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Empirical paper

Push or Pull? The nature of innovation process in the Hungarian food SMEs

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ABSTRACT

In the European Union and in Hungary, the food and beverage industry is the leading manufacturing one. By contrast, food industry is seen less innovative compared to other branches of the economy, especially in the European Union. The level of the R&D spending is very low in the Hungarian food sector. Our paper applies Schmookler's demand pull innovation model in order to explore how external impetuses and internal knowledge resources influence the innovation development in the Hungarian agrifood industry. We applied OLS and hurdle regressions on a large and representative sample of Hungarian food SMEs, covering the whole supply chain. Results show that tacit knowledge is more prominent than explicit one. The use of internal tacit knowledge is significant and relevant in the innovation production process. On the other hand, R&D spending has a negative influence on innovation's success among the food SMEs.

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Introduction

The food and beverage industry is the leading manufacturing industry in the European Union in terms of turnover (16%), value-added (13.8%) and employment (14.6). Food and drink industry is less innovative compared to other manufacturing sectors (EU, 2011). The food industry has been regarded as a sector where the R&D spending is very low. A low level of R&D and innovation represents a significant structural weakness for the EU member states compared with the USA (2.6%) and Japan (3.4%). In the food industry, R&D spending at 0.5% indicates a lower level of innovation (Arundel & Geuna, 2004).

In Hungary, the food sector plays an important role with high level of export share and positive trade balance. On the contrary, since 1990 the domestic sales of the Hungarian food companies decreased by 40% (EFOSZ, 2016). Although its share in the output of Hungarian food industry has decreased over the past decade, the food processing industry still remains one of the most important sub-sectors of the country's economy. The industry employed 124,000 workers in 2011 and generated about 6% of the country's exports (EUGO, 2016). Furthermore, about 96% of food companies are micro, small and medium-sized enterprises. On the other hand, the innovation activities of the Hungarian food industry are far

below the level needed for boosting the competitiveness (EFOSZ, 2016).

Many types of definition exist for innovation in scientific literature. Two major competing approaches can be highlighted in the management domain: the Schumpeterian technological push innovation (linear model of innovation) and the alternative Schmookler's demand pull innovation approach, that refers to innovation stimulated by market demand rather than by scientific discoveries.

According to Schumpeter (1934), innovation can be defined as a launch of a new product, application of new methods, opening new markets, acquiring new resources, etc. All these types of innovations allow companies to realize a competitive advantage and economic benefits. Research brings inventions that should be developed and marketed. The inventions that are successfully introduced to the market result in revenues that exceed investments costs. To this approach, the search for new technologies is more important than the adaptation to the existing patterns of demand. Consequently, the technological innovation is a driver of competition and profitability (Schumpeter, 1934).

On the other side, Schmookler (1966) emphasized the role of economic factors in innovation, as opposed to scientific discoveries. In his famous book "Invention and Economic Growth" Schmookler has stressed the influence of economic conditions in decisions about science and their effects on the demand for inventions. Therefore he underlines that knowledge and requests are necessary since without demand or need no problems would exist and could not be

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solved. Schmookler also framed the debate between technology-push (knowledge-induced) and demand-pull (demand-induced) innovation (Schmookler, 1966:12).

According to Walsh, Schmookler was certainly the major contributor to the demand-pull theories of innovation (Walsh, 1984:212), Freeman confirms that Schmookler was the most influential among economists who has given credibility to the demand hypothesis of innovation (Freeman, 1979:208, 1982:82).

To date, the demand-pull model is rarely employed in the literature and it disappeared from researchers' agendas (Godin, 2013).

Our paper focuses on Schmookler's approach of demand-pull innovation model. The purpose of our current study – according to the Smookler's model – is to explore how external demand signals (deriving mainly from the intense idea- and knowledge exchange along the supply chain) as well as internal readiness and knowledge resources influence the innovation production/development in the Hungarian food industry. We assume that innovation, like other goods or assets, can be produced based on the existing set of knowledge, the absorptive and adaptive capacities of companies together with the availability of new ideas. Therefore, the paper tries to discover, what factors are behind the innovative ideas maintained and developed within the enterprise and – at the end of the process – realized on the market (i.e. *the own innovation production*) of the Hungarian food industry? More specifically, we investigate what factors influence the share of innovation ideas which get realized on the market by the company itself.

