Antecedents of Learning in Networks: An Examination of Low-Technology Firms in an Emerging Market Economy

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ABSTRACT

This paper investigates how low-technology emerging market firms learn in networks during transition to market economy. It argues that while involvement in a variety of network types might enhance firms' external learning, the ways they learn from their external environment might differ according to network types and characteristics of the inter-organizational relationship, with subsequent effects on their performance. We develop an analytical framework drawing on the extant literature on the taxonomy of learning, types of networks, partner characteristics, and initiator, continuity, formality of the relationships. We investigate 467 dyadic inter-organizational relationship processes that took place during 1989-2001period in Polish food-processing and clothing industries. Our results show that low-tech firms learn through different modes that are associated with different types of networks and different characteristics of inter-organizational relationships. Our findings provide detailed elaborations for managers on what factors to focus on when entering into a network in seek of external knowledge.

Track 14. Inter-Organizational Collaboration: Partnerships, Alliances, Networks

INTRODUCTION

Networks serve as a gateway to relatively easier access to external knowledge and learning that would not be available otherwise (Ruigrok and van Tulder, 1995; Zysman, Doherty and Schwartz, 1997; Schmitz, 2004; Peng, Pike, Yang and Roos, 2012; Peng, Yen and Bourne, 2018). Despite the significance attached to learning in networks, neither the underpinnings nor the dynamics of inter-organizational relationships were investigated from the lens of simultaneity of the diverse learning mechanisms taking place in these relations that originally stem from different types of networks.

Such investigation is scant for firms operating in the low-technology sectors. Despite the shift of attention to high-tech industries, statistics substantiate that these industries are still the main engine of industrialisation in most of the developing and emerging market economies. In addition, the shrinkage of low-technology industries in Western Europe and the relocation of firms to emerging and developing economies (Heidenreich 2009) has not only altered the dynamics of these industries through the development of international production networks but also influences the pace of change in emerging markets in general. When low-technology industries are still significant for some economies, such as Poland, which has been recognised as a developed nation since 2017, it becomes crucial to enhance our understanding of the evolution of these sectors and the backdrop for their ongoing importance.

To this aim, this paper specifically asks the research questions 'What network-related factors influence low-technology firms' learning from inter-organizational relationships?' We explore the characteristics of networks of Polish food-processing and clothing firms over a twelve-year period (1989-2001), during the country's transformation to market economy. We analyse how Polish firms learned from their domestic and international partners, in particular what characteristics of inter-organizational relationships played major role in their learning. Examining historical data sheds light into the role of networking for low-technology firms' learning and allows us to explain the continuing importance of these industries in Poland's current economic success.

Paper is structured as follows. Section two describes the theoretical foundations of our analytical framework, which is explained in Section three. Section four the literature on low-tech industry. Section five explains the methods of data collection and analysis technique. Section six presents the results. Section seven provides a discussion of findings and concludes.

THEORETICAL BACKGROUND

External Learning Mechanisms

External learning is an important part of firms' corporate strategy if they are to make successful transition, especially when the boundaries of their industries are shifting and their countries are going through transformation. Yet, being part of networks does not necessarily bring about automatic knowledge transfer or learning; nor is such transfer an easy process due to the difficulty of transmitting tacit knowledge (Polanyi, 1967). Hence, our understanding of the

mechanisms firms employ to learn from their interactions with external partners and how their choice is shaped by characteristics of networks are still unclear.

To examine how firms learn externally, this paper draws on the learning taxonomy developed by Malerba (1992), who argues that firms learn in a variety of different ways. Each learning taxonomy is linked to a different source of knowledge and takes place in different units of the firm, i.e. not only in the R&D unit but also in production, design, engineering, organization and marketing. He distinguishes learning external to the firm (i.e. from sources outside the firm) from learning internal to the firm (i.e. generated directly from the firm activities).[1]

Insert Table 1 about here

Von Tunzelmann and Wang (2007) elucidated the sources of knowledge for external learning in relation to production, consumption and search for supply (Table 1). They linked each learning mechanism with the most dominant type of agents expected to play a role in this type of learning. They argue that production activities generate learning externally through spillovers[2] from competitors and horizontally-related firms. Recent literature on knowledge spillovers does not overlook at the possibilities of spillovers from a variety of cooperation partners and in other business areas than in technology (Gunter, 2005; Audretsch, Lehmann and Warning, 2004). Consumption activities generate learning externally through learning by interacting with suppliers, customers, users, complementary firms and organizations in or related to the industry.

Associated with suppliers of technology and skills, formal search processes generate learning externally through education (universities, specialised consulting or intermediary firms for international technology transfer) and advances in Science & Technology (research institutes, laboratories). Building on their work allows us to encompass learning mechanisms that do not rest only on experience in production and trade relations (i.e. learning by doing and learning by exporting) but also on consumption and search as sources of knowledge arising from firms' interaction with other organizations.

Origins of Networks and Embeddedness of Ties

We consider three broad types of networks based on their origins – in knowledge, production and market domains (Bell and Albu, 1999) and their embeddedness of ties - ties with thick information exchange vs market-mediated or arm's length ties (Uzzi, 1996, 1997) (Table 2). Capturing the variation in the degree of embeddedness of relationships enhances our understanding of the role of trust, resource sharing, joint problem-solving, knowledge transfer in networks (Gulati, 1999; Brass, Galaskiewicz, Greve and Tsai, 2004).

[1] Learning mechanisms internal to the firm is out of scope of this paper.
[2] Spillovers are most often unintended knowledge/information externalities and public sources that can diffuse from its creators to other agents in the economy at less than the original cost (Griliches, 1992).

Arm's length ties occur among various trading parties within the market domain (Powell, 1990; Gelsing, 1992; Kim, 1999a; Coombs and Metcalfe, 2000).[3] The focal arm's length cooperation in this paper are composed of technology transfers such as foreign licensing, turnkey plants, technical consultancy, and import of machinery and equipment. They help to develop skills in design, engineering and project management, to generate change in technological capabilities, and to accumulate problem-solving capabilities for instance in the form of package technology transfer (Dosi, 1988; Kim, 1999b; Humphrey and Schmitz, 2004). They can also be efficient means of transferring codified knowledge as well as knowledge embodied in a product (Inkpen, 1998). Embedded ties located within knowledge and production domains distinguish between the processes of acquisition and accumulation of knowledge through production, trade and knowledge-centred processes (Bell and Albu, 1999).

