Deep or wide? Networking tie's effect on innovation in the European food industry

Abstract

Nowadays, innovation is a crucial element of business development. The globalisation and new technological advances have forced many companies to invest more in innovation, in order to stay competitive in a fast-paced economy. A big difference is observed in the innovation performance of the European Union member states. Based on the European Innovation Scoreboard (2018), the majority of the Southern-European countries and the New Member States joined to the EU in 2004 are moderate innovators. On the top of the list, there are the Scandinavian and the Benelux countries, the UK and Germany, while Bulgaria and Romania are the modest innovators in Europe. From an innovation point of view food industry is seen as a slow sector, which is lagging behind the technology pushed possibilities and the costumers' needs and expectations. In this research, we explore why European food companies do not perform any innovation activities and if they do so, what are the main determinants of their innovation performance? Due to the nature of the innovation distribution, the paper employs double hurdle as well as Heckman two-step model using the Community Innovation Survey (2012) data. These methods allow solving the selection bias problem, which inevitably arises in our case. Results confirm that networking scope as well as networking intensity, play a central role in explaining innovation performance. Furthermore, the size of a company, openness and market obstacles are also significant factors of innovation performance. In sum, the result indicates that those European food processing companies, who engage in innovation activity, have intensive innovation networks. Moreover, companies who targeted to innovate more proposed to extend their innovation networks. By contrast, above a certain level of network relations, the advantage of networks can turn into a negative effect on innovation performance.

Keywords: innovation activity, networking scope and intensity, Community Innovation Survey, European food industry

Introduction

In our time, innovation is an essential driver of economic growth and business development. Recent trends in the agri-food industry are challenging farmers, food processors and stakeholders to improve the efficiency of their operations and to be more responsive to consumer demands (Winger and Wall, 2006).
The globalisation, the high degree of interconnectivity and new technological advances have forced many SMEs to reinvent their products, services, business and organisational models, in order to stay competitive in a fast-paced economy (European Commission, 2018).
Understanding the relationship between innovation and performance in both large and small firms is relevant for researchers and managers of large and small companies alike. Analysing innovations and their relationship with firm performance is more relevant since the EU proclaimed in Lisbon in 2000.
In the past decades, the growth of business networks has attracted various research and identified many different approaches in inter-organisational networks (Araujo and Easton 1996, Grandori and Soda 1995, Brass et al. 2004, Ebers 1997).
During history, Europe's entrepreneurs have always been at the cutting edge of innovation and invention. And this is truer in the 21st century. Europe's human capital, deep science culture and solid technological base holds great potential for delivering major progress in the field of economic relevance (European Commission, 2018).
The food and drink industry is a major contributor to Europe's economy, maintains the characteristics of a stable, resilient and robust sector. Moreover, the EU food and drink industry generated a turnover of 1,098 billion € (2015) and a value-added of 219 billion € (2014). Innovation activities of EU food and drink companies are crucial for competitiveness. Regarding the innovation activity, 46% of the European innovative companies and 21% of non-innovative companies that did not innovate due to barriers. Key barriers to innovation in the EU were: lack of finance, low market demand for innovations and high market competition (Food Drink Europe, 2017).
Despite the increasing importance of the topic, innovation networking activity of the European food processing companies are rarely investigated. In this paper, we analyse how networking scope and networking intensity do motivate innovation performance of the European Union's food industry.
Furthermore, the research explores what are the main drivers of the innovation performance in European food processing companies focusing on the role of innovation networks. The dataset of the scope- and intensity of the innovation network connections in the food processing industry is derived from the European Union's Community Innovation Survey (CIS), available for 13 European countries (2012).[1]
The paper is organized as follows: The section 'Literature review' outlines the recent studies investigating innovation performance and networking activity. The methodology describes the econometric hypothesis to be examined, and detail estimated models. Regression results present the estimations obtained from the analysis. Finally, the last section concludes and discusses.

Literature review

From a management point of view innovation networks are characterised by reciprocal interdependence self-coordination, informal leadership, weak ties (Möller and Rajala 2006).

[1] Bulgaria, Germany, Estonia, Spain, Cyprus, Croatia, Lithuania, Hungary, Portugal, Romania, Slovenia, Slovakia and Norway

Innovation networks are generally recognised as a method to share R&D costs, gain access to rare resources, to manage complex innovation processes, cope with technological uncertainty and create learning opportunities (Pyka 2002, Buchmann and Pyka 2012).

There is an increasing trend in firms' practice that they carry out innovation with their network partners instead of in-house R&D. Furthermore, they are looking for partners beyond the boundaries of their organization, mainly with other firms, universities, research organisations and government agencies (Rampersad et al., 2010). The earlier empirical literature on firms' innovation networks (Dyer and Singh, 1998; Dyer and Nobeoka, 2000; Levinson and Asahi, 1996) has widely discussed and recognised the networks of firms as a fundamental factor for innovation, knowledge creation (Podolny and Page, 2000).

A firms' innovation network consists of a collection of autonomous actors that pursue repeated and enduring reciprocal exchanges aimed at creating new or better products, services for final markets or creating new or improving production or administrative processes (Karlsson at al., 2014, p. 69.). Möller and Rajala (2006) argued that knowledge exploration through weak ties, i.e. external sources to well-established relationships, is needed, and the flexibility of network is essential in innovation networks.

In the last few decades, university-industry collaborations have attracted considerable research attention. A large body of literature has dedicated to the significance of scientific research for a technological change, innovation, and economic performance. Aissaoui (2014) identifies the effect of collaborations with public research organizations on firms' innovative performance. In this context, he concludes that collaborating with universities and other public research organizations increases firm's innovative performance applying the French CIS data.

