160	-2.37	**
Wood/Paper/Printing	-2.417	1.062	-2.28	**
Chemicals/Pharmaceuticals/Petroleum	-0.919	1.126	-0.82	
Rubber/Plastics	-1.168	1.144	-1.02	
Non-metallic Mineral Products	-1.601	1.212	-1.32	
Metals	-2.249	1.032	-2.18	**
Mechanical Engineering	-1.872	1.070	-1.75	*
Electrical and Electronics	-1.478	1.094	-1.35	
Instruments	-0.054	1.156	-0.05	
Vehicles	-3.465	1.159	-2.99	***
Furniture/Sports Goods/Toys (incl. Recycling)	-3.000	1.202	-2.50	**
Wholesale Trade	-2.766	1.100	-2.51	**
Retail Trade/Repair of Vehicles	-3.817	1.138	-3.36	***
Transport/Post	-2.727	1.059	-2.57	***
Financial Intermediation	2.348	1.166	2.01	**
Computer/Telecommunication Services	-2.087	1.161	-1.80	*
Technical/R&D Services	-1.383	1.130	-1.22	
Consulting/Advertising	0.973	1.237	0.79	
Producer Services/Refuse Disposal	-0.574	1.079	-0.53	
Real Estate/Renting	-1.081	1.384	-0.78	
Energy/Water Supply	0.834	1.150	0.73	
Construction	-2.978	1.160	-2.57	***
Motion Picutre/Broadcasting	-0.732	1.512	-0.48	
Constant	8.075	1.142	7.07	***
Ln(sigma)	1.732	0.018	94.89	***
Sigma	5.652	0.103	5.45	***
No. of observations		2,962		
Wald Chi^2		219.7		
Log Likelihood		-5,783.5		

Level of significance: * 10%, ** 5%, *** 1%.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

Table A2d: Impact of different combinations of marketing, organisational and technological innovations introduced between 2002 and 2004 on the profit margin of German firms in 2004: Parameter estimates, standard errors and z values of interval regressions

	Coefficient	Standard Error	z value	
Technological and Marketing Innovation	-0.071	0.300	-0.24	
Technological and Organisational Innovation	0.855	0.299	2.86	***
Technological Innovation only	0.905	0.377	2.40	**
Non-technological Innovation only	-0.229	0.325	-0.70	
No. of employees (log)	-1.027	0.259	-3.97	***
No. of employees (log), squared	0.096	0.026	3.73	***
R&D Intensity	-2.529	4.104	-0.62	
R&D Intensity, squared	-6.134	5.859	-1.05	
Export share	2.251	0.576	3.91	***
Share of high-skilled labour	-0.003	0.007	-0.39	
Co-operation with external partners	-0.689	0.355	-1.94	*
Part of an enterprise group	0.291	0.237	1.23	
Location in East Germany	-0.307	0.240	-1.28	
Food/Beverages/Tobacco	-2.320	1.099	-2.11	**
Textiles/Clothing/Leather	-2.704	1.160	-2.33	**
Wood/Paper/Printing	-2.349	1.065	-2.21	**
Chemicals/Pharmaceuticals/Petroleum	-0.891	1.127	-0.79	
Rubber/Plastics	-1.125	1.147	-0.98	
Non-metallic Mineral Products	-1.565	1.213	-1.29	
Metals	-2.239	1.032	-2.17	**
Mechanical Engineering	-1.870	1.070	-1.75	*
Electrical and Electronics	-1.454	1.094	-1.33	
Instruments	0.010	1.158	0.01	
Vehicles	-3.458	1.160	-2.98	***
Furniture/Sports Goods/Toys (incl. Recycling)	-2.972	1.203	-2.47	**
Wholesale Trade	-2.757	1.100	-2.51	**
Retail Trade/Repair of Vehicles	-3.761	1.139	-3.30	***
Transport/Post	-2.721	1.060	-2.57	***
Financial Intermediation	2.349	1.167	2.01	**
Computer/Telecommunication Services	-2.072	1.160	-1.79	*
Technical/R&D Services	-1.386	1.129	-1.23	
Consulting/Advertising	0.970	1.238	0.78	
Producer Services/Refuse Disposal	-0.543	1.080	-0.50	
Real Estate/Renting	-1.039	1.388	-0.75	
Energy/ Water Supply	0.841	1.150	0.73	
Construction	-2.941	1.161	-2.53	**
Motion Picutre/Broadcasting	-0.677	1.513	-0.45	
Constant	8.053	1.140	7.06	***
Ln(sigma)	1.731	0.018	94.90	***
Sigma	5.649	0.103	5.45	***
No. of observations		2,962		
Wald Chi^2		223.9		
Log Likelihood		-5,781.5		

