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Abstract: This paper applies unique survey data on innovation and external interaction of small food producers in Sweden. The overall purpose is to test if firms that are more engaged in external interaction are more inno-vative. To disentangle innovativeness beyond new goods and services, innovation is measured as new processes, new markets, new suppliers, new ways of organization, and new distributors. Findings point to a positive relationship between firm innovation and external interaction, both in terms of collaboration, external knowledge and support from regional actors. In particular, collaboration regarding transports and sales is shown to enhance most types of innovation. Product and pro-cess innovation benefit from external knowledge from extra-regional firms as well as regional support from the largest firm. Findings sug-gest that current innovation policies can improve their efficiency by increasing their flexibility to enable tailor-made innovation policies at the local level.

Keywords: Innovation; collaboration; food industry; rural regions

JEL codes: L25, L66, O31, R12

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1 Introduction

The ability of firms to renew themselves is becoming increasingly important from the perspective of firm survival and growth. Renewal, technological change, or *innovation*, is also commonly highlighted as the main driver of economic growth, implying that innovation is important from both a micro- and a macro perspective (Audretsch and Mahmood, 1995; Cefis and Marsili, 2005). While most of the previous research on innovation has focused on manufacturing and high-tech industries that have a high research intensity and dependence on high-skilled labour, the focus of the present paper is on the food industry. Although the food industry has traditionally been considered as low-tech with little investment in Research and Development (R&D), the industry is becoming increasingly technology intensive and innovation is expected to play a key role in the future development of the industry (Traill and Meulenberg, 2012). Triguero et al. (2013) argue along these lines and emphasize that advances in biotechnology, higher requirements on food safety, demand for variety and the increasingly global character of food markets imply that innovation may become a necessity rather than an option. Small food producers also operate in markets characterized by monopolistic competition, implying that they have some market power and some control over price setting, due to producing heterogeneous goods, or special varieties (Chamberlain 1933). Each firm is thus unique, which may be due to product differentiation e.g., organic meat or home-made mustard, but it may also be the location that provides the uniqueness, such as for serenely located cafés (Everett, 2008). However, operating in dynamic markets with changes in both supply and demand structures puts pressure on food producers to constantly renew themselves and their products in order to sustain their competitive advantage. Considering the growing importance of innovation for the survival and growth of food firms, there is also a need for a better understanding of the factors, both internal and external, that enhances firms to become more innovative. Especially since the underlying determinants of innovation in the food industry differ significantly from those in the manufacturing industry, as shown by Triguero et al. (2013). Specifically, the food industry provides one example where innovation may occur in other forms than radically new products (Grunert et al., 1997; Smallbone et al., 2003).

The purpose of this paper is to disentangle the determinants of innovation among small food firms in Sweden. Of particular interest is to apply a broad definition of innovation and assess the influence of factors that are external to the firm e.g., the role played by collaboration and networking activities. Having this focus imply that we follow the view of Schumpeter (1934), and the argument that innovation should be regarded as a broad concept that incorporates not only new products, but also new production processes and new ways of doing business. Having access to unique survey data, enables the study to measure innovativeness along seven dimensions, including new; goods, services, production processes, markets, suppliers, organization, and distribution channels. The empirical analysis applies an ordered logit model that relates innovative capacity, along the different dimensions, to factors that reflect firms access to external knowledge, controlling for key firm-specific factors. The sources of external knowledge take many forms, including collaborations with different types of partners, support from different actors (universities and other research organizations) and regional characteristics. These are hypothesized to be important for small and medium-sized firms (SMEs) (Edwards et al., 2005; Rothwell, 1991; Smallbone et al., 2003) as they commonly lack many of the necessary internal resources for innovation, such as financial resources for R&D and access to high-skilled labor. This follows the view that knowledge is the most important resource for innovation, particularly firms access to external knowledge, which provides them a crucial innovative capability (Cohen and Levinthal, 1990; Tödtling and Kaufmann, 2001; Chesbrough, 2003). Since small food firms tend to be located in rural areas an additional dimension is added in that firms in rural regions have lower access to local knowledge resources, such as highly educated employees and research centers (Tödtling and Trippl, 2005). Hence, it is particularly important to distinguish between intra- and extra-regional knowledge.

The approach of this paper is useful from both a methodological and policy viewpoint because it applies an extended empirical analysis that include a broad set of innovations and because it provides new evidence on the role played by external knowledge, support, and collaboration for Swedish food firms. A better understanding of the relationships could help in refining current innovation policies for improving their efficiency, particularly their ability to target small and specialized food firms. Moreover, the fact that different factors seem to have impacts on various types of innovation calls for a national innovation policy that is flexible enough to enable tailor-made innovation policies at the local level. The food industry plays a key role for rural development in Sweden as food producers provide an experience good that attracts tourism (Everett 2008; Sims 2009). This imply improved employment opportunities in the food industry as well as in complementary industries.[1]

The remainder of the paper is organized as follows. The next section provides a conceptual framework and summarizes some of the most relevant previous studies on the relationship between external knowledge in general, and collaboration in particular, and firm innovation. This is followed by a presentation of the empirical design, which provides information on the data, method and variables. The empirical results and analysis are provided in the subsequent section, while the final section summarizes and concludes the paper.

