

Knowledge management for food supply chain synergies – A maturity level analysis of SME companies

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Abstract

Despite the considerable number of papers addressing knowledge management (KM) aspects in supply chains, many research issues in the area are still neglected. One of the main research gaps in this field concerns the maturity level of KM practices adoption by small and medium enterprises (SMEs). This paper addresses this research gap by developing a framework to support the analysis of the maturity level of KM adoption in an SME context. The framework is applied in a multiple case study developed to investigate the extent to which SMEs operating in the food sector are deploying KM practices to support more sustainable initiatives. By relating KM maturity levels, perspectives and processes to sustainable practices concerning food waste and by-product synergies, the paper makes an original contribution to advance theory and practice in the area. The paper also points out potential barriers that companies face to implement sustainability related KM practices.

Keywords: Knowledge management; Food supply chain; Food waste and by-product synergies

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1. Introduction

Food manufacturing represents the single largest manufacturing sector in the UK, where the food and drink manufacturing contributes approximately £27 billion to the economy and employs around 3.8 million people (Defra 2016a). The backbone of the food industry as a whole is formed by a substantial number of small and medium enterprises (SMEs), which together account for over 90% of businesses, 32% of employment and 24% of turnover (Defra 2016b).

In this context, food waste represents a major problem that remains to be addressed. In order to improve its accountability and responsibility towards new expectations of customers and the society, the food sector needs innovative ways of developing concerted actions and collaboration initiatives that improve not only intraorganisational processes within specific production areas, but also the relationship and integration of inter-organisational processes that take into account the flow of food and related by-products across supply chains.

In its 'Ambition 2025: Shaping Sustainable Value Chains' report (FDF 2016), the UK Food and Drink Federation (FDF) acknowledges the importance of working collaboratively with main stakeholders across whole supply chains in order to reduce food waste and improve resource efficiency. To improve the sustainability of food supply chains, the aim is to avoid generating food waste in the first instance and where food waste prevention cannot be achieved, food recovery processes should take place.

In practice, food recovery processes in a supply chain can be implemented through food by-product synergies (BPS) involving concerted and coordinated actions connecting key players such as producers, processors, retailers, consumers, NGOs, governments, etc. In a BPS setting, waste streams from a company's processes are used as inputs into another company's processes where production synergy arises from the opportunity to link waste and by-product streams across companies (Lee and Tongarlak 2017). Major

difficulties to translate such synergy opportunities into actions are, first, to acquire the knowledge of where potential BPS synergies can take place in a food supply chain and, second, how food companies, particularly SMEs, can manage this knowledge to support synergy processes in the supply chain. These are critical issues concerning knowledge management (KM) in supply chains.

Indeed, a recent study by Cerchione and Esposito (2016) points out that KM is a necessary response to the new challenges posed to supply chains and related sustainability issues. Their study shows that although there are a growing number of papers addressing KM in supply chains, many research issues are still neglected and the main research gaps in the area concern the factors affecting the adoption of KM practices (Irani et al. 2017).

This paper addresses this research gap by analysing KM adoption in the food supply chain in an SME context, given the relevance of the sector and the sustainability challenges involved. Accordingly, the specific research questions are set for the study:

RQ1: To what extent can KM be implemented for sustainability purposes in an SME context?

RQ2: What are the main barriers faced by an SME attempting to implement KM to improve food waste and by-product synergies?

To answer these questions we develop a framework for analysing the maturity level of KM adoption in an SME context. For this, we combine core aspects of the Capability Maturity Model Integration (Chrissis, Konrad, and Shrum 2011) and the supply chain maturity grid (Estampe et al. 2013) in order to specify a KM maturity model that can be applied to analyse food waste and by-product synergies. To validate the framework, we apply it to analyse the extent to which particular SMEs operating in the food sector are deploying KM practices to support more sustainable initiatives.

By relating KM maturity level perspectives and processes to sustainable practices concerning food waste and by-product synergies, the paper makes an original contribution to the production and supply chain area by providing a novel framework of analysis that facilitates and supports SMEs to diagnose the extent to which they are implementing KM for sustainability purposes. The paper also points out barriers that SME companies face to implement KM related practices for improving the sustainability of their supply chains. This provides helpful insights to support SMEs in the planning of KM strategies to improve supply chain sustainability.

The paper is organised as follows. The next section develops the theoretical basis for the maturity level framework proposed. In the sequence, we discuss methodological aspects of the research developed. This is followed by a presentation and discussion of the main research findings. The paper concludes by addressing overall conclusions derived from the findings, discussing the research limitations and pointing out directions for future research.

2. Theoretical considerations

The framework here developed is purposefully designed to facilitate the analysis of KM practices related to food waste and by-product synergies in a food supply chain. The synergy processes considered refer to processes involving the exchange of food waste and related by-products between organisations, which may also involve exchange of derived resources such as energy and wastewater. Before specifying the conceptual basis of the framework it is important to address the concepts of ‘food waste’ and related ‘by-product’ the research takes into account.

