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Local User-Producer Interaction in Innovation and Export Performance of Firms

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ABSTRACT. This paper studies the effects of local market attributes on local firms' exports of innovations. Our starting point are three common hypotheses. First, innovations are a major determinant for the export performance of firms. Second, user–producer interaction is an important factor for successful innovations. Third, user–producer interaction is most efficient in close proximity. Taken together this would mean that intense local user–producer interaction increases exports. This reasoning contradicts a main proposition in international management that overt local responsiveness may be hampering export chances of a firm. In order to generate global innovations, an international firm should look at the world market instead, for instance by identifying the global common denominator of national preferences. Yet, many local innovations have become globally successful. This paper investigates the question to what extent local demand is capable of inducing innovations that are export effective. We utilize data from the German innovation survey of 4,786 firms in the manufacturing and service industries. In this survey firms were asked about the sources of their innovation and their export activities. We find evidence that the export orientation and the domestic demand structure stimulate export success.

1. Introduction

In this article we attempt to extend the studies on the relationship between innovation and export performance of firms by including attributes of a firm's home market. We start with combining three strands of literature that are equally accepted today. In a first strand of literature it has been argued that the rate of innovation generated by a firm is positively correlated with its export success because of a technology lead of the innovating firm (Posner, 1961; Vernon, 1966). Empirical results are mixed, however. Some authors find a positive correlation (Lefebvre et al., 1995; Wakelin, 1998; Sterlacchini, 1999; Smith et al., 2002; Roper and Love, 2002) while some do not (Schlegelmilch and Crook, 1988; Ito and Pucik, 1993; Kumar and Siddharthan, 1994). The second strand of literature has pointed to the importance of innovation as an interactive process between users and producers (Gemünden, 1981; Lundvall, 1988,). Various empirical studies have found user-producer interaction to be a significant success factor for new products (among others, see Rothwell et al., 1974; Cooper and Kleinschmidt, 1987). Addressing a third notion, it is suggested that the perception of innovation opportunities is more efficient locally. This assumption was first formulated in the home-market theory, which Linder (1961) originally introduced and which states that a company's new products fit demand conditions in its home market more than in foreign countries.

On the surface, it follows from these different strands that a high degree of close user–producer interaction in innovation development leads to more exports. However, this argument is inconsistent with the well known problem in international management that the more locally adapted an innovation the lower its market success in foreign countries. Although user–producer interaction increases the domestic success of innovations, it reduces export success if demand preferences vary from country to

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country.[1] Lefebvre et al. (1998) test different R&D related activities and strategies on exports and find a negative effect of collaborative R&D with customers on global exports.

A common argument is that innovations become successful internationally after they have been refined in a local feedback process between users and manufacturers. But even improvements of innovations over time through customer feedback tend to focus on locally preferred attributes of the innovation and mostly exclude attributes preferred abroad.

On the other hand, many local innovations have become internationally successful. The relationship between locally induced innovation and the international competitiveness of firms has rarely been discussed (Ruttan, 1997) compared to studies on the general relationship between innovation and export. Also, Fagerberg (1995, p. 244) admits that a positive effect of a high degree of interaction between users and producers on the international competitive position still lacks a theoretical explanation. In this article we attempt to contribute to the understanding of the relationship between innovation and exports by including attributes of the local market into the innovation export equation. These market characteristics might explain which market context increases the exportability of locally demand-induced innovations. The article is structured as follows. In the next section we discuss factors of local market conditions that could stimulate innovations that can be exported. Section 3 presents our model and discusses the data source. This section also presents the result of the estimation. Section 4 concludes with some suggestions for future research.

2. Export efficiency of local markets

In most industries demand plays a vital role in shaping the rate and direction of technical change (Kline and Rosenberg, 1986; Dosi, 1988). When firms respond to local innovation opportunities, a firm's innovations are shaped not only by its technological capacity but also by the characteristics of the demand in the home market. If demand preferences and the quality of demand are equal globally, then innovations increase exports. And 'innovativeness' of local demand, that is the willingness of local customers to adopt innovations independently from other users (Midgley and Dowling, 1978, p. 235), would be the most important attribute of the local market for exports. If, however, the context of each country is considerably different, other characteristics of the local market become important as success factors for exports. In most industries environmental conditions, traditions, tastes, and the purchasing power vary internationally, ensuing different preferences or budgets from country to country, so that each country prefers a different innovation design for the same function (Freeman and Soete, 1997, p. 308). In a world market marked by international diversity, a firm's export potential depends on whether local users adopt innovations that users in other countries will subsequently adopt as well. Several characteristics of the local market of a country can raise the likelihood that local innovations are adopted in other countries. In this section, we discuss some of the characteristics of a local market that can be expected to have a positive effect on the exportability of local innovations.

