Network connections and innovation capacity in traditional agrifood chains

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Abstract – **In the New Economy, the network is considered as more important than the firm itself. In this paper the focus is on chain networks which include vertical networks among chain members, horizontal networks with peers, and networking with third parties. Networks have an important role in the diffusion and adoption of innovations, thus they are the locus of innovation. While previous research focused on the firm, we contribute to the understanding of innovations in chain networks, i.e. we investigate the innovation capacity in vertical networks and how networking with peers and third parties is influencing the innovation capacity of the vertical network. We propose that there is a positive relationship between the network connections the direct chain partners have with peers and third parties and the innovation capacity of the vertical network.**

Data were collected from 90 direct agrifood chains in the traditional food sector. Cluster analysis suggested three clusters of chains corresponding to three distinct levels of innovation capacity: low, medium and high. Via descriptive analysis and binary logistic regression the influence of networking with peers and third parties on the innovation capacity of the vertical network was investigated.

Our results confirm our proposition. However, we found that the chain partners are either horizontally or vertically networking for innovation. Nevertheless, more networking within the chain and with peers and third parties is linked to higher levels of innovation capacity.

Consequently, our study adds to the research in the field of the New Economy by deepening the understanding of how innovation capacity is developed in vertical networks. We can confirm that the network is very important for the development and implementation of innovations and that the innovation capacity of one firm is linked to the innovation capacity of its chain partners.

For future research we propose to investigate the link between networking for innovation and types of innovation which can be achieved. Further, future research should explore further inter-organizational links in the chain network and explore wider networks than the direct chain.

Key words – **SMEs, chain networks, traditional food products**

I. INTRODUCTION

According to the theory of New Economy, many scholars acknowledge the network, a firm is embedded in, as more important for the development and implementation of innovation than the firm itself [e.g. 1, 2-7]. The network is the place where actors within one or between several related industrial sectors interact and collaborate to add value for the customer [8]. In this paper the focus is on chain networks as defined by Lazzarini et al. [9] and Van der Vorst [10]. Chain networks are a set of networks connected via horizontal and vertical relationships. Horizontal networks consist of firms belonging to the same industry, thus being primarily competitors or peers. Vertical networks are composed of the different partners of the agrifood chain involved in all upstream and downstream flows of products, services, finances, and information. The vertical network includes all organizations from the direct chain (supplier, food manufacturer, customer) to the extended chain (suppliers of suppliers and customers of customers) [11, 12]. Beyond that, third parties are contributing to the chain, such as financial providers, third party logistic suppliers, and market research firms [11, 12]. Although they are not directly participating in the chain, they are recognized to contribute to the value creation process in the chain. The role of third parties on the activities in the chain haven't been widely investigated yet [9]. Hence, we further narrow down our focus on networking of the direct chain partners with their peers and their third parties.

Networks, in general, increase the flow of information and play an important role for the diffusion and adoption of innovations [1, 13]. Consequently, they are acknowledged as the place where innovation is taking place [1, 2, 8, 14, 15]. Innovation is the ongoing process of learning, searching and exploring which results in new products, new processes, new markets and new forms of organization [16]. Further the continuous innovation process is characterized by three steps: efforts, activities and results. Thereby, efforts are all assets, such as human and financial assets a firm is investing in innovation activities, such as R&D, training and study tours, possibly leading to innovations. Results are the effects of these activities on tangible (e.g. growth of market share, profit) as well as less tangible aspects (e.g. firm stability, efficiency, and reputation) [17]. Consequently, innovation capacity is the firm's ability to innovate, also in the future, along the whole innovation process [18, 19]. However, as there is a great need for studies contributing to the understanding of innovations in chains and networks [1, 3, 20, 21], we explore the innovation capacity at the level of the vertical network, i.e. the direct agrifood chain.

The increasing complexity of innovation processes has enhanced the dependency of interaction in chain networks in particular for micro, small and medium sized enterprises (SMEs) in the agrifood sector [3, 22]. The agrifood sector is considered as a low-tech and low-innovative industry [23-26]. Hence, in the agrifood industry innovation does not draw purely on R&D but is rather involving a learning process and interaction between different actors as described in the theory of the New Economy [5, 6].

Networking is an important strategy for SMEs in the agrifood sector as several studies have pointed out that they are highly dependent on external sources of information for innovation [26-30]. Thereby, external sources of information for innovation can be the customers, suppliers, competitors and research institutions the SMEs network with to achieve more successful innovation [1, 3, 21, 31].

SMEs face various internal problems related to the introduction of innovations. SMEs mostly face a lack of human and financial resources, resulting in limited organizational capabilities, lacking attitude towards innovation, and lack of a strategic vision [32, 33]. The development and implementation of innovation is further hampered if the SME is not able to efficiently allocate and coordinate its resources, does not have access to relevant information and knowledge and when there is no focus on learning but just on the continuation of the every-day work [33]. Most of these problems can be overcome if SMEs involve in networking. Thus, SMEs are more innovative when they are able to join and manage networking activities [2, 5, 17, 26]. The value of networking for innovation is the fast composition of a complex knowledge base and diffusion system of innovations through streamlining information flows [1, 34]. Networking offers opportunities for new relationships, links or markets and allow access to new or complementary competencies and technologies [1, 9, 35].

Within this paper the focus is on chain networks of traditional food manufacturers, which contain a large majority of SMEs. In the EU an increasing interest is noticed in preserving the cultural heritage of the different European regions [36, 37]. An important element of the cultural heritage is the production of traditional food products. Only few studies about traditional food products have been conducted yet from an economic perspective [38-40]. Even less studies are in reference to innovation in this specific agrifood sector, despite the great need for research in this field, created by the increasing demand for traditional food products in combination with the importance of innovation to gain competitive advantage [3, 41]. There is no common definition of traditional food products. Based on several definitions as by the European Commission and scientific researchers [36-38, 42-45], we propose the following definition. Traditional food products are considered as processed goods, both with and without any form of origin label. Furthermore, four criteria are applied: (1) the key production steps of a traditional food product must be performed in a certain area, which can be national, regional or local. (2) The traditional food product must be authentic in its recipe (mix of ingredients), origin of raw material, and/or production process. Further, (3) the traditional food product must be commercially available for at least 50 years and (4) it must be part of the gastronomic heritage.