In this paper, production networks involve both supply (production) and demand (distribution) side. Production networks occur with suppliers, producers, customers that cover a series of exchanges of information, resources, products and services over a period of time with specifications of the terms and responsibilities of each partner (Ernst, 1997, 2007; Gelsing, 1992; Gereffi, Humphrey and Sturgeon, 2005). Distribution networks with local firms are opportunities to enter new markets for foreign firms (Garette and Dussauge, 2000). They allow the foreign partner to have access to the specific market knowledge of local partners with less effort and time put into learning how to succeed in very different local environments, while the local partner learns about a new area of firm activities. Cooperative marketing activities also take place within production domain.

Knowledge networks aims at increasing the knowledge stock of the firm (Kim, 1998b; Dantas and Bell, 2009) through embedded ties. These interactions comprise not only marketed information (e.g., staff training programmes, market analyses, technical advice, and tangible goods) but also the informal exchange of ideas (e.g., among technicians regarding non-standard technical problems, or among purchasing personnel regarding suppliers of special components) (Gelsing, 1989; von Hippel, 1988; Coombs and Metcalfe, 2000; Owen-Smith and Powell, 2004; Ernst, 2008; Dantas and Bell, 2011).

We consider production and knowledge networks are not mutually exclusive and incompatible; in most cases, they are complementary in terms of the positive learning externalities created in production and knowledge domains (Michalet, 1991; von Tunzelmann, 2010). As firms manage to broaden their relationships within both domains, the interactions among individuals allow them to understand the capabilities and knowledge embedded in the external environment. They will want to tap into these external sources of knowledge and capabilities, share information and knowledge among partners and produce knowledge and innovation through interaction (e.g. 'networks of learning' in Powell, Koput and Smith-Doerr,

[3] For instance, in the context of international technology transfer, Kim (1999a, 1999b) distinguishes market-and nonmarket-mediated ties with foreign technology suppliers. He refers to technology transfers that involve written agreement and payment between the partners as market-mediated (i.e. arm's length cooperation in this research) and exemplifies them as foreign direct investment, foreign licensing, turnkey plants, technical consultancy, made-to-order machinery and import of machinery and equipment. However, technical assistance by foreign buyers and by foreign vendors exemplifies nonmarket-mediated technology transfers (i.e. knowledge networks in this research).

1996; Kogut, Shan and Walker, 1993; Doz, 1996; Mowery, Oxley and Silverman,1996; Inkpen, 2000; Hagedoorn and Duysters 2002), with positive effects on the cumulativeness of both individual and organizational absorptive capacity (Cohen and Levinthal, 1990; Zahra and George, 2002).

This paper argues that while involvement in a variety of network types might enhance firms' external learning, the ways they learn from their external environment might differ according to the network type and characteristics of the inter-organizational relationship, with subsequent effects on their strategy and performance. The knowledge transfer is expected to involve more codified and less tacit knowledge in market-mediated cooperation such as arm's length relations, and more tacit knowledge in production, distribution and knowledge networks (see Table 2).

Insert Table 2 about here

Partner Characteristics

Significant differences in partners' knowledge base in networks are expected to enhance the learning opportunity for the firms (Inkpen, 1998; Kim and Inkpen, 2005; Steensma, Tihanyi, Lyles and Dhanaraj, 2005). The international technology transfer and FDI-spillover literatures are premised on the idea that foreign partners should be able to bring in more up-to-date and state-of-the-art knowledge to the relationship than domestic partners (Lyles and Salk, 1996; Blomstrom and Kokko, 1998; Cassiman and Veugelers, 2002; Mu and Lee, 2005; Dantas, Giuliani and Marin, 2007; Gentile-Lüdecke and Giroud, 2009; Eapen 2012; Lee, Choo and Yoon, 2016). The upgrading literature emphasises 'global' value chains for the same reason (Gerefi 1999, Ernst, 1998, 2007; Ernst and Kim, 2002; Schmitz, 2004; Pietrobelli and Saliola, 2008). Identifying geographical origin of partner is expected to shed light on where the sources of knowledge and knowledge spillovers lie for firms to exploit.

Initiator, Continuity and Formality Aspects of Inter-organizational Relationships

Learning in networks is an outcome of the interaction between partners but not necessarily an automatic one. It depends largely on the way that the inter-organizational relationship is built and the experience (Gulati, 1998; Hakansson and Snehota, 1995; Gulati and Gargiulo, 1999), which depend on (i) who proactively selected the partner and initiated the relationship: the partner or the firm; (ii) how long the relationship continues with the same partner to allow development of routines and trust; and (iii) how interactions are arranged between individuals or groups of people during the relationship.

Extant literature emphasises that firms put considerable effort to find the compatible partner to cooperate with (Hagedoorn, 1993; Simonin, 1997; Dacin, Hitt and Levitas, 1997; Martinez, Zouaghi and Garcia, 2019), while stressing being active or passive as a learner in the relationship (Lane and Lubatkin, 1998). A firm may have a strong vested interest in initiating the

relationship for two reasons. First is actively seeking some specific knowledge from the right partner, i.e. knowledge that is difficult to access through other sources or in-house R&D and search efforts, and this refers to its learning intentions. Second is sharing its own knowledge with a partner whose complementary capabilities will add value to its own operations and this refers to its strategic goals, e.g. in the supply chain or in the process of developing 'linkage capability' (Lall, 1992).[4]

The extent of knowledge transfer and sharing also depends on the partner's willingness to share its knowledge (Inkpen, 1998; Tatikonda and Stock, 2003; Schmitz, 2006). Partners with a better knowledge stock may be protective and reluctant to share knowledge to prevent unintended knowledge transfer (Hamel, Doz and Prahalad, 1989; Inkpen, 1998). So, the firm's initiation of the relationship indicates developed linkage capabilities and an active learning intention by the firm, while the partner's initiation can be taken as an indication of its willingness to share its knowledge and allowing knowledge spillovers in the relationship.

Earlier studies also pointed out the importance of long-term and stable relationships for developing high level of interaction that brings about interpersonal communication in greater magnitude and frequency as well as with richer/denser and more complex knowledge (Hakansson and Johanson, 1988; Simonin, 1997; Tatikonda and Stock, 2003). These continuous relationships improve the elements of trust and knowledge about the partner in the relationship, with significant consequences with regard to reduction of uncertainty in the future behaviour of the partner (Gulati, 1995) and developing an experience of prior ties. Hence, they are expected to generate an impetus for further learning by allowing the firm to develop the capability to learn from the partner easily (Inkpen, 1998; Kim and Inkpen, 2005). They represent higher level of interaction during the relationship, which leads to development of interpersonal communication and thereby to the development of more informal relations among the partners and more knowledge spillovers. The relationships with universities, research institutes, consulting firms, etc. are mostly occasional relations or set at a regular interval. This is because they are used as complementary to the in-house competence of R&D or as a substitute for the lack of it. Some relationships are on an annual basis; for instance, with public research institutes for tests, accreditation, etc. or technical fairs, conferences, symposiums. There are also one-off relations; e.g., technology acquisition packages, unless firms are happy with the technology and the after-sale services of a particular technology supplier. These relationships may have significant impact on the ways the firms learn, as they may gradually turn into reverse engineering capability, as exemplified in the work of Kim (1998a) on Hyundai Motor. Hence, it is expected that learning opportunities do not decrease as the continuity of the relationship decreases.