2.1. *Demand characteristics*

Linder (1961) as well as Vernon (1966) explained exports with a high per capita income in the home market. In countries with a high per capita income, innovations, given they are superior goods, are demanded earlier and more widely than in countries with a lower average income. Demand for the same innovations emerges in other countries when per capita income rises to higher levels. Today, however, per capita income of most industrialized countries has already converged, so that it cannot explain trade between these countries. Porter (1990) suggests that the quality of national demand can have an effect on the international success of innovations. He finds that a country's demand for innovations can be idiosyncratic or anticipatory. Demand is idiosyncratic if users prefer innovation designs that are not in line with global preferences and therefore will not be demanded in other countries. Countries with anticipatory demand in contrast prefer innovation designs which are subsequently demanded

worldwide. The lead user concept by Hippel (1988) offers a similar explanation for the diffusion of innovations. In his extensive study, Hippel found that many innovations are brought about by users who anticipate needs that other users will experience later. This anticipation can be constituted by a trend. A trend can induce demand for specific innovations. Users at the forefront of a trend demand innovations that will later be demanded by other users as well. This suggests that a firm that responds predominantly to users, which anticipate future worldwide needs would gain a competitive advantage.

It has also been suggested that more *efficient* user–producer interaction can explain differences in national competitiveness (Fagerberg, 1995). Even in science-related industries, user–producer interaction can be important. In the pharmaceutical industry international differences in the efficiency of interaction between pharmaceutical producers and hospitals in the crucial phase of clinical testing have been observed as factors of countries' competitiveness. A better interaction leads to smoother approval processes and shorter time-to-market. If demand preferences are equal local firms would gain an export advantage from efficient user–producer interaction. If, however, demand preferences vary from country to country, a higher efficiency of interaction would not lead to an advantage for international competitiveness.

For our study, we expect that the quality of local demand has a positive effect on the exports of innovations by local firms.

2.2. *Competition*

The degree of competition is expected to have an effect on the export performance of innovations. User-producer interaction that is embedded in a competitive market should have a higher export efficiency than in markets with little competition. Competition between domestic companies increases the likelihood of the local market to identify unrevealed preferences, because more alternatives are tested in the market and experiences are gathered on a variety of product concepts. Since new products and technologies are frequently brought about by new companies (see e.g. Audretsch, 1995), the absence of entry barriers (Baumol et al., 1982) increases the discovery function of a market. If preferences do not vary internationally, competitive markets are more likely to discover globally latent needs and select globally successful products which meet those needs best. But even if preferences vary internationally, a competitive market can be the source of a globally successful innovation design. It might find a design that is more beneficial even for users in markets with a low degree of competition. In markets with little rivalry, the innovation designs offered might not be the optimal designs for their respective market environments because the local discovery process is inefficient.

In addition, industrial customers tend to be more demanding towards their suppliers when they face competition than when they are tightly regulated or hold a monopoly position (Porter, 1990). The number of independent buyers, together with an early saturation of a market, creates pressure for a reduction of prices and an improvement in product performance, thus giving buyers an incentive to replace an old product with the new version. Competition makes the domestic technology more price competitive against innovation designs adopted in markets with less competition. For instance, intense competition amongst Japanese companies caused the cost of fax machines to drop 30-fold from 1980 to 1992 (Coopersmith, 1993). Local firms in competitive markets are thus more likely to develop innovations that appeal globally because of their technical superiority, practicability or superior cost-benefit relation.

Empirical evidence for the effect of domestic competition on exports, however, is still more anecdotal than significant. Yet, in the case of Japan, Sakakibara and Porter (2001) find that industries which Japan is dominating in the world market, such as fax machines, robots and cameras, are marked by fierce competition in the Japanese domestic market, whereas government intervention and cartels are significantly associated with industries in which Japan is less competitive internationally.

2.3. *International transfers*

Porter (1990) as well as Douglas and Wind (1987) note that preferences of a country for a specific innovation design can be actively transferred abroad by customers such as businessmen, the military, tourists and multinational firms. These customers demand standardized products and services wherever they travel or operate despite the fact that different products or services might be more appropriate in different national environments. For instance, businessmen demand the same hotel service everywhere to avoid the inconvenience of adapting frequently to different local styles. Multinational companies have a powerful economic incentive to use standardized equipment, software, protocols etc., in all of their foreign subsidiaries. Through cross-border consolidation, multinational firms are increasingly standardizing supplies. For instance, the automobile industry is actively seeking components that can be used in all of their regional brands in the US, Europe and Japan. The larger the standardization advantages are, the more they compensate for the advantages of locally responsive innovations. Therefore, our hypothesis is that multinational firms as customers enhance the export performance of small firms.

2.4. *Export orientation*

The export orientation of firms should also have an effect on their export activities. This export orientation can be guided by local market participants or the local market context. First of all, innovations are easier to export if the environment and market conditions of foreign countries are similar to those of the domestic market which the innovation was designed for. Vernon (1979) suggests that the higher the similarity of cultural, social and economic factors between two countries, the greater the likelihood that an innovation design adopted in one country will be adopted in the other country as well. This leads to the hypothesis that firms from a country with a market context that lies in the middle of the variety of environmental conditions are more likely to export than firms in countries with somewhat more extreme environmental conditions. In addition, local market participants such as customers, suppliers or banks can pressure small firms to increase the exportability of their innovations. Exporting firms want that their suppliers' innovations are compatible to foreign markets. In addition, they often induce demand for spare parts in their export markets. Exports of customers should therefore have a positive effect on exports of their suppliers.

