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Börje Johansson
Sara Johansson
Tina Wallin

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Internal and External Knowledge – Innovation of Export Varieties.

Börje Johansson[1], Sara Johansson[2] and Tina Wallin[2]

CESIS, CEnSE and CIRCLE

Abstract

Firms in local industries maintain their capability to generate innovations by simultaneously exploiting internal and external knowledge resources. The paper introduces the notion variety triplet to distinguish individual export varieties, where a triplet is a unique combination of a firm, a product code and a destination country. For each date the set of variety triplets in each local industry records all remaining past product innovations. In view of this the paper examines how internal and external knowledge of local industries influence the industry's scope and value of export varieties. The paper contributes to existing knowledge firstly by introducing variables that measure a local industry's access to external supply of knowledge, divided into local and extra-local supply. Secondly, the paper sheds light on how internal and external knowledge influence the scope of product innovations in local industries, with firm-level data from Sweden. Thirdly, the paper compares the influence of knowledge on the entire set of variety triplets and on a separate set of recently introduced varieties.

Keywords: Product varieties, innovation, internal knowledge, external knowledge, KIBS

JEL: F12, F14, R12, R32

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[1] CESIS at Jönköping International Business School and the Royal Institute of Technology, and CIRCLE at Lund University

[2] CESIS and CEnSE at Jönköping International Business School

1. Introduction

Recent contributions to the resource-based view of the firm (Almeida and Phene 2012) suggest that a firm generates innovations in a processes that exploits knowledge inputs from the conjunction of internal and external knowledge sources (Cantwell and Zhang 2012). The combination of internal knowledge and accession of external knowledge is cumulated into knowledge of firm routines, product attributes, customers' preference for product attributes in different markets, and routines for how to organize innovation activities (Karlsson, Stough, and Johansson 2009).

Andersson and Johansson (2012) present results that suggest that the number of firms and the number of product-specific export varieties are positively affected by a local industry's accessibility to knowledge-intensive labour in other industries in the regional economy. Knowledge resources outside the industry also seem to affect the unit price of export flows upwards. As developed later in the present paper, these observations can in turn be associated with Feldman's (1999) observations of how agglomeration spillovers stimulate innovations in a region.

A basic assumption in the present study is that a firm's history of product innovation efforts are reflected by the number of unique variety codes and export destinations. Each such combination of a code and a destination corresponds to a unique firm-specific variety. Andersson and Johansson (2008, 2012) introduce a model of firms' export flows, based on a monopolistic-competition framework, which allows the presence of multi-variety firms. In this model they identify product variety triplets as a unique combination of variety code, destination and firm. In this setting each variety triplet is the outcome of a stochastically generated innovation idea that triggers the pertinent firm to innovate, and economies of scope imply that firms have an incentive to supply more than one triplet. While studying the entry and exit of such triplets, they find evidence that the number of variety triplets of a firm provides information about that firm's innovative behaviour in the near past.

The present study examines the role of internal and external knowledge in the creation of product innovations at the industry level, both separately and jointly. This is done both in a static and dynamic setting. Industry is our unit of analysis, while variety triplet is empirically used as a count variable that measures the product innovation frequency of each local industry, as further developed in Section 2.2. Thus, first we count the number of varieties in a local industry at given points in time, and then we count the introduction of new varieties for a given time period. The objective of the paper is to show that similar knowledge structures influence the number of established and novel variety triplets in local industries.

The paper contributes to the understanding of export and innovation of export products by analysing trade flows with their origins in a fine set of 290 local economies and 22 manufacturing industries. This setting allows for an analysis in which one may distinguish between the effects of internal and external knowledge on various dimensions of each local industry's export, such as number of exporting firms, average number of destination-code varieties per firm, average unit price per variety triplet, etc.

The paper suggests a way of describing the local innovation milieu and associated advantages by considering the joint effect of a local industry's internal and external knowledge on the industry's export performance. The paper also contributes by showing that accessibility to external knowledge is positively associated with the number of exporting firms and the unit price for export flows from each industry in each local economy. In this context the paper also contributes by extending the measurement of a local industry's external margin into more than one dimension.

Section 2 presents a theoretical framework that allows us to analyse how the conjunction of internal and external knowledge affects the extensive margin of firms and industries in local economies. Section 3 discusses the empirical approach, presents descriptive statistics and also some dynamics. Section 4 presents and assesses empirical results from two sets of regression analyses and section 5 concludes the study.

2. Theoretical Framework

2.1 Product Innovation and Export Varieties

This paper exploits export statistics as a source for observing product innovation. For each local industry we can identify the codes of the products that firms in the local industry export, and the we can ask: how many codes correspond to an industry across the set of local economies that define a country's economy. Some of the local economies will be represented with a large number of codes and others may have a very small number. With little reflection the analyst will suggest that local economies with many codes in their basket have a more intensive history of product development behind them.

A second step can be taken if we impose the assumption that monopolistic competition prevails, implying that when two or several firms export goods with the same code, each firm is exporting a product that is differentiated from the products with the same code but exported by another firm. With these observations we may for each product code calculate the total number firm-code pairs in every local industry and use this as an indicator of past product-innovation efforts in the pertinent industry.

We may take a third step and consider a third distinction, observing that a firm can export a product with a given code to more than one destination (export market), where each destination corresponds to an importing country. Using this information, it is possible to describe the export flow from a local industry in terms variety triplets, where each triplet is a unique combination of firm-code-destination.

Introduction, expansion, decline and disappearance of variety triplets display change patterns that are associated with product cycles (Vernon, 1966) and spatial product cycles (Johansson and Andersson, 1998). In this model framework a young variety triplet is characterized by a small quantity and above average price, and the introduction of such novel triplets is associated with large shares of knowledge inputs. As the variety triplet matures, the model prediction is that production and sales volumes increase and prices are lowered. At such later stages of the variety cycle the production and distribution routines have developed in the direction of a reduced need for knowledge inputs.

