Socio-economic implications of food waste: Economics of innovation

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1 Executive Summary

The objective of this report, elaborated within the framework of EU REFRESH Task 4.1.5, is to analyse the economics of innovation and its implication for food waste, namely to evaluate the economic factors effecting the adoption, by businesses, of innovations aimed at preventing or reducing food waste. Behavioural factors (typologies and interrelationships) which impact on innovation adoption are, instead, the object of D4.1b. Here, technological and organisational innovations are studied.

The analysis was carried out using a four step approach that included: 1) A literature review to identify different types of innovations (i.e. technological and organizational innovation) and the economic factors affecting the decision to adopt these innovations; 2) An inventory of food waste reduction possibilities along the supply chain through innovation; 3) A mapping of the results of steps 1 and 2, in order to identify the links between factors of adoption and food waste reduction possibilities (food waste drivers), using system map approach; 4) An analysis of the potential economic implications in terms of food waste reduction of innovation deployment and diffusion.

In this report, innovation was defined as «a process of translating an idea or invention into a good or service that creates value or for which customers will pay». In turn, an idea can be called an innovation if it is replicable at an economical cost and satisfies a specific need. Based on literature, the following types of innovation can be distinguished:

1. Technological innovation (process and product innovation),
2. Organizational innovation,
3. Marketing innovation,
4. Non-technological innovation (e.g. social innovation).

As mentioned above, this study focuses on the first two types of innovation.

Technological innovation includes product and process innovation, both associated with the development or application of new technologies. An organisational innovation is the implementation of a new organisational method in business practices, workplace organisation, or external relations

The main findings on technological innovation can be summarised as follows:

- Its adoption is mostly driven by economic incentives;
- Factors hampering its adoption are mainly related to costs/finance and risk associated with the costs;
- Next to the availability of financial resources, the willingness to pay (consumers' acceptance of the innovation) is also an important factor affecting the adoption decision;
- The speed of action is an important factor affecting the path of diffusion;

- Its adoption and diffusion depends also on territorial specificities (social, legal, and cultural context).

The main findings on organizational innovation can be summarised as follows:

- The ultimate drivers of organisational innovation are economic ones: improving firm performance, productivity, (international) competitiveness;
- Research on organisational innovation is still highly dispersed, and empirical findings are hardly comparable;
- There are two main perspectives on the role of organisational innovation: 1) it occurs in the course of process or product innovations, and 2) it is a necessary precondition of technical innovation;
- It presents a number of stylized facts:
  - R&D has a positive effect on product innovation in manufacturing while it is less relevant for organisational innovation;
  - ICT is particularly important for organisational innovation, as the introduction of information technology causes a transformation of the firm, investment in intangible assets, and a change in the relation with suppliers and customers;
  - Other factors affecting organizational innovation are a firm structural characteristics (size, workforce, education level of the work force, market geographic scope) and the external search for new knowledge (through internal sources, market sources, or professional sources);
  - The institutional context may moderate the performance results accrued from organisational innovations;
- Firms' innovation in food industry and retail is affected by their characteristics, managers' characteristics, inter-organisational and intra-organisational ties;
- Drivers of organisational innovations are the reorganisation of management, possibilities of collaboration (suppliers, retailers, customers), and vertical integration.
- Barriers of organisational innovations are low trust levels, pressure of retailers, costs, differences in expectations, vertical integration, and the regulatory environment.

Technological and organizational innovation impact on a number of food waste drivers. Technological innovation may help reduce food waste through:

- Better selection of products in the primary sector (e.g. while fishing),
- Improved storage conditions,
- Access to modern equipment and techniques,
- Better measurement systems,
- Electronic ordering systems and automatic ordering.

Organizational innovation may help reduce food waste through:

- Reduction of production errors, improper stock rotations, grading and sorting of the products by adopting *business practices* for:
  - Employees' development and retention,
  - Knowledge codification (e.g. establishing databases of best practices),
  - Quality control and logistics mechanisms,
  - Management systems;
- Reduction of (cold) chain inefficiencies by improving *workplace organisation:*
  - Build-to-order production systems (integrating sales and production) or integration of engineering and development with production;
- Improvement of inefficient relationships between suppliers and distributors, by targeting *external relations*:
  - New types of collaborating customers, new methods of integration with suppliers, outsourcing or subcontracting of business activities (production, procuring, distribution, recruiting, and ancillary services).

Although innovations can play a crucial role in preventing and reducing food waste, they still have to be economically feasible in order to be adopted by businesses of the food supply chain. The literature review showed that the ultimate reasons for adopting innovation are economical, and can be classified as follows: (1) improving firm performance, (2) improving productivity; (3) improving international competitiveness. Costs, and the risks associated with them, seem to be the most important determinants of technological as well as organisational innovation. All factors which do not relate to the standard economic theory of selfish, profit-maximizing businesses are described in D4.1b. Besides, the literature review pointed out that product and process innovations do not have a positive effect without organisational innovation, and that productivity gains result from the combination of both technological and non-technological innovation .

Geographic scope or territorial specificity was identified as another important determinant of technological and organisational innovations. Cultural differences increase the difficulty of implementing new management practices, especially if the distance is large. Also, due to different enabling environments, technological innovation may be quickly adopted and spread in one location, while in other places its adoption and diffusion may be restricted. In general, innovations are not following the same process of diffusion everywhere, leading to different local outcomes.

Altogether, it can be concluded that the adoption and diffusion of technological as well as organizational innovations to prevent and reduce food waste is a multidimensional process, and there will always be early adopters and laggards.

2 Background and objectives

The overall objective of REFRESH Working Package 4 is to develop an in-depth understanding of food waste related business and consumer behaviour. With reference to the behavioural economics and decision theories, WP4 will identify the main socio-economic drivers and unrevealed economic agents' decisional processes affecting food waste, will integrate evidences across the project to ascertain the most cost-effective mechanisms to reduce food waste, and will provide a decision support tool to allow economic agents' and policy makers' to simulate the outcome of different technological and policy options on food waste phenomena at EU and national levels.

The specific objectives of Working Package 4 include:

Obj. 1: Measuring the effects of major tangible socio-economic factors on food waste, and identifying hidden / emerging profiles of consumer' and business' behaviours implying waste generation and reduction.

Obj. 2: Developing a simulation model to ex-post and ex-ante analyse - on a multi-scale level - the impacts that socio-economic conditions, consumers' and businesses' behaviours, technological and social innovations, and policy measures determine on food waste.

Obj. 3: Enhancing the performances of the food systems, and supporting the enforcement of consumer-oriented measures and close-to-the market interventions.

The present report (D4.1c) is part of Task 4.1 Socio-economic implications of food waste which is aimed at the identification of the causal factors that link the major socio-economic conditions, the economic agents' choices, and the creation / reduction of food waste. D4.1c wants to identify and discuss the potential economic implications of food waste generation and reduction in relation to innovation deployment and diffusion.

3 Introduction

Approximately one third of food produced for human consumption is lost or wasted globally, while millions of people in the world do not have enough food to eat. Food waste, however translates not only into human hunger, but also into a tremendous waste of resources and financial losses to food producers (Parfitt et al. 2010) resulting in less efficient food production. One of the possibilities to enhance food production efficiency is the adoption of innovations aiming at prevention and reduction of food waste. FUSIONS studies have already addressed the importance of social innovation in reduction and prevention of food waste (See Fusions works such as Easteal, 2013; Bromley, 2016). Besides, the need for technological innovations in prevention and reduction of food waste has been highly emphasised (Canali et al., 2014). Although innovations could play a crucial role in preventing and reducing food waste, they still have to be economically feasible in order to be adopted by decision makers in the food supply chain. Thus analysing the economic factors affecting the decision makers' decision to adopt the innovations to reduce and prevent food waste is of high importance.

The objective of this study is to analyse economics of innovation and its implication for food waste, namely to evaluate the factors effecting the adoption of innovations by businesses' to prevent and reduce food waste.