Findings from Gellynck and Kühne [46] suggest, that in the traditional food sector horizontal networks can be producer consortia with the aim of setting the production specifications and guaranteeing the quality towards the consumer or with the aim of achieving national or European protection by labels of geographical or traditional indication. Discussion and exchanges of information or problems with competitors was stated as an important external source for innovation. In vertical networks in the traditional food sector, the food manufacturer and the customer are found to collaborate lesser with each other than the food manufacturer and its suppliers. However, vertical networking seemed related to the size of the chain partners; more networking was stated among partners of similar size. In such cases the retailer's upstream sharing of market information, was perceived as a valuable input for innovation ideas. Nevertheless, it was also stated that innovation occurred under the pressure of larger customers. On the contrary, high levels of networking with suppliers were mentioned. Additionally, in some cases networking with third parties, such as research institutions, food federations and governmental institutions was indicated. Networking with third parties clearly focused on the improvement and implementation of product and process innovations.

The objective of this paper is to quantify the findings from Gellynck and Kühne [46] through the investigation of how networking with peers and third parties is influencing the innovation capacity in traditional agrifood chains.

The paper is structured as follow. First a conceptual framework is developed clarifying the links between innovation capacity and the chain network. Subsequently, the sample, the survey and the analysis are described in the methodology section. In the result section, the innovation capacity in traditional agrifood chains is computed and the influence of horizontal networking and networking with third parties is presented. Finally, conclusions are drawn and managerial implications are provided.

II. CONCEPTUAL FRAMEWORK

The innovation capacity of a firm is dependent on both its internal and its external resources because they are considered as complementary for the innovation process [3, 47, 48]. Internal resources contain a large number of firm characteristics, such as the openness toward new ideas, and the firm's size [49-51]. External resources belong to the firm's strategic environment and include the potential of business-to-business relationships, available infrastructure for collaboration and networking, and access to support from research providers and government [5, 33, 52]. The network is the place where the internal and external resources of a firm are combined and possible transformed into innovation capacity [18].

However, as innovation is nowadays rather taking place in the network than in the single firm, we extend the framework by Gellynck et al. [18] from the firm level to the level of the vertical network (direct chain). Accordingly, we state that the combination and transformation of each partner's internal and external resources contribute to the innovation capacity of the direct chain. Thereby, vertical networking for innovation in the direct agrifood chain is considered as the contributing external resource because it is the most important success factor for the generation of innovation capacity at chain level [19, 20, 33, 53-55]. Hence, the innovation capacity of the direct agrifood chain is composed of the innovation capacities of the individual chain partners. In network theory also the network connections each chain partner possess outside the vertical network are considered as important for innovation in a chain context [20, 56]. As stated above, this refers to horizontal networks, i.e. firms at the same stage of the chain or the same industry, which are basically competitors or peers to each other, and to third parties, such as governmental institutions or research organizations. Information and knowledge exchange with peers and third parties is found to be positively related to enhanced innovation capacity in agrifood firms [18]. Peers are considered as a rich source of new knowledge in the same specific knowledge area, facilitating sometimes even the exchange of tacit knowledge [18, 20]. Third parties, such as governmental institutions are important for creating an environment that stimulates innovation, through policy settings and support of networking [1, 20, 21]. Additionally, universities and other research organizations are acting as independent network mediators and middlemen within chain networks, delivering ideas and means for innovation generation [1, 3, 20]. According to the concept of innovation generation by Roy et al. [20] interactions for innovation in the chain network are influenced by several factors which can be intrinsic or extrinsic to the relationships in the chain network. Intrinsic factors can be managed and controlled by the interacting firms through managerial actions, while the extrinsic factors cannot be influenced by the interacting firms but which can have a major impact on the innovation generation. Intrinsic factors relate to information technology adoption, commitment and trust, while extrinsic factors comprise tacitness of technology, stability of demand and network connections. Among the factors listed by Roy et al. [20] we are interested in exploring the influence of network connections on the innovation capacity.