2 External knowledge and innovation

The importance of external knowledge for firm survival and growth was acknowledged already by Marshall (1890), in his ideas on the advantages of industrial districts. Marshall argued that the co-location of firms creates external economies of scale, due to pooling of skilled labor, supply- and demand linkages, and knowledge spillovers. Duranton and Puga (2004) argue along these lines and identify matching, sharing and learning as the

[1]The importance of the food industry is acknowledged by the Swedish government. In 2008 a food strategy was initiated, carried out through the Swedish Board of Agriculture, with the aim to increase profitability and exports, improve rural development, and attract more tourists. In 2015, the government continued the work with the food strategy, with an increased focus on competitiveness, sustainability and innovation in the Swedish food sector (SOU 2015:15).

micro-foundations for these so called agglomeration economies. In their view, learning is achieved through market effects, in terms of the employment of skilled labor and linkages with suppliers and customers, but also in the form of non-market effects, such as transfer and diffusion of knowledge and information through more or less informal networks. What follows is that networks and collaborations with suppliers, customers, and research institutes, as well as non-market interactions, provide external knowledge sources for firms, which they can exploit in innovation activities.

The role of external knowledge, networks and collaborations for innovation is commonly discussed under the framework of regional innovation systems (RIS) (Asheim et al., 2011). This framework follow the literature on national innovation systems (NIS) (Lundvall, 1992), and build on the ideas of Marshall. The literature on regional innovation systems is also closely related to the cluster literature (Porter, 1990). However, while RIS emphasize social capital, networking and learning, i.e., processes, the latter focus directly on competitiveness and performance, e.g., output (Asheim et al., 2011). Another difference is that networks, such as RIS, require active firm involvement and intentional knowledge transfer, while clusters may exist without non-market relationships. This implies that knowledge spillovers are pecuniary external effects. In addition, networks are aspatial constructs, while clusters are geographically bounded (Ter Wal and Boschma, 2009).

The importance of external knowledge in successful innovation is also emphasized by Chesbrough (2003), in the model of open innovation. A firm that uses open innovation combines internal and external knowledge sources. The boundary between the firm and the surrounding environment is thus transparent, which allows the firm to pick up on potentially successful ideas that may have gone unnoticed and external actors can be used to expand on ideas that do not fit the current product portfolio. In a closed innovation model all R&D activities are internalized, a firm generates, develops and commercializes its own ideas. This requires that the firm is in total control of its intellectual property, which is increasingly difficult due to labor mobility and increases in higher education among employees. In addition, an open innovation system allows for risk sharing between firms (Lazzarotti and Manzini, 2009).

Feldman (1994) tests the significance of the presence of four external knowledge sources; university R&D, industrial R&D, related industries, and specialized business services, on the innovation performance of industries at the state level. All four knowledge sources are found to significantly enhance innovation, especially for smaller firms. Caloghirou et al. (2004) find that external knowledge search and participation in external collaborations enhances the innovative performance of firms in seven European countries. Also Laursen and Salter (2006) find strong support for the hypothesis that wide and deep search for external knowledge increases the innovative performance of firms. Jensen et al. (2007) distinguish between two modes of learning and innovation, the Science, Technology and Innovation (STI) mode, and the Doing, Using and Interacting (DUI) mode. The STI mode focus on the use of codified scientific knowledge, based on e.g. R&D laboratories, universities and research centers, while the DUI mode refers to informal, or tacit, knowledge gained through experiences and learning-by-doing. By use of Danish data, Jensen et al. (2007) show that employing either the

STI mode or the DUI mode increases the likelihood that a firm is innovative. Dahl Fitjar and Rodrguez-Pose (2013) apply the STI/DUI approach to different types of firm interaction. Collaborations with universities, research institutes and consultancies are classified as STI modes of interaction, while collaborations with suppliers, customers and competitors are classified as DUI modes. Using data for Norway, Dahl Fitjar and Rodrguez-Pose (2013) find that collaboration with universities increases the likelihood of product innovation, while collaboration with research institutes affects process innovation. Regarding DUI modes of interaction, collaboration with suppliers is positively related to both product- and process innovation, whereas collaboration with customers to product innovation only.

2.1 Collaboration and innovation

Collaboration with external actors is shown to be particularly important for small and medium-sized firms (SMEs) (Edwards et al., 2005; Rothwell, 1991). Access to external knowledge through collaborations should thus be an important factor that influence the survival and growth of local food producers, as they tend to be small and specialized. Cooke and Morgan (1998) argue along these lines and maintain that the potential of SMEs to innovate is related to their engagement in learning networks. Smallbone et al. (2003) identify three size-related characteristics of SMEs that may imply challenges regarding innovation; *i)* a limited resource base, particularly in terms of finance and management, *ii)* a distinctive organizational culture due to a combination of ownership and management, as well as family ties, and *iii)* less influence over the external environment than larger firms. Hence, SMEs commonly lack the necessary internal financial resources for R&D, as well as high-skilled labor, which are important capabilities for innovation. The implication is that local networks and cooperation between firms, as well as between firms and other actors in the private and public sector, have potential to provide necessary support systems for these firms to engage in innovation activities. External interaction is thus important to overcome the lack of internal resources (Tödtling and Kaufmann, 2001). Besides providing the basic support these collaboration have the potential to give rise to external economies of scale, which provide further benefits for firms.

The importance of external relations for innovation in SMEs is confirmed by several empirical studies (see e.g. Cumbers et al., 2003; Lee et al., 2010; Zeng et al., 2010). Based on previous literature and empirical results for European regions, Tödtling and Kaufmann (2001) find that collaborations with customers and suppliers are of particular importance for innovation in SMEs, i.e., DUI partners. This is explained by weak links and cultural barriers between SMEs and organizations such as research institutes and universities. Further empirical studies confirm the importance of supplier- and costumer collaborations for innovation in SMEs in general (Nieto and Santamara, 2010), and in the food sector in particular (Capitanio et al., 2009; Gellynck and Khne, 2008; Stewart-Knox and Mitchell, 2003).