In the light of these model features this paper investigates two things. The first effort is to reveal the frequency of export-variety innovations that each local industry has developed and introduced in the past, represented by the stock of variety innovations that can be observed for a local industry at each given point in time. The second objective is to count the number of new variety triplets that have been introduced during a given period (t, $t+\tau$) . This is accomplished by selecting all variety triplets that were present in year $t+\tau$ but not in year t.

Variety triplets were used by (Andersson and Johansson 2012) in a model where fixed costs give rise to economies of scope. The model assumes that when a firm introduces a new code variety in its own product portfolio or a destination channel which is new for the firm, then the firm has to make an associated product-innovation investment or a destination-link investment, and this assumption implies that firms will have incentives to increase their scope of variety triplets. In other words, with many variety triplets a firm can exploit economies of scope by employing the same export channel (or link) for several different codes or by selling an already developed product (variety-code) to many destinations. These phenomena provides incentives for the firm to expand its extensive margins.

Table 1 describes how unique variety triplets can be identified by employing the finest level of commodity classification in the Swedish trade statistics, where commodities are identified by a product code. Each of these codes are thought of as a product group. From this basis we add the two additional specifications, one referring to the exporting firm and another referring to the destination country. This implies that if two firms supply an output with the same variety cod these two outputs are considered to be differentiated with regard to essential attributes. Finally, if a firm exports a commodity with the same variety code to two different destinations, these two flows are also considered to be differentiated and can thus be identified as two different variety triplets.

Table 1: Identification of export variety specifications

Variety specification	*Interpretation*
Variety triplet	A variety triplet is the finest level for which distinct varieties can be identified by an index (*a, b, c*), where *a* denotes variety code, *b* destination, and *c* firm. Every triplet is unique.
Firm specification	With monopolistic competition we assume that when two firms, *c* and *c'* supply a product with the same variety code *a*, and the same destination *b* then these firm-specific varieties are differentiated vis-à-vis each other, such that (*a*, *b*, *c*) is a different variety triplet than (*a*, *b*, *c'*).
Destination specification	Each exporting firm *c* may sell the same variety code *a* to several different destinations *b* and *b'*. For every given firm, the model framework treats every unique combination of a variety code and a destination as differentiated from all other deliveries by the same firm. Thus, the triplet (*a*, *b*, *c*) is differentiated from the triplet (*a*, *b'*, *c*).
Variety code specification (product or product group)	The variety code *a* defines a product group containing a set of variety triplets with one and the same code. Product groups have an 8 digit specification.

Based on the distinctions made in Table 1 we can chose several ways to decompose the export flow into different categories in order to characterize the diversity of export flows for each industry in a local economy. The choice we have made makes it possible to identify two categories of extensive margins, where the first reflects the number of firms with positive export, and where the second reflects the number of exported destination-specific varieties per firm.

To illustrate the options for analyses, consider that a local industry consists of F firms and that these firms on average have N distinct combinations of codes and destination links. Then this local industry supplies $T = F \times N$ variety triplets and the scope of the local industry output can be be large due to many firms or to many variety codes or to many destination links.

2.2 Combination of Internal and External Knowledge

A number of studies provide support to the idea that innovations made by firms depend on knowledge resources and capabilities of the innovating firm in combination with knowledge sources that are accessed outside the firm, primarily in its local and regional economy. In (Klette and Kortum 2004) and Kortum (2008) the focus is on internal properties of the firm and how firm capabilities develop in an experience-based learning process. Other contributions have instead investigated the importance of the milieu of the innovating firm and stressed spillovers that take place in the local and regional economy and that also materializes as knowledge flows in networks (Audretsch, and Feldman, 1996 ; Feldman, 1999).

While relying on its cumulated resource base and associated knowledge assets, the innovating firm is characterized by its capacity to exploit in-house knowledge in conjunction with external knowledge sources. If we recognize that the distance between two agents increases the cost of their interaction, it is obvious that a firm's proximity to external knowledge affects the opportunities to acquire useful inputs to the firm's innovation and renewal activities. From this observation we also conclude that the likelihood of interaction between two parties is reduced as the separating distance increases, following a similar probability pattern as in labour market commuting.

As outlined in Johansson and Quigley (2004), there are two principle ways that can simplify and stimulate knowledge interaction and exchange of associated information. The first principle is the *proximity advantage*, which is based on the fact that the frequency of face-to-face (FTF) interaction between two or several parties decreases as the (time) distance between the location of the parties increases. This principle implies that an innovating (and adopting) firm benefits from being located in an environment with rich and diverse knowledge flows and with a multiplicity of relevant knowledge sources and knowledge exchange actors like R&D-intensive firms, knowledge-intensive business services (KIBS) and research organizations, including universities.

Following Johansson and Quigley (2004), the second approach to facilitate knowledge transfer and exchange between two parties is to invest in links (communication channels) between the parties. According to this principle a firm can invest in links and entire networks of interaction links to reduce the friction and costs of interaction over long distance. This opportunity may be termed *network advantage*. Thus, when a proximity solution is not at hand in a given location, then a firm can choose to invest in links to distant collaborators (such as suppliers, customers, KIBS and other knowledge providers) as a means to compensate for the lack of feasible proximity options. In many cases lumpy investments in long-distance links complement investments in links for short-distance interaction. The advantage of a location in an agglomeration is that (i) the need for lumpy link investments is smaller in an urban agglomeration, while such investments at the same time are more easy to establish inside an agglomeration. In particular, when two actors are located in the same functional region the cost of forming an interaction link should generically be smaller than when the same actors are more distant from each other.

Almeida and Phene (2012) claim that contemporary technological conditions require that individual firms generate innovation by integrating internal and external knowledge. Such integration may also be described as a process of combining internal and external knowledge. The authors find support from a series of examples from ICT related innovations. Similar suggestions are also presented in Cantwell and Zhang (2012), where a firm's internal knowledge manifests itself in a capacity to organize knowledge accession.