Literature review

To capture the innovation in a statistical manner an econometric model is needed to establish causal relationships.

In order to investigate the effect of innovation on productivity and growth, Pakes and Griliches (1984) introduced the knowledge production function describing the causal correlation between resources invested in inventive activity, additions to economically valuable knowledge and indicators of expected benefits from invention such as growth, profitability, productivity.

Crepon, Duguet, and Mairesse (1998) analyzed the links between productivity, innovation and research by a structural model of French manufacturing firms. They proposed a four-equation model where the factors are supposed to have an influence on the estimated probability of being engaged in R&D that also influence the estimated productivity and vice versa. They found that firm productivity correlates with labour skills as well as with physical capital intensity.

The modified knowledge production function used by Löf and Heshmati (2002a, 2002b) is an intermediate econometric specification between the Pakes and Griliches (1984) exogenous knowledge production function and the endogenous model by Crepon et al. (1998).

Löf, Heshmati, Asplund, and Nääs (2001) suggest that the R&D and innovation performances might be key factors causing the differences in productivity growth between Finland, Norway and Sweden.

Löf and Heshmati (2002a) analyzed the knowledge capital and performance heterogeneity at the firm level in Swedish manufacturing firms. Their results show that knowledge capital is found to be a significant factor contributing to performance heterogeneity among firms. Furthermore, knowledge capital rises with innovation input, the firm's internal knowledge for innovation, and cooperation on innovation with domestic universities. Moreover, Löf and Heshmati (2002b) reveal a close relationship between innovation output and the level of value added per employee, the level of sales per employee and sales margin for innovations new to the firms compared to cases where innovations are new to the market.

Löf (2004) concludes that innovation is to be a major contributor to productivity growth explored by comparing manufacturing and service firms in knowledge-intensive industries. He confirmed a positive relationship between R&D, innovation and productivity for both knowledge intensive manufacturing firms and business service firms.

Mairesse and Mohnen (2002) underline the expected innovative benefits due to intra-group knowledge spillovers for firms that are members of identical industrial groups. Fritsch and Franke (2004) reveal the role of cooperation agreements in knowledge production function.

A permanent exchange is also possible with companies from different sectors (Bröring & Cloutier, 2008) and universities or other research institutions (Etzkowitz & Leydesdorff, 2000; Grunert et al., 1995) in order to get innovative ideas.

The empirical relevance of academic research for innovative activity is also confirmed by Löf and Heshmati (2002a, 2002b). Academic institutions usually produce substantial R&D spillovers (Mohne & Hoareau, 2003) that increase firms' cooperation with universities because of the generic collaborations, whereas incoming spill-overs do not foster cooperation with suppliers and customers (Mairesse & Mohnen, 2010). On the contrary, Mairesse and Sassenou (1991) point out some important aspects of the difficulties in establishing a reliable statistical relationship between R&D and productivity.

The difficulties arise because R&D effects are fundamentally uncertain; they often occur with long lags and vary firm by firm. Moreover, it should be mentioned that local resources and institutions can create a convenient innovative environment where the productivity derives from knowledge sharing (Cooke, 2001).

This behaviour is very closely related to the concept called open innovation which is based on the fact that SMEs are increasingly using resources outside the boundaries of the firms in order to encourage innovation (Chesbrough, 2003, 2006).

Several studies have already highlighted that a firm's absorptive capacity (Cohen & Levinthal, 1990; Escribano, Fosfuri, & Tribó, 2009; Lane, Salk, & Lyles, 2001; Tsai, 2001; Zahra & George, 2002) is a critical condition for the success of open innovation. Major indicators of absorptive capacity are relating to access to skills and external networks (Escribano et al., 2009; Lane et al., 2001; Tsai, 2001).

In conclusion, the innovation production can be influenced by many factors such as knowledge capital (value added per employee), R&D, knowledge sharing, cooperation and networks (universities or other research institutions), absorptive capacity, firm's cooperation with suppliers and customers.