Various empirical studies find support for the idea that collaborations with public research organizations positively influence firms' innovative performance (Aissaoui, 2014). For example, cooperation with universities is shown to be positively associated with innovative sales in the Netherlands, Germany, and Sweden (Mansfield 1996, Belberdos et al. 2004, Aschhloff and Schmidt, 2008). Thus, empirical evidence is to be found confirming whether collaborations with public research organizations could significantly improve firms' innovative performance.

Colurcio and Russo-Spena (2013) concluded that food SMEs are orientated to collaborate with partners for innovation. Cooperation in innovation networks brings mutual benefits and partners cooperate at the same level. However, the innovation openness is focused on some privileged relationships with few partners often belonged to the current network of SMEs where long-lasting relationship alleviates trust concerns.

In addition, for the more knowledgeable SMEs the interaction for innovation allows the access in a wider network of connected relationships and to better position themselves in value networks.

Chesbrough (2003) suggests that many innovative firms have shifted to an 'open innovation' model, using a wide range of external actors and sources to help them achieve and sustain innovation. There are two factors influencing the success of open innovation. First, the factor called absorptive capacity that depicts access to skills and external networks. Second, complementary resources that include proprietary R&D knowledge, distribution or service networks, and manufacturing capabilities (Fertő et al. 2016).

Gilsing and Nooteboom (2005) provide an empirical study on the density and strength of ties in innovation networks in the Dutch multimedia and pharmaceutical biotechnology industry. They aimed to distinct between exploration versus exploitation and find a stronger sectoral effect in how exploration and exploitation settle in network structural properties than anticipated thus far.

Innovative companies usually establish linkages with other actors and access external knowledge in order to benefit from the dynamic effects of interactive processes. Indarti and Postma (2013) show that the quality of interaction as indicated by the depth of knowledge absorbed from various external parties and intensity of interaction (tie intensity) are better predictors of product innovation than the diversity

of interaction. An understanding of the contribution of external networks to innovation is essential for the effective management and functioning of these networks.
Buchmann, and Pyka (2012) outline a conceptual framework for depicting network evolution patterns of interfirm innovation networks and analysing the dynamic evolution of an R&D network in the German automotive industry. They suggest that structural positions, actor and dyadic covariates describing characteristics of the firms' knowledge bases are influential determinants of network development.
Laursen and Salter (2006) analysed links search strategy to innovative performance, finding that searching widely and deeply is curvilineal related to performance using a large-scale sample of industrial firms. They claimed that firms who are more open to external sources or search channels are more likely to have a higher level of innovative performance. They concluded that searching a variety of search channels can provide ideas and resources that help firms gain and exploit innovative opportunities.
Fertő (2016) concluded that the scope and depth of openness to external organizations have a curvilinear effect on innovative performance and revealed a positive relationship between the scope of open innovation and firms' performance. Moreover, he found that the impacts of the scope of open innovation exist on the company's performance only at the phase of idea development. Chen et al. (2011) analysed how the innovative performance is affected by the scope, depth, and orientation of firms' external search strategies using science, technology, doing-, using- and interacting innovation methods. Their finding suggests that greater scope and depth of openness for both innovation modes improves innovative performance indicating that open innovation is also relevant beyond science and technology-based innovation.
There are three dimensions of external searching strategies in business innovation. First, the scope of the external networks focuses on the diversity of the external sources of innovation (Laursen and Salter, 2006). Second, the depth of a firm's external search is defined as the extent to which firms draw on different external sources (Laursen and Salter, 2006). Third, the orientation of a firm's external search refers to the role of different types of external actors in enhancing the innovative performance of firms (Chen et al. 2011).

Methodology

Preliminary empirical findings suggest that the companies' innovation decisions consist of two main steps: first they make a choice of whether to deal with innovation issues. If they are not motivated to innovate, and if their market does not extort them into this decision, they probably wouldn't innovate at all. The innovation activities, innovative products and processes inherently encompass a certain amount of risk, which can be avoided if the company does not deal with this issue.
Our data proves that the high share of European food processors (in the selected 13 countries) doesn't carry out any innovation activity. Therefore, an appropriate method is selected which takes into account the specific problem of sample selection bias: not all firms should be taken into consideration when the factors influencing the innovation performance is determined, just the ones, which really innovate. In the empirical analysis, a double hurdle estimation is a smart tool for the solution of this selection problem.
The Cragg's (1971) hurdle model combines a selection model that determines the boundary points of the dependent variable with an outcome model that defines its non-bounded values. In this model, individual firms perform zero or a positive amount of innovation, with certainly different factors explaining each of these choices.
By definition, Hurdle models are characterized by the relationship $y_i = s_i h_i^*$, where y_i represents the observed value of the dependent variable. The selection variable, s_i, equals to 1 if the dependent

variable is not bounded or 0 otherwise. In the Cragg model, the lower limit that binds the dependent variable is 0. In this context, the selection model described as follows (Stata User's Guide Release 14):

$$s_i = \begin{cases} 1 & if \quad z_i\gamma + \epsilon_i > 0 \\ 0 & otherwise \end{cases} \tag{1}$$

where
z_i captures a vector of explanatory variables,
γ denoted a vector of coefficients, and
ϵ_i is a standard normal error term.