Level of significance: * 10%, ** 5%, *** 1%.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

Table A2e: Impact of different combinations of marketing, organisational, product and process innovations introduced between 2002 and 2004 on the profit margin of German firms in 2004: Parameter estimates, standard errors and z values of interval regressions

	Coefficient	Standard Error	z value	
Product and Marketing Innovation	-0.263	0.421	-0.63	
Process and Marketing Innovation	0.322	0.478	0.67	
Product and Organisational Innovation	0.873	0.338	2.59	***
Process and Organisational Innovation	0.314	0.343	0.91	
Technological Innovation only	0.972	0.368	2.65	***
Non-technological Innovation only	-0.200	0.317	-0.63	
No. of employees (log)	-0.999	0.258	-3.87	***
No. of employees (log), squared	0.091	0.026	3.54	***
R&D Intensity	-2.776	4.100	-0.68	
R&D Intensity, squared	-5.862	5.857	-1.00	
Export share	2.216	0.576	3.85	***
Share of high-skilled labour	-0.003	0.007	-0.42	
Co-operation with external partners	-0.774	0.355	-2.18	**
Part of an enterprise group	0.278	0.236	1.18	
Location in East Germany	-0.311	0.240	-1.30	
Food/Beverages/Tobacco	-2.350	1.098	-2.14	**
Textiles/Clothing/Leather	-2.694	1.158	-2.33	**
Wood/Paper/Printing	-2.327	1.064	-2.19	**
Chemicals/Pharmaceuticals/Petroleum	-0.895	1.126	-0.79	
Rubber/Plastics	-1.127	1.146	-0.98	
Non-metallic Mineral Products	-1.591	1.212	-1.31	
Metals	-2.204	1.034	-2.13	**
Mechanical Engineering	-1.893	1.069	-1.77	*
Electrical and Electronics	-1.469	1.093	-1.34	
Instruments	0.022	1.158	0.02	
Vehicles	-3.457	1.162	-2.98	***
Furniture/Sports Goods/Toys (incl. Recycling)	-2.963	1.200	-2.47	**
Wholesale Trade	-2.709	1.100	-2.46	**
Retail Trade/Repair of Vehicles	-3.709	1.140	-3.25	***
Transport/Post	-2.706	1.060	-2.55	**
Financial Intermediation	2.296	1.167	1.97	**
Computer/Telecommunication Services	-2.088	1.159	-1.80	*
Technical/R&D Services	-1.371	1.129	-1.21	
Consulting/Advertising	0.993	1.239	0.80	
Producer Services/Refuse Disposal	-0.534	1.080	-0.49	
Real Estate/Renting	-0.971	1.388	-0.70	
Energy/ Water Supply	0.888	1.152	0.77	
Construction	-2.928	1.162	-2.52	**
Motion Picutre/Broadcasting	-0.723	1.518	-0.48	
Constant	8.007	1.140	7.03	***
Ln(sigma)	1.731	0.018	94.91	***
Sigma	5.644	0.103	5.45	***
No. of observations		2,962		
Wald Chi^2		231.7		
Log Likelihood		-5,779.0		

Level of significance: * 10%, ** 5%, *** 1%.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

Table A3a: Impact of non-technological innovations on the success of German firms with product and process innovations: Parameter estimates, standard errors and t values of tobit models

