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Low-Tech Innovation in a High-Tech Environment?

The Case of the Food Industry in the Vienna Metropolitan Region

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Abstract This paper explores the opportunities for low-tech innovations in regional high-tech contexts. The literature suggests that traditional sectors tend to be only weakly integrated in such socio-institutional environments, because the specific innovation mode of low-tech industries is not compatible with the institutional framework of high-tech. Focusing on the empirical case of the food industry situated in the Vienna metropolitan region, the paper provides evidence that the link between old industries and their high-tech contexts may be more complex than commonly thought. Drawing on 20 face-to-face interviews with local companies, knowledge providers (universities and other research organisations) and industry experts it is highlighted that strong and weak forms of integration in the regional innovation system (RIS) co-exist, depending on the specific RIS dimension under consideration. Innovative companies in the local food sector, thus, embed themselves in a selective way in their regional institutional context. They make use of the scientific competences available within the RIS whilst at the same time they tend to “bypass” the RIS and tap into knowledge sources located outside the region.

1 Introduction

The past two decades have witnessed an enormous concern of innovation research and policy with high-technology sectors and science-based growth. Recently, this “obsession” with high-tech industries has been criticised sharply by several scholars (see, for instance, Robertson and Smith 2008, Cappellin and Wink 2009). There is now a growing awareness that medium- and low-technology industries are also innovative, albeit in ways that differ from those observed in high-tech sectors. It has been shown that older industries exhibit a specific innovation mode, which is characterised by little investment in R&D, a high importance of in-house practical knowledge, incremental changes, and a strong reliance on specialised suppliers of embodied technologies.

The recent literature on low-tech sectors has considerably enhanced our understanding of the importance and specific pattern of innovation in traditional sectors. In the current academic debate, however, relatively little is said about the geography of knowledge sourcing activities in mature sectors and consequently the degree and modes of embeddedness of these industries in their socio-institutional context remain poorly understood. This assertion holds in particular true for low-tech industries which are located in high-tech regions and their respective innovation systems. One of the few academic contributions dealing explicitly with this issue has been provided by Hirsch-Kreinsen (2008a). He argues that the innovation pattern of low-tech industries is not compatible with the institutional framework of high-tech, resulting in a rather loose coupling of traditional sectors with most parts of their socio-institutional context (Hirsch-Kreinsen 2008a). Such a perspective, however, might be too simplistic, veiling the complexity of links that may exist between old industries and the elements of the high-tech context in which they are situated.

The central aim of this paper is to examine to what extent and in which ways innovative companies in the Viennese food sector are integrated in their regional socio-institutional environment. Vienna’s regional innovation system (RIS) is in a process of transformation, becoming increasingly oriented on promoting young research-intensive and science-based sectors. The food industry in this region is an old low-tech sector which showed little inclination to innovate in the past. Due to changing context conditions, today the sector faces enormous innovation pressures and learning challenges. Drawing on 20 qualitative interviews with local food companies, research organisations and industry experts, we will investigate how the Viennese food sector can meet its innovation demands in an environment that becomes more and more high-tech oriented. More precisely, the paper will address the following research questions:

- What is the nature of innovation activities and innovation output in the Vienna food sector?
- Which role do the RIS and its various subsystems play in the process of food innovation? Do firms from the Viennese food industry acquire relevant knowledge from local sources or do they tend to bypass the RIS and interact with partners located elsewhere, i.e. at extra-local scales?

The remainder of this paper is organised as follows. Section 2 provides a short literature review on the innovation pattern in low-tech sectors in general and in the food industry in particular. Section 3 contains the empirical part of the paper. After a brief description of Vienna's metropolitan RIS and its food sector, the empirical results on the innovation activities, key knowledge sources and the geography of knowledge linkages in that industry will be discussed. Finally, Section 4 summarises the key findings and draws some conclusions.

2 Conceptual Perspectives and Literature Review

2.1 Innovation in low-tech industries

In the past, both innovation research and policy have strongly focused on high-technology sectors and science-based growth. Recently, this “obsession” with high-tech industries has been criticised sharply by several scholars (see, for instance, Tödting and Tripl 2005, Tunzelmann and Acha 2005, Hirsch-Kreinsen 2008a, 2008b, Cappellin and Wink 2009). In the last few years, a rich literature has emerged, leading to a fresh view and reconsideration of the role that traditional sectors play in modern economies and enhancing our understanding of the importance of innovation and technological change outside R&D-intensive fields (Robertson et al. 2009). There is now a growing awareness that medium- and low-technology industries, which still make up a considerable share of production and employment in developed and developing economies, also face enormous learning and innovation challenges (Lundvall and Borras 1999) and engage in frequent changes of new products and process technologies (Hirsch-Kreinsen 2008a, Robertson and Smith 2008, Robertson et al. 2009). Importantly, through innovation low-tech sectors do not only enhance their own competitiveness. Traditional sectors are often major customers and lead users of high-tech products (Robertson and Patel 2007), contributing in significant ways to the growth of high-tech industries (Hauknes and Knell 2009).