There are two levels of formality in a relationship. Informal mechanisms between individuals and within groups of people with common professional interests and specialisation (Von Hippel, 1988; Grant, 1996; Dahl and Pedersen, 2004; Brass *et al.*, 2004*)* are the main carriers of knowledge between firms in product development, technical advice for problem-solving in production processes, etc. (Dosi, 1988; Grant, 1996; Mason, Beltramo and Paul, 2004; von Hippel, 1988; Ernst and Kim, 2002; Janowicz-Panjaitan and Noorderhaven, 2008).

[4] Intending to be an active learner does not rule out the possibility of barriers to tap into the knowledge sources of the partner or make use of the available knowledge by the partner (Grant 1996).

Communication of individuals at an informal level through telephone, email and fax help codification and articulation of tacit knowledge (Pak and Snell, 2003), and has significant impact on firms during technology acquisition projects and in export-oriented production (in GVCs/GPNs). Verbal forms of instructions and specifications are most often supplemented with written materials at an informal level. They are mostly treated as positive externalities, creating strong links between the networking and knowledge spillovers, e.g., through observation that may lead to reverse engineering (Ernst and Kim, 2002).Formal mechanisms are organised, or determined, by managers in the form of resource and personnel exchange, teamwork, secondment, teams and task forces, meetings and organised personal contact, arranged visits among the partners, organised training, technical consultancies, standard machinery transfer, etc. (Ernst and Kim, 2002; Pak and Snell, 2003). So, informal relationships are expected to be more influential on learning mechanisms than formal ones, with more spillover effects.

ANALYTICAL FRAMEWORK

Our framework seeks to investigate the extent *key characteristics* of inter-organizational relationships, such as network type in which these relations are embedded, partner origin, initiator, continuity and formality of these relations, that underlie initiation, stability, termination, and consequences of inter-organizational relationships for their effects on external learning mechanisms (Figure 1). A representative list of factors was chosen on the basis of the literature survey with the aim of capturing drivers and impediments to a variety of learning mechanisms in different types of networks.

Insert Figure 1 about here

LOW- TECHNOLOGY SECTORS

When compared to the abundance of studies on high-tech sectors, low-technology industries are by and large overlooked (Hirsch-Kreinsen *et al.* 2006, Hirsch-Kreinsen 2008, Freddi 2009). Despite a lack of academic work on low-technology industries in networks and innovation areas, they entice the attention of development economists in the upgrading and GVC/GPN literatures, though with a narrow range of manufacturing industries studied (Coe *et al.* 2008). Empirical studies on the clothing industry from the network viewpoint explain why and how re-location of manufacturing occurs from Western Europe to Central and Eastern Europe (Smith 2003, Yoruk 2004, Dunford 2004, Pickles and Smith 2011, Smith *et al.* 2008).

The OECD classification of industries based on their technology content identifies food-processing and clothing industries whose R&D intensity is less than 0.9% as low-technology sectors (Hatzichronoglou 1997, Mendonca 2009).[5] The consensus on their low-technology

[5] The OECD classification is based on conventional accounting of direct and indirect R&D of the industries (Hatzichronoglou 1997).

characteristics stems from their strong dependence on external technology acquisition from machinery and equipment suppliers, making them also categorised as supplier-dominated industries, to use Pavitt's (1984) term, rather than in-house R&D for innovation (Heidenreich 2009). These traditional industries have historical significance in economic development of today's advanced countries. A growing literature on low- and medium-technology industries emphasises the still ongoing importance of these industries not only in developing/emerging market countries' economic development but also in advanced countries' economies, like Netherlands, Denmark and Switzerland for food-processing, and Italy, Spain, and Portugal for clothing industry (von Tunzelmann 1995, Von Tunzelmann and Acha 2005, Hirsch-Kreinsen 2008, Freddi 2009).

Both of the industries have been going through a radical technological change over the past decades, which helped improving their productivity gap to some extent in the industry when compared to the EU. The large Polish clothing and food-processing firms, as this paper examines, have been highly responsive to the technological, organisational and managerial changes in their respective industries, and they become not only the front-runners of their industries but also attractive for West European producers to become a part of the global supply chains. In general, the competitive edge of the clothing industry now lies in the design of the garments; however, this is also in concert with the developments in the upstream textile industry. Large Polish clothing firms started to adapt to this changing environment as early as 2000s, and the positive outcome of this design capability is apparent in the annual turnover of the Polish firms from the manufacture of wearing apparel in 2018. With around 2.15 billion euros, Polish firms are second after Romanian clothing firms (2.3 billion euros) (Statista website). However, such turnover results cannot be justified only with OEM production within GVCs/GPNs.

Food-processing sector benefits from more scientific and technological opportunities acquired or spilled over from industries to which it is horizontally linked. Cooperation of food producers with other firms and industries, such as biotechnology, pharmaceuticals (e.g., to develop special vitamins that are not destroyed at high temperatures) and advanced materials (whose use in the packaging industry has generated product innovations, especially in the cases of frozen food-processing and ready-made products) encouraged horizontal spillovers of technological know-how (Galizzi and Venturini 1996, von Tunzelmann and Charpiot-Michaud 2000, von Tunzelmann and Yoruk 2004; Alfranca *et al.* 2004, Mendonca 2009).[6] As a result, the industry has been characterised more as a 'multi-tech' industry (Granstrand *et al.* 1997) than as a 'low-tech' one. Significant effects of being a multi-tech industry are most importantly observable in product innovations in the food-processing industry. Mendonca (2009) shows the industry's dynamism and rapid adaptability to the fast changing environments of new technological paradigms not by means of significant patenting performance but by means of utilising the patents created by horizontal industries and sciences, as argued by von Tunzelmann and Acha (2005). Examining these industries' learning from networks during the transition years becomes ever more important to understand their adaptation to changing business environment and hence

[6] For instance, the modification of milk to produce healthier butter is a matter of choice among various available techniques, including the physical, the chemical, the biotechnological, or the agricultural techniques (e.g., changing the feed of the cows). These techniques are integrated into the processing techniques in the food-processing industry, in cooking, pasteurization (UHT milk), in freezing, in production integration and in packaging.

their contribution to the successful economic development Poland with uninterrupted economic growth in the last 27 years, making her the 'economic champion' of Europe.