A first aspect to consider is that food waste does not necessarily mean food that is not proper for consumption, i.e. inedible. For instance, in many food supply chains edible food can be considered as a disposable commodity, and therefore seen as ‘waste’, because

it does not fulfil market aesthetic requisites (e.g. adequate shape, size, weight, visual presentation, etc.) specified by major retailers (Stuart 2009). In some food production scenarios, even food that meets market aesthetic requisites might be considered as waste. This is particularly the case in farming where a surplus of food that meets commerce specifications is produced beyond demand needs as a measure to safeguard against unpredictable weather conditions. Once the supply quota is reached, the surplus produce does not go into the mainstream supply and might end up into disposal processes.

From our framework of analysis, food waste is all food that for any reason is diverted from the supply chain it was originally linked to, regardless of its edibility. This perspective fits the general definition of food waste provided by the Food and Agriculture Organisation (FAO) of the United Nations, which defines food waste as any edible material intended for human consumption that at any point in the supply chain is discarded, degraded, lost, spoiled or consumed by pests (FAO 1981).

The second important concept the framework considers is by-product, which is a form of product residue. According to the European Commission Waste Framework Directive (DG-Environment 2012), a product residue is all material that is not deliberately produced in a production process. A product residue may be a by-product or a waste. To be characterised as a by-product the material should satisfy some requirements such as, it can be lawfully used in other production processes, it can be used without considerable further processing other than normal industrial practice, and its use will not lead to adverse human health and environmental impact. For example, in the apple manufacturing industry pomace is a common by-product whose composition provides a valuable source of carbohydrate, crude fibre, proteins, vitamins and minerals that are of great potential for the biotechnology industry (Mirabella, Castellani, and Sala 2014).

In short, food waste and related by-products are non-desirable outcomes of a food supply chain. These outcomes however may be valuable resources to other processes

inside or outside the supply chain where they were originally generated from. For instance, from a sustainability perspective edible food that is diverted from its original supply chain should flow into alternative food consumption streams. Similarly, food that becomes inedible, and therefore diverted from its original supply chain, may be a valuable feedstock for alternative production systems. These two forms of alternative food waste and by-product supply might not materialise because of knowledge management issues, i.e. the lack of knowledge about potential utilisation streams for the materials involved.

2.1. Maturity level perspectives

A maturity model can be seen as a set of structured managerial capability levels that characterise how well an organisation is performing (Aboelmaged 2014; Bititci et al. 2015). Each maturity level in the model corresponds to a specific stage of managerial capability that a specific organisation is able to implement. In practice, a maturity model is a useful managerial tool that points out strengths, weaknesses and improvement gaps. Achieving a maturity level represents an incremental improvement in performance.

From a process management perspective, a well-known maturity model derived from performance improvement approaches is the classic CMMI – Capability Maturity Model Integration (Chrissis, Konrad, and Shrum 2011). The model specifies five maturity levels of process management practices an organisation may adopt:

1. ***Initial:*** There is no formal specification of processes. Performance is not regularly evaluated either.
2. ***Managed:*** Formal process management activities are in place.
3. ***Defined:*** Processes are formally standardised and aligned with organisational objectives.

4. ***Quantitatively managed***: Performance objectives are set for the processes, whose outcomes are measured quantitatively. Processes are aligned not only with organisational objectives, but also with customer demand.
5. ***Optimising***: The performance of processes is regularly evaluated and improved continuously through formal analysis procedures.

Maturity level perspectives are not limited to intra-organisational managerial practices. They can also involve inter-organisational processes (Pawar and Rogers 2014). This expanded perspective allows the analysis of managerial maturity levels in supply chains. For example, from a supply chain perspective, the supply chain maturity grid specified by Estampe et al. (2013) considers five levels of maturity which includes inter-organisational supply chain relationship and relevant societal aspects, as follows:

1. ***Intra-organisational maturity***: Organisational performance is managed internally only, across different functional areas of the organisation.
2. ***Inter-organisational maturity***: Performance management takes into account integrations with main suppliers and customers.
3. ***Extended inter-organisational maturity***: Performance management takes into account integrations with main organisations upstream and downstream the supply chain.
4. ***Multi-chain maturity***: Performance management takes into account integrations with organisations in other supply chains.
5. ***Societal maturity***: Processes management takes into account alignment with wider industrial production systems which enhance contextual and societal performance.

The maturity models above provide useful frameworks for the characterisation of an organisation's maturity level of KM practices in terms of managerial capabilities and the supply chain scope of the KM processes implemented. In the next section, we develop an integrated perspective of these two frameworks, which are combined to provide maturity level scenarios of KM processes employed to support material synergies in a food supply chain.