Several authors have dealt with the question whether a specific innovation pattern of low- and medium-low technology (LMT) industries exists. Their findings suggest that innovation in traditional sectors differs markedly from those in high-tech industries. It has been shown that old industries are characterised by a low engagement in formal R&D activities, whilst in-house practical knowledge, learning-by-doing and learning-by-using are highly important. There is a dominance of process, organisational and marketing innovations (Heidenreich 2009) and changes are often incremental in nature (Hirsch-Kreinsen 2008a). Furthermore, firms use diverse external sources of knowledge during the innovation process (Robertson and Smith 2008), i.e. they draw on a distributed knowledge base (Smith 2002). It is often argued that suppliers are of utmost relevance in this context. Low-tech sectors, thus, correspond to Pavitt's (1984) class of supplier dominated sectors, as they rely heavily on technology and knowledge embodied in machines, equipment, intermediate goods, etc. (see, for instance, Heidenreich 2009).

The literature on low-tech industries recapitulated above has to be acknowledged for advancing our understanding of the relevance and specific modes of innovation in more traditional sectors. Little attention, however, has been given so far to the spatial dimension of knowledge flows in low-tech industries and, consequently, the role of RISs, particularly those which prevail in high-tech areas, remains poorly understood. Research on the anatomy of high-tech regions and their RISs (see, for instance, Saxenian 1994, Keeble and Wilkinson 2000) has shown that these areas are well endowed with unique factors such as excellent universities, knowledge mediating institutions, agencies promoting academic entrepreneurship, venture capital organisations and university-trained mobile labour. High-tech RISs, thus, provide conditions, elements and inputs which seem to be of limited use for low-tech firms. Consequently one might argue that these areas constitute an environment which – at least at a first glance – does not correspond to the innovation mode of traditional sectors. Such a view is proposed, for example, by Hirsch-Kreinsen (2008a) who notes that innovation processes in mature industries are not compatible with the institutional framework of high-tech. According to Hirsch-Kreinsen (2008a) the innovation capabilities of firms which belong to traditional sectors are only loosely coupled with most of the socio-institutional framework conditions. The only exception in this context might concern the industry structure, where a tight coupling – particularly through strong linkages to specialised suppliers from high-tech sectors – is assumed.

Empirical evidence, however, is too scanty to jump to the conclusion that low-tech sectors are only weakly integrated in high-tech environments. The diverse sources of knowledge that firms in low-tech sectors rely on for their innovation activities are rarely charted (Robertson and Smith 2008) and the geography of knowledge links in traditional industries is still somewhat under-researched. As argued by Hirsch-Kreinsen (2008a) many low-tech companies face the challenge to spatially expand their supplier and customer relations, resulting in an erosion of

regional ties. At the same time, however, it is argued that geographical proximity to suppliers, customers, research organisations, educational bodies and policy actors might have a positive impact on the ability of low-tech sectors to innovate (Hirsch-Kreinsen 2008a). More empirically grounded insights into the spatial dimension of innovation linkages to a variety of knowledge sources seem to be needed to understand to what extent and in which ways low-tech sectors are embedded in high-tech regions.

This paper departs from the RIS approach (see, for instance, Autio 1998, Asheim and Gertler 2005) and proposes the argument that the various subsystems of a RIS (i.e., the subsystem of knowledge generation and diffusion, the subsystem of knowledge application and exploitation and the policy subsystem) and the geography of knowledge sourcing activities require close scrutiny to substantiate our view of the relation between low-tech industries and high-tech environments.

2.2 Innovation in the food sector

In many countries the food industry constitutes one of the largest manufacturing sectors (Smith 2002, Christensen 2008). Generally, the food sector is characterized by a very specific dual structure, i.e. the co-existence of a few multinational companies such as Nestle, Unilever, Danone, etc. with global brands and a rather large number of SMEs (Fryer and Versteeg 2008). Innovation is pivotal for sustaining competitive advantage and fulfilling consumer expectations in this industry (see, for instance, Menrad 2004).

There is an agreement in the literature that the food sector – like other traditional sectors – is characterised by a rather low R&D intensity and a dominance of incremental innovations (see, for instance, Kubitzki et al. 2003). Furthermore, it has been shown that the innovation capacity of food companies is associated with firm size. Larger firms are more R&D intensive and place greater emphasis on new product development than smaller companies (Traill and Meulenbergh 2002). The food industry is regarded as what Pavitt (1984) termed “supplier dominated”, i.e. innovation in this sector strongly depends on suppliers of the machinery for production. However, as noted by Tunzelmann and Acha (2005) the industry is now becoming also more market driven in nature. According to Fryer and Versteeg (2008) the food sector is driven by and responsive to consumer needs such as safety (in terms of microbiology and toxicology), health and well-being (nutritional benefits, health enhancing properties), high quality, convenience, good taste, and price (see also Bruhn 2008).