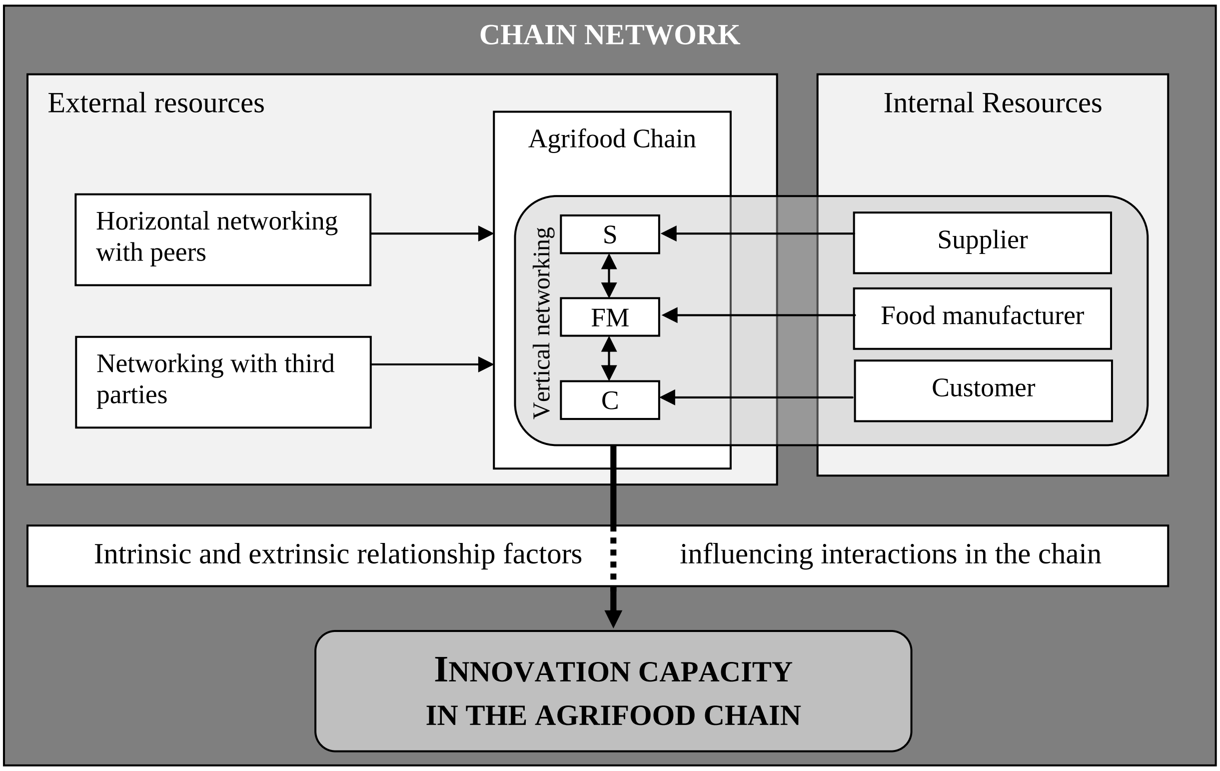

Fig. 1 Conceptual framework for investigating the influence of networking with peers and third parties on the innovation capacity in agrifood chains, adapted from Gellynck et al. (2007) and Roy et al. (2004)

It is generally recognized that SMEs with higher levels of innovation capacity have more network connections, both in their vertical and horizontal networks and outside these networks [3, 18]. The more SMEs network the more experience and capabilities they develop to interact in networks which in return leads to more network connections over time [4, 14]. Therefore we propose that *the more network connections the direct chain partners have outside the vertical network the greater the expected influence of networking is on the innovation capacity of the vertical network*.

III. METHODOLOGY

The innovation capacity in chains was investigated in the traditional food sector due to the increasing interest and the emerging need for research [36-38, 44, 57]. The research was conducted in the frame of the EC FP7 financed project TRUEFOOD (www.truefood.com). Three EU-countries were involved in this research, namely Belgium, Hungary and Italy. In consultation with national and international key informants, traditional food subsectors with a relevant socio-economic importance and relevance in their respective country were selected based on number and size of firms, employment rates (direct and indirect), value added, turnover, investments, import/export, and consumption rates. The following subsectors were selected: Belgium - cheese and beer, Hungary - white pepper, dry sausage and bakery products, and Italy - cheese and ham. Details about the composition of the sample are provided in Table 1. Based on literature and previous research a structured questionnaire was developed, pilot tested and finalized. The questionnaire included measures of the firm's internal innovation process and of the networking behavior of each firm. For the innovation process, information was assessed about the efforts, activities and results for/of innovation at the firm level of each chain partner. Innovation efforts were explored as human and financial efforts. Human efforts relate to the frequency the responsible person for research and development participated in activities for improving human resources for innovation during the last year.

Items included were 'Courses and trainings', 'Self-study (reading professional literature)', 'Seminars', 'Fieldwork (e.g. study tours visiting other companies)', and 'Experimental trials'. The respondents had the opportunity to extend the list with other activities. Innovation efforts were explored on a 7-point frequency scale with 'Never' (1), 'Once a year' (2), 'Once in 6 months' (3), 'Once in 3 months' (4), 'At least once a month' (5), 'Once a week' (6) and 'Several times a week' (7). Financial efforts were assessed as the structuredness any financial resources are spent by the firm in the last year for 'product development', 'process development', 'market research' and organizational development'. The respondents could choose between 'No financial resources spent', 'Spent according to necessity without being budgeted', 'Distinctively budgeted on a project base', or 'Distinctively budgeted on a yearly base'. Innovation activities were investigated as changes the firm had introduced during the last 3 years on a binary yes-no scale with the extra option of not applicable. Several items were used related to product, market and organizational innovation. Process innovations are not included under innovation activities because in traditional food products process innovations are not frequently observed [55]. A detailed overview of these items is provided in Table 2. Finally, innovation results were measured as the perceived contribution of the introduced innovation activities on the business success of the firm. The perceived contribution was assessed on a 7-point Likert scale from 'strongly disagree' (1) to 'strongly agree' (7). The same items were used as for exploring innovation activities (see Table 2) and an answer was only required for those items which were indicated with yes under innovation activities.

Table 1: Sample description

COUNTRY AND PRODUCT	NUMBER OF RESPONDENTS	NUMBER OF CHAINS
BELGIUM: Hard and half-hard cheese	45 Respondents – 7 micro, 4 small, 2 medium, 2 large suppliers – 11 micro, 2 small, 2 medium food manufacturers – 4 micro, 5 small, 2 medium, 4 large customers	15 Chains
BELGIUM: Beer	45 Respondents – 4 micro, 7 small, 1 medium, 3 large suppliers – 8 micro, 5 small, 2 medium food manufacturers – 9 micro, 5 small, 1 large customers	15 Chains
HUNGARY: Bakery products	42 Respondents – 2 micro, 7 small, 5 medium suppliers – 7 small, 7 medium food manufacturers – 8 micro, 3 small, 3 medium customers	14 Chains
HUNGARY: Dried and fermented sausage	33 Respondents – 2 micro, 2 small, 7 medium suppliers – 2 micro, 3 small, 6 medium food manufacturers – 1 micro, 3 small, 7 medium customers	11 Chains
HUNGARY: Processed white pepper	15 Respondents – 3 micro, 1 small, 1 medium suppliers – 1 micro, 2 small, 2 medium food manufacturers – 4 micro, 1 small customers	5 Chains
ITALY: Hard and half-hard cheese	48 Respondents – 10 micro, 6 small suppliers – 13 micro, 2 small, 1 medium food manufacturers – 11 micro, 5 small customers	16 Chains
ITALY: Ham	42 Respondents – 3 micro, 5 small, 6 medium suppliers – 6 micro, 7 small, 1 medium food manufacturers – 2 micro, 6 small, 4 medium, 2 large customers	14 Chains
TOTAL	270 Respondents – 31 micro, 32 small, 22 medium, 5 large suppliers – 41 micro, 28 small, 21 medium food manufacturers – 39 micro, 28 small, 16 medium, 7 large customers	90 Chains

Table 2: Items used for assessing innovation activities and innovation results

Type of innovation	Measurement items
Product innovation	Our company improved the packaging of our traditional product
	Our company improved the quality of our traditional product (through selected ingredients, raw materials, better uniformity of the product etc.)
	Our company improved the convenience of our traditional product
Market innovation	Our company entered new geographical markets for our traditional product
	Our company improved marketing activities for our traditional product
Organizational innovation	Our company introduced new management tools
	Our company improved management practices of research and development
	Our company increased participation in networks

In relation to the networking behavior, each chain partner was asked to indicate whether or not (binary yes-no scale) he/she is involved in joint research and development activities with his/her main supplier and customer, and with his/her peers and/or third parties. Third parties were described as governmental and non-governmental organizations, such as research institutions, universities, technology partners, information technology providers and consultants.