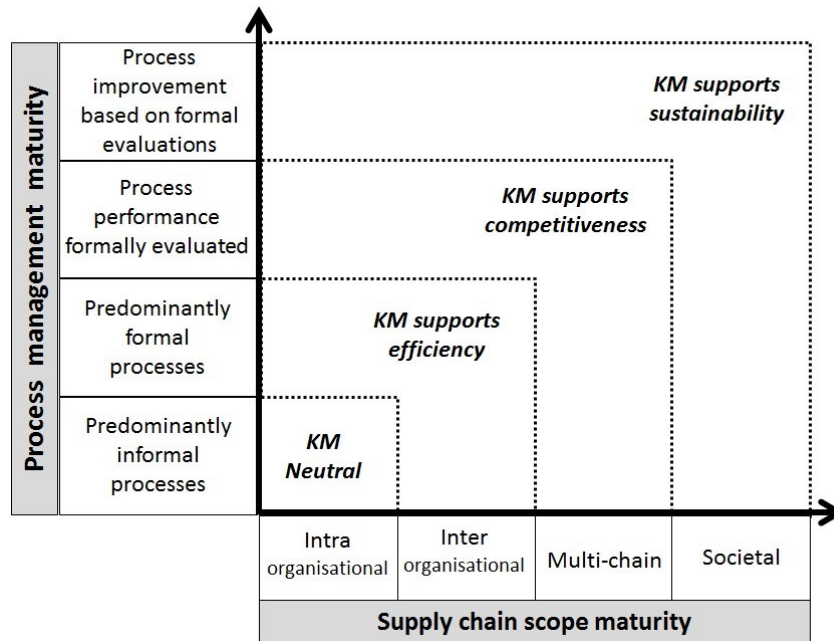
2.2. A KM maturity model for food waste and by-product synergies

In general, the CMMI framework can be summarised in terms of the existence, or not, of formal process management procedures and supporting tools as well as whether process evaluation and improvement activities are being implemented or not by a particular organisation. We use these capability perspectives to specify four levels of increasing maturity degrees ranging from low to high maturity, as follows: (1.) predominantly informal processes, (2.) predominantly formal processes, (3.) process performance formally evaluated, and (4.) process improvement based on formal evaluations.

We draw from the supply chain maturity grid proposed by Estampe et al. (2013) to combine those four process management capability levels with intra and inter organisational dimensions that characterise different maturity levels from a value chain scope perspective. In this sense, scope maturity represents the extent to which KM processes are applied to support value chain processes ranging from functional integrations within an organisation (intra-organisational scope), going through organisational integrations within a supply chain (inter-organisational scope) or between supply chains (multi-chain scope), to wider industrial collaborations (societal scope)

promoting social, economic and environmental sustainability. The resulting integrated framework is shown in Figure 1.

Figure 1 – Organisational maturity of KM adoption



The model above presents four maturity levels, which reflect the potential roles KM can play to support organisational operations and supply chain management. We term the initial maturity level as ***KM Neutral***. At this level, the organisational focus is mainly turned to the internal environment and KM processes are not implemented. Management is characterised by improvisations, where tacit knowledge (i.e. individuals’ implicit knowledge) predominates (Smith 2001). We define the second maturity level as the stage where ***KM supports efficiency***. At this level, operational efficiency becomes the main focus. Explicit knowledge is formally manifested in the form of manuals, procedures, process specifications, inventory levels, production schedules, etc. (Schoenherr, Griffith, and Chandra 2014). KM processes enable more efficient supply chain integrations and collaborations through information exchange and interconnection of software applications between the firm and its major suppliers/customers (Neubert, Ouzrout, and

Bouras 2004). At the third maturity level, KM processes start to be applied to improve organisational competitiveness (*KM supports competitiveness*). KM plays a more strategic role by supporting performance evaluation processes. For example, KM supports processes where Key Performance Indicators (KPIs) are formally established and monitored over time (Valmohammadi and Ahmadi 2015). Historical information and forecasts are stored and made available to managers. Market information is captured through multi-channel integrations that go beyond operational supply chain boundaries, including strategic integrations with supporting businesses (e.g. banks, logistics and solution providers, social media, etc.) which add information value to the organisation's knowledge base and, consequently, lead to improved competitiveness (Ross 2013; Alberghini, Cricelli, and Grimaldi 2014). Finally, at the last maturity level *KM supports sustainability*. In this sense, organisational processes are improved with basis on formal evaluation procedures that take into account sustainability aspects. For instance, KM processes facilitate integrations with external organisations across diverse sectors, where synergistic relationship involving the exchange of resources and information can be developed with the purpose of improving economic, social and environmental performance (Fazey et al. 2013; Pillania 2006).

In a supply chain, high level of collaborations or synergies between firms usually involves the sharing or exchange of resources and knowledge, which leads to better asset utilisation and increased managerial skills and knowledge capability (Bititci et al. 2007). Indeed, among other key KM processes, 'knowledge sharing' is usually considered in different KM classification models. Archetypal KM processes commonly considered in most of the previous studies in the subject are (Hung, Chou, and Tzeng 2011; Sangari, Hosnavi, and Zahedi 2015):

- **Knowledge creation:** The organisation purposefully makes efforts to identify relevant knowledge generated internally (e.g. by converting tacit into explicit

knowledge) or sourced from outside the organisation (e.g. from suppliers, customers or other stakeholders).