Furthermore, there is some indication in recent academic work that several trends will increase the demand for research in the food sector. These include –

amongst others – the “biotechnology revolution”¹, a growing importance of functional food and the need to ensure food safety and nutritional quality. In addition, a finer market segmentation resulting from changes in consumer demand, a more rapid rate of product turnover and the internationalisation of markets require that food firms put more emphasis on developing new products and targeting them to domestic and foreign consumers. This implies that food firms face the challenge to upgrade marketing competencies as well as scientific R&D (Traill and Meulenbergh 2002).

Inter-organisational networks and other forms of external knowledge sourcing activities are regarded to be crucial for innovation in the food sector (Smith 2002, Avermaete et al 2004, Karantininis et al. 2010). Several studies suggest that it is in particular knowledge linkages at the regional level which are highly relevant in this regard (for an overview on this work, see Nielsen 2008). Bertolini and Giovannetti (2006), for instance, have shown that dense regional relationships are pivotal for actors in the agri-food industrial district in the province of Modena (Northern Italy) during the production and innovation process. Gellynck et al. (2007) studied 81 food firms through face-to-face interviews in the peripheral region of Meetjesland located in the Belgian province of East-Flanders. The authors found that an international market orientation and regional networking enhance the innovation competence of firms. More precisely, it is demonstrated that firms which establish contacts with knowledge centres, engage in knowledge exchange with competitors, and participate in formal networks and societal activities are more innovative than those which invest less in regional networking. Consequently, there is evidence that innovation in the food sector is strongly related with knowledge sourcing activities at the regional level, challenging the view that traditional sectors are weakly integrated in their socio-institutional context. We have to take into account, however, that most of the work that finds a positive relation between food innovation and regional networking has been done in the specific context of peripheral regions. Indeed, whilst there is a large body of literature on the food sector and its innovation activities in non-high tech regions and more peripheral areas (Avermaete et al. 2004, Gellynck et al. 2007, Doloreux and Dionne 2008, Arias-Aranda and Romerosa-Martínez 2010, Batterink et al. 2010), little is known about the geography of knowledge links of food companies located in metropolitan or high-tech regions.

¹ Analysing patent statistics, Robertson and Patel (2007) provide interesting empirical evidence in this context, pointing to changing technological activities of large food manufacturing firms. They show that patents in the drugs and bioengineering class almost quadrupled, whilst the share of patents related to food-processing and products decreased. Based on these findings Robertson and Smith (2008, p. 108) conclude that “...this clearly demonstrates a major acquisition of new scientific and technical skills in a sector that is evolving rapidly despite its long history”.

3 Empirical Part: The Food Sector in the Vienna Metropolitan Region

This Section provides a brief overview on the key structures of Vienna's RIS and a short description of the local food industry. This will be followed by an analysis of the nature of innovation activities and the spatial dimension of knowledge linkages in the Viennese food sector.

3.1 The metropolitan innovation system of the Vienna region

Vienna is the capital city of Austria and it is also one of the country's nine provinces ("Bundesländer"). It constitutes a metropolitan innovation system with rather high innovation capabilities (see, for instance, Fischer et al. 2001, Revilla-Diez 2002). Investigating the region's industry structure (i.e. the subsystem of knowledge application and exploitation) reveals a clear dominance of the service sector. Knowledge-intensive services play a particularly strong role and have grown considerably in the past. In 2008 more than 44% of employees were working in this sector (the Austrian average amounts to 32%). Recent years have also seen the rise of high-tech clusters in fields such as biotechnology and ICT (Trippl and Tödtling 2007, Trippl et al. 2009).

Vienna is well endowed with universities and other public and private research institutions. The region hosts not fewer than six major universities, 50 research institutions of the Austrian Academy of Sciences, more than 100 institutes and research sites of the Ludwig Boltzmann Society (focus on human medicine), about 250 further non-university research institutions in different fields and several technical colleges. The excellence of the RIS subsystem of knowledge generation and diffusion reflects the region's role as Austria's scientific centre and its status as metropolitan innovation system. Most important for the purpose of this paper is that all major universities present in the region have research competences that are relevant for the food industry (see also Section 3.3).