In addition, we apply Heckman (1979) two-stage model to CIS data, in order to estimate the marginal effects of explanatory variables on innovation activity.
With help of Heckman estimation, we can distinguish between the innovation activity when the company innovate; alternatively, for companies that do not innovate at all.
Heckman (1979) suggests a two-step estimation procedure. In step one, it estimates coefficients by a probit model (using both companies who innovate and do not innovate) and computes inverse Mills ratio (Mills' lambda).
In the second step, it runs linear regression (using the companies' data who innovate only) that includes both explanatory variables and inverse Mills ratio in a regression.
We would get a biased estimate for the coefficient of innovation performance if we ignore the inverse Mills ratio (representing innovating companies), called as the omitted variable in this context. If the inverse Mills ratio is insignificant it means that selection bias is not a significant issue, we can interpret the result of hurdle estimation (FSB, 2018). By contrast, if inverse Mills ratio is significant, the Heckman's estimation should be interpreted.

Econometric hypotheses

This section presents the econometric models applied and hypotheses to be tested. In line with the methodological approach, described above, we distinguish between the two sets of hypotheses: the first group refers to the selection, while the second to the outcome parts of the model.
In the selection phase, we examine the probability whether a company deals with any kind of innovation, while in the outcome stage, we predict the quantity of total innovation activity of the analysed European food companies. We apply market openness, market obstacles, and company size as control variables determining innovation performance.

Selection hypotheses
Literature of innovation network suggests that innovative firms are using a wide range of external sources (skills, network relations, information) in order to improve innovation performance (Chesbrough 2003, Fertő et al. 2016, Chen et al. 2011). Following the work of Indarti and Postma (2013), we suppose that networking intensity is a good predictor of whether the firms are engaged in innovation activity. If the firm's network relations are more intensive, it provides for companies more information on where to innovate. If network relationships are not significant (its intensity is close to zero), it means that the information on new ideas is not important for them, consequently, they are not interested in carrying out innovation.

H1: The higher the intensity of cooperation with information sources are, the more the propensity to innovate is in European countries.

Firms innovate to meet the unsatisfied needs of consumers. In order to control for this feature, a binary variable is used describing if the firm aimed to enter into new markets and/or to increase its market share (Aissaoui, 2014). Therefore, openness is a good indicator, whether the firm is forced to innovate by the global competition.

H2: The more the European company is exposed to global competitiveness the higher the willingness to innovate is.

We also consider a binary variable which identifies firms who faced obstacles linked to the market that has hampered their innovation activities (Aissaoui, 2014). If they are not, probably they are less motivated for making any kind of risky innovation activity.

H3: Market obstacles of European food processing enterprises might stimulate a company's innovation performance.

The very low (close to zero) values of innovation variables representing H1-H3 suggest that food companies are not getting into innovation.

Outcome hypotheses
The scope and orientation of firms' external search strategies significantly affect innovative performance. Greater scope of openness for innovation modes improves innovative performance indicating that open innovation is also relevant beyond science (Chen et al. 2011). The scope of the external search focuses on the diversity of external sources of innovation (Laursen and Salter, 2006).

H4: The wider the scope of a European firm's innovation networks is, the higher its innovation performance is.

Schumpeter (1942) argues that large firms have the resources that enable them to address the risks associated with innovation activities. Therefore, we control for firm's size measured as the company's total turnover in million Euro.

H5: Company's size provides a resource base for the firm's innovation activity in the European food industry.

For those companies for which the fulfilness of new market needs has got intrinsic value this approach appears at strategic level and they act it accordingly. They do it because they perceive that the outcome from performing that behaviour is positive, therefore they will have a positive attitude towards performing that behaviour (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). The aspiration of the strategic approach to innovation indicates a positive attitude for innovation performance. This fact captures the behavioural aspect of the innovation performance.

H6: Strategic importance of introducing new or significantly improved goods or services positively related to innovation performance in the European Union's food industry.

Based on the empirical evidence and hypothesis, the following equations are estimated here:

Outcome model
$$inno = \beta_0 + \beta_1\, ln\_turn + \beta_2\, STINNP + \beta_3\, tailall + \varepsilon \qquad (2)$$

Selection model (if innovation activity is nonzero)

$$inno = \lambda_0 + \lambda_1 STINNP + \lambda_2 open + \beta_3 mobst + \beta_4 tailint + \varepsilon \quad (3)$$

Equations representing the standard linear and curvilinear effect of networking scope on innovative performance (quadratic form) in the EU in line with Fertő (2016):

$$inno = \beta_0 + \beta_1 ln\_turn + \beta_2 STINNP + \beta_3 tailall + \varepsilon \quad (4)$$

$$inno = \beta_0 + \beta_1 ln\_turn + \beta_2 STINNP + \beta_3 tailall + \beta_3 tailall^2 + \varepsilon \quad (5)$$

The dependent variable of the regression (**inno**) depicts how many product-, process-, organisation- or market innovation activities the European enterprise has performed during the previous 3 years.
Networking scope (tailall) is representing how many kinds of external sources have been used for acquiring new ideas for the firm's innovation.
Networking intensity (tailint) was generated by summing the importance of all kind of information sources and cooperation for innovation activities (market sources, education and research institutes, other sources: e.g. conferences, trade fairs, exhibitions), except internal innovation.
The total turnover in 2012 (turn) expressed in million Euro the company's turnover, in logarithm form.
The **strategic behaviour** (**strat**) variable captures the *importance of introducing new or significantly improved goods or services on the market***.**
We used **market openness (open)** variable for international markets depicting foreign geographic markets (other EU markets and all other countries) in which enterprise sell goods or services between 2010 and 2012.
Finally, **market obstacles (mobst)** variable expresses that companies in a strong competing situation (strong price competition, strong competition on product quality, reputation or brand, lack of demand, innovations by competitors, the dominant market share held by competitors) necessarily have to innovate otherwise they are lagging back behind their competitors.