Regarding the geographical dimension of external collaborations, results from several European projects show that while national and international networks are important for large firms, the region provides the most relevant space for interactions for SMEs (see Tödtling and Kaufmann (2001) for an overview). This is consistent with the STI/DUI framework and the empirical results showing that DUI partners are particularly important for SMEs. As mentioned above, DUI learning is based on tacit knowledge, while STI learning is based on codified knowledge, implying that geographical proximity is likely to be more relevant for DUI interactions. However, Dahl Fitjar and Rodrguez-Pose (2013) find that it is non-regional supply-chain interactions that enhance both product- and process innovation. Similar results for Swedish firms are found by Bjerke and Johansson (2015). Small local food producers are commonly located in sparsely populated rural regions, which are characterized by lower access to market potential as well as lower access to knowledge resources, such as highly educated employees and research centers (Tödtling and Trippl, 2005), compared to urban regions. It may thus be expected that extra-regional knowledge resources are of particular importance for these firms.

The ability to assimilate external knowledge and exploit it in innovation activities is dependent on the absorptive capacity of the firm, which is a function of prior knowledge (Cohen and Levinthal, 1990). The prior knowledge of small firms, who commonly have low R&D investments, is to a large extent determined by the education and (work) experiences of the employees and the manager and/or owner. In addition, the knowledge base, as well as attitudes, of the management team is fundamental for the propensity of a firm to engage in external knowledge networks (Smallbone et al., 2003). This implies that the internal knowledge of firms is important both as direct resources for innovation, and for engaging in collaborations and exploiting external knowledge to promote innovation.

3 Empirical design

Given the focus of the study, a single-industry design is used and the sample is drawn from the entire population of food producers in Sweden (NACE rev.2 code 10 manufacturer of food products). Firms that are producers of pet food, as well as those firms with less than a 1 full time employee and those firms with 250 or more employees, are excluded from the sample. Using Amadeus, a comprehensive database of all firms in Sweden, a total of 1,782 small food firms can be identified. These firms comprise the initial sample. Hence, a unique dataset is collected using both register data and survey methods. Firm-level, register data is obtained from two business databases: Amadeus and Retriever. Aggregated data on firms neighborhood and regional characteristics are collected from Statistics Sweden.

For the survey, a questionnaire is constructed using established practices (Dillman et al., 2014). Trained interviewers administered the questionnaire survey via telephone to the firms CEO or (if the CEO was not available) to a member of the firms management team. The interviewers also noted any difficulties in answering the questions, and these were followed up and clarified. Further, the interviewers informed all the respondents about the confidentiality of their answers. The survey was carried out in spring 2015. Completed surveys (that is surveys with complete answers on all the variables of interest) are available for 416 firms, which represent 23.3 percent of the firms in the initial sample.

3.1 Variables

In order to capture innovativeness of firms beyond new products, seven dependent variables are used, which measure seven dimensions of innovation. All dependent variables are measured on an ordinal scale with five categories, ranging from 0 (No new) to 4 (Many new). Dependent variables are presented in Table 1.

Table 1. Seven dimensions of innovation, dependent variables

Dependent variables	Type of innovation
1.	Introduction of new goods
2.	Introduction of new services
3.	Use of new processes or production methods
4.	Selling to new markets
5.	Use of new suppliers
6.	New ways of organization
7.	New ways of distribution

The explanatory variables of main interest are collaboration, external knowledge, and regional support. Collaboration is measured on an ordinal scale with five categories, ranging from 0 (zero) to 4 (plenty), and captures to what extent the firm engage in collaboration with other actors in the region. External knowledge concerns the importance of knowledge from different actors to develop new goods and/or services and external support. The categorical scales for external knowledge and support ranges from 0 (not important) to 4 (of great importance). Besides the variables regarding external support and collaboration several firm-level control variables are included. Number of employees controls for the size of the firm, since larger firms commonly have more resources to use in innovation activities (Smallbone et al., 2003). One such resource is the education of the employees, which is controlled for by the share of employees with a higher education. Share of female employees as well as share of young and old employees control for the demographic structure of the firm, which may affect innovation through e.g. openness to various ideas. Family firms may operate toward other goals than growth and innovation and family ownership may even hinder innovation potential (Chrisman et al., 2005). Firms that sell on the national and international market, as opposed to only the regional market, are exposed to more competition, which increases the pressure on firms to innovate in order to survive (Porter, 1990).

In addition, control variables for the size of the neighborhood and the size of the region the firm is located in are included. Population density provides a control for various agglomeration economies. Firms located in more urban regions, and/or more dense neighborhoods within regions, may be more innovative due to benefits from better matching on the labor market, sharing of resources and risk, and learning through knowledge spillovers (Duranton and Puga, 2004), as well as greater access to knowledge resources in the surrounding milieu (Tödtling and Trippl, 2005). Table A1 in Appendix 1 present descriptive statistics for the continuous variables and Table 2 provide variable definitions.[2]

[2]Frequency tables for the binary variables can be obtained on request.

Table 2. Variable definitions

	Variables	Definition
Collaboration	Purchases	Degree of involvement
	Production	.
	Marketing	.
	Sales	.
	Product development	.
External knowledge	Own firm	Perceived importance
	Intra-regional firms	.
	Extra-regional firms	.
	Intra-regional competence center and/or university	.
	Extra-regional competence center and/or university	.
External support	Regional university	Perceived importance
	Municipality board	.
	Regional/County Board	.
	The largest firm in the region	.
	Regional competence center or business advisor	.
	Regional chamber of commerce or or other business association	.
Internal controls	Firm size	Number of employees
	Education	Share of employees with higher education
	Female	Share of female employees
	Young	Share of employees < 30
	Old	Share of employees > 60
	Family firm	Dummy=1 if family firm
	National sales	Dummy=1 if Sweden region (base)
	International sales	Dummy=1 if International region (base)
External controls	Population density (local)	Number of inhabitants per sq.km in neighbourhood
	Population density (regional)	Number of inhabitants per sq.km in labour market region