Recalling that our focus is on product innovation we recognize that a firm may search both internally and externally for knowledge about product attributes, production routines and market conditions associated with each sales destination. In general we may conceive the external knowledge as more diversified and the internal more specialized. A particular aspect of the internal knowledge of firms in a local industry is the education asset associated with employees in the industry, which we measure as the total amount of university-education years (education mass). Internal knowledge of firms in a local industry also encompasses (i) know how with regard to the orchestration of innovation efforts, (ii) experience about accession of external knowledge, (iii) know how about approaches that facilitate the combination of internal and external knowledge, and (iv) experience from interaction with external knowledge handlers.

In view of our discussion about how internal and external knowledge can be combined we intend to examine how each of the categories internal and external knowledge contribute to the innovation performance of firms in a local industry. In doing this we especially investigate to what extent internal and external knowledge are substitutes, and to what extent their combination adds to product innovation performance of firms in a local industry – as reflected by the number of exporting firms, number of variety triplets, unit export price, as well as new exporting firms, new variety triplets and unit price of novel varieties.

In addition we identify each local industry's external knowledge as the potential supply of KIBS that can be accessed by firms in each local industry. This approach means that we do not observe the knowledge interaction directly. Instead we characterize the potential external knowledge that exist in every local economy and its environment.

2.3 External Knowledge Accessibility

In the preceding sub section the internal knowledge of a firm is identified as the education mass of the firm, measured as the number of education years of employees. This measure is then used to determine the internal knowledge of a local industry. Such a measure may be thought of as an internal knowledge potential.

The external knowledge potential of a local industry should represent the richness of knowledge opportunities for firms in the particular local economy. From this potential a firm can find advice, purchase innovation support and establish cooperation with external actors, and absorb knowledge flows in general. Our intention is to calculate such a potential for each local economy and hence for the firms in each local industry.

Many earlier studies (e.g. Jaffe et al. 1993; Audretsch and Feldman, 1999) have examined how aggregate knowledge sources and R&D activities inside an urban region generate spillovers and affect innovation activities and innovation outcome of firms located in the region. The conclusion from these contributions are that knowledge flows and spillovers are spatially bounded. With our approach this idea is made more precise as we calculate two external knowledge potentials for each firm location, i.e., for each local industry. The first potential captures the local knowledge accessibility, while the second captures the knowledge accessibility with regard to external knowledge outside the local economy.

Consider now the Swedish geography with 290 local economies, indexed by *i* and *j*. For each of these local economies we can observe the total supply of KIBS, which include R&D services, financial services, export support services, management services, legal advice, ICT services etc. A large share of the employees in these KIBS-activities has university education, and the supply in location *i* is measured by the total KIBS employment, G_i. For each location, *i*, we have two types of time-distance information (Johansson, Klaesson and Olsson, 2003), where the first, t_{ii}, reflects the average time it takes to move between two sub locations (zones) inside the local economy *i*, and where the second, t_{ij}, reports the travel time by car from location *i* to location *j*.

Based on the above definitions we can construct a measure of location *i*'s local knowledge accessibility, , specified as follows:

$$A_{ii} = \exp\{-\lambda_1 t_{ii}\} G_i \qquad (1)$$

which expresses location *i*'s distance-discounted access to the local supply of KIBS, and where λ_1 denotes an estimated parameter for the time sensitivity of face-to-face contacts inside a local economy. For face-to-face contacts between actors in two different local economies, *i* and *j, i*'s distance-discounted access to the supply of KIBS in location *j* is given by $A_{ij} \exp\{-\lambda_2 t_{ij}\} G_j$, where λ_2 denotes an estimated parameter for the time sensitivity of face-to-face contacts outside a local economy. Thus, as described in formula (2) we can sum over all local economies $j \neq i$ to obtain the total distance-discounted access to supply of KIBS outside the local economy *i*:

$$A_i = \sum_{j \neq i} \exp\{-\lambda_2 t_{ij}\} G_j \qquad (2)$$

The accessibility formula, $A_{ij} = \exp\{-\lambda t_{ij}\} G_j$, was given a theoretical motivation by Weibull (1976) and is suggested in (Fujita and Thisse 2002). It can be derived from a random-choice specification (Johansson et al. 2003), and implies that the potential for knowledge flows on the link (*i*,*j*) reduces in value as the time distance t_{ij} increases.

The accessibility measures in (1) and (2) take into account the cost of transferring knowledge from the firm supplying knowledge intensive services to the firm that produces and exports manufactured goods. Much knowledge is tacit or sticky in the sense that it is not codified or incompletely codified. This is particularly true for new discoveries generated by innovation activities. Such tacit knowledge is mainly exchanged through interpersonal contacts in the form of face-to-face communications. The frequency and effectiveness of such communications tend to decrease with the time distance between the agents involved (Pred, 1977; Feldman, 1994). Thus, the transmission and absorption of new and complex knowledge is facilitated by geographical proximity.

Andersson and Gråsjö (2008) employ a model with a knowledge production function, with patent applications of firms representing output, whereas internal and external knowledge sources comprise the inputs. The knowledge production is assumed to depend on R&D activities (man years) in other firms and R&D activities in universities (man years). The influence from these external knowledge resources is discounted according to the principle described in formulas (1) and (2), but separated into local, intra-regional and extra-regional influences. The study demonstrates that such an accessibility approach takes care of the spatial interdependencies by including them in the model. The described approach demonstrates a way to model spatial knowledge interaction opportunities.

Finally, we may also observe that Andersson and Johansson (2010) employ an accessibility measure that relates to the one suggested in the present paper. In their case the knowledge factor, G_j, is the number of university educated workers in location *j*, claimed to be a slowly changing characteristic of the pertinent location. Similar comments also apply to our framework, in which G_j denotes the supply of knowledge-intensive producer services which is greater and more diversified in local economies that form large urban agglomerations.