The results of this study serve as input for Task 4.1.3/ and Task 4.1.4 of REFRESH project. Social and behavioural aspects affecting the adoption decision of innovation are out of scope of this study and will be explored in Task 4.1.3. This Task focuses mainly on technological and organisational innovations. Social innovation is not part of this study since it has been discussed widely in a FUSIONS project and mostly involves social and behavioural factors rather than economic factors that could affect the adoption decision by businesses. For detailed information regarding social innovation please refer to FUSIONS reports[1].

The report is organised as follows. Section 2 describes the objective of this report followed by an explanation of the methodology (section 3). Section 4 is devoted to background information and definitions used in this study. The analysis of food waste reduction possibilities along the food supply chain through innovation and evaluation of the economic factors affecting adoption of innovations are carried out in Sections 5 and 6 respectively. Section 7 finalises the report with conclusions from the study.

[1] FP7 FUSIONS: http://www.eu-fusions.org/index.php/publications/268-stimulating-social-innovation-on-food-waste

4 Methodology

In order to analyse the potential economic implications of food waste generation and reduction in relation to innovation deployment and diffusion, four main steps – summarized in Figure 1 - were undertaken:

1. A literature review to identify different types of innovations and the economic factors/drivers affecting the decision to adopt innovations;
2. An inventory of food waste reduction possibilities along food supply chain through innovation;
3. A mapping the results from steps 1-2 to analyse the links between economic factors of adoption and food waste reduction possibilities (food waste drivers) using a system map approach;
4. An analysis of the potential economic implications of food waste reduction in relation to innovation deployment and diffusion affecting the decision of businesses to adopt a specific innovation.

Figure 1. Methodological steps of the study

First, a literature review is carried out to identify on the one side the different types of innovations in the agri-food sector and on the other side, the economic factors/drivers affecting the decision to adopt innovations to prevent and reduce food waste by businesses. Within this literature review the trade-offs between different economic indicators such as trade-offs between different economic indicators such as public and/or private investments, returns/benefits, risks, incentives, information asymmetries, high up-front costs, learning curve costs reduction and commitment are identified. Furthermore the reason for differential timing in innovation spread are explored.

The literature review has been carried out through the following steps:

- Identification of the research terms (for example: *Type of innovation + adoption of innovation + economic factors of innovation + agri-food sector+ product+ food waste*)
- Identification and research in the relevant databases such as Scopus and Web of Science
- Search of the relevant publications,
- Analysis and summary of the evidence with a specific focus economic factors affecting adoption of innovation and food waste (results from step 3).

Following the literature review, an inventory of the input from FUSIONS study [2] was carried out to explore drivers of food waste in the supply chain that can be prevented and reduced by means of innovations (e.g. technological, organization).

The outputs of the literature review and of the inventory of FUSION inputs were then mapped systematically to present graphically the links between factors affecting the decision of businesses to adopt a specific innovation and the areas where food waste can be prevented and reduced by means of innovations.

Finally, based on this system mapping, potential economic implications of food waste generation and reduction in relation to innovation deployment and diffusion were qualitatively analysed.

[2] FP7 FUSIONS: http://www.eu-fusions.org/index.php/publications

5 Innovation types & adoption factors

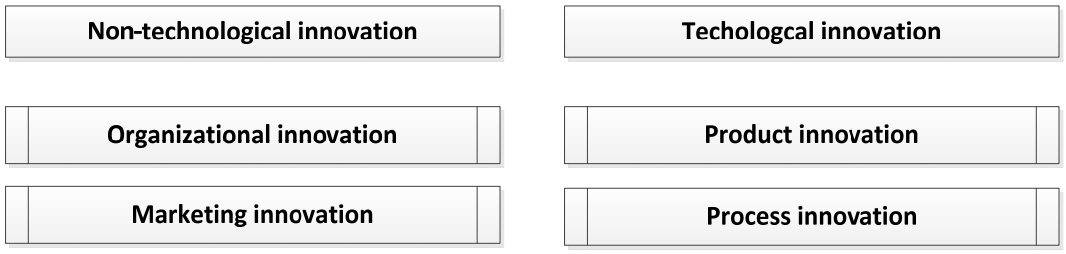
Here "Innovation" is defined as "the process of translating an idea or invention into a good or service that creates value or for which customers will pay". This definition was chosen since there is also a direct link made to the economics of innovation. "To be called an innovation, an idea must be replicable at an economical cost and must satisfy a specific need. In business, innovation often results when ideas are applied by the company in order to further satisfy the needs and expectations of the customers. In a social context, innovation helps create new methods for alliance creation, joint venturing, flexible work hours, and creation of buyers' purchasing power"[3].

The traditional concept of innovation in firms distinguishes **product and process** innovation. Since both are typically associated with the development or application of **new technologies**, these innovations are often called technological innovations. The technological view on innovation has been criticised for not fully capturing innovation in services and for ignoring important elements of innovative activities of firms, e.g. adopting new and re-organise existing business routines, external relations and marketing. The critics conclude that a broader concept of innovation which includes non-technological innovation is needed. The OECD and Eurostat have adopted this view by introducing organisational and marketing innovation (Schmidt and Rammer, 2007).

So, the Oslo Manual for measuring innovation defines four types of innovation: **technological** innovation (consisting of **product** innovation and **process** innovation), **marketing** innovation and **organisational** innovation (OECD, 2005).

The inclusion of marketing and organisational innovations creates a more complete framework for innovation, one that is better able to capture the changes that affect firm performance and contribute to the accumulation of knowledge (OECD, 2005).

Figure 2. Types of innovation



These types of innovation basically come from the literature that distinguishes mainly between process, product / services, business, marketing and organisational innovation (Pleschak and Sabisch, 1996; Porter, 1990; Schülin, 1995; Vahs and Burmester, 2005). Henry and Walker (1991) also mention more diffi-

[3] businessdictionary
http://www.businessdictionary.com/definition/innovation.html#ixzz3l9D3JMCm

cult to define types of innovation such as a shift in corporate culture (Henry and Walker, 1991) or social innovations[4].

As it can be seen from the definitions provided above, the innovation can be broadly defined and can have different types. This study is exploring mainly technological and organisational innovation and touches briefly social innovation. The marketing innovation, particularly correlated to the market activities of the firm, like product diversification, customer satisfaction, etc. and is out of scope of this study thus is not discussed broadly.

In the context of food waste prevention and reduction innovation can play a crucial role. FUSIONS studies have already addressed the importance of social innovation in reduction and prevention of food waste (outcome of WP 3 and WP4). Besides, the need for technological innovations in prevention and reduction of food waste has been highly emphasised (Canali et al., 2014). From an economic point of view it can be the case of investments (as one of economic indicators) in new technologies (e.g. refrigerators/cooling, storage environment, packaging), new services (e.g. redistribution of surplus food), marketing and branding (e.g. promotion on “wonky“ products, “best before”) that can prevent and reduce food waste.

However, there could be a trade-off between the level of investment in innovations (e.g. new technologies) and levels of food waste. Similar trade-offs can be found also in investments in social innovations (e.g. redistribution activities). Thus exploring the factors affecting the driving factors that influence businesses’ and consumers' choices in adoption of a certain innovation in creation/ reduction of food waste is essential.

5.1 Technological Innovation

Technological innovations can be related to products or processes: product innovations involve the creation of new products or services through a process in which ideas are finally produced and commercialized by the firm; whereas, through process innovations the firm develops or modifies new products or services. In general, process innovations are driven by cost-reduction concerns, while product innovations are aimed at differentiation (Martinez-Ros, 2000). In both, the innovative process is influenced by expenditure level, type of R&D (for example, by means of internal or external structures), and by technological characteristics of innovation like uncertainty and appropriability (Rogers, 1983; Teece, 1996).

According to Schumpeter’s model, the innovation process is generated by the creation of an idea; when it reaches the market, it becomes a true innovation and, at the end of the process, it becomes part of normal practice and procedure (Schumpeter, 1939). The evolution process from invention to innovation assumes that the innovator has the financial means, market knowledge, as well as specific skills (Winter, 2006).

[4] Source: http://giqs.org/fileadmin/web_giqs/content/PDFs/dok_maren.pdf.