Looking at the third RIS subsystem – i.e. the policy system – uncovers a strong focus on high-tech industries. Recent work has demonstrated that in the past two decades Vienna's innovation policy has undergone a far reaching transformation, becoming increasingly oriented on promoting young research-intensive sectors such as biotechnology and ICT (Trippl and Tödtling 2007, Trippl et al. 2009). These sectors are the key policy priorities and target of specific actions such as public funding, provision of venture capital, creation of specialised supporting agencies (such as academic spin-off centres), etc. Other sectors, in comparison, receive little attention by the regional policy community. The same holds true for

the national policy level. Radauer and Streicher (2007) note that – although the Austrian innovation system is diversified – programmes that aim at boosting low-tech innovations are scarce. The majority of the funding instruments and support measures are too high-tech oriented and not tailored to the needs of mature industries.

Taking the findings on the RIS together allows for the conclusion that the metropolitan region of Vienna constitutes an environment that is, indeed, characterised by an increasing high-tech orientation.

3.2 Vienna's food sector: current structure, old legacies and new innovation challenges

The food sector is the second largest manufacturing industry in Vienna (measured by the number of employees). As revealed in Table 1, Vienna hosts 302 food companies (representing 7% of the Austrian total), which employ about 8,700 workers (11% of the Austrian total).

Table 1: Number of firms and employees in the Austrian food sector: regional distribution (2007)

	Number		Number	
	firms	Percentage	employees	Percentage
Vienna	302	7.3	8,716	11.3
Lower Austria	919	22.3	17,020	22.1
Burgenland	232	5.6	2,994	3.9
Upper Austria	923	22.4	17,397	22.6
Salzburg	295	7.2	5,227	6.8
Carinthia	258	6.3	4,374	5.7
Styria	579	14.0	10,066	13.1
Tyrol	365	8.9	5,706	7.4
Vorarlberg	250	6.1	5,366	7.0
Total Austria	4,123	100.0	76,866	100.0

Source: Statistik Austria 2009, own calculations

Aurelia database contains employment data for 192 food companies, enabling us to reveal some interesting characteristics of the firm size. As shown in Table 2, more than 50% of the companies are very small, employing fewer than 10 workers. Remarkably, 78 companies (41%) have not more than four employees. Another 24% are classified as small companies, 15% are medium-sized firms and about 15% are large.

Table 2: The Vienna food sector: Firm size

Firm size	Number of firms	Percentage
Micro (fewer than 10 employees)	102	53.1
Small (10 to 49 employees)	46	24.0
Medium (50 to 249 employees)	29	15.1
Large (250 and more employees)	15	7.8
Total	192	100.0

Source: Aurelia database, own calculation

The overwhelming majority of the food firms in Vienna are smaller and rather old home-grown companies. There are only a few subsidiaries of multinational companies (MNCs) such as, for example, Coca Cola, Nestle and Unilever, present in Vienna. However, none of the main R&D centres of these MNCs is located in Vienna; the subsidiaries are mainly engaged in sales and marketing – and to some extent – in production activities.

The Vienna food industry is a long-established sector which showed little propensity to innovate in the past. The sector had been embedded in a stable environment, characterised by strict market regulations and prices clearly above the EU level. In the mid 1990s, however, the framework conditions changed dramatically, bringing innovation to the fore. Two major events coincided in 1995, leading to a collapse of the old institutional set-up. First, Austria's entry to the European Union led to an enormous increase of competition and a dramatic decline in prices of food products (Pollan 1996). Second, in the same year the bankruptcy of the retail giant "Konsum" (the largest financial failure in Austria after the Second World War) enhanced the market power of the remaining chains. Today, the three leading retailers (Billa/REWE Group, Spar, and the discounter Hofer) have a market share of 77% (BMLFUW 2008) and exert an enormous price pressure on food manufacturing companies. Many firms did not succeed in adapting to the new context conditions and the Vienna food sector declined considerably². Those firms which survived embarked on high quality production, development of export markets and – most importantly for the purpose of this paper – permanent innovation as competitive strategy.

² Lack of data impedes to provide exact numbers about the decline of the industry from 1995 to present. According to estimations done by the Chamber of Commerce, both the number of firms and employment in the food sector have shrunk by one third in the period from 1995 to 2008 (FIAA 2010). Using the firm census, i.e. the Austrian "Arbeitsstättenzählung", which provides, however, data only for the years 1991 and 2001, shows that the number of Viennese food plants has dropped from 708 plants in 1991 to 556 plants in 2001, implying that the sector has shrunk by 22%. In the same period the number of employees decreased by almost 30% from 13,383 workers in 1991 to 9,465 workers in 2001.

3.3 Innovation in the Vienna food sector: knowledge sourcing activities and the role of the RIS

In this section we will explore whether and how Viennese food companies can meet their innovation challenges in a regional environment that becomes more and more high-tech oriented. More precisely, we will analyse the nature of innovation activities of Vienna's food companies and the geography of their knowledge linkages to assess to what extent and in which ways they are embedded in the RIS. To get more insights into the specific modes by which the local food firms are integrated in their high-tech environment, we will also investigate the core mechanisms of knowledge exchange with the most important innovation partners.