DATA, VARIABLES AND METHOD

We used mixed methods in this research which creates connections between difficult-to-measure but richer conceptualisations compared to quantitative or qualitative research method alone (Creswell and Clark, 2007; Greene, 2007; Teddlie and Tashakkori, 2009). 'Concurrent nested' design method allowed us to prioritise quantitative analysis of multinomial logistic regression as the primary method of analysis while qualitative research methods are embedded in the primary method by means of sample formation and data collection (Creswell, 2003).

This research was carried out in Poland, at a time when the country was a catch-up economy emerging from a period of systemic change (Varblane, Dyker, Tamm and von Tunzelmann, 2007). We studied large domestically-owned firms (>500 employees), primarily due to the characterisation of Polish industrial structure during the early years of transformation with few large domestic firms and traditional industries (OECD, 2007). Large firms are expected to benefit from opportunities to develop and learn in networks due to being endowed with relatively better means compared to SMEs (Cassiman and Veugelers, 2002). Existing work on emerging markets in Central Europe shows that incumbent big firms became major players in the economy and key nodes in GPNs/GVCs after the transformation (Pickles and Smith, 2011).

We chose to study the food-processing sector, rather medium-technology side of the food industry, over the low-tech side of it (i.e. live animals, raw fruits and vegetables, etc.). Similarly, we chose to study clothing industry, rather low-tech and labour-intensive sector over the textiles industry, which has a relatively higher technology level. In addition, the tobacco sector and leather and footwear sectors are eliminated from the very broadly defined food and clothing industries respectively, due to the need to limit the research to some reasonable sub-sectors. Still, the food-processing industry, on its own, provides a richness of sub-sectors giving an opportunity to present a vast number of types of networking relationships (Table 3). At the same time, being integrated into GPNs/GVCs from the beginning, the clothing industry represents these networks at different geographical levels (i.e. global, national and local).

The governance structure in the value chain of the food-processing industry has also been changing and evolving towards a shift from producer- to buyer-driven value chains, though it is slower than in the West. The extensive research on apparel chain in the last three decades has shown that the clothing industry in the emerging markets has remained part of buyer-driven GVCs. The Polish clothing industry has provided us with a pattern of upgrading through exporting similar to that of other emerging countries; hence our ability to compare with the previous studies.

Data and Sample

The sample was based on a database composed of 78 food-processing and 46 clothing Polish-owned firms registered with Polish Embassy in London.[7] The final sample included eight food-processing firms, representing 10% of the population and eight clothing firms, 17% of the population of large clothing firms. In both industries, large domestic brand manufacturers were studied. They were restricted to market niches in the socialist era and have largely stayed in these markets during the transition years. Some of the food-processing firms function as subcontractors to foreign customers at home, while some export their own products to Europe, US and other parts of the world. Clothing firms function as subcontractors to foreign customers abroad. None of them have exports of their own products. Although the data encompass only two industries, it is a pooled sample of data from two representatives of low and medium-technology (LMT) industries and hence is not expected to create bias in the interpretation of the results.

Unit of analysis is 'dyad' in each network with its own nature, depth, frequency, and varied learning mechanisms (Anderson, Hakansson and Johanson, 1994; Hite and Hesterly, 2001). A unique primary data was collected through face-to-face semi-structured interviews during two a-month visits to Poland in May and November 2001. During the interviews, a set series of questions is used as a structured guide. The content of the interview questions focused on detailing each relationship and learning that occurred through cooperation. Interviews identified relationships with: i) technology and raw material suppliers, ii) customers/buyers/end user firms, iii) downstream distributors/users/other actors, iv) competitor and complementary firms in the industry, v) universities, public or private research institutes/laboratories, vi) consultants, consulting firms, export/intermediary agencies, design agencies, human resource or advertising agencies, vii) Chamber of Commerce or industrial organizations/ associations, governmental institutions.

Thirty-one interviews with core firms and nineteen interviews with ten public and private organizations were conducted. The latter helped triangulate multiple sources of the same evidence and ensured data reliability. In a firm, as many as four top and middle managers who were knowledgeable of the current and past relationships of the firm were interviewed. Each interview took at least four hours, excluding the visit to the production site and conversations with operational managers. The latter served as multiple informants for double-checking, minimising the possibility of common method bias while increasing the reliability of results (Lyles, 1988).

Based on the content analysis of the interviews and subsequent coding through analytical iterations, a dataset of 467 dyads of 16 large Polish firms in the transition period (1989–2001) was constructed (Table 3).

Insert Table 3 about here

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[7] www.polishemb-trade.co.uk/Home_en/Main_en.htm (accessed in October-November 2000). There was no available online resource for the complete register of all firms in these industries in Poland at the time.

Measures

Dependent variable

External Learning Mechanisms (EXTLEARN) represents learning mechanisms employed during a specific inter-organizational relationship by the Polish firm. It is a categorical variable with four categories: learning from knowledge spillovers, learning from advances in S&T and education, learning by interacting, and no learning as the reference category (see Appendix Table A1). This variable was constructed by full understanding of routes knowledge was transferred during the dyadic interaction. We first aimed to establish whether any learning indeed took place during the relationship. Information was sought from the interviewees as to whether they learnt any new knowledge in the relationship as additional to their prior knowledge. If the interviewee was able to illustrate the new knowledge gained with specific examples[8] we recorded these into categories of learning. If no learning took place, we recorded this as the reference category. In either way, this information clarified and assured the conscious awareness within the firm of the impact provided by the new knowledge from the relationship (Nicolini and Meznar, 1995).

Independent variables

Network type (NETYPE) represents the domain the network is embedded. Three types of networks are derived from the literature, i.e. production and distribution networks, knowledge networks and arm's length relations as the reference category. Illustrations of these networks are presented in Appendix, Table A2.

Geographical origin of the partner (GEORIGIN) differentiates whether the partner is foreign or domestic as the reference category. It is used to shed light on the questions of where the sources of knowledge and knowledge spillovers are. Foreign partners involve organizations located abroad[9] such as firms, universities, research institutes as well as FDI and foreign strategic investors with less than 50% share in Polish firms, whereas domestic partners are indigenous organizations located in Poland.

Initiator of the cooperation (INITIATOR) determines whether the firm or the partner initiated the eelationship, the latter being the reference category. If it was the firm, its motivations for doing so and outcomes (intended and unintended) were asked. If it was the partner, its motivations for willingness to share its knowledge with the interviewed firm were elaborated.