- **Knowledge storage:** The organisation applies data management techniques and related technologies (e.g. databases and/or information systems software) to support the storage, organisation, update, retrieval, access and security of relevant information.
- **Knowledge application:** The organisation applies existing knowledge to support decision-making, evaluation and improvement processes.
- **Knowledge sharing:** The organisation actively seeks to disseminate, transfer or exchange relevant knowledge with main stakeholders, internally and/or externally.

The KM processes above mentioned can be used to support a myriad of managerial processes. For example, they can enable learning processes concerning the usefulness (what it can be used for), sources (where it is), availability (how accessible it is), and cost implications (logistics and processing) concerning exchanges and utilisation of food waste and related by-products (Garcia-Garcia et al. 2016; Sgarbossa and Russo 2017). In Table 1 we relate those key KM processes with specific examples of how they can be applied to support food waste and by-product synergies.

Table 1 – KM processes to support food waste and by-product synergies

KM Process	Adoption on food waste and by-product synergies
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<p>Knowledge creation</p>	<ul style="list-style-type: none"> • Food waste and related by-products generated in the company's production processes are mapped and categorised. • The company seeks to gather information from main stakeholders about useful and available food waste and related by-products that can be used as input resources into further production cycles such as production of packaging, fertilisers, organic compost, energy, etc.
<p>Knowledge storage</p>	<ul style="list-style-type: none"> • The company has a catalogue or database where information about food waste and related by-products, either generated in the company or sourced from stakeholders, is systematically recorded. • Information on the availability and usefulness of food waste and related by-products is periodically updated. • Access to the company's database of useful food waste and related by-products is controlled.
<p>Knowledge application</p>	<ul style="list-style-type: none"> • The company uses stored information on food waste and related by-products as a basis to support decision-making processes. • The company regularly assesses the usefulness, sources, availability, and cost implications concerning food waste and related by-products. • New processes are implemented, or existing processes are improved, with basis on information about the usability of

	<p>available food waste and related by-products.</p> <ul style="list-style-type: none"> • The company considers suppliers' potential in terms of useful food waste and related by-products they can provide. • The company uses knowledge on food waste and related by-products to develop its economic, social and environmental performance.
Knowledge sharing	<p><input type="checkbox"/> The company disseminates, transfers or exchanges relevant information about the sources and usability of available food waste and related by-products with relevant stakeholders, internally and/or externally.</p>

Despite the positive aspects above mentioned, several studies have identified potential barriers to KM adoption by organisations (Lotti Oliva 2014; Patil and Kant 2014; Lin, Tan, and Chang 2008). In general, three potential barriers usually emerge from previous studies, namely: (1.) barriers related to technology, (2.) barriers related to the organisation, and (3.) barriers related to people.

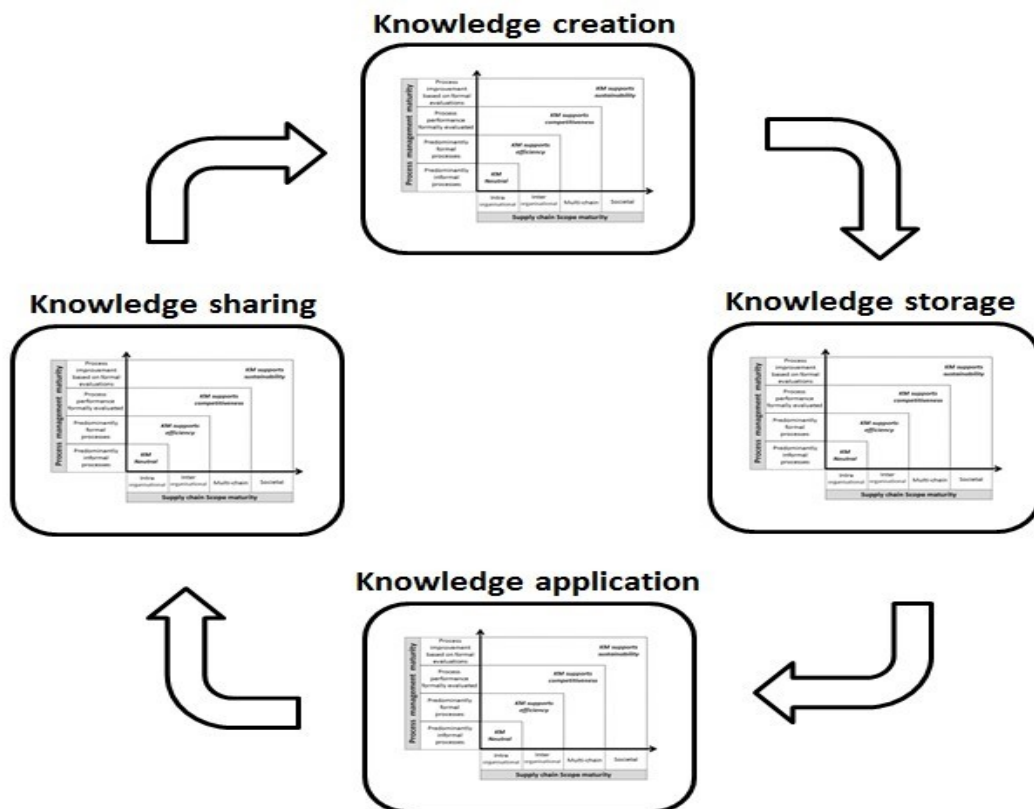
Indeed, technological limitations, inefficient communication channels, unclear process specifications, and cultural aspects might significantly hinder knowledge creation, storage, application and sharing. For instance, a study by Riege (2005) revealed that many organisations fail to implement knowledge sharing when they attempt to change their organisational culture in order to adopt KM practices, rather than adjusting the KM practices to their culture.