3. Econometric model and data

3.1. *The model*

The starting point for our estimation is a general model of determinants of a firm's export activities as proposed in the literature, including innovation activities (see Schlegelmilch and Crook, 1988; Wagner, 1996; Aitken et al., 1997; Wakelin, 1998; Bernard and Jensen, 1999; Ebling and Janz, 1999; Bleaney et al., 2002; Roper and Love, 2002). However, we are most interested in the moderating effect of local market characteristics on the relationship between innovations and exports. We are looking to explain differences in the ability of firms to export by specific local market conditions such as local competition, quality of demand, etc. as well as different external sources of innovations such as local customers or scientific research institutions. Innovation in our model is a mere control variable. We want to compare the exports of firms which have introduced the same amount of innovations but in a different local market context. Therefore, we do not cover the endogeneity problem of an estimation of the effect of innovations on exports.[2] Even though exports might increase the amount of innovations, exports do not affect the types of innovations or the market attributes. Export success may certainly strengthen the choice of external sources for innovations of a firm, but there is no indication that a firm would change the source. Neither do exports of one firm change the conditions of the national market the firm is operating in. We model the export performance of firms in both the manufacturing and service sector. Because we are interested in the effect of the local market, most of the exogenous

variables are industry-specific, which again lessens the problem of endogeneity.

We use the firm level of analysis because it allows us to capture industry specific attributes on a very fine disaggregation level. It also enables us to control for firm-specific attributes of export performance. Hence our full model suggests that the propensity of a firm to export is a function of various firm-specific attributes as well as market characteristics that affect the exportability of a firm's innovations. Among the firm-specific attributes we distinguish between a firm's general exporting capabilities and innovation activities of the firm. The model may be written as follows:

$$E_i = \alpha S_{i(j)} + \beta Z_i + \gamma I_i + u_i \quad (1)$$

where E_i is export performance of firm i in industry j, S is a vector for industry characteristics that have a direct effect on firm i's exports and Z is a vector for firm characteristics other than innovation activities that influence a firm's export performance. I is a vector for a firm's innovation activities. α, β and γ are parameters, and u is an error term. In the following, we define the variables represented by the three vectors S, Z, and I.

The general industry attributes that are supposed to have a direct effect on exports are the actual tradability of products T and the growth of demand (GD). Actual tradability refers to the general export environment for a firm's products that enable or hinder exports, such as tariff and non-tariff barriers to trade and trade impairing transaction or transportation costs. The GD for a firm's products controls for a likely crowding out of export activities due to a strong expansion of demand in the home market, or vice versa for increased export efforts as a result of weak home market demand.

$$S_{i(j)} = e(T_{i(j)}, GD_{i(j)}) \quad (2)$$

The firm-specific characteristics Z that are expected to have a direct effect on exports and therefore are included in the model are the size of the firm Size_i, its capital intensity CI_i, the skill level of employees Skill_i, cost efficiency denoted by unit labor costs ULC_i, whether it is an affiliate of a corporate group GR_i, its closeness to national borders BD_i and whether it is located in East Germany EAST_i. Thus Z_i is defined as a function f with

$$Z_i = f(\text{Size}_i, \text{CI}_i, \text{Skill}_i, \text{ULC}_i, \text{GR}_i, \text{BD}_i, \text{EAST}_i) \quad (3)$$

Size covers a firm's export advantages due to scale economies. Capital intensity and the skill level should reflect the specialization of a firm on production factors with different comparative advantages for the home market economy. We assume that high capital intensity and a high skill level represent a factor combination that provides comparative advantages in trade. Unit labor costs are viewed as a major determinant of price competitiveness on product markets. Being part of a corporate group rather than being an independent firm is used to capture different effects of multinational firms on a subsidiary's exports. A division of regional markets within corporate structures would curtail export activities of the affiliates, because each subsidiary would only serve its local market. On the other hand in the case of intra-corporate specialization by product markets among subsidiaries (world product mandate), affiliation with a multinational firm would improve access to foreign markets, thus positively affecting trade (see Pfaffermayr, 1994). Therefore the direction of the effect of this variable is not clear ex ante.

Physical distance to export markets is likely to affect transaction costs especially of service firms, since services often require direct interaction between customers and firm employees at the customer's location. Therefore, firms located close to a border may show higher export activities. Firms from Eastern Germany may also show a significantly lower export intensity. This can be attributed – besides structural effects such as small firm sizes and high unit labor costs – to the loss of their traditional export markets in Eastern Europe and the short time period since 1990 in which they had to develop new export markets in western countries. Furthermore, East German firms might suffer from a negative reputation and a lack of attractive markets across the border to Poland and the Czech Republic.