Formality of the cooperation (FORMALITY) determines whether the contact was based on arrangement and/or agreement by the top-level managers (i.e. formal and manager-approved) or on contacts among individuals, particularly in the form of individual interaction to build and maintain personal relationship with other individuals such as scientists, engineers, middle-level

[8] Appendix Table A1 presents observations drawn from interviews for each learning mechanism employed during networks.
[9] Most of the foreign partners represent west European firms and organisations.

managers in the partner organization (i.e. informal and employee-driven). Formal cooperation serves as the reference category.

Continuity of the cooperation (CONTINUITY) is defined as the frequency of establishing relationship with the same partner as a source of knowledge. It involves continuous cooperation (i.e. uninterrupted since the relationship started), occasional cooperation (i.e. relationships occurring at irregular or infrequent intervals, e.g. when needed by the firm or the partner, or on an annual basis); and one-off cooperation (i.e. relationships occurring once and terminated) as the reference category.

Control variables

Industry type (INDUSTRY) is used to compare food-processing with clothing industry. We conduct dynamic analysis over three *Time periods (PERIOD)*, 1989-1993 (early 1990s), 1994-1997 (mid-1990s) and 1998-2001 (late 1990s), with the purpose of identifying any emerging patterns in the use of learning mechanisms in networks at a time when there is structural and economic changes in Poland's business landscape.

Our sample inherently contains the firm characteristics by distinguishing large firms from SMEs (size) and from other large firms without reputable brandname (age) (i.e. lower market share and production capability). Additionally, two industries chosen inherently compare export capability of the firms, however, R&D expenditures were not applicable to these industries at the time.

Model Specification

We implement multinomial logistic regression (MLR) (Hosmer and Lemeshow, 2000; Borooah, 2002) which allows use of categorical data set in predicted probabilities in estimate (odd-ratios) interpretation. MLR is particularly suitable for our independent variable, which is a choice indicator with unordered categories (Agresti, 1990).

We specify the model as:

Log (Prob(EXTLEARN=j) / Prob (EXTLEARN=No learning)) = $\alpha_{j0} + \beta_{jk}$ Variables for network type and characteristics of interorganizational relationship + θ_{j1}INDUSTRY+ θ_{j2}PERIOD

In model building and robustness checks, the strategies and tests suggested by Hosmer and Lemeshow (2000) were strictly followed. We compared the model with network type (NETYPE) with the model without. We did not observe any change in the direction of the coefficients, instead noticed a statistically significant improvement with the addition of this variable, χ^2 (6, 467) = 114.37, $p < .001$, indicating that NETYPE reliably predicts learning mechanisms employed during interfirm cooperation. Furthermore, three nested models were specified and progressively refined to check the predictive ability of additional factors and to evaluate the improvement in the subsequent model.

Descriptive Statistics

Descriptive statistics are presented as chi-square tests of independence due to the nature of categorical variables (Table 4). We eliminate the possibility of high multicollinearity by controlling for standard errors of the variables that are greater than 2 after the models are run (Tabachnick and Fidell, 2007; Petrucci, 2009). There was no reason for concern. Table 4 suggests that food-processing and clothing firms are initiators of their inter-organizational relations. The relations they were involved in are predominantly formal and slightly more than half of them are continuous. Clothing firms have networks mostly with foreign partners. Food-processing firms established networks with both foreign and domestic partners. Food-processing firms' inter-organizational relations by learning mechanisms is similar to that of total dyads, with significance attributed to learning from advances in S&T and education (34.4%) more than learning from knowledge spillovers (28.2%) and learning by interacting (23.6%). Majority of learning in clothing firms' inter-organizational relations, on the other hand, occurs by interacting in 40.8% of the dyads and by knowledge spillovers in 25.7%.

Insert Table 4 about here

RESULTS

Table 5 reports the empirical results from MLR estimations. It starts with the baseline model and sequentially adds each factor affecting the inter-organizational relation: Model 1 has the variable NETYPE as the only independent variable, Model 2 has GEORIGIN added to NETYPE, Model 3 is the full model with the addition of the variables, INITIATOR, CONTINUITY, FORMALITY. Comparison of the log-likelihood ratios of each model with the preceding model showed statistically significant improvement, indicating that the added indicators in each model reliably predict EXTLEARN.

Results from the first three main effect models showed that additional factors affecting inter-organizational relations did not qualitatively affect the estimates of the coefficients in the previous model. *Ceteris paribus,* throughout Models 1 to 3, knowledge networks are consistently more likely to lead to learning from knowledge spillovers and learning from advances in S&T and education than arm's length relations. Model 2 highlights the positive and significant impact of networks with foreign partners on learning by interacting and learning from advances in S&T (three times and twice more likely respectively).

The models control for differences between food-processing and clothing industries. Model 3 implies association between food-processing firms and learning from advances in S&T and education (at 10% level of significance). However, PERIOD appears to be statistically not

significant in either of models, suggesting that Polish firms used the three learning mechanisms in their networks over the transition years without distinguishing one over the other.

Learning from knowledge spillovers

Estimation results show that knowledge networks, the partner, the initiator, continuity and formality of the relationship are statistically significant factors that change the odds of learning from knowledge spillovers during inter-organizational relations. Firms tend to learn from knowledge spillovers through knowledge networks three times more than in an arm's length relations, twice more from foreign than domestic partners, twice more when the relationship is initiated by the partner than the firm, almost three times more in continuous relations and seven and a half times more through informal relations. We observe no difference between food-processing and clothing firms. Characteristics that increase the likelihood of learning from knowledge spillovers in networks can be identified as:

- Being involved in knowledge networks
- Continuous and informal relations that are initiated by the partner, and
- This partner being foreign partner.

Learning from advances in S&T and education

Results show that industry type, network type, the partner, the initiator and continuity of the relationship are statistically significant factors that change the odds of learning from advances in S&T and education in inter-organizational relationships. Learning from advances in S&T and education is eight times more likely to occur in knowledge networks and five times in arm's length relations. It is four times more likely to happen when the firm initiates the relation and twice more likely with a foreign partner than a Polish partner, which tends to terminate after occurring once rather than sustained for some time. Food-processing firms are twice more likely to exploit learning from advances in S&T and education than clothing firms. Characteristics that increase the likelihood of learning from advances in S&T and education in networks can be identified as:

- Having knowledge networks and production and distribution networks
- Having one-off relations with a foreign partner that are initiated by the firm, and
- Being a food-processing firm.

Insert Table 5 about here

Learning by interacting

Findings show that network type, the partner and continuity of cooperation are statistically significant factors that change the odds of learning by interacting in networks. Firms are eight times more likely to learn by interacting in production and distribution networks, three times

more likely with their foreign partners and twice more likely in continuous relations. Characteristics that increase the likelihood of learning by interacting in networks can be identified as:

- Having production and distribution networks with a foreign partner, and
- Having this cooperation continuously.