In this study, barriers to KM adoption will be analysed from the three predominant perspectives above mentioned.

3. Methodology

Overall, the conceptual model (Figure 1) and KM process characterisations discussed in the previous section provide a valuable framework for the analysis of maturity levels of KM adoption to support food supply chain synergies. The practical application of the framework involved a recursive approach for the analysis of maturity levels in relation to each of the four key KM processes considered in the study (knowledge creation, storage, application and sharing), as shown in Figure 2.

Figure 2 – Recursive analysis of KM maturity levels



To get in-depth insights and develop an exploratory analysis of the KM maturity level in an SME context, we adopted a multiple case study research method. The case study method is considered to be the most suitable methodology with regard to the exploratory nature of the study (Voss, Tsiriktsis, and Frohlich 2002). The multiple cases approach provided a broader perspective of the organisational processes being studied,

giving researchers the possibility of checking the research issues in different but somewhat similar SME organisational contexts (Yin 2013).

In total, we have contacted 10 SMEs operating in the food sector to participate in the study. These companies were subject of a larger European study being developed in Hungary and Romania. Therefore, convenience sampling where subjects are selected because of their convenient accessibility and proximity to the researcher (Bryman and Bell 2015) was the methodological premise adopted to select the companies for the multiple case study. It was also a valuable opportunity for the researchers to generate insights from these particular developing economies, this way expanding the contribution of the paper not only to theoretical and practical aspects of the subject, but also to providing regional European perspectives of the matter. Six among the 10 invited companies agreed to participate in this study. Table 2 identifies the cases involved in the study. The names of the companies are not revealed in order to keep their anonymity, as requested.

Table 2 – SMEs involved in the study

	Location, country	Main business activity & output	# of employees	# of interviews
1.	Rakamaz, Hungary	Distillation of fruit-mash, approx. 1000 litres a month	4	1 Manager
2.	Kecskemét, Hungary	Seasonal bakes manufacturing, range of 10 organic small bakes	20	3 Managers
3.	Laskod, Hungary	Dry pasta manufacturing, 20 types of pasta	19	4 Managers
4.	Tura, Hungary	Bakery and retail shops, range of 120 baked products	20	5 Managers
5.	Miercurea Ciuc, Romania	Food catering, 500 people a day	20	4 Managers
6.	Odorheiu Secuiesc, Romania	Pickled vegetables manufacturing, 30 types of pickles	2	1 Manager