The Central European countries such as Hungary are facing difficulties in food production especially with regard to innovation. However, Hungary has some cost advantages (low wages) compared to the Western-European countries, the level of innovation in Hungarian food industry is far below to the EU average. Limited literature can be found that analyzed the innovation capabilities or innovation production function in Hungarian food industry, especially in the case of the Schmooklerian demand pull innovation.

In the food industry, most of the innovations are incremental and characterized by a low degree of novelty (Salavou & Avlonitis, 2008). According to Bröring and Cloutier (2008) knowledge sourcing in many cases arises from related suppliers (e.g. ingredients, machinery, and packaging).

Tomlinson and Fai (2013) used the level of reciprocity in external knowledge transfer throughout the food chain studying product and process innovation related to buyers and suppliers. Amara and Landry (2005), Nieto and Santamaría (2007), Tomlinson and Fai (2013) were studying product and process innovation and underlined the importance of reciprocity in external knowledge transfer between competitors.

Table 1
Applied variables: names, content and descriptive statistics.

Variable name	Content	Obs	Mean	Std dev	Min	Max
IDMKTG ^a	Share of IDEA MARKETING carried out within the enterprise	188	3.69	0.70	1	4
NID1 ^b	NEW IDEAS: how often you get them from universities, research institutes	253	1.12	0.46	1	5
NID2 ^b	NEW IDEAS: how often you get them from buyers, downstream partners	252	4.42	0.93	1	5
IDDEV ^a	Share of IDEA DEVELOPMENT carried out within the enterprise	219	3.68	0.73	1	4
KNL ^b	The enterprise owes exclusive and specific knowledge	255	2.16	1.01	1	5
REC ^b	Reciprocity in knowledge sharing: SUPPLIERS and BUYERS	164	3.71	0.73	1	5
R&D ^c	R&D ratio compared to turnover	155	2.18	0.96	1	3
LANG ^d	Share of employees speaking at least one foreign language	257	1.97	0.79	1	3

^a 1: <25%, 2: 25–50%, 3: 51–75%, 4: >75%.

^b 1: Never/not at all, . . . , 5: always/totally.

^c 1: 0%, 2: 1–2%, 3: 3–5%.

^d 1: 0–10%, 2: 10–30%, 3: >30%.

Source: Own composition

The open innovation can especially be interesting for the food enterprises, which are more dependent on economic resources outside the industry than the other branches Archibugi, Cesaratto, and Sirilli (1991).

Tóth and Fertő (2017) found that open innovation is seen as a natural practice of the agri-food SMEs the whole chain behaves like a mature industry where innovations occur in the intense consultation with buyers, suppliers and other business partners. They revealed the impact of open innovation and a company's absorptive capacity on the innovation performance. Fertő, Molnár, and Tóth (2016) employed a ratio of qualified employees measured with the percent of employees speaking at least one foreign language in order to capture absorptive capacity.

In sum, the innovation performance of food companies seems to be determined by several components such as economic resources outside the industry, absorptive capacity, and reciprocity in external knowledge transfer throughout the food chain and ideas from suppliers and other business partners which are especially true for SMEs. However, wide literature can be attributed to the analysis of innovation production, the factors behind innovation knowledge induced by demand pull innovation are understudied yet especially in the food sector.

Methodology

The link between innovative inputs and outputs was introduced by Griliches (1979 and 1990) and developed by Crepon et al. (1998). After Löf and Heshmati (2001) we call it the knowledge/innovation productivity model.

Many different indicators have been used in the literature to measure innovation production and its determinants. Crepon et al. (1998) estimated the innovation and productivity applying R&D capital per employee, number of employee, market share, value added per employee, physical capital per employee, engineers per employee, innovation intensity variable and the effects of demand pull and technological push indicators. Löf and Heshmati (2001) employed firm's main customer, important cooperation partners, important innovation strategies, obstacles to innovation, product life cycle, industrial growth rate, variables for process innovation, organizational innovations and industry dummies as the determinants of innovation input. Löf (2003) used human capital, R&D, innovation output, knowledge spillovers between various actors in the economy, the service production, quality improvements and real growth rates variables to estimate the innovation in explaining the heterogeneity of firm performance. Halpern and Muraközy (2010) estimated the innovation production in Hungary and revealed that many companies can introduce new innovation with low or zero R & D expenditure. Omta, Fortuin, and Dijkman (2014) demonstrates the benefits of collaboration in food SME

sector. They state that collaboration can contribute to the needed enhancement of the innovative potential of the European food industry. Here we investigate what factors determine innovation production realized on the market.