3 Empirical Strategy

Product innovation generates new variety triplets that may correspond to both horizontal and vertical differentiation. At the level of an individual firm, the innovation efforts make use of both internal and external knowledge resources. We study this phenomenon at the semi-aggregated level of local industries. This means that the notion internal knowledge is a summation of the total number of university years schooling (education mass) across individual firms in each local industry. The external knowledge of a local industry is the distance-discounted access to local and extra-local supply of KIBS. From the arguments presented in the previous section, we assume that innovation is positively stimulated by its internal and external knowledge sources and by the conjunction of these two sources.

The process product innovation is observed as (i) new firms starting to export variety triplets and (ii) established export firms developing new variety triplets. In retrospect, product innovation efforts also reveal themselves in a local industry's number of variety triplets and in the unit price level of its triplets. Innovation drivers are internal knowledge, knowledge sources in the local and extra-local milieu.

In order to examine this, then analysis employs data from Statistics Sweden on exports from manufacturing sectors in Sweden's 290 municipalities in the years 2002 and 2006. Manufacturing sectors in this setting refer to the Swedish Standard Industrial Classification (SNI) from 2002 and the two-digit level group 15-36. These data are aggregated to industry level from firm-level data, containing information about export value and export quantity for each firm at the 8-digit level of product classification according to the combined nomenclature (CN). Data on number of employees per firm and their education level are also provided by Statistics Sweden for the years 2002 and 2006. Moreover, the data contains information about every firm's location.

Each firm-level observation in each 8-digit product group (variety code) is regarded as a unique in the sense that it is a firm-specific variety. Each firm is thus assumed to produce a distinct variety, even if several firms produce the products with the same variety code. Consequently, an 8-digit code is looked upon as a product group, and each variety triplet in this group is distinguished by its code, firm and market destination. Accordingly, each variety triplet has a particular export link. The aggregation of firm- and code-specific observations to 22 two-digit level industries across the set of local economies results in a data set containing 2771 industry-location-specific observations with positive export in year 2002 and 2810 observations in year 2006.

3.1 Definition of Independent Variables

Industries are likely to produce more variety triplets the larger they are, as suggested by Andersson and Johansson (2012), who argue that the firms are big as a consequence of many successful variety innovations. In order to take that effect into account the first independent variable is a proxy variable for size of the local industry, i.e. the number of employees in the industry l in the local economy s.

The internal knowledge is measured by the number of years of university schooling of the employees. The measurement of the external knowledge of a local industry is described in sub section 2.3 in formulas (1) and (2). As shown there, the external knowledge is sub divided into local KIBS accessibility and extra-local KIBS accessibility. For a given location (local economy)), such a pair of measures includes the supply of KIBS in the local economy as well as the supply of KIBS in other locations, outside the local economy.

Consider now industry l in location *s*. Its internal knowledge is denoted by IK_{ls}, its local KIBS accessibility by LK_{ls}, and its extra-local KIBS accessibility by EK_{ls}. This means that we are observing knowledge sources as well as export activities at the level of local industries. This means that the likelihood of having positive values for our observables increases considerably, compared to introducing firm-level variables.

The interaction between internal and external knowledge is measured with an interaction variable $DIK_{ls} \times \ln(LK_{ls} + EK_{ls})$, where DIK_{ls} takes on the value one for above the median level of internal knowledge and zero otherwise, while $LK_{ls} + EK_{ls}$ is the total external knowledge accessibility of local industry (*l*, *s*).

Table 2: Overview of explanatory variables

Variable	Definition
S_{ls}	Size of local industry (*l*, *s*), measured by the number of employees
IK_{ls}	Internal knowledge of local industry (*l*, *s*), measured by the number of years of university studies
LK_{ls}	Local KIBS accessibility of local industry (*l*, *s*), as given by formula (1)
EK_{ls}	Extra-local KIBS accessibility of local industry (*l*, *s*), as given by formula (2)
$LK_{ls} + EK_{ls}$	Total KIBS accessibility of local industry (*l*, *s*)
DIK_{ls}	Dummy variable with value one for high level of internal knowledge
$DIK_{ls} \times \ln(LK_{ls} + EK_{ls})$	Knowledge interaction variable, intended to capture the conjunction of internal and external knowledge of (*l*, *s*)

3.2 Dependent Variables and Model

In order to analyse the effects of internal and external knowledge on the structure of export flows one must disentangle how different margins of these flows respond to spatial variations in knowledge or rather variations in knowledge composition across local industries. For this purpose we note that the export flows of a location (local economy) consist of four separable components:

i. the number of exporting firms, F
ii. the average number of code-specific export links per exporting firm, N
iii. the average unit export price, P

iv. the average export quantity, in kilogram, per variety triplet, Q

Variations in the size of regional export flows can be due to variations in any of these four components. Dividing the aggregate export flow from a given industry and locality into these four components results in:

$$V = FNPQ \tag{3}$$

where V denotes total export value in thousand SEK, F is the number of exporting firms, N is the average number of code-specific export links per firm and Q and P denote the average export quantity respectively the average per unit price (also in thousand SEK) of exported variety triplets. We observe that FN amounts to the total number of variety triplets for a local industry. In logarithmic form this relationship is written as:

$$\ln V = \ln F + \ln N + \ln P + \ln Q \tag{4}$$

The different components in equation (3) and (4) can be discussed in terms of extensive and intensive margins. $\ln F + \ln N$ is the extensive margin of the aggregate export flow, which reflects the number of variety triplets in the export flow from a local industry. The sum $\ln P + \ln Q$ represents the intensive margin, consisting of the average per unit price and the average quantity exported of variety triplets, which are firm-code-destination specific flows from a local industry.