Primary data was collected through semi-structured interviews with 18 managers

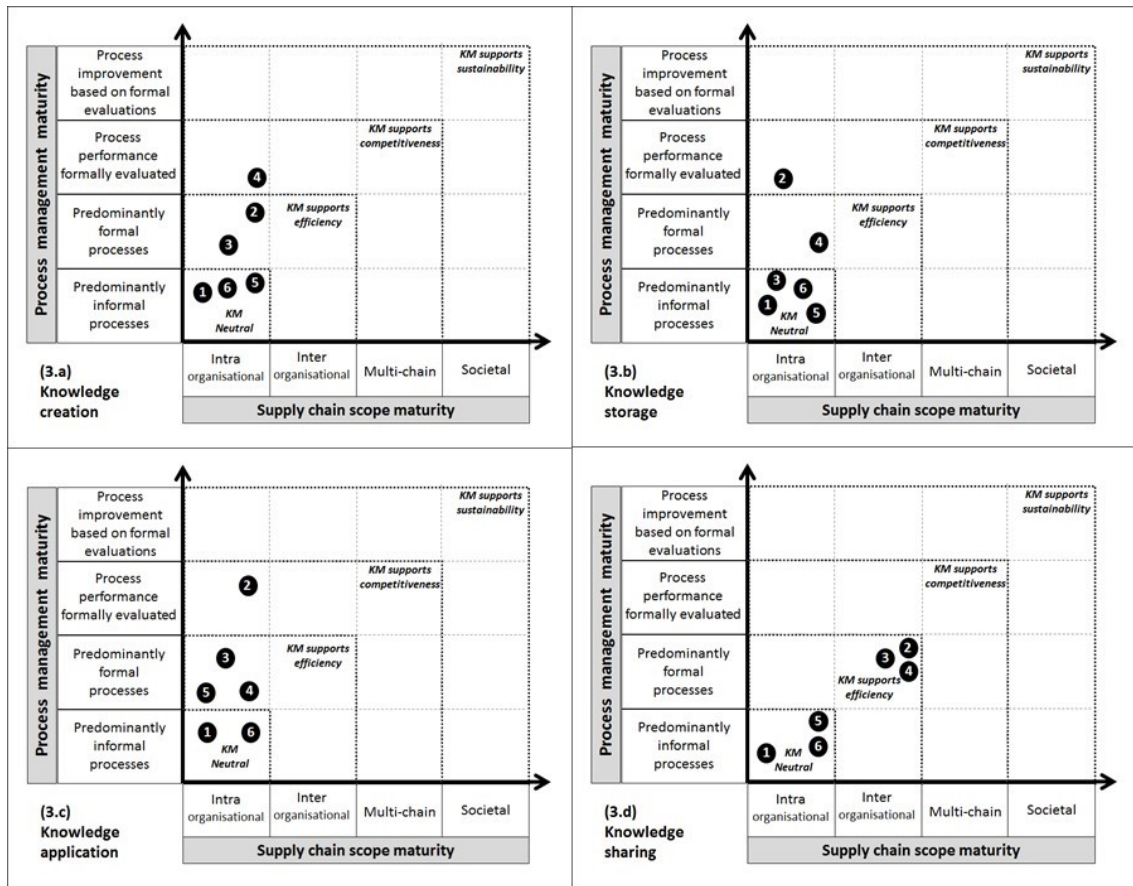
(including owners/managing directors) across the companies who were formally or informally involved with KM processes in their respective organisations. Each interview lasted 60 minutes on average, which was sufficient to capture the main organisational features against the main KM processes to support food waste and byproduct synergies specified in Table 1 and the maturity model of KM adoption shown in Figure 1. The data was analysed according to the recursive approach presented in Figure 2. For this, we have initially mapped each company's KM capability in terms of the KM maturity level manifested in each of the four key KM processes to support food waste and by-product synergies, namely: Knowledge creation, storage, application and sharing.

Specifically, the research team initially analysed data from the interviews conducted in SME company 1 (Table 2) describing process management practices and the supply chain processes that were related to **KM creation** practices (Table 1). Through comparison and discussion of each researcher's individual analysis, a consensual position or point was plotted in the KM maturity level framework (Figure 1) to represent the company's maturity level of KM creation in terms of process management practices and the scope of supply chain processes. The same mapping method was recursively applied to analyse the company's capability concerning **KM storage, application and sharing** (Table 1). The same method was also applied to analyse SME companies 2 to 6 (Table 2). The final outcome of the analysis yielded a graphical view of each's company's KM maturity level (Figure 3) for the four KM processes to support food waste and by-product synergies. The general outcomes of the research are discussed next.

4. Discussion of findings

The results of the qualitative mapping are shown in Figure 3, which is followed by an overall discussion of the findings.

Figure 3 – KM maturity level of the SMEs studied



Knowledge creation

In terms of knowledge creation about food waste and related by-products, most of the companies attempt to generate and capture information on this matter. However, half of the companies studied are mainly KM Neutral and do not implement this process in a systematic manner. Out of the six companies, one company systematically maps and categorises waste and related by-product information aiming at improving their competitiveness. All companies mainly gather information on waste streams from their internal production process, showing intra organisational focus with narrow supply chain scope maturity. Three companies reported that legal regulation from their respective government is a helpful source of information, which they use to improve how they handle waste and related by-product materials.

Further, we examined how the SMEs seek to gather information from main stakeholders about useful, and available food waste and related by-products that can be

used as input resources into further production cycles such as production of packaging, fertilisers, organic compost, and energy. The interviews revealed that there is no systematic and consistent practice on seeking this type of information across the supply chain.

Inquiring about the difficulties SMEs face, we found that it is challenging to get and process information about the available opportunities to reuse and recycle food waste or related by-products. One interviewed company mentioned that there is a need for a central information coordination system, which could facilitate information capture and sharing (e.g. an information ‘hub’ supported by the government or an NGO).

Knowledge storage

In terms of knowledge storage, we examined if the companies have a catalogue or database where information about food waste and related by-products, either generated in the company or sourced from stakeholders, is systematically recorded and how is it used. There is little evidence that SMEs have a well-maintained database for waste and related by-products. There are some forms of databases and formal processes supporting KM efficiency and competitiveness. However, in most cases the figures of food waste and related by-products are roughly estimated and stored in non-automated systems.