We are focusing on the indicators of absorptive capacity, demand pull innovation, the role of academic cooperation and R&D spending. In line with the previous empirical findings, instead of estimating the knowledge productivity model itself we have estimated first a linear knowledge production function consisting of four main factors/categories:

- *tacit knowledge*: specific knowledge of the enterprise, in-house developments of new ideas, the reciprocity in knowledge sharing between suppliers and buyers,
- *absorptive capacity*: foreign language spoken,
- *cooperation, R&D spill-overs*: new ideas stimulated by universities and research institutes
- *explicit knowledge*: R&D ratio compared to turnover.

The model – where the independent variables reflect the four factors above – is specified as follows:

$$\text{IDMKTG} = \alpha + \beta_1 \text{NID1} + \beta_2 \text{NID2} + \beta_3 \text{IDDEV} + \beta_4 \text{KNL} + \beta_5 \text{REC} + \beta_6 \text{R\&D} + \beta_7 \text{LANG} + \varepsilon \quad (1)$$

Table 1 describes the variables.

In general, Probit and Tobit models are used for estimating that innovation occurs in an organization. After we have quantified the OLS relationship, in the second step we employed a linear Hurdle model in order to exclude those companies which do not collect ideas from the food supply chain and those which do not pursue R&D process at all.

The Hurdle model combines a selection model that determines the boundary points of the dependent variable with an outcome model that determines its non-bounded values. Hurdle models treat these boundary values as observed instead of censored, and they are characterized by the relationship $y_i = s_i h_i^*$, where y_i is the observed value of the dependent variable. The selection variable s_i is 1 if the dependent variable is not bounded and 0 otherwise. In the Cragg (1971) model, the lower limit that binds the dependent variable is 0 so the selection model is $s_i = 1$ if $z_i \gamma + \varepsilon_i > 0$ and 0 otherwise. In addition, where z_i is a vector of explanatory variables, γ is a vector of coefficients, and ε_i is a standard normal error term. Cragg hurdle model allows a different lower limit or for the linear model, an upper limit. More specifically, we used Cragg (1971) simultaneous model for modelling participation equation and quantity equation.

In accordant with the empirical innovation literature in the food industry the following five hypotheses are tested here:

- The first hypothesis refers to the positive role of the human components of innovation and tests the effect of the knowledge

capital. This gives a good estimation of the innovation related quality of the companies, examining the role of tacit knowledge.

H1. A firm’s own exclusive knowledge and own idea development efforts have positive effect on innovation performance of SMEs.

- The second hypothesis highlights that customers’ needs would be provided by the suppliers and buyers of the company. This is to be interpreted as demand pull innovation process which refers to the Schmookler’s type demand pull innovation. The reciprocity also refers to the absorptive capacity of the companies.

H2. The knowledge sharing between the food SMEs and their suppliers or buyers enhances innovation development (demand pull innovation).

- The third hypothesis tests the effect of R&D spending on innovation performance for SMEs. This hypothesis is in line with the Schumpeterian approach and investigates the role of disciplinary, codified knowledge.

H3. A firm’s R&D spending has a positive effect on innovation performance.

- As fourth hypothesis, we assume that companies with higher ratio of foreign speaking employees can absorb the new knowledge/innovation more efficiently. The absorptive capacity of companies is partly captured by this indicator.

H4. A higher share of foreign language speaking employee stimulates innovation.

- Finally, the fifth hypothesis investigates the role of academic institutions and universities in firm’s innovation development process. Here the spill-over effect is tested, whether there is any relevant connection between the selected companies’ innovation process and the universities, research institutions (R&D spill-overs).

H5. Cooperation between food companies and research institutions, universities has a positive effect on innovation performance.