In order to identify the direct effects of attributes of the local market on the exportability of

innovations we have to control for the extent of innovations of the firms. Since most market attributes can have a quantitative effect on a firm's innovation output, they could exert an indirect effect on exports via more innovations (given a positive relationship between innovation and export). A firm's innovative activities are captured in our model by four variables. The first is a dummy variable characterizing firms that developed new products PD_i, the second one indicates whether the firm has introduced process innovations PC_i. The resources attributed to innovation are denoted by the relation of innovation expenditures to turnover $Inno_i$. Finally, the "exclusivity" of innovation activities that may result in absolute competitive advantages in terms of a (temporary) monopoly is broadly represented by the share of R&D expenditure in total innovation expenditure RD_i. We therefore define I as a function g so that

$$I_i = g(PD_i, PC_i, Inno_i, RD_i) \tag{4}$$

In order to test the effect of user–producer interaction in innovation on export performance, we differentiate the product innovators according to their degree of interaction with the market. Market interactions shall include all kinds of information received directly from customers or through market research that provide essential stimuli for new products or a significant adjustment of an innovation design. We distinguish firms that reacted upon the demand for innovations by single customers PDC_i and by an anonymous market PDM_i. This distinction refers to typical assertions of firms in interviews we conducted in the past that they developed a specific product innovation because a customer specifically ordered it or because the firm perceived clear signals from the market that there is an opportunity in a specific market segment. PDn_i denotes firms that generated product innovations that were triggered by non-market-related factors such as new scientific findings.

At this point we also include the attributes of a market that we expect to have an effect on the exportability of innovations, as outlined in Section 2. In our model a firm's innovation activities are influenced by the characteristics of industry j which firm i belongs to and of industry k where innovation impulses originated (private households and the government are treated as "industries"). For example, the innovations of a machinery manufacturer is shaped by the context of the machinery industry as well as the context of its customer industries such as the automobile industry. Hence, product innovations are defined as a function h with

$$PD_i = h(PDC_i, PDM_i, PD\text{-}O_{i(j)}, PD\text{-}U_{i(k)}, PDn_i) \tag{5}$$

where PD-O captures the characteristics of firm i's industry and PD-U those of the customer industry. Several local market characteristics are tested whether they influence the exportability of innovations. These characteristics are the degree of competition CP, the presence of multinational firms MN and the quality of demand SP measured both for the product market of the innovating firm (O-CP, O-MN, O-SP) and the market of its customers that triggered innovations (U-CP, U-MN, U-SP). The export orientation of a country in a particular industry EX can only be tested, however, for the industry of the customers (U-EX), because the export orientation of firm i's industry is not exogenous to firm i's export performance. In contrast, the effect of the supplier's export performance on the export orientation of customers should be rather small, so that we can treat the export orientation of the customer industry as an exogenous variable. The attribute vectors are thus defined both for firm i's industry j and the industry k of the customers that initiated innovations at firm i:

$$PD\text{-}O_{i(j)} = p(O\text{-}SP_{i(j)}, O\text{-}CP_{i(j)}, O\text{-}MN_{i(j)}) \tag{6}$$

$$PD\text{-}U_{i(k)} = q(U\text{-}SP_{i(k)}, U\text{-}CP_{i(k)}, U\text{-}MN_{i(k)}, U\text{-}EX_{i(k)}) \tag{7}$$

3.2. *The data set*

To test the empirical model, we use the data of the German innovation survey conducted by the Centre for European Economic Research (ZEW). The innovation survey is an annual,

representative firm survey conducted on behalf of the Federal Ministry of Education and Research. It is the German part of the Community Innovation Survey (CIS) initiated by Eurostat. The survey covers mining, manufacturing, energy and water supply, construction, wholesale and retail trade, transport services, banking and insurance, real estate and renting, telecommunication and software, R&D services, producer-related services, and sewage and refuse disposal. It is based on a stratified random sample of all firms from these sectors with five or more employees.

In the questionnaire sent to the companies in 1999, innovating firms were asked, among other things, about the sources of their innovations differentiated by customers, competitors, suppliers, and research institutions. The exact wording of the question pertaining to customers as the respective source is:

> *"Did you introduce new or significantly improved products or processes in the years 1996–1998 because certain clients or the market demanded them (eventually identified through market research)?"*

Firms were asked to indicate both for "clients" and "general demand" whether such innovations occurred, and the share of sales with products that were triggered by clients or general demand, respectively. Furthermore, firms were to name the industries that provided the most important innovation impulses. The industries cited have been subsequently coded on the 3-digit-level of the European industry classification NACE. Finally, firms were asked whether these customers came from Germany only, from abroad only, or from both Germany and abroad.

The questionnaire was sent to approximately 20,000 companies and 4,786 responded. A non-response analysis was carried out to control for distortions in response behavior between innovating and non-innovating firms. The results of the non-response analysis showed, however, that there is no such distortion, neither concerning the share of innovating firms nor their innovation intensity. The firm sample can thus be regarded as representative for the sectors of the German economy covered by the survey with respect to innovation behavior (see Janz et al., 2001 for more details on the survey).

The particular question on the sources of innovations had to be answered only by companies that introduced at least one product innovation between 1996 and 1998. The number of innovating firms was 2,757. We assume that the non-innovating firms did not use any innovation sources. Exactly 1,798 firms – which is equivalent to 65% of the product innovators – stated that they responded to impulses from single customers or market demand. All of them were able to name specific customer industries. For those firms that cited more than one customer industry, we duplicate the whole firm for each industry cited. In the econometric estimation process, which is a weighted regression corresponding to the sampling strategy, each duplicated firm is weighted down by the number of duplications. For instance, if a firm in the machinery industry cites the automobile industry and the aircraft industry as sources of innovation impulses, we created two identical firms instead of the original one, one citing the automobile industry and the other citing the aircraft industry. All other variables were identical but the weight for both firms was half of the weight of the original firm. On average, each firm that responded to the market named 1.82 different industries that initiated the firm's innovations. This means, that in total we derived 3,272 observations of firms where product innovations were triggered by a specific customer industry.