Although most of the companies have full access and control of the information about their food waste and related by-products, most of them occasionally update information on the availability and usefulness of food waste and related by-products in order to maintain mandatory bookkeeping and regulatory standards.

The main difficulties the SMEs have to store information on food waste and related by-products are lack of knowledge management systems and lack of KM

managerial skills, i.e. there is little knowledge on what to measure and how to systematically store information on food waste.

Knowledge application

We explored how SMEs use stored information on food waste and related by-products as a basis to support decision-making processes. Interestingly, despite the lack of formalised and searchable database about food waste and related by-products, most of the SMEs tend to use their tacit knowledge in the area to improve their operational efficiency. One SME in particular emphasised that information on waste dynamically influence the decisions on their products' price. Most of the SMEs also use food waste information for community engagement purposes. In addition, although informally, they attempt to regularly assess the usefulness, sources, availability, and cost implications concerning food waste and related by-products. One manager highlighted, *“the decisions we make are based on evaluating the cost-benefit of waste disposal and reuse”*.

Further, most interviewed SMEs have developed new production processes, or improved existing ones, with basis on information about the usability of available food waste and related by-products. For instance, one respondent reported that *“we introduce new product, for example pickle without preservatives, which may also reduce the amount of waste in our production”*.

We further inquired if the companies consider suppliers' potential in terms of useful food waste and related by-products they can provide. In most cases, the SMEs do not make use of the potential of their suppliers to use food waste. However, they acknowledged that this type of information could play a critical role on facilitating engagement with suppliers.

One interesting finding relates to how SMEs use knowledge on food waste and related by-products to develop their economic, social and environmental performance. There is a clear difference between comparatively larger SMEs and the smaller ones with

limited work force and resources. Larger SMEs seek to use existing knowledge on food waste to develop their sustainability performance. However, this does not represent a concern of smaller SMEs.

Finally, most of the SMEs reported that the main difficulty of using information about food waste and related by-products as a mean to improve their competitiveness and sustainability performance is the lack of a measurement framework. In practice, the SMEs are still struggling to find a systematic method to acquire information, store and use when applicable. One SME manager mentioned, “*The method of how to destruct [reuse or recycle] waste/by-products is too circumstantial, expensive, not cost-effective and it is not feasible at small-scale level*”.

Knowledge sharing

About knowledge sharing, we investigated if the SMEs disseminate, transfer or exchange relevant information about the sources and usability of available food waste and related by-products with relevant stakeholders, internally and/or externally. In this regard, most of the SMEs seek to share information with key stakeholder. However, half of them implement this process on an informal basis and tend to focus more on internal communications. The other half attempts to share information through more formal communication processes with other organisations. Yet, these processes tend to happen more on an ad hoc basis, almost incidentally.

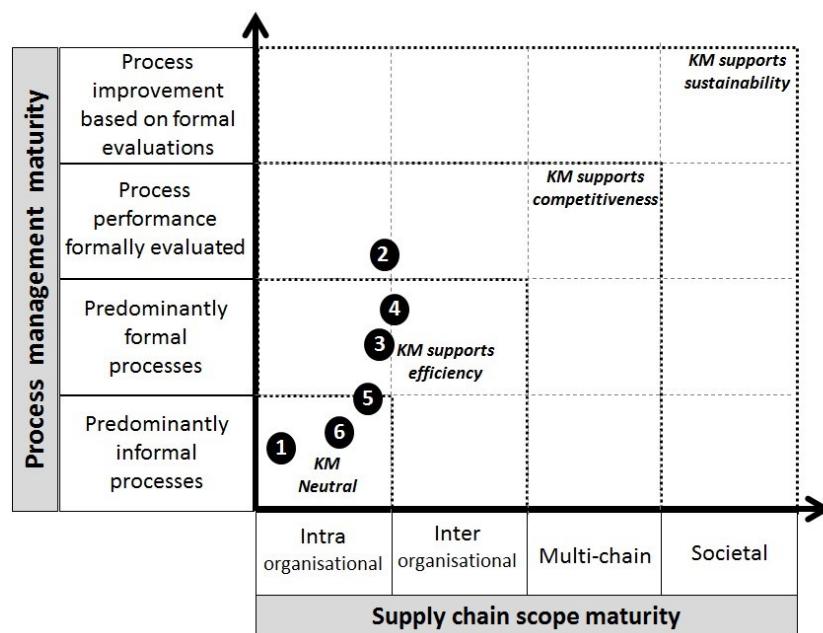
A common aspect of the three SMEs seeking to implement KM to support efficiency (Figure 3.d) is the close connection to their respective association organisations, which according to them is a valuable central point for information exchange in general and exchange of information about useful food waste and related by-products in particular. Again, the smaller companies are more reluctant to share their knowledge compared to larger companies.