Data were collected from 90 individual direct agrifood chains, i.e. 270 direct chain partners (food manufacturers and their most important supplier and customer). Hence, three slightly different questionnaires were developed. The differences referred to the part on the networking behavior in order to correspond to the right relationship direction in the vertical network. The food manufacturer needed to answer to both relationship directions, upstream and downstream, i.e. the food manufacturer is the supplier of his/her customer and the customer of his/her supplier. Then the supplier needed to answer questions regarding his/her customer (the food manufacturer), while the customer had to answer towards his/her supplier (the food manufacturer).

Data collection took place between December 2007 and June 2008 in the three above mentioned European countries (Belgium, Hungary and Italy). Non-probability judgment sampling was applied, whereby the food manufacturer needed to be a medium, small or micro-sized traditional food manufacturer (companies that employ fewer than 250 people and have a maximum turnover of fifty million Euros) according to the definition by the European Commission [58]. Besides, the main supplier and customer were allowed to be also larger firms.

Prior to the survey, the traditional food manufacturers were identified by NACE-code and the member list of the national food federations or specific food federations. Via national statistics the list of manufacturers was further narrowed down corresponding to the maximum size and turnover assuring the solely inclusion of SME-food manufacturers. Further, via secondary sources (e.g. specific food federations and the EC DOOR Database) or during the first telephone contact it was ensured that the food manufacturer was producing traditional food products according to our definition. During the first telephone contact the food manufacturer was introduced to our study and his/her willingness to participate was explored. After a positive reaction, an interview was appointed at the premises of the food manufacturer. During the interview the main supplier and customer were identified by the traditional food manufacturers in form of snowball sampling, which is an appropriate method if the ex-ante identification of respondents (in our case the main supplier and customer of the food manufacturer) is nearly impossible [59]. The choice of who the ‘main’ supplier and customer were, was up to the food manufacturer. Subsequently, the identified supplier and customer were contacted and interviewed in respect to his/her food manufacturer. In case the supplier or customer was not willing to participate the chain was excluded from the dataset. Data collection continued until the aim of 90 individual chains with complete triplets of direct chain partners was achieved.

Data were analyzed using SPSS 15.0 and R 2.1.9. The unit of data collection was the firm, but the unit of analysis was the direct chain. Therefore, the data set was organized by chains, i.e. 90 chains embracing each a triplet of direct chain partners. The innovation capacity in the chains was analyzed through hierarchical and k-medoid cluster analysis on standardized and aggregated scores of innovation efforts, activities and results of each chain partner and the variables on vertical networking between the chain partners. For more details on this analysis we refer to Gellynck et al. [60]. For the description of the clusters the median and the interquartile range (IQR) are used due to the rather ordinal character of our data. The IQR is the difference between the 75^{th} and 25^{th} percentile and hence, includes the middle 50% of all values [61]. It is a robust statistic, because it is not influenced by outliers and has a breakdown point of 25%. The smaller the IQR values the closer the values of the sample are to the median. Dissimilarities between the resulting clusters were explored using the nonparametric Kruskal-Wallis test and Mann-Whitney-U test, as well as with cross-tabulation of Chi^2-statistics. Chi-square tests the hypothesis that there is heterogeneity across the clusters for each of the variables. If the chi-square values are small (<0.100) significant differences between the clusters are considered. The smaller the chi-square values the more significant the heterogeneity is confirmed. The Kruskal-Wallis test is a non-parametric equivalent of the One-Way ANOVA, examining the hypothesis that there is heterogeneity across the clusters for k independent samples. If the Kruskal-Wallis (K-W) values are small (< 0.100) significant differences between the clusters are considered. The smaller the K-W values the more significant the heterogeneity is confirmed. The Mann-Whitney-U test is a non-parametric equivalent of the Duncan post hoc test and is used to explore the statistical significant difference between two independent samples indicating specific significant differences within the sample, i.e. the clusters in our case.

The variables for horizontal networking with peers and networking with third parties were described by means and standard deviation due to the binary character of the variables, ranging from 0 to 1 in a closed interval. Additionally, the frequency of respondents indicating yes (1) for networking for innovation are presented. Dissimilarities between the clusters were analyzed with Kruskal-Wallis and Mann-Whitney-U test.

Finally, binary regression was used to identify significant differences between the clusters of chains modeling the influencing role of horizontal networking and networking with third parties by each chain partner on the innovation capacity of the direct agrifood chains. For the binary regression analysis dummy variables were created for each cluster, setting the value 1 if the chain belongs to the particular cluster and 0 if not. Significant differences were explored by the Wald-statistic test, which is commonly used to test the significance of individual logistic regression coefficients for each independent variable in order to test the null hypothesis in logistic regression that a particular logit coefficient is zero. The Wald statistic is the squared ratio of the unstandardized logistic coefficient to its standard error [62]. If the Wald statistic is significant (i.e. <0.05) then the parameter is useful to the model. [63].

IV. RESULTS & DISCUSSION

In this section first the results of the cluster analysis are presented, showing that our sample consists of three distinct groups of chains with different levels of innovation capacity. Subsequently, descriptives are provided for networking with peers and third parties. Finally, the influence of these networking activities on the innovation capacity in traditional agrifood chains is assessed.

A. Innovation capacity

Three clusters were identified compiling chains with different levels of innovation capacity. Descriptives and significant differences between the cluster centers are described in Table 3. In the first cluster chains with overall low scores on the innovation capacity indicators are compiled and hence, this cluster is called “Chains with low innovation capacity” (LICCs). In the second cluster the scores for the innovativeness of the chains are similar but slightly lower as the scores in the third cluster. In contrast, but equally to the first cluster, there is hardly any collaboration for innovation among the chain partners. Therefore the second cluster is named “Chains with medium innovation capacity” (MICCs). Finally, the third cluster includes the chains with the highest scores on all indicators for innovation capacity, including collaboration for innovation capacity among all chain partners. Consequently, this cluster is identified as “Chains with high innovation capacity” (HICCs).