DISCUSSION AND CONCLUSION

This paper investigated how firms learn in networks. We distinguished between three different learning mechanisms and identified the inter-organizational relationship characteristics, such as partner, initiation, formality and continuity of such relations that shape these learning mechanisms. We studied networks of Polish low-technology firms during transition time period. These networks allowed Polish low-technology firms to have access to learning experience which was not available otherwise, and to benefit from overcoming the challenges exposed by changing environment (Pickles, Smith, Bucek, Roukova and Begg, 2006). We do not observe any pattern in the choice of network types over twelve year period, suggesting that Polish low-technology firms were open to any source of knowledge and learning. By distinguishing between learning types and associating inter-organizational relationship characteristics with different types of learning, we contribute to learning and network literatures and extend their findings.

Network types

Our results suggest that the network types characterise learning mechanisms employed in inter-organizational relationships. Consistent with the prior research on knowledge networks revealing more of spillover effects (Dantas *et al.,* 2007; Ernst, 2008; Eapen, 2012) and production networks leading to positive learning effects (Gereffi, 1999; Schmitz and Knorringa, 2000; Ernst and Kim, 2002; McDermott and Corredoira, 2010; Ozatagan, 2010; Navas-Aleman, 2011), we found that in Polish low-technology firms, knowledge networks were strongly associated with learning from advances in S&T and education and learning from knowledge spillovers, while production networks were strongly associated with learning by interacting.

In line with Uzzi (1997), we found that firms adapt to new advances in S&T through learning in combination of knowledge networks and arm's length relations. Technology transfer relies on arm's length relations with technology suppliers, but it provides some scope for learning, and may have an effect on shaping the early stages of transition. Polish low-technology firms used them as a source of new knowledge to update their production processes, providing them initial upgrading opportunities, and subsequently opportunities to learn from these new technologies and advances in S&T (Mowery and Oxley, 1995; Contractor, 1998; Kim, 1999). The latter shows that these low-technology firms have a certain, though modest, level of absorptive capacity that is required in order to be aware of the advances in S&T, have access to them (e.g. through importation) and use them (Cohen and Levinthal, 1989).

The strong association of production networks with learning by interacting implies that there is learning in favour of Polish suppliers in GVCs/GPNs (Schmitz and Knorringa, 2000;

Ernst and Kim, 2002). Our study provides evidence of Polish firms learning not only of product and process related knowledge, but also managerial, distribution and marketing knowledge, which they put into practice, i.e by creating their own supply, production and distribution chains with Polish partners (Syzmanski, Gorton and Hubbard, 2007). Hence, this result extends our understanding of learning by interacting beyond relations in GVCs/GPNs.

Geographical origin of the partner

Foreign partner is associated strongly with all three learning mechanisms. This confirms that the knowledge Polish low-technology firms were in need of during the transition resided most frequently in foreign partners. This can be partly attributed to the changing economic system resulting in weakening social and human capital and production system (Dyker, 2010). However, in the food-processing industry, inward FDI has impacts on determining the level of national competition, as a fostering factor behind technological and organizational change. Unintended spillovers and backward and forward linkages in the national market shape the structural transformation of the sector (Gurgul and Lach, 2018). In the clothing indsutry, it is the foreign links abroad (subcontracting in GVCs/GPNs) that allow knowledge transfer of production techniques, training, design and chain management.

Transferring state-of-the-art technology and receiving training from foreign technology suppliers allowed firms learn from advances in S&T. Firms with relatively higher absorptive capacity also benefited from spillovers during this cooperation process. This is evidenced by the positive learning effect from knowledge spillovers in networks with foreign partners on Polish low-technology firms. This supports Ernst's (1997) *knowledge spillover effects* as one of the indirect forms of knowledge diffusion within the subcontracting relations of Polish firms with foreign firms in GVCs. The latter put Polish firms on potentially dynamic learning curves observed by upgrading researchers (Hobday, 1995; Ernst, 1997; Gereffi, 1999; Schmitz, 2006) and enabled direct learning by interacting with the global buyers.

Initiator of the relationship

The strong association between firm initiating the relationship and learning from advances in S&T and education indicates the willingness and agility of the firm to upgrade its technology and keep up-to-date with scientific developments. Considering these firms were operating as production units in the socialist period, them developing such linkage capabilities to find the right partner so quickly indicates their strategic goal of actively learning specific knowledge in the domain of the partner. The implications of this willingness to learn new technologies do not generally lie in the appropriability of technologies but definitely in the prospects for product development with the use of new advanced knowledge and technologies. In addition, this type of learning appears to be significant for food-processing firms relative to clothing firms, indicating the greater technological orientation of food-processing compared to clothing. Partner initiation leads to learning from knowledge spillovers, as the donor partner is more willing to share knowledge than not, and therefore shares its knowledge openly with recipient Polish low-technology firm.

Continuity of the relationship

Consistent with the literature, our results confirm that continuous relationships help develop trust and a common language between partners leading to higher density of interaction via interpersonal communication at informal level generating more spillovers and learning opportunities (Hakansson and Johanson, 1988; Simonin, 1997; Inkpen, 1998; Tatikonda and Stock, 2003; Kim and Inkpen, 2005). In the case of learning by interacting with the suppliers, continuous and long-term relationships may also aim to decrease supplier's opportunistic behaviour (Lui and Ngo, 2010).

However, one-off relations provided more access to new advances in S&T in the form of technology acquisition packages, consulting services or contract R&D with universities and research institutes. This indicates relationships with technology suppliers and scientific community are not built on mutual interaction that has continuity. In a way, this result seems to be in line with the assumption that low-technology firms are user or recipient of scientific and technological knowledge as they are involved in cooperation to obtain the results of such research that are suitable for their industrial specification. The industry-specific reasons can be identified as the shift in the direction of competition in these industries to product differentiation and higher product quality (the industry shifted from being supply-driven to demand-driven), and therefore the lack of interest in costly long-term research investments.

Formality of the relationship

Our results suggest that informal and employee-driven relations are crucial in learning from knowledge spillovers during inter-organizational relations. This result confirmed the significant role of informal mechanisms in knowledge diffusion among individuals (Dahl and Pedersen, 2004; Brass *et al.*, 2004*;* Mason *et al.*, 2004; Janowicz-Panjaitan and Noorderhaven, 2008) as well as positive externalities that create a strong link between networks and spillover effects (Ernst and Kim 2002). While the Polish low-technology firms' ability to learn from spillovers depends largely on the partner's interest in sharing its knowledge, our results confirm that the spillover effect is strong only when the partner initiates the relationship. This finding extends Gunter's (2005) findings on networks as a spillover channel.