To test the hypotheses about how the spatial variation in internal and external knowledge influences the structure of export flows we apply a cross location-industry regression model, using export data aggregated to local economies (municipalities) and 2-digit industries. Hence, the regression model includes both a spatial and sectoral dimension and can be written in reduced form for local industry (*l*, *s*) as follows:

$$\begin{aligned} \ln Y_{ls} = \alpha + \beta_1 \ln S_{ls} + \beta_2 \ln IK_{ls} + \beta_3 \ln LK_{ls} + \beta_4 EK_{ls} + \\ \beta_5 DIK_{ls} \times \ln(LK_{ls} + EK_{ls}) + \beta_6 D_l + \varepsilon_{ls} \end{aligned} \tag{5}$$

where Y_{ls} represents the five variables shown in equation (4) and Table 3 for local industry (*l*, *s*), D_l is an industry dummy and ε_{ls} is a normally distributed random error term. The remaining variables are introduced in Table 2.

The variables presented in Table 3 will each be regressed against the explanatory variables in equation (5). The first equation with export value, V_{ls}, as dependent variable can take on high values due to many variety triplets, large quantities, high unit prices, and this means there are substitutions such that high unit prices may correlate with small average quantities of varieties – and vice versa. In other words: for a given number of variety triplets, the export value depends on the product P_{ls} Q_{ls}.

Table 3: Overview of five dependent variables

Variable	Definition
V_{ls}	Export value from local industry (*l*, *s*)
F_{ls}	Number of exporting firms in local industry (*l*, *s*)
N_{ls}	Average number of distinct combinations of codes and destination links for (*l*, *s*)
P_{ls}	Average unit export price of variety triplets supplied from local industry (*l*, *s*)
Q_{ls}	Average export quantity of variety triplets supplied from local industry (*l*, *s*)

The conjunction notion introduced in this paper implies that firms that already have a high level of internal knowledge will be more able to access and absorb external knowledge (Johansson and Lööf, 2008). This is captured by the conjunction variable $DIK_{ls} \times \ln(LK_{ls} + EK_{ls})$, expressing that high internal knowledge combined with high external-knowledge accessibility. However, this may still allow the separate knowledge variables IK_{ls} , LK_{ls} , and EK_{ls} can add to the explanation of export-product innovation. The specification of the five different regression models also includes a vector of industry dummy variables, D_l , controlling for unobserved industry heterogeneity and an error term subject to the usual assumptions of a zero mean and normal distribution.

3.3 Hypotheses about Export-Product Innovations

In the empirical analyses in Section 4 and 5 aggregate export flows from local industries are disentangled into number of firms, variety codes, destinations, and into average prices and quantities. The analyses are carried out in a cross section setting, which is complemented by a formulation that focus on the introduction of new variety triplets during a four-year period.

In this study we distinguish between product innovations that affect the extensive margin of trade flows from local industries, and product innovations that influence the intensive margin of export flows from local industries. With these distinctions it is possible to test several hypotheses about the influence of internal and external knowledge on innovation and export-product renewal activities. Differences in the structure of export flows across industries and locations can be assumed to reflect the capacity for innovation in the set of local economies. Such differences can be related to the knowledge milieus of different locations and their factor proportions. Specifically, the empirical analysis aims to test the following hypotheses for local industries:

H1: The number of exporting firms is positively associated with (i) the size of the local industry, (ii) the size of internal knowledge of the local industry, (iii) the local external knowledge accessibility, and (iv) the conjunction of internal knowledge and external knowledge accessibility.

H2: The number of code-specific destinations is positively associated with (i) the size of the local industry, (ii) the size of internal knowledge of the local industry, (iii) the local external knowledge accessibility, and (iv) the conjunction of internal knowledge and external knowledge accessibility.

H3: Average unit price of exported variety triplets is positively associated with (i) the size of the local industry, (ii) the size of internal knowledge of the local industry, (iii) the local external knowledge accessibility, (iv) and the conjunction of internal knowledge and external knowledge accessibility.

H4: Explanatory variables that have a positive effect on average unit price also have a negative effect on the average export quantity, and vice versa.

Hypotheses H1-H4 are assumed to apply to the total stock of variety triplets in year 2006. Moreover, the sane hypotheses are also assumed to apply to the new variety triplets that were present in 2006, but did not exist in year 2002, referred to as gross introduction in the period 2002-2004.

It could be observed that the variable expressing extra-local external knowledge accessibility have been excluded from the formulations of hypotheses. If this variable has any effect on export-product innovation, it is expected to be a similar but weaker effect than the one generated from local external knowledge accessibility.

4. Swedish Export Flows from the Manufacturing Sector

Descriptive statistics of the different export margins in 2006 are presented in Table 4. As the figures reveal, there are large variations in the different margins of export flows across local industries. The average number of exporting firms per industry and locality is 3.32, yet the maximum number is 187. The number of product-specific export links is approximately 27 in the average local industry but the median value is only 7.55. Hence export activities in most local industries are concentrated to a few firms, which export a few products to a few destinations. Turning the interest to the intensive margin, the figures in Table 4 show that both the average value of export goods and the average quantity exported on each products-specific link varies substantially across industries and/or localities. As the extensive margins the intensive margins show skewed distributions with their median values substantially lower than their means.

Table 4: Descriptive statistics of dependent variables for local industries in 2006

	Minimum	*Maximum*	*Mean*	*Median*	*Standard deviation*
Aggregate export value (thousand SEK)	10	76466885	273758	7655	2387190
Number of exporting firms	1	187	3.32	2	6.83
Number of product specific export links	1	3933	27.37	7.55	101.58
Average unit export price (thousand SEK)	0.03	100446.89	577.92	92.82	2741.41
Average export quantity (kg)	1	99303978	209780.37	3003.56	2284846.40

Moreover, a correlation matrix of the different margins of export flows for 2006, displayed in the appendix, shows some interesting properties of the relations between the different margins and the aggregate export flow. The aggregate export value is strongly correlated with both the number of product (code) specific export links and the average export quantity. This suggests that local industries, that have a high aggregate export value, tend to export large quantities through many export links rather than exporting goods with high unit prices. This property is also shown by the negative correlation between the average export price and the aggregated export value. In general, it seems like industries either export large quantities at small unit prices or small quantities at high unit prices. The price variable is also negatively correlated with the number of firms per local industry, which suggests that variety triplets of relatively high value are only produced and exported by local industries with a relatively small number of firms.