Further, significant structural and sectoral differences between the clusters are explored (Table 4). The LICCs are to almost fifty percent composed of Italian cheese chains and to about a third of Belgian cheese chains. Hungarian bakery products account for about one fifth of all LICCs. On the contrary, the MICCs are more equally composed several traditional agrifood chains. The majority (one third) is hold by the Belgian beer chains, which are only found in this cluster. They are closely followed by Hungarian sausage and bakery products and Italian ham chains. Italian and Belgian cheese chains are found least in this cluster. Finally, the HICCs consist to forty percent of Italian ham chains and the twenty percent each of Italian and Belgian cheese chains. The Hungarian products account for the remaining twenty percent in this cluster. The low innovation capacity of the cheese chains is contradictory to the high innovation capacity of the dairy sector in total [23]. However, cheese can be considered as a mature product and innovations occur rather seldom in this product category. Our results suggest that in most of the traditional cheese segment no innovations are taking place. The comparably high rate of cheese chains with low innovation capacity in Italy could also be related to the high amount of PDO-labeled cheese products in Italy [64]. PDO products have precise product specifications [37] which imply that there is little space for alterations through product or process innovation. Other factors influencing the innovation capacity of chains could be related to different education and innovation support policies in the different countries, as suggested by several authors [16, 65, 66].

Regarding the number of employees, significant differences between the clusters are revealed. While the LICCs are mainly composed of micro-sized chain partners (< 10 employees), the size of the chain partners is gradually increasing in the other two clusters. Remarkably, the MICCs include a majority micro- and small-sized (11-50 employees) food manufacturers, medium-sized (50-250 employees) and larger suppliers (> 250 employees) but micro-sized customers. On the contrary, HICCs are composed of medium-sized to large customers, small-sized suppliers and both micro- and medium-sized food manufacturers, with a minority of small-sized food manufacturers. These findings indicate that micro-sized firms face the largest problems related to innovation capacity. This reciprocal relationship between firm size of the food manufacturer and innovativeness was also found by Avermaete et al. [27] and Coppola and Pascucci [67]. However, our results also indicate that a smaller size is not necessarily connected with low innovation capacity. In case larger chain partners (i.e. larger customers and/or suppliers) are involved the micro-sized food manufacturers seem to be able to overcome their limitations related to their size. However, only collaboration for innovation among the chain partners is leading to high levels of innovation capacity. We can support the results by Gellynck and Kühne [46] that chain partners of similar size seem to be more collaborating with each other than firms of dissimilar size (indicated by the lower IQR values in the third cluster for food manufacturer-supplier collaboration for innovation, and vice versa – the smaller the IQR values the more chains in this cluster indicated collaboration for innovation with their respective chain partner) and that larger customers seem to have an influence on higher innovation capacity levels, maybe through forcing innovations upstream in the chain [68].

Table 3: Innovation capacity of traditional agrifood chains[#] n=90

Innovation capacity	Cluster: 1) Chains with low innovation capacity		2) Chains with medium innovation capacity		3) Chains with high innovation capacity		Total		K-W Sig.[$]
	Median (IQR)	Cluster medoid	Median (IQR)	Cluster medoid	Median (IQR)	Cluster medoid	Median (IQR)	Cluster medoid	
Human innovation efforts[1]									
Food manufacturer	1.00 (2.00)	0.00[a]	3.00 (2.00)	0.33[b]	4.00 (1.25)	0.50[c]	3.00 (3.00)	0.33	0.002
Supplier	1.00 (2.00)	0.00[a]	3.00 (1.00)	0.33[b]	4.75 (2.00)	0.63[c]	3.00 (2.50)	0.33	0.000
Customer	1.00 (2.50)	0.00[a]	2.00 (2.00)	0.17[a]	3.00 (1.25)	0.33[a]	2.00 (2.50)	0.17	0.069
Financial innovation efforts[2]									
Food manufacturer	1.00 (0.50)	0.00[a]	2.00 (1.00)	0.33[b]	2.00 (1.00)	0.33[b]	2.00 (1.00)	0.33	0.000
Supplier	1.00 (0.50)	0.00[a]	2.00 (0.25)	0.33[b]	1.50 (2.00)	0.17[b]	2.00 (1.00)	0.33	0.000
Customer	1.00 (0.50)	0.00[a]	1.00 (1.00)	0.00[a]	2.50 (1.13)	0.50[b]	1.00 (1.00)	0.00	0.000
Innovation activities[3]									
Food manufacturer	0.33 (0.11)	0.33[a]	0.56 (0.33)	0.56[b]	0.72 (0.22)	0.72[c]	0.44 (0.33)	0.44	0.001
Supplier	0.22 (0.25)	0.22[a]	0.44 (0.22)	0.44[b]	0.44 (0.36)	0.44[b]	0.44 (0.28)	0.44	0.000
Customer	0.33 (0.44)	0.33[a]	0.44 (0.44)	0.44[a]	0.50 (0.44)	0.76[b]	0.44 (0.44)	0.44	0.002
Innovation results[4]									
Food manufacturer	5.00 (2.00)	0.67[a]	5.50 (1.00)	0.75[a]	6.00 (0.63)	0.83[a]	5.50 (1.00)	0.75	0.094
Supplier	5.00 (1.50)	0.67[a]	5.50 (1.25)	0.75[b]	5.00 (1.00)	0.67[b]	5.00 (1.00)	0.67	0.000
Customer	5.00 (1.50)	0.67[a]	5.50 (1.75)	0.75[a]	5.00 (0.13)	0.67[a]	5.00 (2.00)	0.67	0.215
Collaboration for innovation[5]									
FM-S*	0.00 (0.25)	0.00[a]	0.00 (0.00)	0.00[a]	1.00 (0.25)	1.00[b]	0.00 (1.00)	0.00	0.000
FM-C*	0.00 (0.00)	0.00[a]	0.00 (0.00)	0.00[a]	1.00 (1.00)	1.00[b]	0.00 (0.00)	0.00	0.001
S-FM*	0.00 (0.00)	0.00[a]	0.00 (1.00)	0.00[a]	1.00 (0.00)	1.00[b]	0.00 (1.00)	0.00	0.000
C-FM*	0.00 (0.00)	0.00[a]	0.00 (1.00)	0.00[a]	1.00 (1.00)	1.00[b]	0.00 (1.00)	0.00	0.002
Number of chains	n=31		n=49		n=10		n=90		