A limited amount of research is available on the adoption of technologies and innovations within agricultural contexts in developed countries. These have covered the adoption of organic or genetic engineering practices within Australian agriculture (Wheeler, 2008), precision agricultural technologies (PATS) (Tey and Brindal, 2012), vineyards in New Zealand (Cullen et al., 2013) and Australian wool farmers (Sneddon et al., 2011). These studies demonstrate that whilst there is overall little difference between more general technological innovation adoption, some context specific factors do exist, such as the specifics of industry types or differing national regulatory environments. Despite the increasing support for innovation practices in the agrifood sector from institutions and public policies, innovation in this sector has spread quite slowly (Avolio et al., 2014) and traditionally has been considered to be a low-tech sector in comparison with other sectors (Christensen *et al.*, 1996; Garcia-Martinez *et al.*, 2000; Minarelli et al., 2015). Minarelli et al., 2015 provide 2 reasons for this phenomenon :1) innovation in the food industry does not often make use of scientific inputs as innovation in this sector tends to be more incremental than radical related to the fact that consumers are typically conservative and reject radically novel food products (Garcia-Martinez *et* al., 2000) 2) the food industry is mostly characterised by small and medium-sized enterprises (SMEs), a size typology that is often lacks the internal resources necessary to undertake innovation. However, the technological needs of the food sector are increasing as a result of the introduction of new technology due to increasing food safety and quality (Traill and Meulenbeurg, 2002). In particular, the food industry has increased the use of technological inputs to meet emergent economic social requirements (Baregheh *et al.*, 2012) and to keep pace with the globalisation of demand in the food market (Grunert *et al.*, 1997). Hence in order to become competitive it is necessary for SMEs to develop the capacity to innovate, that must be maintained in the future, along the whole process of innovation (Gellynck *et al.*, 2007). Research in innovation studies has been discussed looking into two pathways. One path is based on understanding patterns of diffusion and the second path is understanding the structure and process of decision-making that influenced the adoption of innovations (Montalvo, 2008).

5.1.1 Barriers of adoption and diffusion of technological innovation

Several types of barriers are mentioned in literature to be relevant in the adoption and diffusion of technological innovations. A key barrier often discussed in the literature is the cost or financial factor. According to Long et al. (2015), the cost of many technological innovations is prohibitive, especially early on in the diffusion process due to difficulties in initial commercialisation efforts. The expense of establishing production facilities, as technology developers transform themselves into technology producers, often means that profits are hard to obtain and increase the costs of the innovative product or service (Cullen et al., 2013; Faber and Hoppe, 2013; Luthra et al., 2014). These can be expressed as 'early adopter costs' (del Río Gonzalez, 2005), and impact both technology users as well as technology producers. Other important factors that impact the costs of innovations include changes to input prices (Kemp and Volpi, 2008), if perverse subsidies exist for current technologies (Weiss and Bonvillian, 2013) or the willingness of customers to pay price premiums for products or processes with a lower environmental impact (Reinstaller, 2008). Furthermore, the availability of the necessary skills and capabilities to integrate and use the innovation by adopter has also impact on the costs of innovation. Moreover, the capital life

(long or short) of a current technological stock also affects relative cost of innovations. This is due to the fact that long capital life is damaging the relative economic benefits of new investments in new innovations (del Río Gonzalez, 2005; Montalvo, 2008). Other key factors affecting adoption of innovation identified in the literature are uncertainty and risk perceptions (del Río Gonzalez, 2005; Johnson, 2010), market failures (such as information asymmetries) (Weber and Rohracher, 2012), and internal and external stakeholder pressures (Montalvo, 2008).

Apart from abovementioned factors Guerin (2001) has identified principle-agent issues that can affect the adoption of innovation. For instance landowners refusing efficient technologies for tenant farmers. Cultural barriers (linked to consumer habits and expectations) (Ceschin, 2013) and the credibility and authority of advisers or consultants (Guerin, 2001; Johnson, 2010) have been also identified as having impact on adoption decision. Fagerberg (2003) has characterised the key aspects of innovation as follows (Fagerberg, 2003):

- uncertainty, due to the risk of failure
- speed of action, otherwise overrun by new innovations proposed by others
- structural strength of the social, legal and cultural context in which it is introduced

Risk has often been considered to be a major factor reducing the rate of adoption of a new technology (Marra et al. 2003). The innovation adoption take places in two stages: 1) at the first stage a firm takes decision to adopt innovation or not 2) second stage shows the speed of innovation adoption (early adopters, lagged etc.)

Uncertainty about the future value of an investment and its sunk costs provide an alternative explanation for investment lags (Arrow and Fisher, 1974). According to Dixit and Pindyck (1994), ‘‘the ability to delay irreversible investment expenditure can profoundly affect the decision to invest’’. A firm with an opportunity to invest is holding an option to wait for new information to arrive that could affect the desirability or timing of the expenditure. When a firm invests, it gives up this option. This option value is an opportunity cost that must be included as part of the cost of the investment (Dixit and Pindyck, 1994). Option value is determined by the current price of an underlying asset and by the degree of uncertainty about that price over the term of the option contract (Purvis et al., 1995). Investment expenditures are sunk costs and thus irreversible, when they are firm specific (Dixit and Pindyck, 1994).

A series of papers in the economics literature developed these notions as they apply to the investment decisions in manufacturing. To agricultural investment problems this notion has been applied since last decade (Chavas, 1994; Purvis et al., 1995; Zhao, 2000). Chavas argues that, because of sunk costs, it may be socially optimal for government-provided price floors to reduce the uncertainty of the investment. Purvis et al. 1995 applied this idea to dairy farmer investment in new waste management technology and found that, compared to the net present value approach to the investment decision, the option value approach implied a significantly higher income stream was required before investment would take place. Zhao, (2000) using a game-theoretic approach, considered the case where

the option value of waiting to adopt is related to the opportunity to observe earlier adopters' experience with the technology. Aramyan et al. 2007 have analysed the investment decision in energy saving technologies in Dutch horticulture and argued that in case of energy-saving technologies, investments are largely irreversible because most capital goods have no alternative application, and the variation in energy price is an important source of uncertainty. In some cases investments in energy-saving technologies may not be profitable if the energy price declines after a new technology is adopted.

Martinez and Briz (2000) identified the following factors hampering innovation activities:

Economic factors

- No need for innovation
- Small size of the company
- Lack/scarcity of appropriate source of finance
- Innovation cost too high
- Excessive perceived risks

Innovation Potential

- Company's innovation potential too small
- Lack of skilled personnel
- Lack of information on technology
- Innovation cost hard to control
- Resistance to change in the company
- Deficiencies in the availability of external sources
- Lack of opportunities for co-operation with other firms

Sirilli and Evangelista (1998) have provided similar list of factors affecting technological innovations in services and manufacturing:

Factors hampering innovation

- Lack of appropriate sources of finance
- Innovation costs too high
- Pay-off period of innovation too long
- Constraints due to legislation, norms, regulations and standards
- Lack of skilled personnel
- Lack of customer's response
- Innovation potential (R&D, design, etc.) insufficient
- Resistance to change within the firm
- Innovation costs hard to control

- Perceived risk too high
- Lack of information on technologies
- Lack of information on markets
- Lack of appropriate external technical services
- Lack of technological opportunities
- Risk to be imitated by competitors

Triguero et al., 2013 emphasised the role of the firm size and the skills of the labour force for adoption of innovation. Most of empirical studies for food firms have confirmed that large firms are more likely to innovate (Triguero et al., 2013). This implies a positive sign between firm size and innovation adoption.

Innovation results also depend on the skills of the labour force. Specifically, the skills of the workforce and the firm's investment in such skills contribute substantially to product and process innovation in the food firms (Avermaete et al., 2004; Triguero et al., 2013). It has been suggested that the higher the quality of the firm's human capital, the more frequent is product innovation in food firms although this relation is not observed in the case of the process innovation (Capitanio et al. 2010; Triguero et al., 2013.