The empirical results reported below are based on 20 face-to-face interviews (using semi-structured questionnaires) conducted in the year 2009 with different groups of actors in the local food sector. Ten interviews have been undertaken with local companies. When selecting firms for interviews, our focus was on the most innovative companies in the local food industry. Using various sources (annual reports of companies, new product announcements in business magazines, and personal interviews with industry experts), we identified around 30 companies which continuously carry out innovation activities. However, about 20 companies refused to participate in our study, resulting in a rather low number of investigated firms. The positions of people interviewed varied by company, but generally included the owner or chief executive. To compensate to some extent for the low number of firm cases we carried out five interviews with industry experts (including representatives of the chamber of commerce and consultancy firms) who have an excellent overview on innovation challenges in the food industry, the innovation capacity of local companies and their typical knowledge sourcing activities. Interviews with these experts, indeed, provided a useful complement to the firm interviews. Finally, five interviews with scientists from the university sector and private research organisations have been taken.

To be sure, we do not claim that the empirical findings discussed below are representative for the Vienna food industry as a whole. The small sample of firms, however, might not be a too strong restriction for our study, because its aim was to characterise innovation activities and the pattern of knowledge sourcing in the Vienna food sector, and the ten firms studied here are amongst the most innovative players in the local food industry.

All interviewed firms are old and home-grown companies and they belong to very different subsectors, reflecting quite well the heterogeneity of Vienna's food industry. Furthermore, the investigated companies differ rather strongly in size as well as regarding their orientation on international markets (see Table 3).

Table 3: Firm characteristics, innovation activities, knowledge sources and their geography

Main activity	Year of foundation	Number of employees	Turnover (Mio Euro)	Export quota (% of turnover)	Type of Innovation	Knowledge Sources (Location Source)
Manufacture of beer	1837	200	73.3	4	Product Packaging Process Marketing	ROs (regional, international) Suppliers-1 (international) Other actors (international)
Manufacture of bread, fresh pastry goods and cakes	1860	800	50.0	0	Product Process	Clients (regional) Suppliers-2 (regional) ROs (national)
Manufacture of condiments and seasonings	1929	8	1.1	66	Product Process	Clients (national, international) Suppliers-2 (national) Competitors (international)
Production of meat and poultry meat products	1931	485	110.0	55	Product Process	Consultants (regional, national, international) ROs (regional, national)
Manufacture of condiments and seasonings	1935	20	4.5	10-20	Product	
Production of meat and poultry meat products	1937	15	1.6	15	Product Process	Clients (national) Suppliers-1 (national) Suppliers-2 (national, international) Competitors (regional, national) Firms from other food-subsectors (regional, national) ROs (regional)

Main activity	Year of foundation	Number of employees	Turnover (Mio Euro)	Export quota (% of turnover)	Type of Innovation	Knowledge Sources (Location Source)
Operation of dairies and cheese making	1949	170	120.0	30	Product Process Packaging	Clients (regional, national) Suppliers-1 (regional, international) Suppliers-2 (national, international) ROs (regional) Other actors (international)
Manufacture of cocoa, chocolate and sugar confectionery	1953	200	13.4	5	Product	Competitors (international) Suppliers-2 (national, international) Consultants (international) ROs (regional)
Manufacture of bread, fresh pastry goods and cakes	1970	1,280	80.0	0.8	Product	Clients (regional) Suppliers-1 (international) Suppliers-2 (national) ROs (regional)
Other processing and preserving of fruit and vegetables	1971	35	7.0	40	Product Process Marketing	Clients (regional) Suppliers-2 (national, international) Competitors (national) ROs (regional)

Notes:

ROs ... Research organisations

Suppliers-1 ... Suppliers of machinery and packaging products

Suppliers-2 ... Suppliers of agriculture and intermediate products

Types of innovation and in-house innovation activities

All interview partners from the firm sector stated that nowadays innovation has a very high importance as competitive strategy and reported introducing more or less continuously a number of mainly smaller innovations. To gain more insights into the nature of innovation, firms were asked to indicate the most important forms of innovation generated in the last three years (i.e. from 2006 to 2008). The results show that innovation in the Vienna food sector takes many different forms. Our results suggest that new product development plays the most important role in this context. Product innovations include new products based on new ingredients and slightly changed products based on new or improved flavour, unique flavour combinations or new recipes. Apart from product innovations also process innovations were found to be significant. Example for process innovations are the introduction of new heating technologies (allowing for a better taste of products), clean room technologies (expansion of shelf life), as well as new food processing and lyophilisation techniques. Furthermore, there is also evidence for packaging innovations and the use of new closure technologies which enhance product quality. To a lesser extent also marketing innovations could be observed. As revealed in Table 3, the majority of the local food companies included in our study are engaged in various forms of innovation, i.e. their competitive strategy rests on a combination of different types of innovation. However, most of the innovations reported by the investigated firms tend to be incremental. Due to little consumer acceptance in Austria, more radical innovations such as functional food or the integration of biotechnology do not play a role in the Vienna food sector. Interviews with industry experts confirmed the finding that innovation in the local food industry is strongly incremental in nature. The common view of the experts is that the Vienna food sector as a whole is not outstandingly innovative. According to the experts there are only a few innovative companies, whilst the large majority is best described as imitators.