The feature that high value products are exported from a limited number of firms is partly generated by variations in the nature of goods across industries, but also by variations in the nature of goods within industries, e.g. the average unit prices for goods with low value added are often relatively low, and such goods can be produced by a large number of firms without requiring special types of inputs or factors. Products with a high value added may, on the other hand, require very particular types of inputs or more specialised knowledge or labour skills that can only be provided by a limited number of firms. The importance of different knowledge sources on the structure of local export flows are thoroughly analysed in the next chapter.

When product innovations occur in the Swedish manufacturing this will bring about changes in the stock. In order to get a an understanding of these dynamics the entry and exit of varieties are presented in Table 5. Since there are only four years between 2002 and 2006 part of the data sets should be overlapping, i.e. some variety triplets are being exported in both years, while some new enter and established disappear.

Overall the Swedish manufacturing exports sector has become smaller in terms of variety triplets over the investigated period. The reduced number of variety triplets is due to a diminished number of export firms and fewer product codes. However, the exports have at the same time become more diverse in terms of the destination countries.

Table 5: Entry and exit of firms, destinations, codes and variety triplets in Sweden's manufacturing sector, 2002-2006

	Observations existing in both years	Observations that exit between 2002 and 2006	Observations that enter between 2002 and 2006	Net change
Firms	6106	3513	3256	-257
Export destinations	211	11	17	6
Product codes	5403	1936	1028	-912
Variety triplets	92479	229895	224249	-5646

What is particularly interesting is the large turnover on the micro level, e.g. approximately 71 per cent of the variety triplets that existed in 2006 did not exist in 2002. Thus, at the micro level there is an intensive dynamic process of exit and entry. At the same time the net change in variety triplets during the period was a small decline, amounting to less than 2 per cent. These observations indicate that the total number of varieties change at a slow pace, and the distribution of varieties across firms and local industries maintain an unchanged shape.

Table 4 suggests a large variance in the number of variety triplets supplied by each firm. On average, each firm supplied 27 varieties in 2006. The median value for the same variable was only about one quarter of the mean value. Table 6 provides an overview of the dispersion of export varieties per firm for both 2002 and 2006.

In both years a little bit more than 50 per cent of the total number of export firms supplied between 1 and 5 different export varieties only. The proportion of firms having a wide range of export varieties is very small; only about 3.5 per cent of the firms had more than 100 export varieties. Hence most firms produce only a small range of export varieties. The table also displays the tendency for the structure of exports to change slowly. Moreover, the pattern reflected in the table is compatible with our framework that assumes the presence of economies of scope, combined with monopolistic competition between varieties in each destination market.

Table 6: Number of export varieties per firm in 2002 and 2006

Varieties per firm	Number of firms in 2002	Cumulative percentage	Number of firms in 2006	Cumulative percentage
1	2136	22.21	2333	24.92
2-5	2860	51.94	2933	56.25
6-10	1243	64.86	1161	68.66
11-25	1469	80.13	1186	81.33
26-50	821	88.67	738	89.21
51-100	560	94.49	508	94.64
101-150	186	96.42	177	96.53
151-200	110	97.57	97	97.56
201-250	53	98.12	57	98.17
More than 250	181	100	171	100
Total	9619		9361	

Not only do structural changes occur slowly, but they also tend to preserve the distribution of the entire stock of variety triplets across firms. In other words, the distribution of varieties that enter between 2002 and 2006 is congruent with the stock distributions for 2002 and 2006.

5. The influence of internal and external knowledge on the scope of export varieties in local industries

The purpose of Section 5 is to assess regression results in specifications where the export value of a local industry is explained by (i) the size of a local industry, (ii) its internal knowledge, (iii) its local external knowledge, (iv) its extra-local external knowledge, and (v) its conjunction of internal and external knowledge. Moreover, as shown in equation (4) the export value of a local industry is decomposed into its extensive margin (number of firms and code-specific destinations) and its intensive margin (average unit price and average quantity), with a special focus on number of firms, code-specific destinations, and unit prices of local industries.

Equation (5) is applied to each of the dependent variables listed in Table 3. With this approach each parameter in column 1 of Table 7 equal the sum of the corresponding parameter values in column 2-5 in the same table. In this way we can compare how the total export value is the combined effect of the extensive and intensive margin of export flows.

We shall start by assessing the regression results based on the total stock of export varieties in year 2006 and compare these with the results that obtain when data from 2002 are employed. Thereafter we apply the same regression approach to the data defined as the gross introduction of new varieties between 2002 and 2006. In all cases we should observe that the conjunction variable make use of both internal and external knowledge, which may cause multicollinearity. Calculating variance inflation factors indicate that this problem is modest and does not disturb the results.

5.1 Regression Results for the Total Stock of Variety Triplets 2006

Consulting Table 7 we can make two major observations before the parameter estimates are used to assess our hypotheses. The first observation is that the size of the local industry has a positive effect on all export performance indicators except the unit price level. The predominant positive effect of local-industry size is found for the average quantity exported across all product-specific export links. The effect of industry size on average per unit export price is, in contrast, negative. These findings indicate that local industries that are relatively large tend to export mature varieties of relatively low value in comparatively large volumes.

The second major observation is that the conjunction of internal and external knowledge has a clear and positive effect on the aggregate export value of a local industry, whereas the two external knowledge accessibility variables have no positive effect. In addition, there is a separate positive effect on aggregate export value from the internal-knowledge variable.