The main difficulties the companies face in terms of knowledge sharing with suppliers are the concern with market competition. Due to the complexities involved, they also find it difficult to provide information required by new government regulations in the area. In this respect, one SME manager reported, “...small businesses are not prepared for these kinds of regulations at all, neither regarding the amount of waste nor multi-directional waste handling”.

Overall, there is little evidence of cooperation among stakeholders in terms of information sharing on food waste and related by-product use. However, a larger SME with more resources is likely to implement knowledge sharing processes with key stakeholders in order to establish more efficient supply chain integrations.

To summarise the main research findings discussed above, Figure 4 presents an aggregate model indicating the overall KM capability of the organisations analysed.

Figure 4 – Overall KM maturity level of the SMEs studied



Likewise, Table 3 presents a summary of the main barriers the SMEs face to implement KM practices to improve food waste and by-product synergies.

Table 3 – Main barriers to implement KM processes

KM Process	Implementation barriers
Knowledge creation	<ul style="list-style-type: none"> • Difficulty to get and process information about the available opportunities to reuse and recycle food waste or related by-products • Inexistence of a central information coordination system, which could facilitate information capture and sharing (e.g. an information ‘hub’ supported by the government or an NGO)
Knowledge storage	<ul style="list-style-type: none"> • Lack of KM systems (i.e. software application systems) • Lack of KM managerial skills • Lack of knowledge on what to measure
	<ul style="list-style-type: none"> □ Lack of knowledge on how to systematically store information on food waste
Knowledge application	<ul style="list-style-type: none"> • Lack of a KM measurement framework • Difficulty to find a systematic method to acquire information, store and use when applicable
Knowledge sharing	<ul style="list-style-type: none"> • Concerns with market competition • Difficulty to provide information required by new government regulations in the area due to the complexities involved

5. Conclusion

An important overall conclusion we reached from the analysis above is that the implementation of knowledge management to support sustainability initiatives such as food waste and by-product synergies across the food supply chain is still far from the operational reality of most SMEs. Understandably, SMEs with a small workforce and limited information system resources do not focus their attention on implementing KM processes for sustainability purposes. Due to external constraints, e.g. government regulations pressing for the environmental sustainability of businesses, they mainly attempt to capture, process and provide information about food waste and related byproducts derived from their internal processes. Such initiatives however are predominantly informal and not systematic, based mainly on tacit knowledge capabilities.

Despite these limitations, the awareness of the benefits promoted by sustainable initiatives is growing and SMEs with a more defined growing strategy for their businesses are attempting to develop their KM capabilities in order to move from a KM Neutral state to more mature levels that in the long term can reach the level to support their sustainability efficiency and competitiveness. Still, the current initiatives by the SMEs studied are mainly developed to improve their internal processes and they are not necessarily targeted at improving wider supply chain collaborations.

The study makes valuable theoretical and practical contributions. For instance, on the theoretical side the analytical framework provides an integrated perspective of analysis that combines core aspects of the CMMI (Capability Maturity Model Integration) related to process management maturity and the supply chain maturity grid that take into account the scope of the inter-organisational supply chain relationships and relevant societal aspects (Estampe et al. 2013). The paper also characterises the KM capabilities related to the four intersection points of the two maturity perspectives (process management

maturity and supply chain scope maturity) combined, suggesting a typology for 4 KM maturity levels, namely: KM Neutral, KM supports efficiency, KM supports competitiveness and KM supports sustainability. On the practical side, the paper provides a helpful managerial tool to diagnose the KM maturity state of specific organisations regarding the sustainability capability of their supply chains. Overall, the framework facilitates analysis by providing a logical conceptual basis and a practical graphical reference to position organisational capabilities in terms of KM processes and supply chain scope.

The study and proposed framework are however not exempt from the limitations inherent to the research approach here developed. We cannot generalise the research findings and conclusions reported in this paper to organisational and regional settings beyond the ones considered in the study. Such research limitation nonetheless is typical of case study approaches and, as also typically justified in such types of research, our intention was not necessarily to derive generalisations from the study, but to validate the application of the framework developed on field. Such validation inherits the research limitations of the approach and this very fact determines the areas where future research can be developed.

For example, the framework developed can be used in further research to analyse the KM maturity level for the sustainability of SMEs in other sectors and regions. Moreover, despite its qualitative basis the framework is a potentially quantifiable analytical tool. In other words, it can be used as a basis for future quantitative studies in which its dyadic dimensions (process management maturity and supply chain scope maturity) and their respective characterisation constructs can be quantified. Such quantitative approach can be used in large surveys to investigate relationships between the dimensions and constructs developed, as well as to support comparative analysis between companies and regional contexts.

Finally, the SME weaknesses identified, in what concerns organisational KM capabilities to promote food supply chain synergies, at the very least points out relevant gaps calling for more professional managerial practices and further investigations of the theoretical aspects addressed.

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