To explore the innovation networks in the selected 12 European food industries and to test the determinants of innovation performance, the dataset was collected from the 2012 Community Innovation Survey (CIS), by a harmonised survey questionnaire. Individual (micro) data were provided by the Eurostat. CIS Nace rev 2. statistical classification of economic activities (manufacture of food products, beverages, and tobacco products) was applied for the selected countries (EUROSTAT, 2008, p. 65). As a whole, the size of the samples varied between 92 (Slovakia) and 2146 (Spain) observations with an average of 519.

Innovation was defined as the introduction of a new or significantly improved **product, service, process, organisational-**, or **marketing** method by the enterprise. Innovation must have characteristics or intended that it is new or which provide a significant improvement over what was previously used or sold by the enterprise.
However, an innovation can fail or take time to prove itself. An innovation need only be **new or significantly improved for the enterprise**. It could have been originally developed or used by other enterprises (CIS 2012).
Table 1 contains the descriptive statistics of variables used in our models.

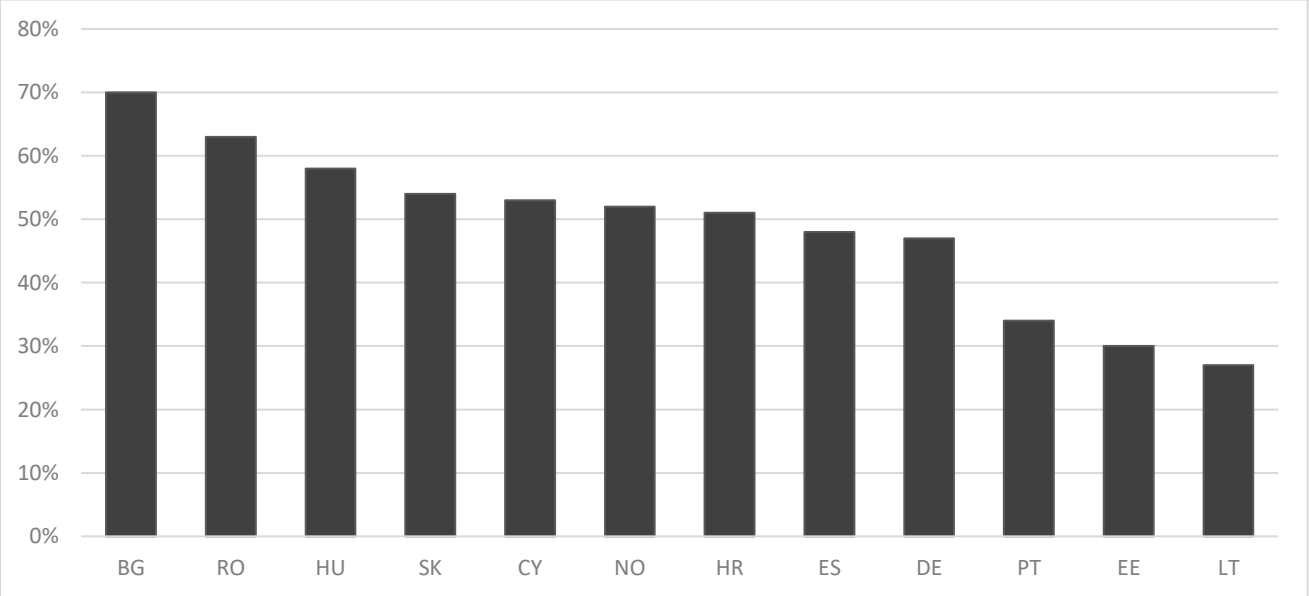
Table 1 Descriptive statistics of variables

	Obs.	Mean	Std. Dev.	Min	Max
Innovation performance	6317	1,7	2,57	0	12
Networking intensity	6317	3,85	6,44	0	30
Networking scope	6317	2,06	3,35	0	10
Strategic behaviour	3823	1,54	1,06	0	3
Market obstacles	6317	5,16	5,13	0	15
Market openness	6317	0,77	0,86	0	2
Total turnover in 2012 (million €, log)	6315	15,1	2,03	6,24	22,52

Source: own calculation based on CIS (2012)

We can learn from the very basic descriptive data that doing innovation is a severe problem among the European food manufacturers. All in all, majority of the food companies did not carry out any kind of innovation activity during the preceding 3 years. Of course, the picture is different across the countries: the "non-making innovation at all" data ranges from 28% (LT) to 70% (BG). The landscape is shown in Figure 1.

Figure 1 The share of companies without any innovation activities in the selected countries



Source: own calculation based on CIS (2012)

Regarding the pattern of the data, the most commonly used innovation activity was the *design or packaging of a good or service* or the "*New or significantly improved goods*", while the less attractive innovations were the "*New methods of organising external relations with other firms" and "New or significantly improved services*" (Appendix I).

Based on the data, in general, the relative importance of the several innovation activities said to be similar in all the countries with some exceptions (e.g. in Hungary and in Romania the importance of "New or significantly improved methods of manufacturing" and "New or significantly improved supporting activities" was lower compared to the others, while on the contrary "*New or significantly improved supporting activities*" was relatively much more important in Portugal. "*New methods of*

pricing goods or services" was more crucial in Lithuania and Portugal, and the "*New or significantly improved logistics*" in Cyprus.

Regression results

The results of double hurdle and Heckman two-step estimations of innovation network tails and intensity on innovation performance are presented in this section. The regression results (including all selected 12 countries) show the determinants of innovation in the European food industries (Table 1).

In hurdle regression (linear and exponential), both selection and outcome model hypotheses were confirmed by the estimations. By contrast, in Heckman model, mills lambda is significant, indicating the relevance of selection bias therefore Heckman estimation fits better to the data.