A firm's export performance E is measured as the ratio of exports to turnover (both prior to VAT) for the reference year 1998. Exports of innovations are not available in the database, but it is reasonable to assume that the export share of innovations is highly correlated with a firm's total export share. Any possible distortions such as that only innovations or only old products can be exported are unreasonable because a firm can easily react to such distortions by adjusting the product life cycle period appropriately in order to balance exports of the whole product spectrum. We therefore approximate the export share of innovations with the total export share. For the service industries the

endogenous variable is a dummy variable that is one for the firms with export activities and zero for non-exporters, since most of the firms do not export. Product innovators PD are defined as firms that have successfully introduced a new or significantly improved product in the preceding 3 years period (1996–1998). Process innovators PC, accordingly, are firms that adopted a new or significantly improved process in the same period. Our definition of innovation follows the Oslo-Manual of OECD and Eurostat (see OECD and Eurostat, 1997). Innovation expenditures include all current expenditures and investments for innovation projects in the reference year 1998. Innovation expenditures are used as a share of turnover in 1998 (Inno). R&D expenditures cover all intramural and extramural current expenditures and investments for research and development, following the definition for R&D as given in the Frascati-Manual by the OECD (1994). They are included in the model as a share of total innovation expenditures (RD) in the case of manufacturing firms. For service firms, we only use a dummy variable denoting firms that carry out R&D continuously (RD*c*) because the quality of the data on absolute figures of R&D expenditures is rather dubious. The dummy variables on the innovation-related interaction with users take the value 1 if a firm uses clients (PDC) or (anonymous) demand (PDM) as a source for product innovation. The dummy variable PD*n* denotes product innovators that did not use clients or the general demand as the dominant source of innovation.

All these variables were surveyed in the questionnaire. The market characteristics that are suggested to increase the exportability of innovations are derived from various data sources that were available on different industry aggregation levels. In general, when data on 3-digit level of NACE are not available we assign the higher level of industry class to a sub-sector. Little data is available on the degree of competition (CP). As a proxy we use the price level in a sector compared to that in other countries. Intense competition on a market normally results in low prices. Thus we expect that relatively low prices improve the exportability of innovations. In addition, low prices can also lead to a higher export orientation of companies seeking for profitable markets abroad. Data was taken from the OECDs' purchasing power parities (PPP) statistics of 1996. In this database more than 200 product groups have been assigned to NACE 3-digit-level. In the case that more than one product group has been assigned to a sector, price levels were weighted using the absolute size of demand for the respective product group. Relative prices for German sectors are calculated as the PPP for each sector divided by the PPP for the German economy as a whole. Therefore, CP is approximated by the relative price level in a specific industry in the OECD divided by the price level in Germany. We expect the co-efficient of CP to have a positive sign.

The specialization of foreign direct investments (MN) of Germany in a particular industry is used as a proxy for the extent at which German firms in that industry are transferring local innovations to their affiliates abroad. The variable is constructed as the relation of foreign direct investment of a certain sector in Germany to the total domestic gross fixed investment of this sector in Germany, divided by the OECD average of this relation. The resulting variable MN is a specialization index that denotes an international leverage effect of German multinationals. Data on foreign direct investment for Germany by sectors are available from the Central Bank in Germany, the Bundesbank. Total gross fixed investment is available from the Federal Statistical Office. Data on foreign direct investment and gross fixed capital investment in OECD countries are taken from the UNCTAD Database and the STAN Database of the OECD. The index is measured for the average of the years 1997–1998 in order to avoid special effects in a single year.

The quality of demand SP is approximated by an index of the demand specialization of Germany per sector. We measure the demand specialization as a sector's share in total demand in Germany divided by the sector's average share in total demand in OECD countries. High values thus indicate a positive demand specialization in Germany in a certain sector. Our argument is that a higher share of a particular sector in total demand of a country indicates that the market is more demanding in this

sector, has a higher willingness to pay and invests more in evaluation and searching. Data from the OECDs' STAN Database is used to calculate this index for the average of the years 1997 and 1998. We calculate demand as domestic production minus exports plus imports.

Export orientation EX of an industry is measured by the share of exports in total turnover for each sector in Germany divided by the respective ratio for large OECD countries in 1998. This indicator thus measures the relative export performance of an industry in Germany compared to the average export intensity of this sector in the OECD. The STAN-Database is used again to calculate the index for the average of the years 1997 and 1998.

Virtually all product innovators that specified users or the market as sources answered that they interacted with domestic users. Among those firms, 43.9% stated that the users were solely from Germany, while 55.3% stated that they were both from Germany and abroad. Only 0.8% interacted solely with users from abroad. We excluded only the latter group of firms from the data set. Personal follow-up interviews with product managers from some firms of the largest group, which stated both domestic and foreign customers confirmed that the vast majority of demand driven innovations was attributable to Germany. This means that we can assume that the demand sectors k mentioned by the firms as sources for their product innovations overwhelmingly refer to domestic demand even when firms stated domestic as well as foreign sources.