3.2 Estimated models

As a first step, the relationships between innovation and external interaction are estimated using summated scales of the key variables. The seven innovation variables, the six collaboration variables, the four external knowledge variables (excluding own firm) and the six regional support variables are averaged to create one summated scale variable for innovation, one for collaboration, one for external knowledge and one for regional support. The minimum value for each variable is zero while the maximum value is four. The four summated scale variables comply with general rules of thumb. Item-to-test correlations exceed 0.5 and item-to-rest correlations exceed 0.3.[3] Cronbachs alpha exceeds 0.7 in all cases, ranging from 0.72 to 0.82, which indicates reliability of the summative scales (Hair et al., 2010). These summated scale variables can be considered as continuous, which allows for linear estimation by ordinary least squares specified in the following:

$$I_i = \beta_0 + \beta_1 F_i^{'} + \beta_2 E_i^{'} + \zeta G_i^{'} + \epsilon_i \tag{1}$$

where I_i denote the dependent variable which is the averaged summated scale of innovation for firm i. The explanatory variables are categorized into three groups, where external interaction is a vector of the summated scales for collaboration, external knowledge and regional support $E_i^{'}$. Firm controls and geographical controls are denoted by $F_i^{'}$ and $G_i^{'}$, respectively and ϵ_i is an idiosyncratic error term. As a control for spatial autocorrelation,

[3]But not 0.6, which implies that they can enter estimations separately without causing problems with multicollinearity.

e.g. that innovation may be more or less common in different regions, we apply robust standard errors, clustered on labor market regions.

To get a first insight of possible relationships between different forms of innovation and various types of external collaboration and support, we apply Pearsons chi-squared test. This provides a test statistic that compares the observed frequency to the expected frequency for all combinations of two variables with categorical data. A significant test statistic implies that the relationship between the two variables in question is statistically significant. The last step in the analysis is to utilize the full information in the data set, with separate estimations on different dimensions of innovation, allowing for various types of external collaboration and support, and including control variables. When the dependent variables are based on an ordinal scale, ordered logit estimation is a viable option for regression analysis. Ordered logit estimates the cumulative probability of being in one category versus all other. Following Williams (2006), the ordered logit model can be written as follows:

$$P(y_i > j) = \frac{exp(X'_{ik}\beta_k - k_j)}{1 + \{exp(X'_{ik}\beta_k - k_j)\}}, j = 0, 1, 2, 3 \tag{2}$$

Where X'_{ik} is a vector of k explanatory variables for firm i, β_k a vector of the parameters to be estimated, j represents the categories of the dependent variable (less one), and k_j are the cut points (which equal the negative of the constants). While these cut points varies with j, the βs do not, which implies an assumption (and restriction) that the influence of the independent variables are proportional across each category of the dependent variable, or in other words, that the distance between each category is proportional. When this proportional odds (or parallel lines) assumption is violated, which is commonly the case (Williams, 2006), standard errors are incorrect and parameter estimates are biased (Yatchew and Griliches, 1985). The Brant specification test (Brant, 1990; Long and Freese, 2006) shows that this assumption is indeed violated for many of the ordered logit estimations in the present case. In these cases heterogeneous choice models (ordinal generalized linear models, oglm) are estimated as robustness tests, using heteroscedastic ordered logit estimation, which allows for dropping the proportionality constraint only for those variables that violate it. Hence, the β parameters are estimated taking error variances into account. The heterogeneous choice model, in logit form, can thus be written as follows (Williams 2010):

$$P(y_i > j) = \frac{exp(\frac{X'_{ik}\beta_k - k_j}{\sigma_i})}{1 + \{exp(\frac{X'_{ik}\beta_k - k_j}{\sigma_i})\}}, j = 0, 1, 2, 3 \qquad (3)$$

If $\delta = 1$ for all observations, which is the case when there is no difference in error variances between categories, Equation 3 collapses into the ordered logit model in Equation 2. For both the ordered logit estimations and the heteroscedastic ordered logit estimations, the results are presented in terms of odds ratios. These provide a straightforward interpretation, if the odds ratio is greater than one the relationship between the explanatory variable and the dependent variable is positive, while it is negative if the odds ratio is smaller than one. More specifically the interpretation is that the odds ratio shows how many times larger the odds for firms in categories greater than m is, than for firms in categories equal to or less than m, if the respective explanatory variable increases by one unit, keeping all other variables constant. Other possible approaches to estimate ordinal models that violate the proportionality assumption are multinomial logit models and generalized ordered logit models. Multinomial logit models are the least attractive in the present case since, even though the distances between the categories of the dependent variables may be non-proportional, there is a clear ordering of the responses (ranging from no new products/services/etc. to many new products/services/etc.). Regarding generalized ordered logit models, Williams (2010) argues that due to e.g. equal performance and relative simplicity, heterogeneous choice models may be preferred to generalized ordered logit models.

4 Estimation results

Table 3 presents the results from the estimations on summated scales, using ordinary least squares (Equation 1). Table 3 shows that the relationship between collaboration, external knowledge and regional support, and innovation is highly significant and positive, also with the addition of control variables. An increase by one unit in either one of the averaged summated scale indices for external interaction is associated with an increase of between 0.16-0.18 in the averaged summated scale index for innovation. This implies that small food producing firms that are more engaged in collaboration with other firms in the region, that use more external knowledge in their development of new goods and/or services, and/or that feel that they get support from actors within the region to develop their firms, are more innovative. These results broadly support much of the previous literature on the role of external knowledge and collaboration for innovation (Asheim et al., 2011; Chesbrough, 2003; Porter, 1990). Although marginally different, the coefficients for the three variables are not statistically different from each other, which implies that no type of external interaction is relatively more important. Another observation from Table 3 is that the external interaction variables account for the largest share of the explanatory power of the model, which strengthens the conclusion that engagement with external actors is important for firm innovation.