Martinez and Briz (2000) argued that consumer acceptance is essential for the adoption and diffusion of new technologies in food production and the ultimate market success of any new product developed. The example of such consumer acceptance is the study of consumer reactions to food irradiation. Despite the potential benefits to food manufacturers from irradiation (Blackholly & Thomas, 1989), consumers have clearly developed a negative attitude towards irradiated food products, and thereby constrained the introduction of the technology (Henson, 1996). Martinez and Briz (2000) therefore, suggest that technological change and innovation in the food and drink industry is determined by the role of final demand—demand-pull, rather than by new technology—discovery-push. Consequently, consumer acceptance is essential for the adoption and diffusion of new technologies in food production and the ultimate market success of any new product developed. This applies to new technologies and products which are directly communicated to consumers. Blijlevens et al. (2009) states that companies that are able to communicate a certain meaning (e.g. prestige) through the appearance of a product design can create a competitive advantage in the market and increase the product's chance of success.

Next to consumer acceptance of new technologies currently there is another trend in adoption of technological innovation related to consumers, which is especially obvious at retail sector. As consumers acquire more next-generation smart phones and access the Internet through them technological innovations in food retail sector recently have been connected to mainly adoption of emerging technologies related to mobile marketing such as development and adoption of apps via smart phones and internet access. Mobile marketing is becoming increasingly important in retailing (Shankar and Balasubramanian 2009 and Shankar et al., 2011; Ailawadi et al. 2011). More and more food retailers have started to integrate mobile marketing into their integrated marketing communications and develop promotional campaigns based on short message services (SMS) and apps. Some retailers make use of touchscreen tablets placed onto shopping

carts, which then serve as personal shopping assistants (Kalyanam, et al.,2006; Ailwadi et al. 2011). This means that technological innovation has contributed to the emergence of new price and promotions models as a result of emerging technology.

Timing of adoption

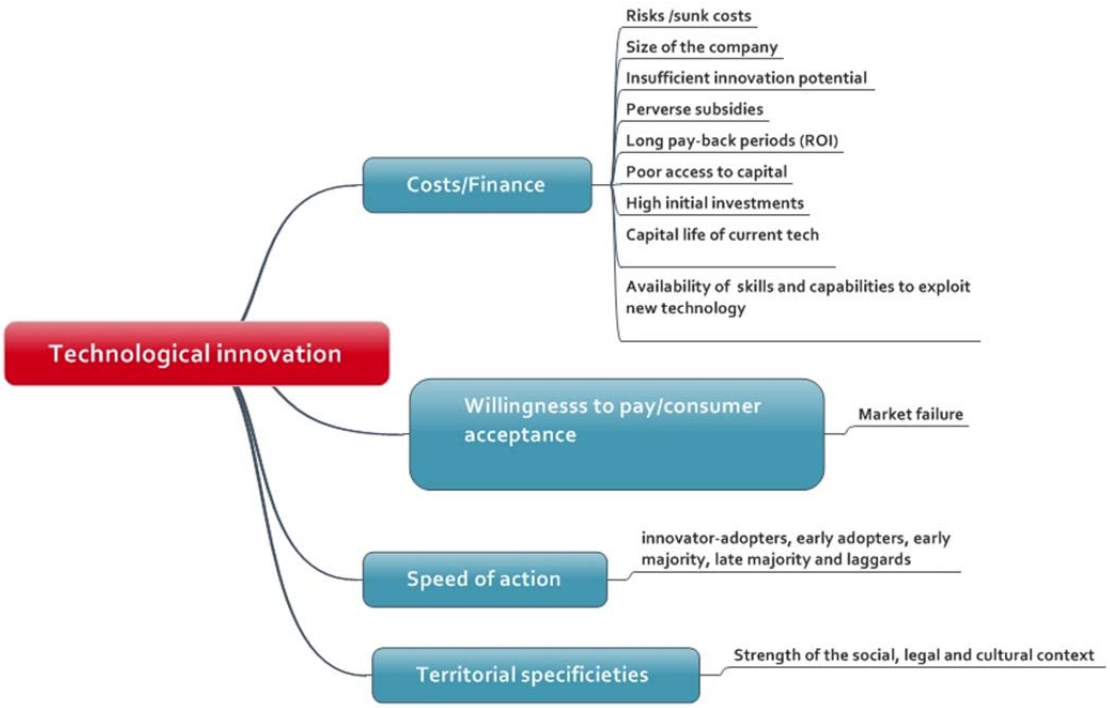
When we talk about innovation there is a need to distinguish between the innovator (who proposes the innovation) and the adopter (who adopts the innovation) since not all individuals in a social system adopt innovation at the same time (according to Rogers 1983) and they may be classified into five adopter categories according to their degree of innovativeness, i.e. the extent to which they are ready to adopt an innovation earlier than others:

5. innovator-adopters
6. early adopters
7. early majority
8. late majority
9. laggards can be distinguished

However, the impact of the structural strength of the social, legal and cultural context in which it is introduced should also be taken into consideration. The environment in which innovation occurs influences the birth, development and outcomes of an innovation. The territorial specificities, namely those related to technology, society, economy and institution, are important variables which can enable or disable the innovation process (Abadi Ghadim and Pannell, 1999; Klerx et al., 2012; Avolio et al; 2014). These territorial specificities may affect the adoption of innovation both positively and negatively. Depending on the enabling environment innovation can be quickly adopted and spread in one place while in other place the adoption and diffusion may be restricted. In other words, innovation is not likely to follow the same process of diffusion in different places, nor it will lead to the same outcomes (Avolio et al; 2014).

Summarising the results of the literature study on economic factors explaining the adoption of technological innovation it can be concluded that the main drivers affecting the adoption and diffusion of technological innovations are related to the costs and finances and risks associated with these costs. Another important factor explaining the adoption and diffusion of innovation is the willingness to pay and/or consumer acceptance and related to that the possibility of the market failure. Furthermore, the diffusion of innovation depends on the speed of the action (innovator adopters, early adopters, etc.). Last but not least important factor is the territorial specificities related to strength of institutional legal and cultural context. The last factor implies that the same innovation can have different adoption and diffusion pattern in different places. The results of the study are provided schematically in Figure 3 using a system map on economic factors affecting technological innovation adoption and diffusion.

Figure 3. System map on economic factors affecting adoption and diffusion of technological innovation



Box 1. Take outs – Adoption factors of technological innovation.

- The adoption of technological innovations by businesses is mostly driven by economic incentives
- The adoption of technological innovations is mainly hampered by its costs/finance, and by the risk associated with the costs.
- Next to the availability of the financial resources for innovation, the willingness to pay (consumers' acceptance of the innovation) is also one of the major factors affecting the adoption decision.
- The speed of action is an important factor affecting the diffusion of innovation, and distinguishes businesses among innovators, early adopters, etc.
- The adoption and the diffusion of innovations depends also on territorial specificities (social, legal and cultural context).

5.2 Organization Innovation

An **organisational innovation** is the implementation of a new organisational method in the undertaking's **business practices**, **workplace organisation** or **external relations** (OECD, 2005). In all cases, the innovation needs to be new to at least the firm, and may be developed by the firm itself or by another enterprise (or in collaboration).

Organisational innovations in **business practices** involve the implementation of new methods for organising routines and procedures for the conduct of work. These include, for example, the implementation of new practices to improve

learning and knowledge sharing within the firm. An example is the first implementation of practices for codifying knowledge, e.g. establishing databases of best practices, lessons and other knowledge, so that they are more easily accessible to others. Another example is the first implementation of practices for employee development and improving worker retention, such as education and training systems. Other examples are the first introduction of management systems for general production or supply operations, such as supply chain management systems, business reengineering, lean production, and quality-management systems (OECD, 2005).

Innovations in **workplace organisation** involve the implementation of new methods for distributing responsibilities and decision making among employees for the division of work within and between firm activities (and organisational units), as well as new concepts for the structuring of activities, such as the integration of different business activities. An example of an organisational innovation in workplace organisation is the first implementation of an organisational model that gives the firm's employees greater autonomy in decision making and encourages them to contribute their ideas. This may be achieved through the decentralisation of group activity and management control or the establishment of formal or informal work teams in which individual workers have more flexible job responsibilities. However, organisational innovations may also involve the centralisation of activity and greater accountability for decision making. An example of organisational innovation in the structuring of business activities is the introduction for the first time of build-to-order production systems (integrating sales and production) or the integration of engineering and development with production (OECD, 2005).