The rather incremental nature of innovation in the Vienna food sector is also – at least to some extent – reflected in the specific characteristics of the in-house innovation activities. None of the investigated firms has a R&D department or employs specialised personnel for R&D activities. Many interview partners stated that it is the owners or CEOs who are responsible for innovation and are an essential source for ideas and impulses. Furthermore, workers involved in the production process who are possessors of practical knowledge were also found to be important. As one interview partner put it: “Research, development and innovation activities occur permanently through many employees during the work time.” Some firms seem to have well-established procedures to generate innovations. “We encourage our employees to play a part in innovation and to suggest new ideas. If an idea is promising, we develop a prototype which is then tasted by five

to ten specialists in our company. The next step is consumer testing of the new product in our own chain stores”. Another firm stated: “We do not have an own department for research or innovation. New ideas are tried and tested by an exquisite circle within the firm and the new product is refined until the product corresponds to our expectations. Sometimes it takes many rounds of improvements and change until a new product is born.” These cases show that in the Vienna food sector internal innovation activities are best described as institutionalised processes, characterised by well-established routines, learning-by-doing and trial and error procedures.

Knowledge sourcing activities and the role of the RIS

Except from one company all investigated food firms reported using external knowledge sources and collaborating with innovation partners during the innovation process. Table 4 provides an overview on the respective partnering activities. It shows that suppliers of raw materials from agriculture and intermediate products, machinery and packaging play the most important role. Next to suppliers, knowledge generating organisations (universities, private research institutes, technical colleges, etc.) constitute relevant knowledge sources, “feeding” Vienna’s food firms with scientific knowledge. Whilst knowledge providers are overwhelmingly located in Vienna, suppliers could be mainly found outside the region, i.e. at the national and international scale. Furthermore, local and national customers as well as extra-local competitors and specialised consultants play a certain role.

Table 4: Knowledge sources and their spatial dimension (number of firms)

	Vienna	Austria	International	Total
Customers	4	3	1	8
Suppliers of raw materials from agriculture & intermediate products	1	7	3	11
Suppliers of machinery, packaging	1	1	3	5
Competitors (firms from the same food sub-sector)	1	2	2	5
Firms from other food-subsectors	1	1	-	2
Other firms (consultants)	1	1	2	4
Universities, Technical Colleges	7	2	1	10
Other actors / organizations	-	-	2	2
Total	16	17	14	47

These findings confirm the view in the literature (see Section 2) that low-technology sectors rely on a variety of knowledge sources and make use of a distributed knowledge base. Furthermore, we can draw first conclusions regarding

the relevance of the local level and the role of the RIS. Although there is a high importance of extra-local knowledge sources, the role of the RIS must not be neglected. Local customers and – even more importantly – highly specialised and competent knowledge generating organisations constitute key innovation partners of the investigated food companies. In a next step we will explore in more detail the nature of linkages sustained by innovative food companies to suppliers and knowledge providers. This will provide further insights in the RIS dimensions of knowledge generation and application. To complete the picture, we will also look at linkages between Viennese food companies and the RIS subsystem of policy-making.

Extra-local suppliers

As noted above, suppliers located outside the region are the most important knowledge sources and innovation partners (measured by the number of contacts) for the surveyed Viennese food companies. This fits well with the findings from the literature review discussed in Section 2, where the food industry has been characterised as a classic supplier-dominated sector. Two groups of suppliers were found to be essential for innovative firms in the Vienna food sector.

First, Vienna's food firms interact with suppliers of raw materials from agriculture and intermediate products during the innovation process. A firm active in the jelly industry, for example, reported strongly collaborating with fruit growers in Austria and Hungary. Knowledge exchange among these actors concerns a sharing of practical know-how and it is mainly informal in nature and based on social proximity, i.e. on relations characterised by friendship and high levels of mutual trust. Interaction between these partners is leading to new breeds and cross-breedings of fruits, which allow for producing better characteristics of the final product. Unsurprisingly, most of the suppliers of agricultural inputs are located outside the region. Vienna is a metropolitan region, and its innovation system does not host considerable parts of the food value chain.