Industry types

Industry effects are strongest in learning from advances in S&T and education relative to learning from knowledge spillovers and learning by interacting, specifically for food-processing firms. This indicates more learning opportunities arise for food-processing firms than clothing firms from networks with technology suppliers, universities, research institutes, laboratories, specialised consulting or intermediary firms for international technology transfer. As the results on network characteristics that affect learning from advances in S&T and education reveal, knowledge networks with these types of partners are more a means for transferring scientific, technological and technical knowledge. This is consistent with the technological shift in the nature of food-processing industry, manifesting itself in the increasing need for such collaboration to gain access to advances in S&T as early as possible, for instance

to improve process technology and/or develop new product. Food-processing firms also make use of learning opportunities through interacting with suppliers, customers, users; complementary firms and organisations in the same or a related industry, most often through arm's length relations. In either case, food-processing firms initiate these networks themselves, as they know what specific knowledge they need. Unfortunately, they tend to discontinue the relationship, unless they do not have a successful outcome of the relationship.

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TABLES AND FIGURES

Table 1 External learning mechanisms.

Sources of knowledge	Taxonomy of learning	Definition of the learning category
From production	Learning by spillovers	Learning from activities of what competitors and other horizontally-related firms in the industry are doing
From consumption	Learning by interacting	Learning by interacting with upstream suppliers or downstream customers, users, and with other firms/organizations in the industry
From search 'supply'	Learning from advances in S&T and education	Absorbing new developments in S&T, particularly in close cooperation with suppliers of technology and skills (e.g. universities, research labs, consultancy firms)

Source: Based on Malerba (1992), Von Tunzelmann and Wang (2007), Lundvall (1988, 1992), Von Hippel (1988).

Table 2. Derivation of network types from the literature.

Uzzi (1996, 1997)	Arm's length ties	Embedded ties	
Bell and Albu (1999)		Production systems	Knowledge systems
Gelsing (1989, 1992)	Trade networks (user-supplier relationships)	Production chain or the value added (vertical chain), + Production complexes (filières)	Knowledge networks
Michalet (1991)		Hollow corporation or Network firm	Alliances
Ernst (1997)	Standard coalitions	Supplier, producer, customer relationships	Technology cooperations
Coombs & Metcalfe (2000)	Predominantly market-mediated relations	Multi-firm collaborations with the special purpose of producing generic knowledge	Application-oriented collaborations + Strategic alliances
Humphrey and Schmitz (2004)	Arm's length market relations	Global value chains (GVC); Quasi-hierarchy	
Gereffi, Humphrey and Sturgeon (2005)	Markets	Modular, Relational, Captive value chains	
Ernst (2006, 2007, 2008)		Global production networks (GPN)	Global knowledge networks, global innovation networks

THIS RESEARCH	Arm's length relations	Production and distribution networks	Knowledge networks

Figure 1. Analytical framework: The relationship between the characteristics of interfirm cooperation and external learning mechanisms employed in cooperation

Characteristics of interfirm cooperation	Operational measure
Network type	Knowledge network Production and distribution network Arm's length relations
Geographical origin of partner	Foreign partner located abroad and in Poland Polish partner
Initiator of the inter-organizational relationship	The firm The partner
Continuity of the inter-organizational relationship	Continuous Occasional/Regular Once
Level of formality of the inter-organizational relationship	Informal Formal

Learning mechanisms employed during inter-organizational relationship	Learning from knowledge spillovers Learning from advances in S&T and education Learning by interacting No learning

Table 3. Basic characteristics of the dataset

	No of firms	No of dyads	% in total dyads	Average number of dyads per firm	min/max no of dyads
Food-processing	8	195	41.8	24.4	10/44
Clothing	8	272	58.2	34.0	22/47
Total	16	467	100	29.2	10/47

Table 4. Descriptive statistics

	Total number of inter-organizational relationships			Industry type						Pearson Chi-Square Test (Asymp. Sign. 2-sided): INDUSTRY vs (VARIABLE)
				Inter-organizational relations of Food-processing firms			Inter-organizational relations of Clothing firms			
	count	%	Chi-square test (Asymp. Sig.)	count	%	Chi-square test (Asymp. Sig.)	count	%	Chi-square test (Asymp. Sig.)	
Sample size	467	*100*		195	*41.8*		272	*58.2*		
Learning mechanisms in networks (EXTLEARN)			0.000***			0.000***			0.000***	0.000***
learning from knowledge spillovers	125	*26.8*		55	*28.2*		70	*25.7*		
learning from advances in S&T	109	*23.3*		67	*34.4*		42	*15.4*		
learning by interacting	157	*33.6*		46	*23.6*		111	*40.8*		
no learning	76	*16.3*		27	*13.8*		49	*18.0*		
Network Type (NETYPE)			0.000***			0.000***			0.000***	0.000***
knowledge network	141	*30.2*		103	*52.8*		38	*14.0*		
production network	180	*38.5*		36	*18.5*		144	*52.9*		
distribution network	40	*8.6*		14	*7.2*		26	*9.6*		
arm's length relations	106	*22.7*		42	*21.5*		64	*23.5*		
Geographical origin of partner (GEORIGIN)			0.002***			0.519			0.000***	0.000***
foreign partner	267	*57.2*		93	*47.7*		174	*64.0*		
domestic partner	200	*42.8*		102	*52.3*		98	*36.0*		
Initiator of the relationship (INITIATOR)			0.000***			0.000***			0.002***	0.079*
firm	292	*62.5*		131	*67.2*		161	*59.2*		
partner	175	*37.5*		64	*32.8*		111	*40.8*		
Level of formality in the relationship (FORMALITY)			0.000***			0.000***			0.000***	0.028**
informal	110	*23.6*		36	*18.5*		74	*27.2*		
formal	357	*76.4*		159	*81.5*		198	*72.8*		
Continuity of the relationship (CONTINUITY)			0.000***			0.000***			0.000***	0.012**
continuous	245	*52.5*		103	*52.8*		142	*52.2*		
occassional	90	*19.3*		48	*24.6*		42	*15.4*		
one-off	132	*28.3*		44	*22.6*		88	*32.4*		
Time period (PERIOD)			0.000***			0.000***			0.000***	0.025**
late 1990s	262	*56.1*		117	*60.0*		145	*53.3*		
mid-1990s	132	*28.3*		58	*29.7*		74	*27.2*		
early 1990s	73	*15.6*		20	*10.3*		53	*19.5*		