New organisational methods in a firm's **external relations** involve the implementation of new ways of organising relations with other firms or public institutions, such as the establishment of new types of collaborations with research organisations or customers, new methods of integration with suppliers, and the outsourcing or subcontracting for the first time of business activities in production, procuring, distribution, recruiting and ancillary services (OECD, 2005).

Changes in business practices, workplace organisation or external relations that are based on **organisational methods already in use** in the undertaking, changes in management strategy, mergers and acquisitions, ceasing to use a process, simple capital replacement or extension, changes resulting purely from changes in factor prices, customisation, regular seasonal and other cyclical changes, trading of new or significantly improved products are not considered organisational innovations.[5]

Yet again, the distinguishing features of an **organisational innovation compared to other organisational changes** in a firm is the **implementation of an organisational method** (in business practices, workplace organisation or external relations) that has not been used before in the firm and is the result of strategic decisions taken by management (OECD, 2005).

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[5] Community framework for state aid for research and development and innovation (2006/C 323/01).

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2006:323:0001:0026:EN:PDF.

5.2.1 Influence of organizational innovation on firm economics

In recent years, a lot of research has been conducted to learn about the existence, diffusion and effectiveness of organisational innovations and new knowledge management practices. But research in the field of organisational innovation is still highly dispersed and, because research questions, conceptual frameworks and methods applied by various scholars differ quite significantly, **empirical findings are hardly comparable** (Schienstock et al., 2009). Much research assumes that firms are forced to initiate organisational restructuring programmes or to even **introduce totally new organisational models due to increasing global innovation competition** (Schienstock et al., 2009). So, Schmidt and Rammer observe a likely close link between organisational and process innovation, since introducing new technologies in production or distribution may demand reorganizing business routines, which may trigger the introduction of new business practices or new organisational models. Organisational innovation may also occur in the course of product innovations. For instance, new products often induce the establishment of new production or sales divisions and call for re-organization of workflows, knowledge management or external relations.[6] Hence, technological (process and product) and non-technological (organisational) innovations should not be conceived as alternative activities; these are rather complementary strategies, which are more effective when combined (Schmidt and Rammer, 2007).

However, Lam (2005) emphasises that the role of organisational innovation from another perspective: "Economists assume that organisational change is a response to technical change, when in fact **organisational innovation could be a necessary precondition for technical innovation**." In this sense, organisational innovations are not only a supporting factor for product and process innovations; they can also have an important impact on firm performance on their own.

Figure 4 represents schematically a positive impact of organisational innovation on firms' performance and innovativeness (see the upper part of Figure 4).

First of all, it is crucial to understand why firms innovate, and in particular for the focus in this chapter, why firms innovate organisationally. The ultimate reason of innovation in general is to improve (OECD, 2005):

1. Firm performance (economics);
2. Productivity (economics);
3. International competitiveness (economics).

Finding of Schmidt and Rammer (2007) is in line with this reasoning and confirms the general view that product and process innovations request organisational and marketing changes in order to effectively stimulate productivity and

[6] Note: Marketing innovations may also be closely connected to product innovation. New products may demand new ways of marketing and urge for introducing new marketing methods. Marketing innovation interacts with process innovation too. New production technologies may result in increased production capacities or in improved quality characteristics of products. In order to market this increased capacity or improved quality, new marketing approaches may be required (Schmidt and Rammer, 2007).

international competitiveness. In particularly, organisational restructuring programs (which might evolve the introduction of totally new organisational models) might be relevant, when opening to international markets (Schmidt and Rammer, 2007).

Specifically, organisational innovations can be intended to increase a firm's performance by reducing administrative costs or transaction costs, improving workplace satisfaction (and thus labour productivity), gaining access to non-tradable assets (such as non-codified external knowledge) or reducing costs of supplies (OECD, 2005). Furthermore, organisational innovations can improve the quality and efficiency of work, enhance the exchange of information, and improve firms' ability to learn and utilise new knowledge and technologies (OECD, 2005).

The following examples describe how specific elements of organisational innovation positively influence firms' performance:

- Firms can increase demand through product differentiation, by targeting new markets and by influencing demand for existing products. Changes in organisational methods can improve the efficiency and quality of their operations, thereby increasing demand or reducing costs (OECD, 2005).
- Innovation can improve performance by increasing the firm's ability to innovate. For example, improving the capabilities of production processes can make it possible to develop a new range of products, and new organisational practices can improve the firm's ability to gain and create new knowledge that can be used to develop other innovations (OECD, 2005).
- A firm's organisational structure can affect the efficiency of innovation activities, with some structures better suited to particular environments. For example, a greater degree of organisational integration may improve the coordination, planning and implementation of innovation strategies. Organisational integration can work particularly well in industries characterised by incremental changes in knowledge and technologies. A looser, more flexible form of organisation, which allows workers greater autonomy to make decisions and define their responsibilities, might be more effective in generating more radical innovations (OECD, 2005).

In this regard, literature on organisational innovation focuses on the role of organisational structures, learning processes and adaptation to changes in technology and the environment. The latter includes the institutional framework and markets (OECD, 2005).

It is, however, important to note that similar to other innovation types (see discussion on technological innovation above), the implementation of new organisational methods is fraught with **uncertainty**. Uncertainty can lead firms to hesitate to implement significant changes, even as they face a volatile environment that increases pressures to introduce new products, seek new markets and introduce new technologies, practices and organisational methods into their production processes. Uncertainty can also make it more difficult for firms to obtain external funding for their innovation projects. Furthermore, the search for and collection of relevant information can be very time-consuming and costly (OECD, 2005).

5.2.2 Elements of organizational innovation

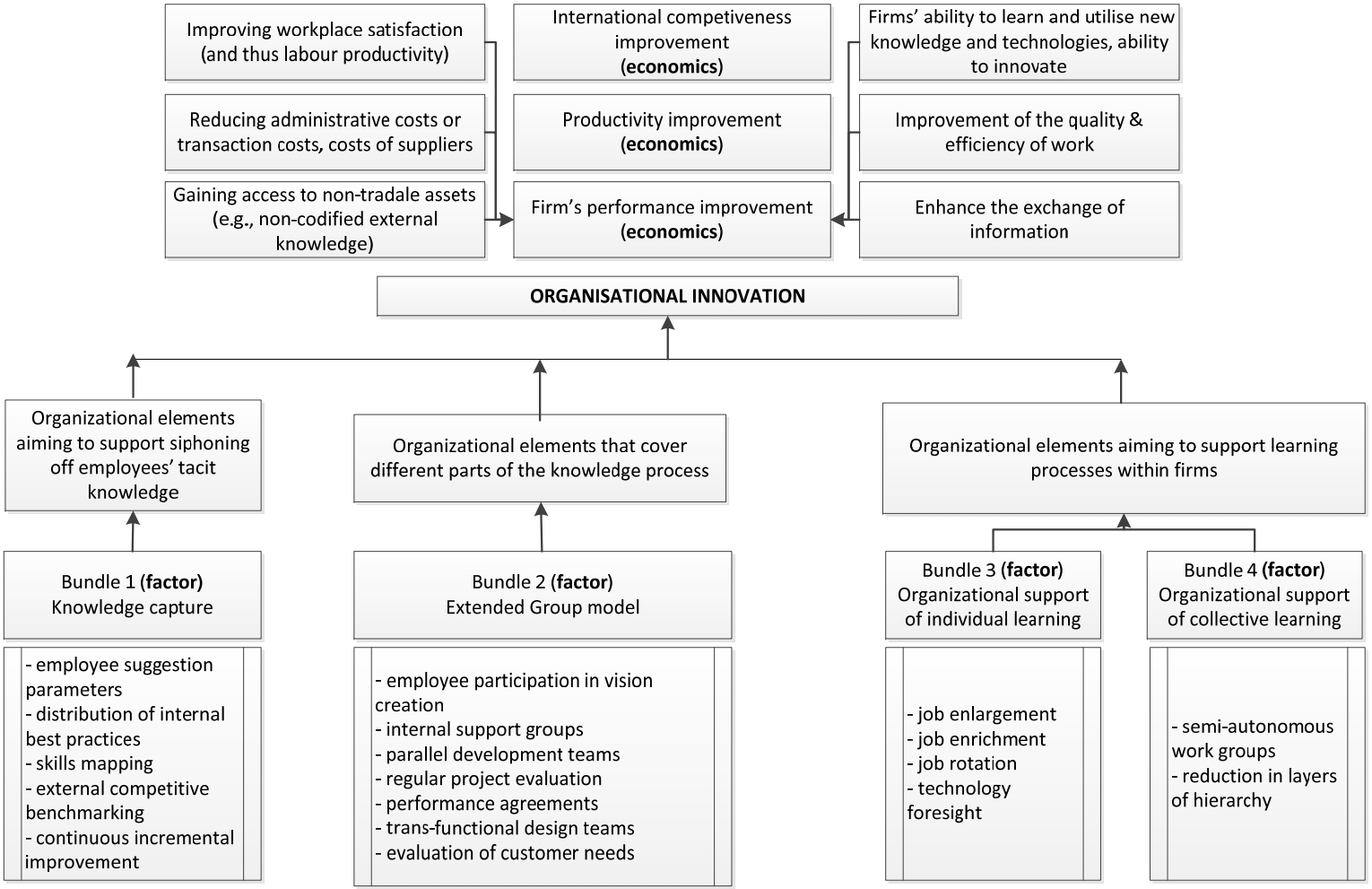
According to research outcomes of Schienstock et al. (2009), **there are no organisational innovations or knowledge management practices that produce best results concerning all performance criteria**. Single organisational innovations and knowledge management practices represent best practice only concerning particular performance criteria; they cannot be characterized as generic best practice. **Organisational innovations and new knowledge management practices are often introduced in bundles of new organisational elements.**