Second, national and international suppliers of machinery, processing equipment and packaging products play an important role, pointing to the penetration of new technologies into the Vienna food sector. These linkages go beyond a simple buying of “embodied” technology or other forms of knowledge” but often include more interactive relations between Viennese food companies and specialised suppliers of machinery and new packaging solutions. There is hardly any evidence of local contacts to this kind of suppliers, because Vienna's RIS lacks strengths in the machinery sector and packaging industry and the local companies tend to search for the best solutions worldwide. As a representative from the firm sector put it: “Our aim is to be always at the state of the art. We acquire new machinery and equipment from the best suppliers worldwide.”

To summarise, Vienna's RIS subsystem of knowledge application and exploitation hardly provides impulses for innovation in the local food industry. The investigated companies purchase embodied technologies and use knowledge provided by suppliers located at the national and international level. These findings point to a rather weak integration of innovative food companies in their regional context.

Local universities and other research organisations

Our findings show that innovative food firms do not rely exclusively on extra-local knowledge sources during the innovation process. They also draw on competences and expertise available within the boundaries of the RIS. As noted above there is some evidence that the local food companies are engaged in rather informal knowledge exchange activities with local customers. The most important knowledge sources at the local level, however, are universities, other research organisations and technical colleges.

The high importance of local scientific and research organizations reflects (1) the excellence of the knowledge infrastructure of the RIS and (2) a growing pressure on Vienna's knowledge providers to commercialize their research findings. Vienna hosts internationally renowned knowledge generating institutions in the area of food and food related research. Almost all universities present in the region have specialised competences in this fields. These include the University of Natural Resources and Applied Life Sciences, University of Veterinary Medicine Vienna, University of Vienna, and Vienna University of Technology. Furthermore, there are several other research organisations located in the region which promote innovation in the Vienna food sector. Examples comprise OFI (Austrian research institute for chemistry and technology) and LVA (food testing & research institute Vienna).

Interviews with local research organisations have shown that the strong competences and excellent reputation of Vienna's knowledge providers have attracted the interest of Austrian and international companies. Indeed, we found evidence that the investigated universities and research organisations have a large number of innovation contacts to national firms and global major companies from the food industry. At the same time, all interviewed representatives of the local research organisations reported maintaining links with firms from the Vienna food sector, pointing to rather intense forms of local knowledge transfer. Interviews with universities and research organisations, thus, confirm the findings from interviews with local firms. Knowledge exchange between knowledge providers and industry within the region takes place in a variety of fields, including amongst others nutritional health care, shelf life technology (cold pasteurisation, high pressure processing, cleanroom technology), etc. and it covers a wide spectrum of activities ranging from joint product development to quality assurance. In most cases local

knowledge exchange between research organisations and firms is based on rather formal arrangements, particularly on collaborative R&D projects and contract research. More informal modes of knowledge transmission play only a minor role in comparison.

Vienna's universities and research organisations act rather professionally and have accumulated experiences in commercialising their research and dealing with secrecy rules, intellectual property rights, etc. Many of them even adopt a rather proactive approach, i.e. they do not only respond to firms' inquiries, but actively contact firms and offer them their recent research findings. Moreover, a few years ago, they have established the network TechNet to enhance the transfer of knowledge and technology from science to business. TechNet is coordinated by LVA and offers not only scientific inputs and competences in food technology, technical consulting feasibility studies, laboratory tests, but also a wide range of other services such as joint idea searches, project application formulation, project management, partner searches, etc. These services are particularly relevant for smaller companies, which lack competencies in project management. As one interview partner from a private research organisation put it: "The small food firms in Vienna do not know how to plan a large project and they do not have the human resources for carrying out such a project. They need a partner, not only concerning technology but also regarding project management."

The high importance of local scientific and research organisations and the proactive "knowledge selling approach" adopted by these institutions have to be seen in the light of ongoing changes in the RIS subsystem of knowledge generation and diffusion. Like in many other countries, research organisations in Austria and Vienna face a growing pressure to transfer their knowledge to industry and to commercialise their scientific findings (Trippel and Tödting 2008). In Vienna, this trend was first observable in the fields of biotechnology and ICT. Meanwhile, also other university departments and research organisations, including those which carry out food relevant research, adopt such strategies. In the case of the RIS subsystem of knowledge generation and diffusion, thus, Vienna's attempts to embrace the knowledge economy are positive for innovation in the local food sector, fostering a strong embeddedness of firms in their regional institutional context.

These findings must not hide the fact that in Vienna's food sector some barriers to fruitful university-industry partnerships exist. Interviews with representatives from knowledge providers and industry experts have shown that some firms are still rather reserved when it comes to establish contacts to and interact with universities. Furthermore, firms' limited financial resources for R&D, their low propensity to financially compensate for the knowledge generated by research organisations and a lack of expertise and know-how, reflecting problems of cognitive distance and absorption capacity on the side of the companies have been identified as factors complicating successful forms of knowledge transfer.