First, the statistically significant regression results prove that the number of networking scope or tails (tailall) contributes to the innovation performance in most of the European countries analysed.

Second, networking intensity (tailint) plays an important role in explaining innovation performance in nearly all the selected European food industries.

Third, the firm's openness to foreign markets (other EU or extra EU markets) and strategic goals for enhancing innovation equally stimulate innovation performance. These findings are in line with the behavioural theory of innovation (so-called Theory of Reasoned Actions).

Table 1 Churdle and Heckman regression result for the EU countries

	Churdle lin	**Churdle exp**	**Heckman**
Outcome model			
Total turnover	0.333***	0.060***	0.205***
Strategic behaviour	0.731***	0.107***	0.446***
Networking scope	0.469***	0.072***	0.352***
constant	-6.006***	-0.348***	-1.928***
Selection model			
Strategic behaviour	0.197***	0.197***	0.197***
Market openness	0.256***	0.256***	0.256***
Market obstacles	0.024***	0.024***	0.024***
Networking intensity	0.241***	0.241***	0.241***
constant	-1.336***	-1.336***	-1.336***
lnsigma constant	1.123***	-0.413***	
/mills lamda			0.553**
Pseudo R^2	0.19	0.25	
N	3,822	3,822	3,822
Selected			1,629
Nonselected			2,193

*** p<0.01, ** p<0.05, * p<0.1

The individual country level data estimation is found in Appendix II. These estimates reveal a diverse picture of innovation performance in the 12 selected countries.

In Lithuania and Slovakia, the networking intensity did not significantly influence innovation performance.

The market obstacles stimulate the Bulgarian and Hungarian food companies only to go forward the competition and accelerate its innovation activity to conserve its market position. We can conclude that in the majority of the selected EU countries (Bulgaria, Croatia, Hungary Portugal and Romania), the innovation performance significantly depends on the company's size and its firm's strategic goals. The importance of companies' size suggests the validity of the Schumpeterian (1942) approach of innovation.

Comparing the result of double hurdle model with Heckman estimation, in case of Spain (mills lambda is significant at 5%), Germany (at 10%) and Cyprus (at 10%), the Heckman estimation reveals a sample selection bias, therefore, in these countries, the Heckman estimation is interpreted only.

In German and Cyprian food companies, the innovation activity is positively influenced by strategic behaviour, networking scope while companies' turnover and networking scope are significant factors of innovation performance in Spain.

In sum, the result indicates that those European food processing companies, who engage in innovation activity, benefit from its intensive innovation networks.

On the other hand, European companies who targeted to innovate more are proposed to extend their innovation networks. By contrast, those companies who are exceeding certain level network relations can account for a negative effect on innovation performance (Table 2), confirming the inverted U-shape form (Fertő 2016).

Table 2 OLS regression result for EU countries

	OLS	**OLS with quadratic term**
Total turnover	0.165***	0.166***
Strategic behaviour	0.293***	0.281***
Networking scope	0.492***	0.629***
(Networking scope)^2		-0.032***
constant	-2.096***	-0.710***
N	3,822	3,822
R^2	0.49	0.5

*** p<0.01, ** p<0.05, * p<0.1

Conclusion and discussion

The food sector plays a significant role in the European Union, by contrast, innovation activity in food processing sector may depict different picture in certain European countries.
Studying the relationship between innovation and performance is relevant for researchers, policy-makers, and managers of large and small companies alike.
The paper analysed the main drivers of their innovation performance in the EU and in the selected 12 European food industry. Data were derived from the EU Community Innovation System survey questionnaire conducted in 2012.
Regarding the food industry, our findings are generally in line with the performances indicated by the European Innovation Scoreboard for most of the industries. Bulgaria and Romania were one of the least innovative countries, while among the countries included in the sample Germany and Norway took the leading position. Portugal, Estonia and Lithuania had better innovation-oriented characteristics, especially compared to the other Eastern European countries.
Our econometric strategy and models aimed multiple objectives. First, we explored the impact of innovation network intensity (modes of cooperation) and networking scope (networking sources) on

innovation performance in the EU food industries. Second, our selection hypotheses tested the role of international openness and market obstacles to innovation. Third, control variables as company size and strategic goals were also tested by econometric models.
We employed Cragg (1971) double hurdle and Heckman two-step model to estimate the role of innovation networks on innovation performance. This method also helps in disabling the problem of selection as well as omitted variable bias. In addition, a curvilinear effect of networking scope on innovative performance were also tested.
The Heckman estimation revealed a sample selection bias in the case of Spain, Germany and Cyprus. Outcome model shows that if the network relationships (networking scope, i.e. how many information sources firms utilize) were weak in term of internal sources, the food companies do not innovate at all (H4).
Moreover, estimation results prove that networking intensity (H1) played a significant role in explaining innovation commitment in the food industry (Chesbrough 2003, Fertő et al. 2016, Chen et al. 2011) in the selected countries.
The selection results suggest that European companies internationally not exposed to the global market requirements are less likely to innovate because they do not force to be innovative by their competitors (H2). Company's size (H5) and market obstacles (H3) were also determinant factors of the firm's innovation decisions in line with the findings of Aissaoui (2014).
The motivation for innovation determined by firm's attitude and strategic goals were in line with the theory of reasoned action (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975; Indarti and Postma 2013). Furthermore, European food companies' innovation performance significantly depends on the company's size and its strategic goals in the EU.
Interestingly, the market obstacles are rather stimulating factors of firm's innovation highlighting the Schumpeterian approach of innovation. The statistically significant results show similarities among the countries analysed, though the influence of the several factors may somehow differ.