Figure 4 shows an overview of new organisational elements of organisational innovation grouped in 4 main bundles (factors) forming organisational innovation (see the lower part of Figure 4), as identified by Schienstock et al. (2009).

Schienstock et al. (2009) differentiate between two factors that include mainly new knowledge management practices and two factors that include only organisational innovations. “The first factor can be characterized as ‘knowledge capture’ (Quintas, 2003). Knowledge capture primarily concerns employees’ knowledge; the aim is to siphon off employees’ tacit knowledge, which can then be transferred into public knowledge, stored for multiple future use and distributed within the company (Foray, 2004). Examples are employee suggestion programmes, skills mapping/creation of knowledge map, continuous incremental improvement programmes and internal distribution of best practice, as mechanisms to capture, codify and distribute personal knowledge. However, knowledge capture can also include the external sphere; companies aim at capturing new knowledge through external competitive benchmarking.”

“The second factor is less homogenous and more difficult to characterize. The key element of this factor is the application of an extended group model (establishment of internal support groups, parallel development teams, trans-functional development teams, performance/target agreements between management and employees, regular project evaluation and employee participation in vision creation), which covers different parts of the knowledge process. The third and fourth factors include organisational innovations, the aim of which is to support learning processes within firms. The third factor includes organisational elements that aim at supporting individual learning (job enlargement, job enrichment and job rotation), while the fourth factor includes organisational elements that aim at supporting collective learning in the first place (semi-autonomous work groups and reduction of layers of hierarchy).”

Figure 4. Organisational Innovation and its Contribution to Economics of Firms



5.2.3 Firm clusters of organizational innovation

The above 4 main bundles (factors) were further used by Schienstock et al. (2009) to identify linkages between the various bundles of new organisational elements in firms' restructuring approaches. Four clusters of firms were identified. Each cluster is characterized by a specific organisational restructuring approach.

"Cluster 1 is characterized by the fact that firms have introduced most of the identified organisational bundles in a formal way, the only exception being the wider group model to support firms' knowledge processes. Concerning this configuration, mostly informal solutions have been practiced. We can characterize the firms in this cluster as active firms as they engage in a more complex formal restructuring process" (Schienstock et al., 2009).

"Firms in Cluster 4 represent the total opposite; they have not introduced any of the configurations of organisational innovations and knowledge management practices formally. And only with respect to the configuration characterized as support of collective learning have informal solutions emerged. We can characterize firms represented in this cluster as static firms, because their organisational model has hardly changed" (Schienstock et al., 2009).

"Cluster **2** and **3** are characterised by the emergence of mainly informal solutions, the only exception being that all firms represented in Cluster **2** have introduced formal solutions concerning the stimulation of collective learning. Having introduced at least some new elements formally we can characterize these firms as (partly formally) adaptive. Firms in Cluster **3** can be characterized as passive. These firms have not introduced organisational changes formally, but they have adapted to the demands of innovation competition by developing at least informal solutions concerning all dimensions of organisational restructuring. The fact that they practice informal organisational and knowledge management solutions distinguishes these companies from static firms. But the fact that management has not initiated organisational change formally has led to the characterization of these firms as passive" (Schienstock et al., 2009).

A summary of these clusters is presented in Table 1. The table also summarizes the main characteristics of the 2 most distinguished clusters: active firms (cluster 1) and static firms (cluster 4).

Table 1. Firm Clusters of Organisational Innovation and New Knowledge Management Practices

	Active Firms (cluster 1)	Adaptive firms (cluster 2)	Passive firms (cluster 3)	Static firms (cluster 4)
Factors forming organisational innovation				
Knowledge capture	Mainly formal solutions	Mainly informal solutions	Mainly informal solutions	No formal solutions
Wider group approach to support the knowledge process	Mainly formal solutions	Mainly informal solutions	Mainly informal solutions	No formal solutions
Organisational innovations to support personal learning	Mainly informal solutions	Mainly informal solutions	Mainly informal solutions	No formal solutions
Organisational innovations to support collective learning	Mainly formal solutions	Only formal solutions	Mainly informal solutions	No formal solutions Informal solutions
Main characteristics				
Competitiveness	Firms operating in a highly competitive global market environment			Small and old firms, with low export intensity facing comparably less intensive competition
Business strategy	No differences concerning the business strategy			No differences concerning the busi-

			ness strategy
Inward/outward orientation	Inward orientation as well as a combination of inward and outward orientation can be found more often among active than among static firms		While both clusters of firms do not differ significantly in their representation of outward orientation, many static firms have not developed particular orientation pattern.
Information sources on innovation	Active firms relay significantly more often on internal knowledge sources than static firms		
Knowledge transfer	Actively restructuring firms are more involved in knowledge transfer from & knowledge exchange with a limited number of other organizations in their environment. Being connected with universities in particular seems to be important for active firms. aiming at smoothing flows of knowledge with external and internal sources requires the application of major restructuring activities		

No formal solutions = No formal introduction of any of the configurations of organisational innovations

In general, Table 1 also shows that only few organisational innovations and new knowledge management practices have been introduced formally by most of the clusters of companies; nevertheless, many of them are practiced informally by firms (Schienstock et al., 2009).

5.2.4 Role of R&D and ICT investments in innovation outputs

Despite sharing a clear common ground (that is innovation is considered to be a key driver of productivity growth and efficiency), it seems that there are roughly two separate strands of literature to be distinguished: one strand dealing with **R&D driven technological innovation**, and another strand that seeks to explain productivity differences from **organisational changes propagated by the use of information and communication technology (ICT)** (Polder et al., 2010).

R&D

Schienstock et al. (2009) tested empirically the impact of the R&D intensity (among other variables[7]) on a firm's output (innovations new to the firm and new to the market, overall performance).

According to results of Schienstock et al. (2009), the strongest factor that influences the production of **innovations that are new to the market** is R&D intensity (next to an explicit strategy to develop new products, and the use of suppliers as information sources for innovation activities). One could have expected that firms' R&D intensity would have had a positive impact on the creation of innovations new to the market; in general, this type of innovation requires some kind of new knowledge created through applied research. The fact that an explicit strategy to develop new products has a positive impact on the development of innovations new to the market also represents a finding, which is quite obvious. Such a strategy implies that, because firms are conscious about the importance of innovation competition, they put more effort into creating new produces and encourage employees to use their creativity. That customers represent an important information source for firms' innovation activities confirms a well-known empirical finding. Often firms have to develop new technologies according to the specific demand of their customers, which means that they are in general new to the market (Schienstock et al., 2009). Conclusion: that R&D intensity is positively related to the development of innovations new to the market.