Table 5. Estimation results

	Model 1			Model 2			Model 3		
Variables	Learning from knowledge spillovers	Learning from advances in S&T and education	Learning by interacting	Learning from knowledge spillovers	Learning from advances in S&T and education	Learning by interacting	Learning from knowledge spillovers	Learning from advances in S&T and education	Learning by interacting
Network type									
knowledge network vs arm's length relations	1.36***	1.53***	-0.336	1.44***	1.67***	-0.16	1.01**	2.06***	-0.58
	(0.40)	(0.39)	(0.61)	(0.41)	(0.40)	(0.62)	(0.47)	(0.46)	(0.65)
production & distribution network vs arm's length relations	0.53	-2.90***	2.15***	0.59	-2.81***	2.26***	-0.03	-1.66**	2.05***
	(0.35)	(0.77)	(0.37)	(0.35)	(0.77)	(0.38)	(0.45)	(0.82)	(0.46)
Characteristics of the partner									
foreign vs domestic				0.39	0.68**	0.82***	0.69**	0.69*	1.10***
				(0.30)	(0.34)		(0.36)	(0.40)	(0.37)
Characteristics of inter-organizational relationships									
firm as the initiator vs partner as the initiator							-0.73**	1.45***	-0.12
							(0.37)	(0.52)	(0.37)
continuous relations vs one-off relations							1.05***	-1.43***	0.70*
							(0.42)	(0.50)	(0.39)
Occasional relations vs one-off relations							0.62	-0.18	0.31
							(0.49)	(0.47)	(0.53)
informal relations vs formal relations							2.02***	0.37	0.67
							(0.42)	(0.51)	(0.44)
Control variables									
food-processing vs clothing							0.14	0.70*	0.53
							(0.38)	(0.39)	(0.37)
Constant	-0.11	0.13	-0.69**	-0.35	-0.32	-1.24***	-0.96	-1.83***	-1.87***
	(0.27)	(0.25)	(0.32)	(0.32)	(0.34)	(0.38)	(0.60)	(0.73)	(0.65)
No of observations		467			467			467	
Log Likelihood		-101.77			-147.48			-291.20	
LR Chi-Square		262.48			271.36			381.82	
Degrees of freedom		6			9			24	
Prob > Chi-Square		0.000			0.000			0.000	
Pseudo R2 (McFadden)		0.208			0.215			0.302	

*** p < .01; ** p < .05; * p < .10; standard errors are in parenthesis. Reference category for dependent variable 'No learning'. Restricted specification by backward elimination method.
Omitted variables: PERIOD and INDUSTRY in Model 1 and Model 2; PERIOD in Model 3.

APPENDIX

Table A1. External learning mechanisms and its exemplifications.

Learning mechanisms	Descriptive examples based on observations from this research
Learning by knowledge spillovers	Strategic investor's supportive activities in managerial, technical, technological and/or scientific matters, Cooperation with sister companies' research/product development units for product or process development, Managerial and technical harmonization after merger with a horizontally-related firm, Participation in conferences, seminars, scientific meetings arranged by universities or industrial organizations such as Chamber of Commerce, Interactions at personal level in trade shows, fairs and exhibitions where competitors and horizontally-related firms participate, Distribution licensing of a brand of a foreign horizontally related firm, Visits to production plants of the partner or to technology supplier companies before transfer of technology, Training by the global buyers and their technicians situated within the firm, Technical assistance by the representative of foreign partner located in the firm for a certain period of time to guide the production processes and training provided to recipient firm's employees in order to improve the firm's production and technical capabilities to the desired advanced level required by the foreign partner.
Learning by interacting	Subcontracting of a complementary firm for production purposes or of raw material suppliers (such as farmers in the food industry with whom extensive scientific training is undertaken by the firm to introduce new advanced S&T techniques), Technical training by raw material supplier firm as to how to make use of its product in different ways, Projects with design firms, consulting firms for adapting and improving technical, organizational and managerial processes, for problem-solving Organizational and managerial training outside the company by consulting firms and universities Marketing agencies before launching a new product to the market, Market or product-related demands and feedbacks of wholesalers or hypermarkets, Feedback loops between the firm and its supplier and customer. Observing the products a foreign customer requested to be produced and the associated production processes it taught.
Learning from advances in S&T	Transfer of new-to-firm technologies, Technical training during technology transfer, Licensing of new-to-firm or state-of-the-art process technology, Contracting research to the university, research institutes or labs for new ingredient, product, or process development, Participation into advanced training and/or postgraduate programs for technical, technological or scientific improvements by universities Hiring skilled people, consultancy services for international technology transfer, Participation into research projects run by university as 'application' partner, Joint projects with consulting firms for quality management (e.g. in food industry) in order to get specific certifications and/or for IT-related managerial training, Contacts with academics at the universities for problem-solving and trouble-shooting. Presence at the firm of post-graduate students and post-doctoral fellows as part of their degree work or joint projects (cf. Murray, 2002)

Table A2. Categorisation of networks observed in this research

Cooperation type	*Description of inter-organizational relationship observed in this research*
Arm's length relations	Machinery and equipment purchases; Technology purchases in the form of R&D contract and licensing; Contracting of R&D activities to universities and research labs; Intermediary agents (e.g. for finding customers, improving marketing and distribution); Market research agents; Participation in fairs and exhibitions; Participation in conferences, seminars and symposiums; Cooperation with human resource development and recruitment agencies, advertisement agencies, design agents, consulting firms, industry associations, Chambers of Commerce, etc.
Distribution (and marketing) networks	Cooperation / strategic alliance in distribution with competitor, distributor or complementary firms; Licence agreement for marketing and distribution; Franchising; cooperation between wholesaler/retailers and the firm's sales representatives (in the form of feedback for product improvement and /or development, training, etc.).
Production networks	Subcontracting (outward processing, OEM), contract manufacturing; Licensing for production; Cooperation with competitors, customers, suppliers (e.g. training, technical and organizational assistance and advice, etc. for attribute or component pricing system), with complementary firms in the industry (e.g. for new product and process manufacturing), with sister firms and strategic investor.
Knowledge networks	Relationships with other firms (such as sister firms, strategic investor firm, supplier firm, user firm, complementary firms, etc.) in product and process improvement and/or development, quality improvement, scientific advice, experimentation, etc.; Cooperation with universities, public and private research institutes, R&D laboratories, technology suppliers, etc. (e.g. for new product and process development, access to new advances in S&T, technological improvements of production processes); Relationships developed with individuals who obtain specialised knowledge on the basis of personal acquaintance; Firm visits and observation (e.g., among partners); Relationships including/based on technical and organizational assistance, advice and training (e.g. from technology suppliers, raw material suppliers, universities, design agents, consulting firms, industry associations, Chambers of Commerce); Relationships with consulting firms for re-organization of production process, product-market strategy development; Cooperation with universities, consulting firms, etc. for training in business functions, planning, and design and technology management.