In conclusion, those companies who were able to innovate in the examined food processing industries generally had a positive vision and well-maintained innovation network relationships (H6).
The strategic behaviour, networking scopes were significant factors in German and Cyprian food companies while Spanish companies were encouraged by its total turnover and networking scope.
All in all, the findings indicate that those European food procession companies, who engage in innovation activity, have intensive innovation networks. Moreover, companies who targeted to innovate more, proposed to extend their innovation networks. By contrast, above a certain level of network relations, this advantage can turn into a negative effect on innovation performance confirming the inverted U-shape form (Fertő 2016).

Our findings also emphasize that the food industry in Europe has shifted from the "open innovation" paradigm into the mutuality based "networking innovation" one, where we need to take into consideration the behavioural aspects of innovation performance as well.

Acknowledgement

This work was supported by the National Research, Development and Innovation Office [grant number 120563, "Innovation resilience in food production and consumption"]. The authors gratefully acknowledge the financial support.

References

Araujo, L. and G. Easton (1996), "Networks in Socioeconomic Systems," in *Networks in Marketing*, Iacobucci, D. (ed.) Thousand Oaks, CA: SAGE Publications, Inc. http://dx.doi.org/10.4135/9781483327723.n6

Aissaoui, S., 2014. A double–hurdle model for innovative performance: the role of university-industry collaborations. International Journal of Innovation and Applied Studies, 9(3), pp. 1087-1096

Ajzen, I., and Fishbein, M., 1980. Understanding attitudes and predicting social behaviour. Englewood Cliffs, NJ: Prentice-Hall.

Aschhloff, B. and Schmidt, T., 2008. Empirical evidence on the success of R&D cooperation - Happy together? Review of Industrial Organization, vol. 33, pp. 41-62

Belberdos, R. Carree, M., Diederen, B. Lokshin, B. and Veugelers, R., 2004. Heterogeneity in R&D cooperation strategies, International Journal of Industrial Organization, vol. 22, pp 1237-1263

Buchmann, T. and Pyka, A., 2012. The Evolution of Innovation Networks: The Case of the German Automotive Industry, University of Hohenheim, Center for Research on Innovation and Services (FZID), FZID Discussion Papers, number 70-2013. Available at: https://www.econstor.eu/bitstream/10419/71188/1/738555983.pdf

Buchmann, T. and Pyka, A., 2012. Innovation networks, Handbook on the Economics and Theory of the Firm, in Handbook on the economics and theory of the firm, eds. M. Dietrich, J. Krafft, Edward Elgar, Cheltenham, pp. 466-484.

Brass, D.J., Galaskiewicz, J., Greve, H. R. and Tsai, W. (2004), "Taking Stock of Networks and Organizations: A Multilevel Perspective," *Academy of Management Journal*, 47(6), 795-817.

Chesbrough H., 2003. Open Innovation. Harvard University Press: Cambridge, MA.

CIS, 2012. Data of Community Innovation Survey of the European Union, conducted in Hungary in 2012

Colurcio, M. and Russo-Spena, T., 2013. Collaborative Innovation — A Focus on Food SMES in Agricultural and Biological Sciences, Chapter Food Industry (ed.) Innocenzo Muzzalupo, ISBN 978-953-51-0911-2, January 16, 2013 INTECH. Available at http://dx.doi.org/10.5772/54616

Cragg, J., 1971. Some statistical models for limited dependent variable with application to the demand for durable goods, Econometrica, vol.39, pp. 829-944, 1971.

Dyer, J. H, & Nobeoka, K., 2000. Creating and Managing a High Performance Knowledge Sharing Network: The Toyota Case. Strategic Management Journal, 21, 345-367.

Dyer, J. H, & Singh, H., 1998. The Relational View: Cooperative Strategy and Sources of Interorganizational Competitive Advantage, Academy of Management Review, 23 (4), 660-679

Ebers, M. (1997), "Explaining Inter-organizational Network Formation," in *The Formation of Interorganizational Networks*. M. Ebers, ed., Oxford: Oxford University Press, 3-40.

European Commission (2018) Horizon 2020 - Work Programme 2018-2020 Innovation in small and medium-sized enterprises. Available at: http://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-sme_en.pdf

European Innovation Scoreboard, 2018. report Available at: https://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en

EUROSTAT, 2008. Methodological working papers NACE Rev. 2 Statistical classification of economic activities in the European Community. Luxembourg: Office for Official Publications of the European Communities Available at: http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF

Fertő, I., 2016. The influence of external technology sources on the performance of Hungarian food economy. EAAE 152nd Seminar on Emerging Technologies and the Development of Agriculture, Novi Sad, Serbia, 30 September - 1 August 2016.

Fertő, I., Molnár, A., Tóth, J., 2016. Borderless ideas - Open Innovation in the Hungarian Food Chain. British Food Journal, 118 (6). pp. 1494-1515.

Fishbein, M., & Ajzen, I., 1975. Belief, attitude, intention, and behaviour: An introduction to theory and research. Reading, MA: Addison-Wesley

Food Drink Europe (2017) Data & trends EU food and drink industry. Report 2017 Available at: https://www.fooddrinkeurope.eu/uploads/publications_documents/DataandTrends_Report_2017.pdf

FSB (2018) Farmer School of Business, Miami University, Heckit Model. Available at: https://www.fsb.muohio.edu/lij14/411_ldv3.pdf

Gilsing, V. A. and Nooteboom, B., 2005. Density and Strength of Ties in Innovation Networks: An Analysis of Multi-Media and Biotechnology (February 2005). CentER Discussion Paper No. 2005-41. Available at: https://ssrn.com/abstract=706851 http://dx.doi.org/10.2139/ssrn.706851

Grandori, A. and Soda, G. (1995), "Inter-firm Networks: Antecedents, Mechanisms and Forms," *Organization Studies*, 16 (2), 183-214.