FM: Food manufacturers, S: Suppliers, C: Customers.
IQR: Interquartile range is the difference between the 75th and 25th percentile and hence, includes the middle 50% of all values
[#] The median and IQR are presented for the original values, while cluster medoids are reported for the standardized variables for each cluster column.
[a,b] Various superscripts indicate significant differences of cluster means (per row) in the Mann-Whitney U test ($p < 0.05$)
[$] Reports estimated significances of the Kruskal-Wallis test
[1] Measured on a 7-point frequency scale, with 1 (never making human innovation efforts) to 7 (Making human innovation efforts several times a week)
[2] Measured on a 4-point scale, with 1 (never spending financial resources for innovation efforts) to 4 (having a distinct budget on year-base for innovation efforts)
[3] Measured on a Yes-No-Non applicable scale for introduction of innovation activities, presenting the relative score of applicable innovation activities on a range from 0 (no innovation activities are applied) to 1 (all applicable innovation activities are applied).
[4] Measured on a 7-point Likert scale indicating the extent of agreement that the applied innovation activities (see [3]) contributed to success of the company, with 1 (strongly disagree) to 7 (strongly agree)
[5] Measured on a binary scale with 0 (no collaboration for innovation) and 1 (collaboration for innovation)
*Indicates the collaboration for innovation between two chain partners, whereby the first mentioned is answering whether he/she collaborates with the second mentioned, e.g. 'FM-S' refers to the answers of the food manufacturer towards his/her supplier

Table 4: Structural and sectoral description of the different clusters, Frequencies based on Crosstab, Chi2 and ANOVA, n=90

Cluster	1) LICCs	2) MICCs	3) HICCs	Total		Sig.
Structural & sectoral variables	%	%	%	%	N	Chi^2
Country & Type of product[1]						0.000
Italian cheese	43.3	2.2	20.0	18.8	16	
Italian ham	10.0	15.6	40.0	16.5	14	
Hungarian bakery products	16.7	17.8	10.0	16.5	14	
Hungarian sausage	3.3	20.0	10.0	13.0	11	
Belgian cheese	26.7	11.1	20.0	17.6	15	
Belgian beer	0	33.3	0	17.6	15	
Total	100	100	100	100	85	
Nr of employees – FM[2]						0.070
< 10 employees	64.5	34.7	40.0	45.6	41	
11 - 50 employees	22.6	38.8	20.0	31.1	28	
50 - 250 employees	12.9	26.5	40.0	23.3	21	
Total	100	100	100	100	90	
Nr of employees - Supplier						0.004
< 10 employees	54.8	26.5	10.0	34.4	31	
11 - 50 employees	35.5	30.6	60.0	35.6	32	
50 – 250 and more employees	9.7	42.9	30.0	30.0	27	
Total	100	100	100	100	90	
Nr of employees - Customer						0.074
< 10 employees	56.7	42.9	11.1	44.3	39	
11 - 50 employees	30.0	32.6	33.3	31.8	28	
50 – 250 and more employees	13.3	24.5	55.6	23.9	21	
Total	100	100	100	100	88	

[1] Without the Hungarian vegetable sector (white pepper, n=5)
[2] FM: Food manufacturer

B. *Networking for innovation with peers*

In total, the partners of traditional agrifood chains are not much networking with their peers. Thereby, about one-third of the food manufacturers and suppliers and only about one-fifth of the customers network for innovation with their respective peers (see Table 5).

However, there are significant differences found among the networking activities of the supplier and customer in the three clusters. The food manufacturers are similarly active in networking with their peers in all three clusters. Thus, while the suppliers of the LICCs are least networking with their peers (< 10%), in the MICCs and HICCs almost half of the suppliers are actively in networking for innovation with their peers. On the contrary, the customers of the LICCs and HICCs are very little networking with their peers (around 10%) and also in the MICCs only about one-third of the customers do network for innovation with their peers. On the one hand, this might be due to the majority of micro-sized customers in the first two clusters, which might face larger barriers to participate in networks, such as lack of time and lack of human resources [1]. On the other hand, there is strong competition and an ongoing concentration process in the retail sector, which might prevent customers from networking with their peers.

When comparing clusters generally, in the LICCs only the food manufacturer is found to be somewhat active in networking with his/her peers. In the MICCs, all chain partners are about at the same level of networking, with the supplier standing out. And in the HICCs both the food manufacturer and the supplier are intensively networking with their respective peers, but the customer is on a very low level.

Our expectations, that networking activities for innovation with peers would be highest in the HICCs, only holds true for the food manufacturer and the supplier, although these results are very similar to networking activities of these chain partners in the MICCs. However, as expected, networking activities for innovation with peers are lowest in the LICCs for all chain partners, where levels of innovation capacity are lowest. Thus, if food manufacturers and suppliers are networking with their respective peers it might have a positive effect on increasing their innovation capacity and hence of the whole chain

Next, it is also interesting to investigate whether there is a difference in the intensity of networking in the chain, i.e. the number of chain partners that are networking with their respective peers. In general, the intensity of networking with peers is not very high, with mainly no or only one chain partner networking with his/her respective peer. However, in Table 5 significant differences in cluster means are presented. The lowest horizontal network intensity is found in the

LICCs, while surprisingly the highest intensity is found in the MICCs. Thereby, only in the MICCs there are chains where all three chain partners network with their respective peers (about 13%). This is clearly linked to the higher networking activity of the customers in this cluster in comparison to the customers in the HICCs, which is also explaining why the intensity of networking is lower in the HICCs than in the MICCs. Nevertheless, while in fifty percent of the HICCs there is networking of two chain partners with their peers, in less than forty percent of the MICCs two or three chain partners network with their peers. Thus, even if one chain partner is less networking with his/her peers, high levels of innovation capacity can still be reached, if the other two chain partners are both actively networking for innovation with their peers and when there is collaboration for innovation among the chain partners as well.