Whether R&D intensity has a positive impact on the creation of **innovations new to the firms themselves** and on the overall performance is primarily less clear. Often innovations new to the firm represent incremental improvements without R&D. Often innovations new to the firm represent incremental improvements without R&D. Results of Schienstock et al. (2009) show, however, that R&D intensity has also a significant impact on the creation of innovations which are new to the firms themselves.

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7 A firm's general and structural characteristics (size, age, export intensity, subsidiary, headquarters, industries), the skill level of the workforce, and the R&D intensity. In latter models we also include type of learning, inward/outward orientation, membership in organisational clusters and type of region as independent variables.

ICT

Literature review by Polder et al. (2010)[8]:

Changes in organization and in particular its combination with investment in ICT is the topic of empirical work. In this work, **information technology enables organisational investments** (business processes and work practices), which in turn lead to cost reductions and improved output and, hence, productivity gains. Investment in ICT can therefore be considered as a separate input into the innovation process, which can lead to new services (e.g. internet banking), new ways of doing business (e.g., B2B), new ways of producing goods and services (e.g. integrated management) or new ways of marketing (e.g. electronic cataloguing) (=**economics**). Besides the emphasis on the complementarity between ICT and changes in the organization of the firm, there is evidence that the use of ICT also has a positive effect on product innovation and productivity (Van Leeuwen, 2008).

There is an apart line of literature that motivates the **importance of ICT for organisational innovation** in particular. Case studies reveal that the introduction of information technology is combined with a transformation of the firm, investment in intangible assets, and a change in the relation with suppliers and customers. Electronic procurement, for instance, increases the control of inventories and decreases the costs of coordinating with suppliers. In addition, ICT offers the possibility for flexible production: just-in-time inventory management, integration of sales with production planning, etc. (**economics**). A lack of proper control for intangible assets seems to be the answer to the famous remark by Solow that "one can find ICT everywhere but in the productivity statistics". In addition, a lack of investment in intangible assets is seen as a possible candidate for explaining the differences in productivity growth that are observed between Europe and the US. The available econometric evidence at the firm level shows that **a combination of investment in ICT and changes in organizations and work practices facilitated by these technologies contributes to firms' productivity growth**. Using Community Innovation Survey (CIS) data for the UK, they find a positive effect on firm performance of the interaction between IT and organisational innovation, but not for the individual variables. They also find a significant effect of competition on organisational innovation.

Relationships identified by Polder et al. (2010):

- ICT investment is important for all types of innovation in services, while it plays a limited role in manufacturing, being only significant at 10% for organisational innovation.
- The most striking aspect is that in both sectors, namely manufacturing and services, the combinations of innovations that contribute significantly to a higher productivity all involve organisational innovation: organisational innovation only, process combined with organisational innovation, and the combination of all types of innovation. Product and process innovation increase productivity significantly only when accom-

8 For original references used to summarise these findings, please refer to Polder et al. (2010).

panied by an organisational innovation. The omission of non-technological innovation in existing studies is therefore a possible explanation for the varying results with respect to the effect of different types of innovation on productivity[9].

- Overall, combinations with product and process innovation do not have a positive effect on productivity when performed in isolation or jointly, but do have a positive effect when combined with an organisational innovation. This finding is consistent with the idea of possible complementarities between technological and organisational innovation.

Conclusions

Productivity gains are not solely achieved by product innovation. Organisational innovation is the only innovation type that leads to higher contemporaneous total factor productivity (TFP) levels. Product and process innovation only lead to higher TFP when performed in combination with an organisational innovation. This is true for both sectors (manufacturing and services), though stronger effects in services are found. Testing for complementarity and substitutability shows that organisational and product innovations are substitutes. While their combination without organisational innovation does not lead to significantly higher productivity, product and process innovation are complements. Organisational innovation and process innovation are found to be complements, although in some non-baseline variants both complementarity and substitutability are accepted. All in all, **product and process innovations do not have a positive effect without organisational innovation**. Moreover, in both sectors **ICT investment and application** are found to be important **drivers of organisational innovation** Polder et al. (2010).

Hence, productivity gains appear to be determined by innovation activities, but it is not just a question of introducing new IT-based processes and/or new products; it is rather **the combination of both technological and non-technological innovation activities**, which determines productivity gains (Morone et al., 2011).

5.2.5 When firms introduce new management practices as part of organisational innovation

New management practices – which specific firms are more appropriate for management innovation?

[9] To reinforce this point, Polder et al. (2010) re-estimated their model excluding organisational innovation. The results show that the combination of product and process innovation increases total factor productivity (TFP) significantly in manufacturing but not in services. However, when these results are confronted with those of Table 3, it can be seen that in manufacturing the positive effect of the combination of product and process innovation only occurs in the presence of organisational innovation (the effect of TP(1,1,0) being non-significant), whereas in services the insignificant effect of the combination of product and process innovation could be due to the mixture of the significant positive effect in the presence of organizational innovation and the significant negative effect in the absence of organizational innovation. These contrasting results show that leaving out organizational innovation from the analysis can lead to different (possibly misleading) conclusions about the contribution of product and process innovation to productivity.

Management innovation (as part of organisational innovation) is the introduction of management practices new to the firm and intended to enhance company performance. Building on the organisational reference group literature, Mol and Birkinshaw (2009) empirically show that management innovation is a consequence of a **firm's internal context** (size, workforce, market-geographic scope) and of the **external search for new knowledge** (knowledge sources: internal sources, market sources, professional sources). Namely, in addition to internal structural factors, management innovation comes about through **interaction with internal and external knowledge sources**; more specifically from market participants such as consultants from internal and professional areas.

Furthermore, Mol and Birkinshaw (2009) demonstrate a **trade-off between context and search**, in that there is a negative effect on management innovation associated with their joint occurrence. Namely, **internal knowledge sources correlate negatively with the context factors of firm size, employee education level and geographic scope**. Such a negative correlation suggests that the **overlap between internal sources of knowledge and the three contextual factors** (firm size, education level and geographic scope) **limits diversity in knowledge and ideas**. Moreover, **firm size** is the most important organisational factor influencing the mitigating effect of knowledge sources. The results show that larger firms have less need for using different sources of knowledge for management innovation which confirms that there is a positive correlation between management innovation and firm performance. Thus, suggesting that new management practices can enhance a firm's competitive advantage (Lei-Yu, W., 2010).

Finally, the study of Mol and Birkinshaw (2009) shows that management innovation is positively associated with company performance in the form of subsequent productivity growth.

“In terms of contextual setting, Mol and Birkinshaw's research shows how specific characteristics of UK firms and their interactions with knowledge sources enhance a firm management innovation in a highly developed economy. However, this raises an interesting question: Which firms should implement management innovation? Given the fact that firms are heterogeneous based on difference in nationality, **a similar research model may not be plausible in a newly developing economy, such as Hungary or Poland**. This discrepancy does not lessen the contributions of Mol and Birkinshaw's research in the area of management innovation studies. On the contrary, future management innovation studies are encouraged to investigate whether different organisational contexts interacting with knowledge sources in a different national context have an impact on management innovation and firm performance” (Lei-Yu, W., 2010).

General considerations

Although Mol and Birkinshaw (2009) recognize Luk et al.'s (2008) study that the **institutional context may moderate the performance results accrued from organisational innovations**, Mol and Birkinshaw did not test the moderating effect in this study. For instance, **firm size** may have a negative moderating effect on the relationship between management innovation and performance. Larger firms are inclined to have inertia and which may cause them to resist change or to adopt new management practices (Hannan and Freeman, 1984). As can be seen in many cases, larger firms face more challenges when they attempt

to introduce new management practices into their organizations. Moreover, the **education level of work forces** will also moderate the relationship between management innovation and firm performance. Highly educated work forces may be more willing to accept a new concept of management practice or innovative behaviours (Janssen, 2000), which in turn leads to better firm performance. **Geographic scope** is another moderator of the relationship between management innovation and firm performance. A wider geographic scope means that a firm may have to deal with cross-cultural administrations in different markets (Hofstede, 1980). Cultural differences increase the difficulty of implementation of new management practices, especially if the culture distance is large as in Asia and the west. Thus, geographic scope may have a negative moderating effect on the positive relationship between management innovation and firm performance. The above mentioned moderating effects of internal organisational context need further investigation in the future studies (Lei-Yu, W., 2010).