Indarti, N. and Postma T., 2013. Effect of networks on product innovation: Empirical evidence from Indonesian SMEs Journal of Innovation Management, (1):2, p. 140-158 Available at: http://www.open-jim.org/article/view/14

Jin Chen, Yufen Chen, Wim Vanhaverbeke, 2011. The influence of scope, depth, and orientation of external technology sources on the innovative performance of Chinese firms, Technovation, (39):8, 2011, pp. 362-373, available at https://doi.org/10.1016/j.technovation.2011.03.002.

Karlsson, C., Johansson, B., Stough, R. R. ed. (2014) *Agglomeration, Clusters and Entrepreneurship: Studies in Regional Economic Development* New Horizons in Regional Science Edward Elgar Publishing Limited., Cheltenham, UK, Northampton, MA, USA

Laursen, K., Salter, A. J., 2006. Open for Innovation: The Role of Openness in Explaining Innovation Performance Among U.K. Manufacturing Firms. Strategic Management Journal, 27, pp. 131–150. available at https://doi.org/10.1002/smj.507

Levinson, N. and Asahi, M. (1996) Cross-National Alliances and Interorganizational Learning *Organizational Dynamics* 24(2):50-63 https://doi.org/10.1016/0090-2616(95)90071-3

Mansfield, E., 1996. The modern university: contributor to industrial innovation and recipient of industrial R&D support, Research Policy, 25, pp.1047-1058

Möller, K. and Rajala, A. (2006) Business Nets: Classification and Management Mechanisms, Helsinki School of Economics, *Working Papers* W-407, Helsinki, p p.3.

Podolny, J. M. and Page, K. L., 1998. Network forms of organization. Annual Review of Sociology, 24, 57-76.

Pyka, A., 2002. Innovation networks in economics: from the incentive-based to the knowledge-based approaches, European Journal of Innovation Management, vol. 5, no. 3, pp. 152-163.

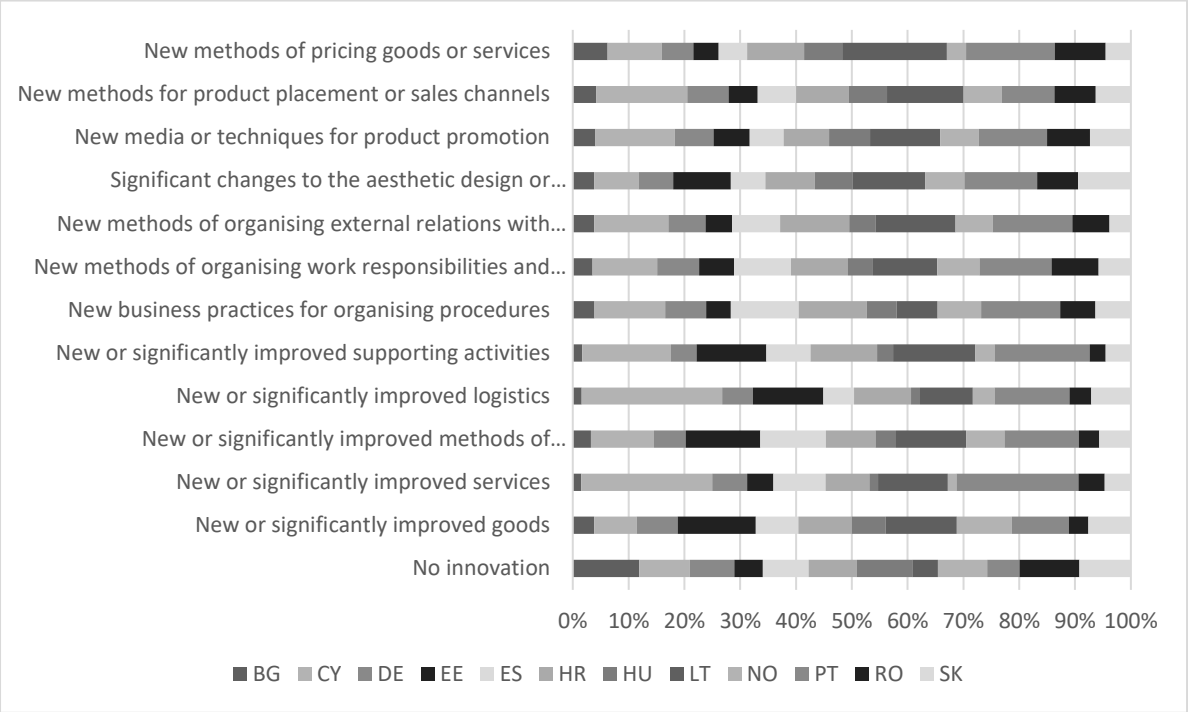
Rampersad, G., Quester, P., Troshani, I., 2010. Examining network factors: commitment, trust, coordination and harmony. Journal of Business & Industrial Marketing, 25/7, 487–500.

Schumpeter, J. A., 1942. Capitalism, Socialism and Democracy, Harper, New York, 1942.