Table 3. Estimated relationships between all innovation categories and external support, knowledge and collaboration

	OLS	OLS	OLS
Variable	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)
Collaboration (summated)	0.202*** (0.050)	0.194*** (0.051)	0.160*** (0.052)
External knowledge (summated)	0.208*** (0.053)	0.169*** (0.060)	0.185*** (0.062)
Regional support (summated)	0.189*** (0.063)	0.149*** (0.064)	0.184*** (0.069)
Firm controls			
Size *(ln)*	-	-0.151 (0.056)	-0.016 (0.038)
Education	-	0.003** (0.001	0.003** (0.001)
Female	-	0.001 (0.002)	0.001 (0.002)
Young	-	0.003 0.001	0.003* 0.001
Old	-	-0.004* 0.002	-0.004* 0.002
Family firm	-	-0.081 (0.070)	-0.088 (0.068)
Sales Sweden	-	0.320** (0.128)	0.268** (0.128)
Sales international	-	0.279** (0.118)	0.269** (0.131)
Geographical controls			
Population density, local (*ln*)	-	-	-0.014 (0.130)
Population density, regional (*ln*)	-	-	0.021 (0.033)
Constant	1.023*** (0.068)	0.856*** (0.126)	0.704*** (0.149)
F-value	30.670***	13.810***	9.260***
R-square	0.141	0.190	0.191
Observations	424	401	382

***, ** indicate significance at the 1 and 5 percent levels. Dependent variable: Innovation (measured as the averaged summated scale of all innovation categories 1-7 in Table 1).

Turning to the control variables (Table 3), the innovativeness of firms is positively associated with the percentage of employees that have a higher education as well as with the percentage of employees that are younger than 30 years. On the other hand, firms with a larger share of employees above 60 years of age are less innovative. In addition, firms that sell on the national and international market, as opposed to only the regional market, have a higher degree of innovation. We find no agglomeration effect from the neighborhood but regional population density is positively associated with firm innovation. This implies that firms in more urban regions are more innovative, which may be due to better matching on the labor market, sharing of resources and/or learning through knowledge spillovers (Duranton and Puga, 2004).

Table 3 shows that external interaction is important for innovation in general terms. However, to disentangle innovation in small food firms we measure innovation in the seven dimensions; new goods, new services, new processes, new markets, new suppliers, new ways of organization and new ways of distribution. In addition, the individual components of collaboration, external knowledge and regional support are analysed. As a first test of the relationships between these variables and the various types of innovation we test the bivariate correlations, by using the Pearson test, as described above. Table B1 in Appendix B presents the results from this test for all combinations of innovation and external interaction. Although not every relationship is significant in Table B1 the overall impression is that there is a positive bivariate relationship between various forms of collaboration, external knowledge and regional support, and various types of innovation. This represents that firms that score higher on the ordinal scales for external interaction also score higher on the ordinal scales for innovation. It is difficult to discern any clear patterns from the correlations. For instance, it may be expected that collaboration regarding R&D is especially important for goods innovation, while collaboration regarding production is more important for process innovation, as well as collaboration regarding transports for new ways of distribution. Regarding external knowledge, correlations indicates that extra-regional actors may be more important for innovation than intra-regional actors. In addition, regional support seems to be mostly associated with new goods and services. Hence, these correlations gives a glimpse of potential relationships between the various forms of external interaction and the various types of innovation. The question is then if these relationships hold when we add control variables at firm and regional level. Tables 4-6 present the results for the variables on external interaction from ordered logit estimations, including all control variables. If the Brant chi2-value is significant we estimate heteroscedastic ordered logit models as robustness tests. The results from these estimations are presented in Appendix C (Tables C1-C3) and are commented on in case of non-robust results.

4.1 Collaboration, external knowledge and support

Table 4 provides the results for collaboration. Since collaboration refers to interaction with other firms, all forms of collaboration are examples of Doing, Using and Interacting (DUI) modes of learning (Dahl Fitjar and Rodriguez-Pose, 2013; Jensen et al., 2007). Table 4 shows that collaboration with other firms in the region regarding at least one aspect is positively significant for all types of innovation, besides new ways or organization. Regarding the different forms of collaboration, transports and sales seems to be most important. Collaboration regarding transports has a positive relationship with firm innovation in terms of new goods, new services, new processes, new markets as well as new ways of distribution. For a one unit increase in collaboration regarding transports, the odds of scoring greater than m versus scoring lower than or equal to m on new goods innovation is 1.14 times larger. Apart from new processes, these types of innovations also benefit from collaboration regarding sales, which is also the case for the using of new suppliers. Collaboration regarding R&D is insignificant throughout. It may be so that small food firms in general do not engage in pure R&D activities or that they do not perceive their collaboration with other firms as pure R&D activities, even though the result may be the development of new goods and/or services. Besides collaboration regarding sales and transports, also collaboration regarding marketing is positively significant, albeit only for innovation in terms of new suppliers.