To investigate the innovation of SMEs and to test the determinants of innovation production function, the dataset was collected by a Hungarian survey in 2014. The SME is defined here as a firm with less than 250 employees (CIAA, 2005). Our sample covers three stages of the food chain companies: producers, processors and retailers. The survey includes information on “Knowledge accumulation and use in the food industry” as well as on “Cooperation and clustering as the keys of intense and effective business”.

The sample was drawn from the database of Hungarian Central Statistical Office and the surveyed 302 firms include 100 producers, 101 processors and 101 retailers.

Results

Our results (Table 2) suggest that interestingly the explicit knowledge (R&D) influences negatively the innovation of SMEs in Hungarian food sector, R&D variable is insignificant and has a negative effect on innovation marketing. Consequently, the majority of the marketed new innovations do not come from this source. This result is very much in line with the one which shows that new ideas deriving from universities and research institutions significantly hinder the innovation process: namely the sign of NID1 variable is negative.

Table 2
Results of the regression.

Variables	OLS model	Hurdle model	Marginal effect
NID1	-0.216***	-0.275***	
NID2	0.243***	0.202***	
IDDEV	0.548***	0.368***	
KNL	0.112**	0.079**	
REC	0.066	0.030	
R&D	-0.062	-0.058	
LANG	-0.086	-0.140***	
Constant	0.663**	1.923***	
Selection.II(1)			
REC		1.041***	0.175**
R&D		-0.282	-0.095
Constant		0.151	
F	0.0000		
χ ²		0.0000	
Adjusted R ²	0.7629		
Pseudo R ²		0.5512	
Number of observations	103	103	103

* p < 0.1; ** p < 0.05; *** p < 0.01.

Note: Selection.II(1) denotes selection for value 1 in REC and R&D variables, These values were excluded for REC and R&D variables because in that case, the knowledge sharing was missing and the companies did not spend on R&D.

Source: Own composition.

The firm’s inner idea development (IDDEV) has more deterministic positive effect on realizing innovative business ideas in the food SME sector. Furthermore, the business ideas from buyers or downstream partners (NID2) and specific tacit knowledge (KNL) had a positive effect on innovation performance.

As the reciprocity in knowledge sharing (REC) is concerned, our estimation indicates that innovative business ideas (provided by suppliers and buyers) have got positive – albeit not significant – effect on innovation performance suggesting that demand pull innovation is there.

Absorptive capacity (LANG) has a negative significant effect of knowledge production function inducing that foreign language knowledge of employees is not necessarily fostering innovation development.

In selection part of the hurdle model we have used the reciprocity of knowledge sharing with chain partners (REC) and R&D ratio to forecast which ideas are to be developed and marketed within the companies.¹ As we can see from the results, the explicit type of knowledge has got negative, although not significant effect. On the other side, the tacit knowledge, which was acquired by mutual and voluntary exchange of information plays exclusive determining and significant role.

Regarding the specific role of tacit and explicit knowledge we wanted to figure out their marginal effects as well. Therefore, we have calculated the average marginal effect of these two variables. Results show that the marginal effect of tacit knowledge creation is positive and significant for the whole innovation production process, while the explicit knowledge accumulation plays negative, though insignificant role.

The high R-square confirms a good model fit (0.7629) for OLS estimation. The relatively high value of pseudo R² (0.55) also validates a good explanation power of Hurdle regression model. In sum, our estimations are robust for OLS and Hurdle models.

Discussion

Our study investigated the role of the explicit and tacit knowledge in marketed innovation of Hungarian food SME sector. Based

¹ The selection procedure itself determines which ideas are not to be developed, but at the same time it also predicts, which are to be developed and marketed within the company.

on the regression results, we can conclude that the tacit knowledge (specific knowledge of the enterprise) as our first factor is more essential and more significant than explicit knowledge in the Hungarian food SMEs with respect to their in-house innovation production. (*H1: A firm's own exclusive knowledge and own idea development efforts have positive effect on innovation performance of SMEs. Confirmed.*)

The number of new product ideas and new research projects can be considered as possible signals of firm's transformation activity. According to the traditional definition of absorptive capacity² (Cohen & Levinthal, 1989), it depends crucially on prior related knowledge.