	Sales share with new products				**Sales share with market novelties**				**Cost reduction share through process innovation**			
	Coef.	Std. Err.	t value		Coef.	Std. Err.	t value		Coef.	Std. Err.	t value	
Non-technological Innovation	1.988	1.505	1.32		3.573	1.820	1.96	**	2.154	1.321	1.63	
No. of employees (log)	-3.379	1.402	-2.41	**	-3.331	1.611	-2.07	**	-0.821	1.082	-0.76	
No. of employees (log), squared	0.198	0.137	1.45		0.257	0.154	1.66	*	0.076	0.105	0.72	
R&D Intensity	58.174	15.207	3.83	***	72.774	16.873	4.31	***	33.618	15.043	2.23	**
R&D Intensity, squared	-23.742	22.817	-1.04		-48.676	24.640	-1.98	**	-59.079	27.638	-2.14	**
Export share	3.193	2.937	1.09		15.052	3.289	4.58	***	1.958	2.326	0.84	
Share of high-skilled labour	0.194	0.033	5.80	***	0.158	0.039	4.03	***	0.011	0.029	0.39	
Co-operation with external partners	0.507	1.505	0.34		3.871	1.734	2.23	**	-1.215	1.234	-0.98	
Part of an enterprise group	0.777	1.426	0.54		2.921	1.705	1.71	*	1.243	1.111	1.12	
Location in East Germany	2.259	1.437	1.57		-7.925	1.752	-4.52	***	-1.301	1.128	-1.15	
Food/Beverages/Tobacco	5.786	7.368	0.79		-4.881	8.527	-0.57		-14.370	5.797	-2.48	**
Textiles/Clothing/Leather	12.873	7.589	1.70	*	-0.637	8.581	-0.07		-15.593	5.920	-2.63	***
Wood/Paper/Printing	5.612	6.977	0.80		-7.243	7.997	-0.91		-12.917	5.192	-2.49	***
Chemicals/Pharmaceuticals/Petroleum	3.035	6.888	0.44		-5.327	7.756	-0.69		-14.337	5.311	-2.70	***
Rubber/Plastics	13.239	7.103	1.86	*	-2.877	8.066	-0.36		-11.522	5.370	-2.15	**
Non-metallic Mineral Products	3.145	7.610	0.41		1.264	8.579	0.15		-10.913	5.917	-1.84	*
Metals	7.605	6.838	1.11		-6.312	7.776	-0.81		-12.209	5.142	-2.37	**
Mechanical Engineering	13.476	6.785	1.99	*	-4.127	7.651	-0.54		-12.331	5.260	-2.34	**
Electrical and Electronics	18.223	6.824	2.67	***	-1.776	7.704	-0.23		-10.009	5.241	-1.91	*
Instruments	15.587	6.849	2.28	**	-0.494	7.716	-0.06		-7.876	5.336	-1.48	
Vehicles	17.000	7.291	2.33	**	5.250	8.204	0.64		-15.573	5.572	-2.79	***
Furniture/Sports Goods/Toys (incl. Recycl.)	19.878	7.550	2.63	***	-1.575	8.667	-0.18		-5.747	5.660	-1.02	
Wholesale Trade	10.291	7.567	1.36		-8.334	8.766	-0.95		-17.907	5.821	-3.08	***
Retail Trade/Repair of Vehicles	9.446	10.354	0.91		-26.010	16.385	-1.59		-17.215	7.305	-2.36	**
Transport/Post	4.992	7.161	0.70		-11.612	8.373	-1.39		-13.042	5.328	-2.45	**
Financial Intermediation	6.719	7.115	0.94		-2.915	8.135	-0.36		-15.143	5.349	-2.83	***
Computer/Telecommunication Services	11.337	7.073	1.60		-11.505	8.106	-1.42		-17.302	5.530	-3.13	***
Technical/R&D Services	2.363	6.971	0.34		-9.812	7.912	-1.24		-17.938	5.360	-3.35	***
Consulting/Advertising	7.366	7.606	0.97		-13.915	8.856	-1.57		-12.926	5.636	-2.29	**

Table A3a: Ctd.