Table 4. Estimated relationships between innovation categories and *collaboration*, Ordered logit

	(1) Goods	(2) Services	(3) Processes	(4) Markets	(5) Suppliers	(6) Organization	(7) Distrib.
Variable	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)
Transports	1.144*	1.175**	1.226***	1.174***	0.916	1.026	1.186**
	(0.092)	(0.084)	(0.079)	(0.072)	(0.063)	(0.064)	(0.096)
Purchases	0.909	0.929	0.955	0.880	1.093	0.916	0.884
	(0.071)	(0.086)	(0.085)	(0.076)	(0.091)	(0.083)	(0.087)
Production	1.020	0.980	1.071	1.131	1.013	1.044	1.045
	(0.093)	(0.105)	(0.116)	(0.109)	(0.108)	(0.121)	(0.114)
Marketing	1.065	1.051	0.990	1.096	1.221*	1.099	0.963
	(0.108)	(0.091)	(0.118)	(0.141)	(0.118)	(0.101)	(0.113)
Sales	1.181*	1.251**	1.072	1.307**	1.318***	0.932	1.224**
	(0.117)	(0.129)	(0.157)	(0.148)	(0.140)	(0.106)	(0.110)
R&D	1.080	0.878	1.072	1.093	0.929	1.168	1.137
	(0.135)	(0.111)	(0.168)	(0.146)	(0.098)	(0.127)	(0.131)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald Chi2	84.21***	90.37***	90.37***	83.88***	78.06***	49.68***	54.14***
Brant Chi2	66.19**	48.49	63.21	99.43***	84.74***	63.20*	71.58
Observations	424	420	420	425	424	425	422

***, **, * indicate significance at the 1, 5 and 10 percent levels, respectively. Robust standard errors, clustered on labour market regions, in brackets. Wald Chi2 shows goodness of fit. If Brant Chi2 is significant the corresponding heteroscedastic ordered logit estimation can be found in Appendix C in Table C1.

Table 5 presents the estimation results for external knowledge, as well as knowledge from the own firm. The results show that the higher the firms value their own knowledge the more innovative they are, regarding all types of innovation except new suppliers and new organization. Following Dahl Fitjar and Rodrguez-Pose (2013) external knowledge from other firms are considered as DUI modes of interaction, while knowledge from universities and research institutes are Science, Technology and Innovation (STI) modes of interaction. Results indicates that external knowledge from other firms is more important for innovation in small food firms than external knowledge from more science-based institutions. This supports previous research on innovation in the food industry (Capitanio et al., 2009; Gellynck and Khne, 2008; Stewart-Knox and Mitchell, 2003), and may be due to cultural barriers and weak links between academia and business, especially concerning small- and medium sized firms (Tödtling and Kaufmann, 2001). In addition, external knowledge is significant only for extra-regional firms, which is in line with Dahl Fitjar and Rodrguez-Pose (2013) and Bjerke and Johansson (2015). This implies that small food firms operate in knowledge networks that extend beyond the own region and that it is these types of networks that matter for innovation. In addition, external knowledge seems to be important primarily for traditionally recognized types of innovation, i.e. new goods, services and processes, although it is also weakly significant for new ways of organization. Regarding new processes, external knowledge from extra-regional firms is weakly positively significant in the heteroscedastic ordered logit model (see Table C2 in Appendix C). Innovation in terms of new processes is the only type of innovation that is positively related to an

STI mode of interaction, i.e. external knowledge from universities and/or research institutes. As opposed to external knowledge from other firms it is intra-regional universities and/or research institutes that matter. This may be explained by that cultural barriers and weak links between academia and business are partly overcome by geographical proximity. In addition, many universities in Sweden has a regional focus and interact with businesses in their own region, e.g. by cooperation regarding student project work and theses. A one unit increase in the importance of external knowledge from intra-regional universities and/or research institutes raises the odds of scoring greater than m versus scoring lower than or equal to m on new processes by 1.42 times.

Table 5. Estimated relationships between innovation categories and *External lnowledge*, Ordered logit

	(1) Goods	(2) Services	(3) Processes	(4) Markets	(5) Suppliers	(6) Organization	(7) Distrib.
Variable	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)
Own firm	1.173**	1.165**	1.197**	1.212**	1.054	1.065	1.151*
	(0.080)	(0.084)	(0.102)	(0.091)	(0.083)	(0.089)	(0.085)
Intra-regional firms	1.139	1.106	0.928	1.125	1.195	1.095	1.126
	(0.098)	(0.139)	(0.112)	(0.119)	(0.135)	(0.116)	(0.143)
Extra-regional firms	1.286***	1.358**	1.175	1.130	1.159	1.174*	1.090
	(0.110)	(0.171)	(0.147)	(0.097)	(0.111)	(0.113)	(0.117)
Intra-regional universities	1.062	1.107	1.424*	1.064	0.911	1.002	1.015
	(0.187)	(0.264)	(0.285)	(0.215)	(0.165)	(0.159)	(0.176)
Extra-regional universities	0.871	0.870	0.916	1.208	1.194	1.136	1.007
	(0.110)	(0.171)	(0.154)	(0.216)	(0.198)	(0.228)	(0.178)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald Chi2	128.46***	86.25***	98.49***	78.58***	52.80***	55.27***	31.08***
Brant Chi2	47.46	27.79	63.73**	84.36***	88.71***	-70.33	60.89*
Observations	424	414	418	419	418	419	416

***, **, * indicate significance at the 1, 5 and 10 percent levels, respectively. Robust standard errors, clustered on labour market regions, in brackets. Wald Chi2 shows goodness of fit. If Brant Chi2 is significant the corresponding heteroscedastic ordered logit estimation can be found in Appendix C in Table C2.

Table 6 provides the results for the importance of support from regional actors for the development of the firm. Support from the largest firm in the region appears to be important for innovation in terms of new goods, services and processes. This confirms the results on external knowledge from Table 4, that external interaction with other firms is especially important for the traditionally recognized types of innovation. In addition, this is in line with previous studies on innovation in the food industry (Capitanio et al., 2009; Gellynck and Khne, 2008; Stewart-Knox and Mitchell, 2003). Regarding innovation beyond products and processes, the results show that small food firms benefit from support from the regional, county and/or municipality board. Also new goods innovation is positively related to support from a regional board. This indicates that political decisions and activities undertaken at these levels have an effect on firm innovation.