Moreover, the business ideas proposed by buyers or downstream partners have encouraged innovation performance. Our estimation indicates that innovative business ideas are rather provided by suppliers and buyers suggesting the presence of demand pull innovation. (*H2: The knowledge sharing between the food SMEs and their suppliers or buyers enhances innovation development (demand pull innovation). Confirmed.*)

The B2B innovation from both supplier (upstream) relationships and customer (downstream) relationships contributes to both the knowledge-based theory of the firm (Grant, 1996) and relationship marketing theory (Dwyer, Schurr, & Oh, 1987).

The second factor – absorptive capacity – had a negative significant effect of knowledge production function inducing the foreign language knowledge of employees. It might be about the insignificant and sometimes negative effects of disciplinary, explicit knowledge. However, many businesses are losing trade through lack of language skills. SMEs can experience intercultural as well as language barriers when operating across borders or practise export activity in the EU (ELAN, 2006). (*H4: A higher share of foreign language speaking employee stimulates innovation. Rejected.*)

The third factor, communication and R&D spillover has shown up significant negative effect on innovation production, proving that within the food SMEs the Schumpeterian innovation model is generally challenged. Similarly, Belderbos, Carree, and Lokshin (2004) confirmed that new product sales are rather stimulated by incoming knowledge spillovers and not due to collaboration with customers, universities or research institutes. By contrast, customers and universities are important sources of knowledge in case of radical innovations, which facilitate growth in innovative sales in the absence of formal R&D cooperation. (*H5: Cooperation between food companies and research institutions, universities has a positive effect on innovation performance. Rejected.*)

Finally, the codified or explicit knowledge creation (R&D ratio compared to turnover) had negatively stimulated the realization of innovative business ideas in food SMEs. In consequence, the R&D spending does not foster innovation performance in the Hungarian food sector. (*H3: A firm's R&D spending has a positive effect on innovation performance. Rejected.*)

The results marginal analysis has proved that reciprocity in knowledge sharing with chain partners is beneficial for the whole innovation progress, but the classical way of accumulating and applying new knowledge (increasing R&D activity) is contradictory for the Hungarian food SMEs. Tóth (2016) also confirmed that there is positive relationship between the knowledge sharing with chain partners and the innovativeness in the Hungarian SME's food chain.

Conclusions and limitation

In the European Union and in Hungary, the food and beverage industry is the leading manufacturing industry. However, in the

² It is the ability to recognize the value of new information, assimilate it, and apply it to commercial ends.

food sector, the level of the R&D spending is very low in these regions of the world. Therefore, our study aimed to explore how external impetuses and knowledge resources influence the innovation development in the Hungarian food industry in line with Schmookler's demand-pull innovation model.

To investigate the innovation of SMEs and to test the determinants of innovation production function, the dataset was collected by a Hungarian survey in 2014. The sample covered three stages of the food chain companies: producers, processors and retailers. Several different indicators have been used in order to measure innovation production and its determinants. We were focusing on the indicators of tacit knowledge, absorptive capacity, the role of academic cooperation and R&D spending.

We run OLS and censored two-step linear Hurdle regression models to include the knowledge transfers among the players of food supply chain and stimulating ideas carried out within the enterprise.

In conclusion, the disciplinary knowledge does not play a significant role in market innovation in Hungarian SMEs, resulting from the rejection of the third hypothesis of the paper. On the other hand, the current and newly generated tacit knowledge is very important, confirming our first hypothesis about the role of tacit knowledge. According to the innovation production model, the own innovation performance is derived from present knowledge. This knowledge of SMEs is coming mainly from their food chain networks, underlining the importance of reciprocity and absorptive capacity. These facts probably not hold for the larger food processing enterprises (that usually has more developed innovation strategy).

As a conclusion, the outcome of the paper is threefold. First, it analyzed the demand pull innovation in Hungarian food sector. It revealed that tacit knowledge is more prominent and significant than explicit knowledge in the Hungarian food sector. Second, it suggests a negative role of R&D in SME sector. Finally, our survey and research were conducted on a large and representative sample of Hungarian food SME's, covering the whole supply chain.

It should be mentioned, as a limitation of the study, that to investigate the innovation production function for the different players of the food supply chain – producers, processors and retailers – might produce different results. One of the future research directions would extend our research for the larger food companies and will concentrate on the food processing companies all around Hungary.

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