Effects on the number of firms

In a concordance with hypothesis H1, Table 7 shows that the number of export firms is positively associated with the size of the local industry, the local external knowledge accessibility (local access to KIBS), and the conjunction of internal and external knowledge. However, separately the internal knowledge has an insignificant parameter. This observation indicates that internal and external knowledge are complements rather than substitutes.

Effects on the number of code-specific destinations

The estimation results for code-specific destinations are compatible with hypothesis H2 in the sense that the following variables have a positive effect on the number of code-specific destinations: (i) the size of a local industry, (ii) the size of its internal knowledge, and (iii) the conjunction of its internal and external knowledge. On the other hand the parameter for local external knowledge accessibility is negative and significant, whereas the parameter for the extra-local external knowledge accessibility is positive and significant. This could reflect that export firms with extensive destination links and many variety codes in their portfolio are located in small local economies (with small access to local supply of KIBS) bur close to large local economies (with large access to supply of KIBS outside the local economy but in the proximity of the local economy.

Table 7: Export indicators for local industries in 2006, regression results

	Dependent Variables				
	Aggregate export value	*Extensive Margin 1:* *Number of exporting firms*	*Extensive Margin 2:* *Number of code-specific export markets*	*Intensive Margin 1:* *Average price per unit exported*	*Intensive Margin 2:* *Average export quantity*
Total employment in local industry (*l*, *s*)	1.184** (17.083)	0.220** (12.245)	0.274** (8.329)	-0.514** (-11.489)	1.204** (16.489)
Number of university years in local industry (*l*, *s*)	0.464** (6.784)	0.021 (1.200)	0.313** (9.500)	0.275** (6.225)	-0.145* (-2.008)
Local accessibility to KIBS in location *s*	-0.326** (-10.723)	0.135** (17.139)	-0.225** (-15.379)	0.095** (4.816)	-0.331** (-10.331)
Accessibility to KIBS outside location *s*	-0.029 (-1.284)	-0.006 (-0.961)	0.018 (1.651)	0.051** (3.445)	-0.092** (-3.849)
Conjunction of internal and external knowledge in local industry (*l*, *s*)	0.087** (5.327)	0.017** (4.108)	0.031** (3.985)	-0.009 (-0.861)	0.047** (2.755)
Constant	9.649** (30.843)	-1.446** (-17.837)	0.572** (3.802)	3.741** (15.509)	6.783** (20.580)
R^2-value	0.668	0.573	0.527	0.486	0.547
Number of observations	2810				

All regressions include 2-digit industry dummies, controlling for industry heterogeneity, not displayed in the table. The t-statistics from robust regressions are shown in parentheses. ** denotes significance at the 1% level and. * denotes significance at the 5% level.

Effects on unit export price

In line with the hypotheses in H3, we can observe a positive effect on the export price from (i) the size of internal knowledge, (ii) the local external knowledge accessibility, (iii) the extra-local external knowledge accessibility, whereas there is no effect from the conjunction of internal and external knowledge. The interpretation of this observation is that for the price level (often referred to as the quality of varieties) internal and external knowledge inputs function as substitutes rather than complements.

As regards the effect of the size of a local industry on unit price, the estimated parameter is negative and significant. This is likely to reflect that large local industries have mature varieties, for which prices are moving downwards in combination with increasing quantities. Although this was not expected according to hypothesis H3, it is fully supporting the statement in H4, which clarifies that export price and export quantity are substitutes in the sense that (i) every factor that has appositive effect on price also has a negative effect on quantity, and (ii) every factor that has a negative effect on price has a positive effect on quantity.

5.2 Regression Results for the Gross Entry of Variety Triplets 2002 - 2006

Sub section 5.1 investigates and assesses factors that affect export indicators for the entire set of variety triplets in 2006. The export indicators comprise export value, number of export firms and varieties, and unit export price for local industries, and these indicators are assumed product innovation performance of local industries. Sub section 5.2 deals with exactly the same questions but now the population is constrained to variety triplets that are introduced between 2002 and 2006. We call this set the gross-entry population. These varieties are new products, and that means that hypothesis H4 does not apply, since it concerns the difference between "mature" and "novel" varieties. In the present analysis all varieties examined are novel varieties. Finally, we stress that the five independent (explanatory) variables are observed and recorded for the starting year (2002) of the period 2002-2006.

The regression results for the gross-entry population are presented in Table 8. Comparing the results in this table and the preceding one (Table 7) reveals that the results are the same in both tables, with small exceptions. This is a strong results as Table 7 is based on the entire set of existing varieties, whereas Table 8 refers to regressions on the set of novel varieties, i.e., varieties that were introduced in the period 2002-2006. This implies that our previous assessment of hypotheses H1-H3 with some exceptions also applies to the set of novel varieties. The main difference is that hypotheses in H1 get stronger support in the case of novel varieties.

In summary we may make the following conclusions in association with Table 8:

(i) The size of a local industry has a positive effect on export value, number of firms, number of code-specific destinations and export quantity
(ii) The internal knowledge of a local industry has a positive effect on export value, number of firms, number of code-specific destinations, and export price
(iii) The local external knowledge has a positive effect on number of firms and export price
(iv) The conjunction of internal and external knowledge has a positive effect on export value and number of firms.

As a special observation we note that the three individual knowledge factors all have a positive impact on the average unit export price, while the conjunction of internal and external knowledge has no effect. This leads to the suggestion that for the price effect, the knowledge factors interact as substitutes rather than complements.