The results for new ways of distribution changes in the heteroscedastic ordered logit estimation (see Table C3), from a positive relationship with support from a regional level to a positive relationship with support from the municipality level. In addition, new ways of distribution benefits from support from regional competence centers and/or business advisors. Apart from support from the largest firm, innovation in terms of new services is positively related to support from a regional university, a STI mode of interaction (Dahl Fitjar and Rodrguez-Pose, 2013; Jensen et al., 2007), as well as from the regional chamber of commerce or other business association. The only negative relationship between innovation and an external interaction variable is new ways of distribution, which is lower for firms who get more support from the regional chamber of commerce or business association.

Table 5. Estimated relationships between innovation categories and *Support*, Ordered logit

	(1) Goods	(2) Services	(3) Processes	(4) Markets	(5) Suppliers	(6) Organization	(7) Distrib.
Variable	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)
University	0.998 (0.133)	1.221* (0.130)	1.045 (0.169)	0.867 (0.139)	0.959 (0.185)	0.881 (0.124)	0.878 (0.115)
Municipality board	0.947 (0.091)	1.012 (0.078)	1.053 (0.107)	1.184* (0.095)	1.014 (0.085)	1.153* (0.094)	1.143 (0.126)
Regional/County board	1.241** (0.122)	1.096 (0.132)	1.007 (0.097)	1.322** (0.187)	1.421*** (0.185)	1.327** (0.162)	1.261* (0.149)
Largest firm	1.326*** (0.135)	1.174** (0.088)	1.232** (0.123)	1.092 (0.099)	1.060 (0.085)	0.911 (0.077)	0.957 (0.086)
Competence center	1.157 (0.149)	0.903 (0.137)	1.229 (0.162)	1.096 (0.122)	0.889 (0.101)	1.181 (0.138)	1.144 (0.152)
Business association	0.959 (0.102)	1.311** (0.173)	0.924 (0.120)	1.062 (0.170)	1.073 (0.131)	0.807* (0.104)	0.848 (0.118)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald Chi2	107.03***	94.10***	70.14***	74.12***	33.97***	62.77***	25.03***
Brant Chi2	72.66**	55.03	59.49	67.68**	62.73*	50.27	88.44***
Observations	416	410	415	416	416	416	414

***, **, * indicate significance at the 1, 5 and 10 percent levels, respectively. Robust standard errors, clustered on labour market regions, in brackets. Wald Chi2 shows goodness of fit. If Brant Chi2 is significant the corresponding heteroscedastic ordered logit estimation can be found in Appendix B in Table B3.

Appendix C and Table C3 presents the results from ordered logit estimations, and heteroscedastic ordered logit estimations when applicable, for the various types of innovation and the control variables. These results are in line with the ones presented above, although there is variation across the different dimensions of innovation. Firms with a larger share of highly educated employees are also more innovative in terms of new goods, services, markets and suppliers. Introduction of new processes and new ways of organization are more common in larger firm. In general, firm innovativeness is increasing with increases in the share of young employees, while it is decreasing with increases in the share of employees with old employees. Family firms are less innovative, at least in terms of new services, new processes and new ways of distribution. As discussed, firms that engage in international trade score higher on innovation, which is also the case for firms that sell on the national market, as opposed to only the regional market.

5 Conclusions

In this paper we have disentangled innovation in small food firms, by distinguishing between various types of innovation that extend beyond the development of new products. We argue that this is necessary to capture the full innovation potential of especially firms with e.g. low capital intensity and low orientation towards research and development (R&D), which is the case for many small food producers located primarily in rural regions. Since small- and medium firms commonly have limited internal knowledge and financial resources, the focus of the paper is the relationship between external interaction and firm innovation. External interaction is measured in terms of collaboration with other firms in the region, importance of external knowledge in innovation activities, and support from regional actors in the development of the firm. From the results we can conclude that there is a clear positive relationship between firm innovation and external interaction, for small food producers in Sweden. In particular, collaboration regarding transports and sales enhances most types of innovation. More conventional forms of firm innovation, such as new goods, services and processes, benefit from external knowledge from extra-regional firms as well as regional support from the largest firm. Other types of innovation, such as selling on new markets, use of new suppliers, new ways of organization and new distribution channels, increase mostly from support from regional and municipality boards. If our results and conclusions can be generalized, they have clear policy implications. It has almost become a mantra that local collaboration is a key factor for rural firms that act on small local markets and who need to attract customers from outside. This study also shows the importance of extra-local and extra-regional connections for rural firms innovation. This finding indicates that rural firms can compensate for lower accessibility and other disadvantages that firms located outside metropolitan regions have. However, such specialized links to selected extra-regional partners probably have higher establishment and maintenance costs than corresponding partner links in metropolitan regions. This is a strong argument for supporting this kind of link building for rural firms. From a more general view, the fact that different factors seem to have impacts on various types of innovation calls for a national innovation policy that is flexible enough to enable tailor-made innovation policies at local level. That is: a multilevel innovation policy.