	Sales share with new products				Sales share with market novelties				Cost reduction share through process innovation			
	Coef.	Std. Err.	t value		Coef.	Std. Err.	t value		Coef.	Std. Err.	t value	
Producer Services/Refuse Disposal	1.680	7.329	0.23		-11.599	8.697	-1.33		-22.026	5.764	-3.82	***
Real Estate/Renting	-10.764	9.008	-1.19		-18.005	11.724	-1.54		-19.340	7.471	-2.59	***
Energy/Water Supply	-2.005	8.250	-0.24		-20.850	10.470	-1.99	**	-21.211	5.737	-3.70	***
Construction	12.322	10.811	1.14		-17.860	13.854	-1.29		-16.416	8.177	-2.01	**
Motion Picutre/Broadcasting	8.675	9.204	0.94		-9.413	11.064	-0.85		-16.581	6.944	-2.39	**
Constant	18.611	7.240	2.57	***	-4.652	8.309	-0.56		12.342	5.589	2.21	**
Sigma	23.988	0.446	23.11	***	24.630	0.716	23.23	***	14.940	0.469	14.02	***
No. of observations		1,543				1,562				1,179		
LR Chi^2		326.1				274.0				81.3		
Log Likelihood		-6,896				-3,721				-2,891		
Pseudo R^2		0.023				0.036				0.014		

Level of significance: * 10%, ** 5%, *** 1%.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

Table A3b: Impact of marketing and organisational innovations on the success of German firms with product and process innovations: Parameter estimates, standard errors and t values of tobit models

	Sales share with new products				**Sales share with market novelties**				**Cost reduction share through process innovation**			
	Coef.	Std. Err.	t value		Coef.	Std. Err.	t value		Coef.	Std. Err.	t value	
Market Innovation	1.613	1.323	1.22		3.409	1.551	2.20	**	1.227	1.041	1.18	
Organisational Innovation	0.939	1.389	0.68		2.151	1.662	1.29		2.142	1.199	1.79	*
No. of employees (log)	-3.320	1.402	-2.37	**	-3.230	1.611	-2.00	**	-0.787	1.081	-0.73	
No. of employees (log), squared	0.192	0.137	1.40		0.244	0.154	1.58		0.068	0.105	0.65	
R&D Intensity	57.227	15.229	3.76	***	70.705	16.894	4.19	***	33.424	15.076	2.22	**
R&D Intensity, squared	-22.599	22.843	-0.99		-46.178	24.667	-1.87	*	-59.197	27.835	-2.13	**
Export share	3.223	2.937	1.10		15.087	3.290	4.59	***	2.109	2.325	0.91	
Share of high-skilled labour	0.193	0.033	5.80	***	0.159	0.039	4.05	***	0.009	0.029	0.30	
Co-operation with external partners	0.545	1.509	0.36		3.899	1.739	2.24	**	-1.298	1.233	-1.05	
Part of an enterprise group	0.736	1.427	0.52		2.748	1.707	1.61		1.106	1.113	0.99	
Location in East Germany	2.267	1.437	1.58		-7.861	1.752	-4.49	***	-1.276	1.130	-1.13	
Food/Beverages/Tobacco	5.222	7.398	0.71		-6.146	8.560	-0.72		-14.688	5.814	-2.53	**
Textiles/Clothing/Leather	12.652	7.597	1.67		-1.166	8.590	-0.14		-15.601	5.913	-2.64	***
Wood/Paper/Printing	5.191	7.006	0.74		-8.293	8.031	-1.03		-13.016	5.204	-2.50	**
Chemicals/Pharmaceuticals/Petroleum	2.883	6.892	0.42		-5.562	7.753	-0.72		-14.400	5.307	-2.71	***
Rubber/Plastics	13.107	7.109	1.84	*	-3.199	8.068	-0.40		-11.436	5.367	-2.13	**
Non-metallic Mineral Products	2.862	7.622	0.38		0.685	8.594	0.08		-10.866	5.924	-1.83	*
Metals	7.549	6.839	1.10		-6.419	7.770	-0.83		-12.130	5.136	-2.36	**
Mechanical Engineering	13.384	6.786	1.97	**	-4.389	7.647	-0.57		-12.343	5.255	-2.35	**
Electrical and Electronics	18.110	6.828	2.65	***	-1.965	7.703	-0.26		-9.930	5.236	-1.90	*
Instruments	15.338	6.860	2.24	**	-0.983	7.724	-0.13		-7.736	5.339	-1.45	
Vehicles	17.118	7.291	2.35	**	5.410	8.197	0.66		-15.324	5.567	-2.75	***
Furniture/Sports Goods/Toys (incl. Recycl.)	19.588	7.560	2.59	***	-2.033	8.670	-0.23		-5.712	5.660	-1.01	
Wholesale Trade	9.898	7.576	1.31		-9.382	8.779	-1.07		-18.074	5.818	-3.11	***
Retail Trade/Repair of Vehicles	8.854	10.382	0.85		-27.357	16.453	-1.66	*	-17.378	7.303	-2.38	**
Transport/Post	4.735	7.165	0.66		-12.388	8.381	-1.48		-13.144	5.327	-2.47	**
Financial Intermediation	6.319	7.127	0.89		-3.876	8.149	-0.48		-15.310	5.357	-2.86	***
Computer/Telecommunication Services	11.177	7.077	1.58		-11.956	8.109	-1.47		-17.340	5.530	-3.14	***
Technical/R&D Services	2.446	6.971	0.35		-9.724	7.905	-1.23		-17.669	5.356	-3.30	***