Winger, R. and Wall, G. (2006) *Food product innovation*. Background paper. Food and Agriculture organization of the United Nations, Rome, Italy available at http://www.fao.org/docrep/016/j7193e/j7193e.pdf

Appendix

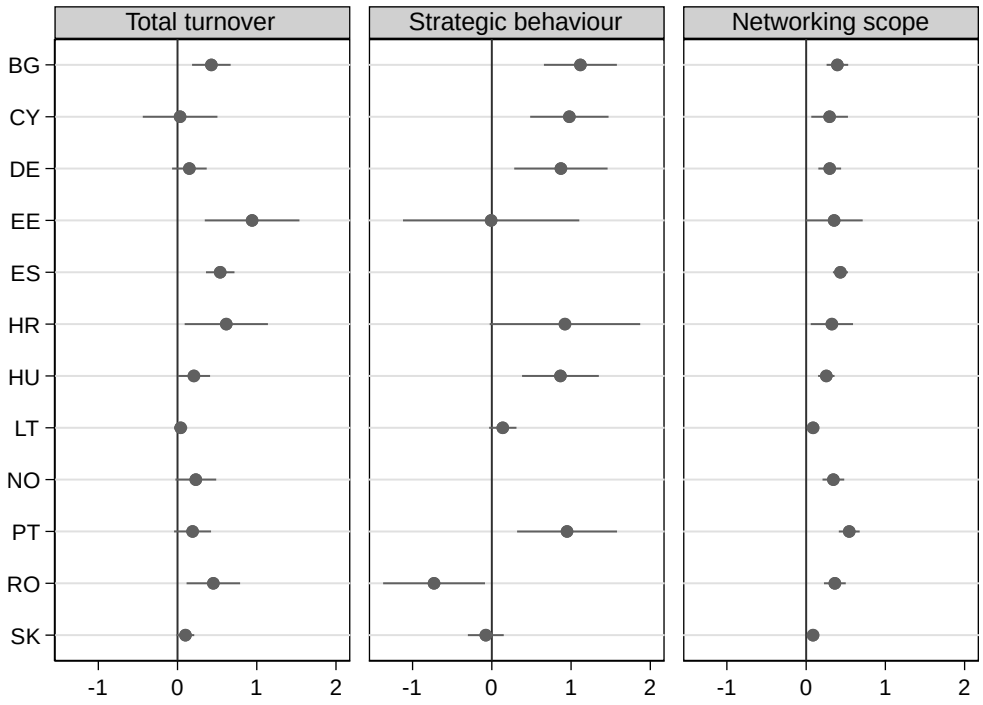
Appendix I. Types of innovation in the selected countries[2]



Source: own calculation based on CIS (2012)
Note: more types of innovation could be selected therefore the sum of the percentages can be more than 100%

[2] BG: Bulgaria, CY: Cyprus, DE: Germany, EE: Estonia, ES: Spain, HR: Croatia, HU: Hungary, LT: Lithuania, NO: Norway, PT: Portugal, RO: Romania, SK: Slovakia

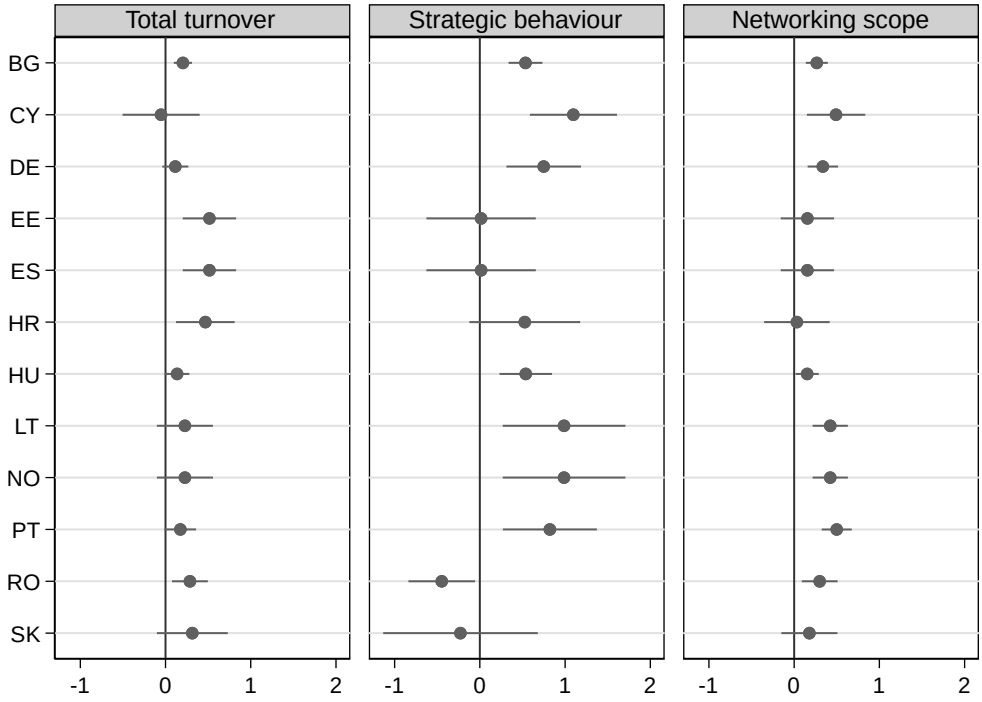
Appendix II. Cragg's double hurdle regression results, coefficients of outcome variables[3]



Note: The plot displays the point estimates and their 95% confidence intervals.
Because in the case of LT and SK the linear hurdle estimation did not exist, the exponential model was estimated.
Source: own calculation based on CIS (2012) data

[3] BG: Bulgaria, CY: Cyprus, DE: Germany, EE: Estonia, ES: Spain, HR: Croatia, HU: Hungary, LT: Lithuania, NO: Norway, PT: Portugal, RO: Romania, SK: Slovakia

Heckman regression results, coefficients of outcome variables



Note: The plot displays the point estimates and their 95% confidence intervals.

Source: own calculation based on CIS (2012) data