Table 5: Network connections for innovation with Peers, n=90

Clusters	1) LICCs		2) MICCs		3) HICCs		Total		Sig.
	%[1]	Mean (Std)	%[1]	Mean (Std)	%[1]	Mean (Std)	%[1]	Mean (Std)	KW-test[2]
Chain partner's activities									
Food manufacturer	30.0	0.30[a] (0.47)	34.7	0.35[a] (0.48)	55.6	0.56[a] (0.53)	35.2	0.35 (0.48)	0.373
Supplier	7.1	0.07[a] (0.26)	45.8	0.46[b] (0.50)	50.0	0.50[b] (0.53)	33.7	0.34 (0.48)	0.001
Customer	10.0	0.10[a] (0.30)	33.3	0.33[b] (0.48)	11.1	0.11[a/b] (0.33)	23.0	0.23 (0.42)	0.041
Intensity of networking[3]		0.54[a] (0.81)		1.15[b] (1.03)		1.13[a,b] (0.99)		0.95 (0.99)	0.034
(0) No networking	65.4		33.3		37.5		43.9		
(1) At least 1 chain partner	15.4		31.3		12.5		24.4		
(2)At least 2 chain partner	19.2		22.9		50.0		24.4		
(3) All 3 chain partners	0		12.9		0		7.3		
Number of chains		**31**		**49**		**10**		**90**	

[1] Cell value presents the part of respondents who indicated 'yes' for networking for innovation (measured on a binary scale with no (0) and yes (1))
[2] Reports estimated significances of the Kruskal-Wallis test (KW-test), assessing the hypothesis that there is heterogeneity across the clusters for each of the innovation capacity categories and chain partners. If the K-W values are small (< 0.100) significant differences between the clusters are considered. The smaller the K-W values the more significant the heterogeneity is confirmed.
[3] Intensity of networking on a scale from 0 (no networking) to 3 (all 3 chain partners are networking), Mean (Std) are presented for the whole chain.
[a,b] Various superscripts indicate significant differences of cluster means per chain partner and network intensity category in the Mann-Whitney U test ($p < 0.05$)

C. Networking with 3rd parties

In contrast to networking with peers, the different chain partners are more active in networking with third parties, though again the food manufacturers and the suppliers are more active than the customers (see Table 6). However, this time there are significant differences for the former two between the different clusters. Overall, customers network very little with their third parties (< 20%), while the food manufacturers and suppliers are increasingly networking with higher levels of innovation capacity. Since supplier's collaboration can have a positive effect on the customer's performance [14], the customers in traditional agrifood chain may not be in need for information from other networks.

Almost all food manufacturers (90%) and the majority of suppliers (70%) of the HICCs are networking with third parties, in contrast to the customers (~ 10%). Meanwhile in the MICCs, the suppliers are equally active in networking with third parties as in the HICCs, while the food manufacturers' networking activities are comparable to the levels of the LICCs. Nevertheless, the lowest network activities with third parties are found in the LICCs. Thus, our expectation of more networking activities with third parties in the clusters with higher innovation capacity was fulfilled. Also the intensity of networking with third parties is significant different between the different clusters. In contrast to the networking intensity with peers, the intensity for networking with third parties is linearly correlated with increasing innovation capacity in the chains. Except for the LICCs, the MICCs and HICCs contain at least few chains (about 10%) where all three chain partners are networking with their third parties. Furthermore, networking with third parties is conducted in majority by at least two chain partners. In particular, among the HICCs no chains are found where no networking is taking place.

In the next section, we will explore whether there is causality between increasing innovation capacity and networking intensity in the chain.

D. Influence of networking with peers and 3rd parties on innovation capacity

Binary regression reveals that networking with peers has a greater significant influence on the innovation capacity in traditional agrifood chains than networking with third parties (Table 7). This confirms earlier work by Gellynck et al. [18] who found that participation in a variety of networks is an important factor for explaining differences in innovation capacity in the agrifood sector.

In particular the network connections of the supplier and customer are important for achieving innovation capacity. Low networking activities of these two chain partners are significantly related to lower innovation capacity of the whole direct agrifood chain (see results for LICCs). In contrast, the networking activities of the food manufacturer are reversely connected with higher levels of innovation capacity. If food manufacturers network with their peers they have a greater chance to be a member of the LICCs. Additionally, only supplier's networking with third parties is significantly negative related to lower innovation capacity, i.e. the chance is higher to be a member of the LICCs. Thus, networking of only one chain partner, while the other two are rather not networking with peers and/or third parties explains lower innovation capacity levels in the traditional agrifood chain.

On the opposite, horizontally networking suppliers and customers are significantly, positively related to chains with medium innovation capacity. Likewise, suppliers which network with their third parties are included in this cluster. However, in the MICCs, food manufacturers are significantly neither networking with their peers nor with their third parties. These results suggest that low levels of vertical networking for innovation can be compensated by higher levels of horizontal networking and networking with third parties.

Table 6: Network connections for innovation with 3rd parties, n=90

Clusters	**1) LICCs**		**2) MICCs**		**3) HICCs**		**Total**		**Sig.**
	%[1]	Mean (Std)	%[1]	Mean (Std)	%[1]	Mean (Std)	%[1]	Mean (Std)	KW-test[2]
Chain partner's activities									
Food manufacturer	40.0	0.40^a (0.50)	44.9	0.45^a (0.50)	90.0	0.90^b (0.32)	48.3	0.48 (0.50)	0.019
Supplier	31.0	0.31^a (0.47)	67.3	0.67^b (0.47)	70.0	0.70^b (0.48)	55.7	0.56 (0.50)	0.005
Customer	13.3	0.13^a (0.35)	16.7	0.17^a (0.38)	11.1	0.11^a (0.33)	14.9	0.15 (0.35)	0.872
Intensity of networking[3]		0.85^a (0.86)		$1.29^{a,b}$ (1.01)		1.67^b (0.71)		1.19 (0.96)	0.053
(0) No networking	44.4		27.1		0		29.8		
(1) At least 1 chain partner	25.9		29.2		44.4		29.8		
(2)At least 2 chain partner	29.6		31.3		44.4		32.1		
(3) All 3 chain partners	0		12.5		11.1		8.3		
Number of chains	**31**		**49**		**10**		**90**		

[1] Cell value presents the part of respondents in the particular cluster who indicated 'yes' for networking for innovation (measured on a binary scale with no (0) and yes (1))

[2] Reports estimated significances of the Kruskal-Wallis test (KW-test), assessing the hypothesis that there is heterogeneity across the clusters for each of the innovation capacity categories and chain partners. If the K-W values are small (< 0.100) significant differences between the clusters are considered. The smaller the K-W values the more significant the heterogeneity is confirmed.