Table 8: Export indicators for variety triplets introduced in local industries during 2002-2006, regression results

	Dependent Variables				
	Aggregate export value	*Extensive Margin 1:* *Number of exporting firms*	*Extensive Margin 2:* *Number of product specific export markets*	*Intensive Margin 1:* *Average price per unit exported*	*Intensive Margin 2:* *Average export quantity*
Total employment in local industry (*l, s*)	0.727** (10.324)	0.159** (9.254)	0.170** (5.235)	-0.322** (-7.522)	0.720** (10.556)
Number of university years in local industry (*l*, *s*)	0.504** (6.923)	0.059** (3.331)	0.301** (8.991)	0.131** (2.951)	0.013 (0.188)
Local accessibility to KIBS in location *s*	-0.141** (-4.062)	0.137** (16.171)	-0.145** (-9.107)	0.108** (5.146)	-0.241** (-7.155)
Accessibility to KIBS outside location *s*	-0.003 (-0.108)	-0.003 (-0.417)	0.025* (2.123)	0.046** (2.975)	-0.072** (-2.879)
.Conjunction of internal and external knowledge	0.048** (2.561)	0.016** (3.515)	-0.003 (-0.303)	-0.012 (-1.032)	0.046* (2.550)
Constant	10.157** (28.998)	-1.247** (-14.621)	0.729** (4.523)	3.399** (15.978)	7.276** (21.430)
R^2-value	0.528	0.541	0.396	0.440	0.459
Number of observations	2653				

All regressions include 2-digit industry dummies, controlling for industry heterogeneity, not displayed in the table. The t-statistics from robust regressions are shown in parentheses. ** denotes significance at the 1% level and * denotes significance at the 5% level.

6. Concluding Remarks

In summary the findings of this empirical analysis confirm, to various degrees, all four hypotheses. The suggestion that internal and external knowledge are complementary input factors get a clear support in the sense that conjunction of internal and external knowledge has a positive effect on the export value of local industries. This positive effect is further supported by each local industry's internal knowledge.

For novel varieties (introduced between 2002 and 2006) the number of exporting firms is positively stimulated by a local industry's internal knowledge, by its local external knowledge, and by its conjunction of internal and external knowledge. At the same time it is clear that the knowledge factors display a less distinct picture of how they influence the number of code-specific destinations (the second part of the extensive margin). In this case there is a positive effect from the internal knowledge, a negative effect from the local external knowledge, and no effect from the conjunction variable.

The strongest result concerns the unit export price. In this case we first find that the size of a local industry is negatively correlated with the pertinent export price and positively with the average export quantity. Moreover, internal knowledge, local external knowledge and extra-local knowledge are substitutes that each affect the unit export price in a positive way.

Everything else equal, the size of a local industry affects price negatively and quantity positively, where the latter effect is stronger. This observation is valid for the whole set of varieties 2002, 2006 and for the set of variety triplets introduced between 2002 and 2006. For the latter set of novel variety triplets, the internal knowledge of a local industry positively affects export value, number of export firms, number of code-specific destinations and average export price. Combining these two observations indicate a spatial product-cycle phenomenon: a large local industry with limited internal knowledge associates with products based on routinized production and sales in large quantities such that export value expands although prices are kept down. Moreover, for novel products supplied by local industries with large internal knowledge, we can observe an increasing number of variety triplets sold at a higher price.

The external knowledge on the other hand enhances smaller export quantities with higher prices, possibly products that still require more development and marketing efforts and therefore cannot be produced on a large scale.

What are the challenges for future research? A first consideration is to find alternative formulations that capture the distinction between internal and external knowledge. A second option is to replicate the analysis with exporting firms as observation units instead of local industries. A third ambition could be to make the distinction between established and novel variety triplets more precise.

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Appendix

Table A.1 Correlation matrix

	Aggregate export value	Number of exporting firms	Number of product specific export links	Average unit export price	Average export quantity	Size of industry	Years of university education	Local accessibility to external knowledge	Non-local accessibility to external knowledge
Aggregate export value	1	0.529**	0.815**	-0.227**	0.741**	0.748**	0.724**	0.150**	0.033
Number of exporting firms		1	0.261**	-0.134**	0.294**	0.656**	0.629**	0.379**	0.087**
Number of product specific export links			1	-0.057**	0.423**	0.580**	0.614**	0.078**	0.066**
Average unit export price				1	-0.768**	-0.278**	-0.137**	0.088**	0.115**
Average export quantity					1	0.563**	0.447**	-0.016	-0.082**
Size of industry						1	0.912**	0.284**	0.045*
Years of university education							1	0.379**	0.123**
Local accessibility to external knowledge								1	0.270**
Non-local accessibility to external knowledge									1

Table A.2: Export indicators for local industries in 2002. Regression results

	Dependent Variables				
	Aggregate export value	*Extensive Margin 1:* *Number of exporting firms*	*Extensive Margin 2:* *Number of product specific export markets*	*Intensive Margin 1:* *Average price per unit exported*	*Intensive Margin 2:* *Average export quantity*
Total employment in local industry (*l*, *s*)	1.119** (17.896)	0.189** (11.146)	0.284** (9.102)	-0.431** (-10.625)	1.077** (16.659)
Number of university years in local industry (*l*, *s*)	0.376** (5.939)	0.056** (3.248)	0.285** (9.109)	0.258** (6.293)	-0.223** (-3.409)
Local accessibility to KIBS in location *s*	-0.297** (-9.700)	0.134** (16.105)	-0.198** (-12.987)	0.078** (3.926)	-0.310** (-9.803)
Accessibility to KIBS outside location *s*	-0.052* (-2.256)	-0.000 (-0.010)	0.026* (2.235)	0.064** (4.255)	-0.141** (-5.928)
Conjunction of internal and external knowledge	0.098** (6.020)	0.015** (3.425)	0.022** (2.668)	-0.008 (-0.750)	0.069** (4.107)
Constant	10.237** (32.396)	-1.392** (-16.245)	0.509** (3.227)	3.335** (16.285)	7.785** (23.842)
R^2-value	0.644	0.570	0.500	0.479	0.532
Number of observations	2771				

All regressions include 2-digit industry dummies, controlling for industry heterogeneity, not displayed in the table. The t-statistics from robust regressions are shown in parentheses. ** denotessSignificance at the 1% level and * denotes significance at the 5% level.