Table A3b: Ctd.

	Sales share with new products				Sales share with market novelties				Cost reduction share through process innovation			
	Coef.	Std. Err.	t value		Coef.	Std. Err.	t value		Coef.	Std. Err.	t value	
Consulting/Advertising	7.173	7.608	0.94		-14.386	8.850	-1.63		-12.874	5.630	-2.29	**
Producer Services/Refuse Disposal	1.505	7.330	0.21		-11.999	8.696	-1.38		-22.040	5.765	-3.82	***
Real Estate/Renting	-11.102	9.031	-1.23		-18.418	11.722	-1.57		-19.139	7.461	-2.57	***
Energy/Water Supply	-2.118	8.250	-0.26		-21.310	10.487	-2.03	**	-21.100	5.731	-3.68	***
Construction	11.914	10.820	1.10		-18.722	13.838	-1.35		-16.551	8.162	-2.03	**
Motion Picutre/Broadcasting	8.176	9.219	0.89		-10.694	11.096	-0.96		-16.412	6.966	-2.36	**
Constant	18.971	7.223	2.63	***	-4.356	8.279	-0.53		12.146	5.561	2.18	**
Sigma	23.983	0.446	23.11	***	24.618	0.716	23.21	***	14.918	0.469	14.00	***
No. of observations		1,543				1,562				1,179		
LR Chi^2		326.6				277.8				83.9		
Log Likelihood		-6,896				-3,719				-2,889		
Pseudo R^2		0.023				0.036				0.014		

Level of significance: * 10%, ** 5%, *** 1%.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

Table A3c: Impact of different combinations of marketing and organisational innovations on the success of German firms with product and process innovations: Parameter estimates, standard errors and t values of tobit models