The innovation survey also provides information on firm characteristics that are represented in vector Z in equation (3). Firm size Size is measured as the log of employees for the year 1998. In addition, we include the squared log of employees Size2 in order to control for a non-linear relationship. We use two variables to control for closeness to borders. The first variable BD indicates whether the firm is located in a district that borders a foreign country directly and the second BD2 denotes firms in districts that are only one additional district away from a foreign country. CI is measured as the gross stock of tangible assets at the beginning of 1998 (as stated by the surveyed firms) divided by the number of employees. Since data on tangible assets for most service firms were not available, we use gross fixed investment in 1998 instead (InvI). The share of graduates in total employment is our proxy for human capital intensity of production (Skill). The total number of graduates covers both graduates from universities and technical colleges (''Fachhochschulen''). ULC is measured as the ratio of total labor costs to value added for manufacturing firms, and for service firms as the ratio of total labor costs to turnover (ULCS) because of difficulties in properly calculating value added in service firms.

Two sector-specific variables shall control for export determinants represented in vector S in equation (2). Tradability T should reflect the actual framework for export activities and is measured by the OECD countries' export ratio in the sector which firm i belongs to. Sector-specific export ratios for the OECD countries in total are calculated using the most disaggregated level (partially 3-digit, partially 2-digit) of the OECDs' STAN database for the manufacturing sector. Similar information is not available for service sectors due to lack of data for most countries. For services we assign each sector to one of three classes according to their export orientation as indicated by the data of those countries for which export figures are available. The first group T1 includes non-exporting service sectors (retail trade, post and courier activities, real estate, local producer services such as industrial cleaning and provision of personnel, sewage, and refuse disposal), the second group T2 comprises service sectors with a low level of export activities (construction, supporting transport services, banking and insurance, renting, software) and the third group T3 represents service sectors with a medium to high level of export activities (wholesale trade, transport, telecommunication, knowledge-intensive producer services such as engineering services, R&D services, marketing and consulting). Lastly, GD in a certain sector in Germany is calculated as the change in domestic demand, which is the production volume minus exports plus imports, between the average of the years 1991–1993 and the average of the years 1997–1998. For this indicator we again use data from the OECDs' STAN database.

3.3. *Estimation results*

In order to choose the appropriate estimation model we have to take into account that a large share of firms in the sample are not exporting in the observed year. In the manufacturing sector, 28.4% of all firms in our sample are non-exporters. In the service sector, this ratio is even 72.3%. The problem is that the non-exporters might have a different propensity to export, which we cannot observe. For instance some of them have exported the year before or the year after and some have never been able to export. The endogenous variable export share is therefore censored from below at point $E_i^* = 0$. In this case the appropriate econometric approach is using a Tobit Model. A Tobit model takes into account that we have censored data at the lower end of the observable values. For service firms we can only distinguish exporting from non-exporting firms. We thus estimate the service firms separately using a Probit model. The Tobit and the Probit models are estimated with heteroscedasticity, which is caused by the industry affiliation. We therefore use industry dummies for the heteroscedasticity term. Results of the heteroscedastic Tobit and heteroscedastic Probit Maximum Likelihood estimations are presented in Table I for the manufacturing sector and Table II for the service sector.

We estimated model (1) in three variants. The estimation starts with a model (A) that tests only the hypothesis that innovation activities of a firm affect its export success without taking endogeneity into account. Both innovation input in form of R&D as well as innovation output of a firm have a significant positive effect on exports. Yet, process innovations (PC) have a negative effect in the manufacturing sector. Process innovations might be an indicator for fierce price competition, where on average German companies face competitive disadvantages (see Lucke et al., 2004). The negative sign of the cost indicator ULC for the manufacturing sector points in the same direction. As expected, export performance increases with firm size (Size) and firms located in Eastern Germany (East) have a smaller export share compared to their Western counterparts. Manufacturing firms that are affiliates of a larger corporation seem to be more focused on the domestic market, while service affiliates are more likely to engage in export activities than independent firms of the same size. Closeness to the border is only a significant export stimulator for service firms but not for manufacturing firms. The indicators that control for tradability (T) and domestic market growth (GD) show the expected signs and are significant with the exception of growth of domestic demand in the service sector, which exerts a positive effect on exports. This may be explained by learning effects and scale economies that result in increased international competitiveness.

In the next step (B) we substitute the variable for product innovations with three indicators that denote whether local customers (PDC), anonymous demand (PDM) or other external sources (PDn) have induced innovations of a firm. In general, both specific clients as well as the market as a whole show a positive effect on export performance. Yet, the effect of the market is not significantly different from the effect of other external sources of innovation. It seems that it does not matter for exports which factors triggered the innovations. In the next estimation (C), we test whether specific market attributes and customer industries have an additional export enhancing effect.