[3] Intensity of networking on a scale from 0 (no networking) to 3 (all 3 chain partners are networking), Mean (Std) are presented for the whole chain.

[a,b] Various superscripts indicate significant differences of cluster means per chain partner and network intensity category in the Mann-Whitney U test ($p < 0.05$)

Table 7: Network connections and innovation capacity classification°

Cluster	1) LICCs		2) MICCs		3) HICCs	
	Parameter estimates	Wald-statistic[#]	Parameter estimates	Wald-statistic[#]	Parameter estimates	Wald-statistic[#]
Networking with Peers						
Food manufacturer	1.486	3.607*	-1.257	2.91*	-0.369	0.127
Supplier	-2.794	7.890***	1.829	5.468**	0.797	0.571
Customer	-1.821	4.227**	1.999	6.655***	-1.438	1.574
Networking with 3rd parties						
Food manufacturer	0.188	0.100	-1.253	4.060**	2.855	5.860**
Supplier	-1.228	4.318**	1.312	4.717**	-0.259	0.080
Customer	0.371	0.197	0.069	0.008	-0.0998	0.655
Nagelkerke R		0.373		0.340		0.262
-2 Log-likelihood		87.570		97.598		50.078
Chi^2 (2df)		2.071 (7df)		1.345 (7df)		5.136 (7df)
N		90		90		90

° By means of binary logistic regression
[#] Significance of Wald statistic: ***significant at 0.01, **significant at 0.05, * significant at 0.10.

Finally, the HICCs are only significant different from the other two clusters for the networking activity of the food manufacturer with his/her third parties. In this cluster the food manufacturers are significantly more networking with their third parties than in the other two clusters. However, in the HICCs the chain partners are intensively collaborating for innovation with each other. It might be that the networking capabilities and resources for each chain partner are limited and that the chain partners have to make a trade-off between vertical networking and networking outside the direct chain for innovation. Nevertheless, joint innovation activities outside the direct chain by at least one chain member remain an important external source for innovation in the chain.

In general, our results support the findings of other scholars, who found that firms learn from their collaboration experience and over time develop more capabilities to interact with various kind of actors [19]. Thus, the more experience a firm has in collaboration and networking the more network partners this firm will seek and maintain.

V. CONCLUSIONS

In this paper we tested the proposition that the more network connections the direct chain partners have outside the vertical network the greater is the expected impact of networking on the innovation capacity of the vertical network. We can, partly, confirm this proposition. In general, more networking for innovation has a positive effect on the innovation capacity in the traditional agrifood chain. However, it seems that either vertical or horizontal networking for innovation contributes to the innovation capacity levels. A lack of vertical networking in the chain can be compensated through horizontal networking for innovation by the individual chain partners. Nevertheless, the chain partners in the HICCs reported higher values for the constructs of the innovation process than the members of the MICCs. Accordingly, vertical networking for innovation seems to be somewhat more important than horizontal networking for innovation in traditional agrifood chains.

Other scholars found that the upstream chain partners (i.e. supplier and food manufacturer) are more motivated to search for new information and sharing this information with different partners of the chain network than the downstream chain partners [4, 20]. In our case, horizontal networking activities for innovation of the supplier and customer are more influential than the activities of the food manufacturer. However, the networking activities with peers for innovation by the supplier and food manufacturer are more important than those of the customer. However, the majority of the customers are not networking with their peers or with third parties. Thus, we can confirm the results by Matthyssens et al. [4] and Roy et al. [20]. Furthermore, the networking activities of the upstream partners can have a positive effect on the customer’s performance [14], thus the customers in traditional agrifood chain might be in less need for information and innovation input from other network partners.

Furthermore, the networking intensity for innovation with peers and third parties in the chains is increasing with higher levels of innovation capacity. This means that in chains with higher innovation capacity levels more chain partners are networking with their respective peers and/or third parties. However, the networking intensity with third parties is higher than with peers. Research on vertical networking for innovation in chains has pointed out that the networking intensity can be linked to different innovation types. For incremental innovation mostly only one chain partner is involved, while for radical innovation usually two or more chain partners need to collaborate with each other [69]. This would be an interesting point for further research in this field.

In conclusion, networking with peers and third parties is clearly linked with higher innovation capacity of traditional agrifood chains confirming previous studies by Avermaete and Viaene [5] and Gellynck et al. [18]. Thereby, it is important that the chain partners network with each other for innovation or with their third parties and peers. This is in line with previous research findings confirming that networking in general is a very important tool for the access to information and ideas for innovation[1, 26-29]. We extend these results showing that it is not only the access to external sources for innovation of the SME food manufacturer which is important, but also that the direct chain partners are highly active in networking and accessing external sources for innovation. Thus, we further contribute to and support previous research in the New Economy, where the network of a firm is found to being more important for the development and implementation of innovation than the single firm alone [1-6].

However, generalization of our results should be done with care. First, our sample cannot be considered as representative for the European market or the national markets of the countries investigated. Nevertheless, our study provides a first insight in the development of innovation capacity in direct agrifood chains with identified and inter-linked triplets of chain partners. Second, measuring the perception of the firm's managers rather than organizational behavior can also reduce the reliability and validity of the data. … we have chosen this approach due to the specificities and limitations of SMEs in the agrifood sector of providing sufficient data for actual organizational behavior [18, 47].

From our research three topics for further research can be identified. First, following the research by Pannekoek et al. [69] and Pittaway et al. [1] the link between networking for innovation and the type of innovation should be explored. Second, it should be investigated whether networking is also taking place between chain partners and the peers and third parties of the other chain partners. And third, it would be interesting to explore a broader network setting, e.g. whether chain partners are jointly involved in the same networks.

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