	Sales share with new products				Sales share with market novelties				Cost reduction share through process innovation			
	Coef.	Std. Err.	t value		Coef.	Std. Err.	t value		Coef.	Std. Err.	t value	
Marketing Innovation, no organisational innovation	2.552	2.459	1.04		3.238	2.941	1.10		0.134	2.293	0.06	
Organisational Innovation, no marketing innovation	1.362	1.675	0.81		2.072	2.022	1.02		1.735	1.418	1.22	
Both Marketing and Organisational Innovation	2.619	1.762	1.49		5.543	2.095	2.65	**	3.231	1.492	2.17	**
No. of employees (log)	-3.343	1.403	-2.38	**	-3.226	1.613	-2.00	**	-0.767	1.082	-0.71	
No. of employees (log), squared	0.195	0.137	1.42		0.244	0.155	1.58		0.065	0.105	0.62	
R&D Intensity	57.439	15.235	3.77	***	70.664	16.904	4.18	***	33.417	15.091	2.21	**
R&D Intensity, squared	-22.835	22.847	-1.00		-46.137	24.675	-1.87	*	-59.451	27.914	-2.13	**
Export share	3.189	2.938	1.09		15.091	3.291	4.59	***	2.173	2.328	0.93	
Share of high-skilled labour	0.194	0.033	5.80	***	0.159	0.039	4.05	***	0.008	0.029	0.29	
Co-operation with external partners	0.547	1.509	0.36		3.898	1.739	2.24	**	-1.298	1.233	-1.05	
Part of an enterprise group	0.739	1.427	0.52		2.745	1.708	1.61		1.087	1.114	0.98	
Location in East Germany	2.267	1.437	1.58		-7.860	1.752	-4.49	***	-1.280	1.130	-1.13	
Food/Beverages/Tobacco	5.230	7.398	0.71		-6.147	8.560	-0.72		-14.717	5.814	-2.53	**
Textiles/Clothing/Leather	12.625	7.597	1.66	*	-1.163	8.589	-0.14		-15.660	5.915	-2.65	***
Wood/Paper/Printing	5.133	7.007	0.73		-8.287	8.032	-1.03		-12.999	5.204	-2.50	**
Chemicals/Pharmaceuticals/Petroleum	2.880	6.892	0.42		-5.562	7.753	-0.72		-14.433	5.307	-2.72	***
Rubber/Plastics	13.039	7.111	1.83	*	-3.190	8.069	-0.40		-11.411	5.367	-2.13	**
Non-metallic Mineral Products	2.852	7.622	0.37		0.683	8.593	0.08		-10.894	5.924	-1.84	*
Metals	7.548	6.839	1.10		-6.420	7.770	-0.83		-12.176	5.136	-2.37	**
Mechanical Engineering	13.380	6.786	1.97	**	-4.392	7.646	-0.57		-12.343	5.255	-2.35	**
Electrical and Electronics	18.098	6.827	2.65	***	-1.962	7.702	-0.25		-9.919	5.236	-1.89	*
Instruments	15.323	6.860	2.23	**	-0.983	7.724	-0.13		-7.689	5.340	-1.44	
Vehicles	17.055	7.292	2.34	**	5.417	8.197	0.66		-15.230	5.569	-2.73	***
Furniture/Sports Goods/Toys (incl. Recycl.)	19.588	7.560	2.59	***	-2.034	8.670	-0.23		-5.709	5.659	-1.01	
Wholesale Trade	9.948	7.576	1.31		-9.400	8.783	-1.07		-18.125	5.819	-3.11	***
Retail Trade/Repair of Vehicles	8.856	10.382	0.85		-27.361	16.454	-1.66	*	-17.318	7.306	-2.37	**

Table A3c: Ctd.

	Sales share with new products				Sales share with market novelties				Cost reduction share through process innovation			
	Coef.	Std. Err.	t value		Coef.	Std. Err.	t value		Coef.	Std. Err.	t value	
Transport/Post	4.762	7.165	0.66		-12.398	8.382	-1.48		-13.161	5.327	-2.47	**
Financial Intermediation	6.348	7.127	0.89		-3.885	8.150	-0.48		-15.284	5.357	-2.85	***
Computer/Telecommunication Services	11.165	7.077	1.58		-11.958	8.109	-1.47		-17.355	5.530	-3.14	***
Technical/R&D Services	2.420	6.972	0.35		-9.720	7.905	-1.23		-17.625	5.356	-3.29	***
Consulting/Advertising	7.182	7.607	0.94		-14.389	8.850	-1.63		-12.837	5.631	-2.28	**
Producer Services/Refuse Disposal	1.541	7.330	0.21		-12.011	8.698	-1.38		-22.027	5.766	-3.82	***
Real Estate/Renting	-11.143	9.031	-1.23		-18.402	11.723	-1.57		-19.116	7.462	-2.56	**
Energy/Water Supply	-2.108	8.250	-0.26		-21.311	10.486	-2.03	**	-21.080	5.732	-3.68	***
Construction	11.909	10.820	1.10		-18.721	13.838	-1.35		-16.622	8.158	-2.04	**
Motion Picutre/Broadcasting	8.212	9.219	0.89		-10.703	11.097	-0.96		-16.244	6.966	-2.33	**
Constant	18.745	7.240	2.59	***	-4.311	8.305	-0.52		12.418	5.583	2.22	**
Sigma	23.982	0.446	23.11	***	24.618	0.716	23.21	***	14.917	0.468	14.00	***
No. of observations		1,543				1,562				1,179		
LR Chi^2		326.8				277.8				84.2		
Log Likelihood		-6,896				-3,719				-2,889		
Pseudo R^2		0.023				0.036				0.014		

Level of significance: * 10%, ** 5%, *** 1%.

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.