The results, however, are less definite than hoped. With respect to the characteristics of the firm's own product market, the level of competition (O-CP) has a positive impact on a firm's export success both in manufacturing and services, although the effect in manufacturing is not quite significant. The effect of demand specialization (O-SP) shows the expected positive sign in manufacturing while it is negative in the service sector. The negative effect of MN firm activity (O-MN) for service firms indicates that foreign direct investment in services may be a substitute to export activities, which is plausible given high transaction costs for exports. Overall, in the manufacturing sector we can only identify a significant effect of the demand specialization. A firm can export those products more easily where the market in Germany exerts relatively more attention to as compared with the market in other countries.

TABLE I
Estimation results for manufacturing firms

Dependent variable: export share	A	B	C
Sector-specific			
T	0.219***	0.210***	0.203***
	(0.035)	(0.035)	(0.372)
GD	−9.186**	−8.793**	−15.328***
	(4.089)	(4.080)	(4.640)
Firm-specific			
logSize	14.876***	14.795***	14.411***
	(1.369)	(1.361)	(1.359)
logSize2	−0.921***	−0.926***	−0.888***
	(0.126)	(0.125)	(0.125)
BD	0.736	0.840	1.059
	(1.629)	(1.625)	(1.624)
BD2	0.900	0.906	0.960
	(1.525)	(1.518)	(1.511)
East	−11.833***	−11.920***	−11.575***
	(1.355)	(1.352)	(1.350)
GR	−2.854**	−2.707**	−2.837**
	(1.348)	(1.341)	(1.335)
ULC	−1.518**	−1.541**	−1.649**
	(0.764)	(0.769)	(0.775)
CI	−0.673	0.817	0.959
	(4.293)	(4.258)	(4.211)
Skill	26.277***	25.060***	25.543***
	(5.006)	(4.989)	(5.062)
Inno	5.080	5.442	4.122
	(6.581)	(6.522)	(6.485)
RD	3.329*	3.938**	3.550**
	(1.826)	(1.761)	(1.772)
PC	−2.962*	−2.052***	−2.607*
	(1.697)	(1.573)	(1.577)
PD	8.967***		
	(2.014)		
PDC		8.581***	6.184***
		(1.628)	(1.736)
PDM		2.544*	1.939
		(1.493)	(1.532)
PDn		3.626*	2.824
		(1.922)	(1.963)
Own industry			
O-SP			5.687**
			(2.374)
O-CP			7.323
			(4.999)
O-MN			0.868
			(0.839)
Customer industry			
U-SP			−1.923
			(2.041)
U-CP			−0.365
			(4.870)
U-MN			0.695
			(0.702)

TABLE I
Continued

Dependent variable: export share	A	B	C
U-EX			0.243** (0.114)
Constant	−53.062*** (4.013)	−51.367*** (3.989)	−52.981*** (4.217)
Wald test: chi^2	624.79	643.85	678.14
Prob chi^2	0.000	0.000	0.000
Observation summary	2149 853 3002	Uncensored observations Left-censored observations Total observations	

Tobit Estimations with heteroscedasticity, heteroscedasticity term includes 12 industry dummies. Standard errors in brackets. Coefficients with significance to the level of 99% (95%, 90%) are marked with *** (**, *).

The results on the characteristics of the customers' industries are equally disappointing. Only one attribute of the customer industry has a significant effect. The export orientation of customers (U-EX) increases the export success of suppliers. In the service sector, there is a positive albeit only slightly significant effect of multinational firm activity (U-MN). The insignificance of the other market attributes could also mean that the variables used are not suitable as indicators for the market attributes that were intended to be tested. Other effects might be involved. The price level – here used as an indicator for competition – could be an indicator of the willingness to pay or the quality preferred in a country. In the latter case, a low-price level may indicate export hampering characteristics of local demand.

Moreover, the insignificant effects of industry characteristics may result from an inappropriate sector aggregation level. For three of our four indicators – MN firm activity, competition and demand specialization – internationally comparable sector data are available basically at a 2-digit level only. Such broadly defined sectors only weakly correspond to product markets. Consequently, the indicators used tend to blur existing differences on a more disaggregated level and lead to insignificant estimation results. In contrast, the indicator on export orientation was measured on a three digit-level and produced statistically significant results.

4. Conclusions and further research

Overall, export success of firms certainly depends on innovations. However, many innovations are triggered or shaped by local customers and the local market preferences. Responsiveness to customers and the market is seen as an important success factor of innovation. In this article, we test the hypothesis whether this local adaptation of innovations has a positive or negative effect on exports and whether particular characteristics of the local market reduce or enhance the exportability of innovations. In order to find measures for the degree of export efficiency of a local market, we test several attributes of local markets that are supposed to strengthen (or weaken) the exportability of innovations of local firms. We find that a higher specialization of a home market on specific products and export activities of customer industries have a significant positive effect on exports of a firm. The specialization or relative market size is an indicator for the sophistication and attention of the local market for a particular product. A local market spends relatively more money on a product when this good is more important in this country. As a result, customers