The regional policy system

Finally, we also explored whether the investigated food companies have linkages to Vienna's policy system. We found only little evidence for such relations. This result is not surprising, given the "high-tech mania" that dominates in the local policy community and supporting organisations. As already noted in Section 3.1, the regional policy subsystem is characterised by a strong focus on promoting young research-intensive sectors. There are hardly any policy initiatives, financial incentives and support measures for boosting innovation in more traditional industries.

4 Summary and Conclusions

In the past, innovation and technological change have often been equated with high-technology industries. Recent academic work on low-tech innovation has demonstrated that this view is too narrow and misleading, because more traditional sectors also face substantial learning challenges and engage in different forms of innovation activities. Various scholars have highlighted that innovation in low-tech sectors differs markedly from those in high-tech industries, pointing to low levels of R&D, a high relevance of in-house practical knowledge, a strong reliance on suppliers of embodied technologies and a dominance of incremental innovation.

Whilst this literature has increased our appreciation of the richness of the innovation process in traditional sectors, little is still known about the degree and modes of embeddedness of low-tech sectors in their socio-institutional environments. This holds in particular true for low-tech industries which are situated in high-tech contexts. The paper departed from the RIS approach and proposed the conceptual argument that the different RIS subsystems and the spatial dimension of innovation links to various knowledge sources require close investigation to enhance our understanding of how low-tech sectors are related to their high-tech environments.

Empirically, the focus of the paper was on the food sector in the Vienna metropolitan region. It has been demonstrated that Vienna's RIS is characterised by an increasing high-tech orientation. The food industry located in this region was found to be an old low-tech sector which showed little propensity and capacity to innovate in the past but nowadays faces enormous learning challenges. Based on 20 face-to-face interviews with local firms, research organisations and industry experts, the nature of innovation activities and the geography of knowledge linkages have been analysed.

The empirical results on innovation activities have shown that Vienna's food firms engage rather frequently in new product development and process innovations. To a lesser extent we found also evidence for packaging and marketing innovations. However, it was also highlighted that innovation in the Vienna food sector is best described as accumulation of small changes. Innovation activities in the local food industry were found to be not formalised in R&D departments. Learning-by-doing and -using were identified as core strategies leading to a further development of in-house practical knowledge.

Our analysis has demonstrated that innovative firms in the Vienna food sector embrace a wide range of different knowledge sources at various spatial scales, ranging from the local to the global one. It has been shown that interactions with a variety of actors such as customers, competitors and specialised consultancy firms matter, but two specific knowledge sources, namely extra-local suppliers and local research organisations, proved to be of particular importance.

The role of the Vienna's RIS was found to be ambiguous. There were hardly any impulses from the regional policy subsystem, because public authorities and funding agencies in Vienna are mainly focused on promoting high-technology activities and tend to understate the importance and specific needs of more mature sectors. The RIS subsystem of knowledge application and exploitation (i.e. the industry structure) appeared to be of little relevance, too. Vienna is a metropolitan city dominated by the service sector and it was therefore not surprising to observe that it does not host considerable parts of the food value chain, i.e. suppliers of agricultural and intermediate products. However, and less obvious than in the case of the primary sector, we have seen that Vienna also lacks specific strengths in the machinery and packaging industry, forcing local food firms to find partners and specialised suppliers from these sectors elsewhere. In sharp contrast to the aforementioned RIS dimensions, the subsystem of knowledge generation and diffusion (i.e. the knowledge infrastructure) turned out to be an essential driving force for innovation in the Vienna food sector.

Consequently, there was evidence of a "selective embeddedness" of the local food industry in the RIS, i.e. on a coupling with specific parts of the institutional context. Intensive knowledge exchange with local research organisations has indicated rather high levels of integration of the food sector in its socio-institutional context, whilst the absence of local links to companies and policy actors has pointed to rather weak forms of embeddedness. The food sector, thus, meets its innovation demands by using knowledge available within the RIS, whilst at the same time it bypasses the RIS by tapping into the knowledge pools located outside Vienna.

The case of the Vienna food industry has shown that the relation between old industries and their high-tech contexts are more complex than suggested by some

parts of the literature. Vienna's RIS offers potentials and inputs that are mobilised by innovative food companies. Arguably, given the small number of investigated firms we cannot claim that our results hold true for the entire food sector situated in Vienna. Furthermore, given the nature of our study, we do not argue that our findings may be generalized to other low-tech industries and regions. More empirical research is required to enhance our understanding of the opportunities and limits of low-tech innovation in high-tech environments.

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