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Appendix A

Table A1. Summary statistics of continuous variables

Variable	Obs.	Mean	Median	Min.	Max.
Firm size	501	10.81	4.33	1	150
Education	489	15.30	0	0	100
Female	496	51.88	50	0	100
Below 30	497	27.04	20	0	100
Above 60	493	10.12	0	0	100
Pop. density, local	475	3130	130.2	0.05	193.29
Pop. density, regional	501	66.55	33.13	0.25	278.7

Appendix B

Table B1. Bivariate relationships; innovation, collaboration, external knowledge and support

	(1) Goods	(2) Services	(3) Processes	(4) Markets	(5) Suppliers	(6) Organization	(7) Distrib.
Collaboration							
Transports	29.85**	20.22	46.23***	38.15***	11.26	24.58*	32.25***
Purchases	21.10	45.46***	60.75***	23.61*	20.93	28.74**	22.79
Production	30.89**	47.10***	44.98***	53.81***	29.08**	33.52***	59.64***
Marketing	35.25***	21.74	26.08*	37.70***	36.70***	23.50	23.93*
Sales	35.17***	37.37***	37.74***	47.07***	37.15***	15.17	47.61
R&D	32.22***	15.24	27.68**	45.61***	29.66**	21.70	45.81***
External knowledge							
Own firm	12.76**	19.41	38.10***	36.70***	21.48	30.72**	29.07**
Intra-regional firm	20.69	18.13	7.02	16.88	40.60***	26.69**	14.93
Extra-regional firm	52.79***	38.98***	27.50**	31.50**	34.60***	36.50***	22.19
Intra-regional university	13.64	13.00	20.28	33.12***	21.47	22.54	19.60
Extra-regional university	16.70	31.46**	18.84	29.13**	24.28*	19.64	24.22*
Support							
University	24.76*	44.67***	19.14	19.88	22.04	16.16	15.45
Municipality	24.45*	27.63**	20.50	31.60**	27.32**	26.82**	42.28***
County	44.79***	43.45***	18.29	39.69***	33.33***	32.53***	49.52***
Largest firm	37.46***	50.59***	22.87	26.74**	24.36*	20.63	23.73*
Competence center	34.32***	33.67***	34.10***	24.32*	39.95***	31.12**	30.13**
Business associate	33.56***	42.64***	30.90**	28.42**	29.11**	16.74	22.27

***, **, * indicate significance at the 1, 5 and 10 percent levels, respectively. All relationships are positive.

Appendix C

Table C1. Estimated relationships between innovation categories and *collaboration* heteroscedastic ordered logit model

	(1) Goods	(3) Processes	(4) Markets	(5) Suppliers	(6) Otganization	(7) Distribution
Variable	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)
Transports	1.129*	1.246***	1.275**	0.944	0.994	1.189**
	(0.079)	(0.097)	(0.143)	(0.046)	(0.052)	(0.105)
Purchases	0.921	0.984	0.835	1.053	0.937	0.871
	(0.068)	(0.096)	(0.115)	(0.073)	(0.067)	(0.091)
Production	1.010	1.040	1.226	1.010	1.067	1.022
	(0.082)	(0.127)	(0.197)	(0.075)	(0.099)	(0.108)
Marketing	1.046	1.072	1.116	1.139*	1.070	0.984
	(0.100)	(0.155)	(0.255)	(0.086)	(0.083)	(0.135)
Sales	1.163*	1.043	1.452*	1.174*	0.931	1.286**
	(0.104)	(0.174)	(0.321)	(0.088)	(0.092)	(0.147)
R&D	1.072	1.021	1.266	0.983	1.128	1.151
	(0.122)	(0.192)	(0.325)	(0.081)	(0.092)	(0.166)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes	Yes	Yes	Yes
Wald Chi2	128.46***	86.25***	46.58***	224.40***	121.32***	107.18***
Observations	424	414	425	424	425	422

***, **, * indicate significance at the 1, 5 and 10 percent levels, respectively. Robust standard errors, clustered on labour market regions, in brackets.

Table C2. Estimated relationships between innovation categories and *External knowledge* heteroscedastic ordered logit model

	(3) Processes	(4) Markets	(5) Suppliers	(7) Distribution
Variable	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)
Own firm	1.157** (0.084)	1.379** (0.201)	1.046 (0.088)	1.151* (0.084)
Intra-regional firms	0.879 (0.090)	1.204 (0.225)	1.145 (0.148)	1.126 (0.143)
Extra-regional firms	1.176* (0.114)	1.286 (0.200)	1.136 (0.105)	1.090 (0.118)
Intra-regional universities	1.381** (0.216)	1.199 (0.448)	0.951 (0.194)	1.015 (0.176)
Extra-regional universities	0.947 (0.109)	1.396 (0.457)	1.251 (0.247)	1.007 (0.178)
Firm controls	Yes	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes	Yes
Wald Chi2	172.84***	51.74***	102.31***	31.08***
Observations	418	419	418	416

***, **, * indicate significance at the 1, 5 and 10 percent levels, respectively.
Robust standard errors in brackets.

Table C3. Estimated relationships between innovation categories and *Support*, heteroscedastic ordered logit model

	(1) Goods	(4) Markets	(5) Suppliers	(7) Distribution
Variable	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)	Coef. (Std.Err.)
University	0.994 (0.116)	0.804 (0.193)	1.042 (0.118)	0.856 (0.087)
Municipality board	0.939 (0.075)	1.394** (0.187)	1.007 (0.051)	1.225*** (0.095)
Regional/County board	1.193** (0.093)	1.545* (0.347)	1.253*** (0.097)	1.122 (0.106)
Largest firm	1.311*** (0.105)	1.075 (0.132)	0.999 (0.053)	0.960 (0.071)
Competence center	1.142 (0.131)	1.091 (0.197)	0.892 (0.067)	1.170* (0.112)
Business association	0.953 (0.091)	1.116 (0.256)	1.047 (0.073)	0.809 (0.093)
Firm controls	Yes	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes	Yes
Wald Chi2	180.11***	79.05***	112.62***	117.93***
Observations	416	416	416	414

***, **, * indicate significance at the 1, 5 and 10 percent levels, respectively.
Robust standard errors in brackets.