TABLE II
Estimation results for service firms

Dependent variable: export yes/no	A	B	C
Sector-specific			
T2	0.284	0.260	0.304
	(0.202)	(0.192)	(0.201)
T3	0.633***	0.583***	0.628***
	(0.193)	(0.186)	(0.198)
GD	0.698***	0.706***	0.904***
	(0.271)	(0.260)	(0.318)
Firm-specific			
LogSize	0.291***	0.278***	0.280***
	(0.081)	(0.079)	(0.081)
logSize2	−0.029***	−0.028***	−0.028***
	(0.008)	(0.008)	(0.009)
BD	0.308**	0.310**	0.340**
	(0.138)	(0.135)	(0.139)
BD2	0.234**	0.235**	0.244**
	(0.110)	(0.108)	(0.110)
East	−0.877***	−0.863***	−0.859***
	(0.097)	(0.096)	(0.096)
GR	0.338***	0.384***	0.408***
	(0.092)	(0.091)	(0.094)
ULCS	−0.093	−0.088	−0.095
	(0.071)	(0.068)	(0.072)
InvI	−0.488	−0.460	−0.516
	(0.480)	(0.463)	(0.485)
Skill	0.729***	0.710***	0.712***
	(0.179)	(0.178)	(0.186)
Inno	0.629	0.583	0.357
	(0.463)	(0.445)	(0.431)
RDc	0.965***	0.900***	0.895***
	(0.142)	(0.142)	(0.145)
PC	0.031	0.028	0.005
	(0.113)	(0.104)	(0.108)
PD	0.326***		
	(0.111)		
PDC		0.302***	0.219*
		(0.100)	(0.115)
PDM		0.262**	0.187
		(0.106)	(0.123)
PDn		0.255**	0.192
		(0.125)	(0.149)
Own industry			
O-SP			−0.364***
			(0.137)
O-CP			0.473**
			(0.237)
O-MN			−0.190**
			(0.078)
Customer industry			
U-SP			0.198
			(0.144)

TABLE II
Continued

Dependent variable: export yes/no	A	B	C
U-CP			−0.298
			(0.329)
U-MN			0.085
			(0.055)
U-EX			0.039***
			(0.012)
Constant	−2.205***	−2.117***	−2.158***
	(0.316)	(0.306)	(0.142)
Wald test: chi^2	187.78	197.25	216.74
Prob chi^2	0.000	0.000	0.000
Number of observations		3291	
Number of firms with export activities		900	

Probit Estimations with heteroscedasticity, heteroscedasticity term includes seven industry dummies. Standard errors in brackets. Coefficients with significance to the level of 99% (95%, 90%) are marked with *** (**, *).

put more effort in information searching, evaluation of the product and in the interaction with the producers. They are likely to pressure the producers to improve the product. The market thus increases the quality of the good.

Furthermore, we find that export activities of the customer industry have a strong, positive effect on the exports of a firm. The export orientation trickles down to the supply chain. If a product is exported, local supplies are more exportable as well, since the customer industry demands that the supplies and components match the conditions in the foreign markets they serve. Firms in other countries often seek to use the same components the exporters of globally successful products use in order to ensure compatibility. Examples are semiconductors and software in a personal computer. In addition, spare parts might be exported directly by the suppliers.

The results for the service industry are ambiguous. While customers have a positive effect on exports in the service sector as well, in contrast to our expectation, the variable for the specialization of demand has a negative sign and local market growth has a positive effect. On the other hand, local competition within the service industry and export activities of customers have a positive effect on exports as expected. The ambiguousness of the results might reflect the imprecise concept of exports in the service sector. In addition, there is a high heterogeneity in this sector. Some services cannot be exported at all and firms often establish foreign subsidiaries to serve foreign customers.

Our results largely confirm other empirical results on market structure and export activities. The estimation results, however, do not fully identify the attributes of the domestic market that are responsible for the positive influence on the exportability of the innovations of local firms. Its seems that the most important role of the local market is still the effect on the amount of innovations. This implies the following random rule: while not all innovations are exportable, the more a firm innovates the more innovations will be exported.

The results are relevant for firms as well as for politics. Most firms regard markets as unattractive that are characterized by a high level of competition and low profits due to low prices. In fact, those markets would be especially attractive for innovation active firms as a test market and springboard to the world market. Politics can help to strengthen the market factors that lead to more exports, such as by maintaining or supporting a high degree of competition. The most important task for future research is to

find better indicators for characteristics of country markets that have an effect on export efficiency such as competition, demand sophistication and demand preferences. Especially, more disaggregated sector data are needed in order to adequately represent differences in market structures across countries.

Another issue is to deal with potential endogeneity between innovation and export performance of firms. A test of Granger causality of the data we used has shown that innovation activities positively affect export performance but there is no influence of exports on innovation (see Ebling and Janz, 1999). These results refer to cross-section analysis, however, while it may very well be the case that export performance in the past will affect innovation activities, including the use of different sources for innovation, in the future. In order to investigate into these relations and to incorporate them into our model, panel data of our model variables would be required. These are currently not at hand, however.

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Notes

[1] This dilemma is similar to the general problem of customization. Companies that respond to the specific preferences of single customers have a high rate of innovations, but may be less profitable than companies with a standardized product programm if they cannot sell those customized innovations to other customers. Therefore, the empirical observation that customer responsiveness leads to more innovations is ambiguous if the profitability of innovations is not taken into account as well.

[2] An endogeneity problem emerges when exports increase the amount of innovations of a firm making innovations and exports mutually reinforcing (see Ebling and Janz, 1999; Smith et al. (2002).

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