5.2.6 Organisational innovation and competition: trends and evidence in food industry

Box 2. Case study – *Innovation in the Food Industry; An International Benchmark Study for The Netherlands.*

The Danish food industry is most innovative among eight food industries compared (Denmark, Germany, the Netherlands, France, Italy, Poland, Spain and the United Kingdom). The Dutch food industry ranks third. The Netherlands scores highly on the indicators that describe the input side of the innovation system, but the companies generate less revenue from new products and are less focused on marketing and **organisational innovations** than most other countries. Production process efficiency and cost reduction are often the main focus areas of Dutch companies. In the longer term, this could cause the competitiveness of and jobs in the Dutch food industry to come under pressure. For an overview of benchmark indicators and the data sources used, refer to van Galen et al. (2013).

Key findings:

- Compared with the other countries studied (Denmark, Germany, France, Italy, Poland, Spain and the United Kingdom) the Dutch food industry has a relatively strong position in terms of R&D intensity and a strong position in cooperation in innovation.
- The only country with a greater number of patent applications to European Patent Organisation (EPO) per million inhabitants than the Netherlands is Denmark. This indicates the relatively high importance of the food companies in the Netherlands. However, the majority of patent applications come from a small number of large high-tech food companies.
- This large number of patents does not lead to a proportionately large number of new products. Far from all innovations in the food industry are based on patents and thus lack the protection of patents.
- In the Netherlands, most innovations come from a relatively small group of companies. Many innovations come from start-ups on the one hand and large companies and multinationals on the other. Most of the implemented innovations are product and process innovations; organisational and marketing innovations are seen to a lesser extent.
- The available data about innovation by companies in the food and beverages industry does not allow for a comparison of different branches of the industry.
- Revenue from new products in the Netherlands lags behind that in the other countries surveyed. The revenue is mainly generated by existing or slightly modified products. To remain competitive, food companies focus primarily on efficiency of production processes and distribution.
- The number of SMEs in the food industry in the Netherlands is relatively large. SMEs are less likely to have formal R&D and innovation, but are more often involved in other forms of innovation, such as in niche markets. Both the market concentration in the food industry itself (in some sectors a limited number of companies control a large share of Dutch production) and the changes in the sales

structure (concentration at customers) and competition with private labels vary by country and sub-sector. To what extent these variations are an explanation for much or little innovation is a question that requires further investigation.

- The relatively high public investments in innovation and knowledge in the Netherlands are reflected in the quality of the knowledge institutions. However, it is impossible to determine what proportion of public spending on knowledge and innovation specifically reaches the food industry. In terms of scientific quality in the food domain, the Netherlands does relatively well.

Complementary findings:

- The food industry consists of various sectors, each with its own structure. In the Netherlands, the food industry is the largest branch of industry and consists of a relatively large number of SMEs.
- In some sectors of the Dutch food industry, the concentration is high to very high.
- Denmark is the leader among the countries surveyed when it comes to efforts for innovation: firms' R&D expenditures, collaboration in innovation, knowledge and business environment. Germany tops the list when it comes to the results of innovation. However, we have several remarks concerning the comparability of the figures for this indicator from the CIS survey.
- The food industry exhibits a limited dynamism in all countries except the United Kingdom. For these countries, including the Netherlands, this indicates limited internal competition and relatively high entry thresholds.
- A good business environment is important for innovation and can be improved in the Netherlands through steps such as reducing the costs and duration of procedures for establishing new businesses and obtaining building permits.

Source: van Galen et al. (2013)

Box 3. Case study – *Supply Chain Innovation as part of organisational innovation in traditional food networks; Barriers and Drivers of Innovation for SME.*

This case study investigates barriers and drivers of organisational innovation developed by TFFs, with specific focus on small and medium sized enterprises (SMEs), in traditional food networks. The analysis is performed in three European Countries, which represents different European regions and hereby different cultural heritages – Northern Europe (Belgium), Southern Europe (Italy) and Central Europe (Hungary).

Food supply chain networks (FSCN) are seen and analysed as external resource of the food firm. Supply chain network resources include supplier-buyer relations as well as third actors, such as logistic suppliers, financial providers or market research firms.

Literature findings[1)]:

- A network, rather than a single firm determines the potential for innovation.
- The implementation of organisational innovation contributes to the performance and effectiveness of traditional food firms (TFFs) and their networks. Therefore, innovation is regarded as an important strategic tool to obtain competitive advantage.
- In TFFs the focus is mainly on product and process innovation, but seldom on organisational innovation.
- Innovation in TFFs is often achieved through the improvement of networking. Therefore, TFFs need an environment that stimulates innovation and improves networking activities. The creation of such an environment can be supported by government, for instance by improving the infrastructure for networking. However, evidence shows that TFFs are mainly not aware of the importance of being innovative and often face difficulties to gain access to institutions, such as research centres, and government.
- The innovation capacity of a network is depending on the innovation capacity of the participating firms. TFFs are more innovative when they are able to join, cooperate and manage interactions in networks. Consequently, this leads to an increased innovation capacity of the network. However, the

development and adoption of innovations through networking is often hampered by lacking resources for the formation and participation in networks.

Key findings:

- Drivers of organisational innovations in traditional FSCN are reorganisation of the management, possibilities for collaboration (supplier, retailers, customers), and vertical integration.
- Barriers of organisational innovations are low trust levels, pressure of retailers, costs, differences in expectations, vertical integration and the regulation environment.

Source: Kühne et al. (2007)

[1)]For original references used to summarise these findings, please refer to Kühne et al. (2007)

Box 4. Case study – *Key factors influencing organisational innovation in small rural food industries.*

This case study analyses key factors influencing organisational innovation in small rural food industries.

Literature findings[1)]:

- Factors which can **potentially** affect radical and incremental innovation are classified in 4 main factors of **firms' characteristics, managers' characteristics, inter-organisational ties and intra-organisational ties**.

Innovation and organisational ties (inter-organisational ties and intra-organisational ties)

- Organisational ties help SMEs establish their network. There can be at least two types of inter-organisational and intra-organisational ties for any organization.
- *Inter-organisational ties* (dependency on customers and on various information networks) play an important role in the adoption and implementation process of small firms. Facing fast technological changes and global competition, inter-organization collaborations have become increasingly important for firms to enhance their competitiveness. Inter-organisational collaborations are critical for a firm's innovation, particularly when firms lack sufficient internal R&D resources.
- *Intra-organisational ties* are also very important for innovation and performance of firms. It is necessary for organizations to put together different capabilities and services with the goal, through cooperation between suppliers and customers, service providers and scientific institutions to achieve innovations of high quality:
  - cooperation with customers has a positive impact on performance;
  - there is positive significant relationship between the inter-firm cooperation and innovative performance;
  - there is a significant positive correlation between inter-firm cooperation and innovation performance of SMEs;
  - close linkage and cooperation with customers and suppliers have a direct and significant positive impact on the innovation performance of SMEs;
  - cooperation with government agencies does not have an impact on innovative performance of firms.

Firm's characteristics

- Characteristics of firm (e.g., firm age and size, R&D, capacity for production (tons), sector) can potentially influence the level of innovation in firms: doing more R&D has a positive effect on product

innovation in manufacturing while it is unimportant for organisational innovation;

- information technology, training, and incentives are directly affecting the organisational performance;
- firm size has a strong positive effect while competition had a strong negative effect, on organisational innovations;
- strong competition is negatively associated with innovation, and this is more the case for process and organisational innovations than for product and marketing innovations;
- a significant difference between agro-industry subsectors such as meat, fruit, and dairy fat/oil is observed in terms of innovation. The meat, fruit, confectionary and fish-based subsectors all had higher rates of innovation compared to grain subsector.

Organisational innovation and manager's characteristics

- Managers play a central role in deciding to adopt an innovation.
- The success of the project depends on management's correctly positioning the R&D to fulfil a need or fill a niche.
- Managers need to be technically competent and able to orchestrate new ideas through the organization.
- Managers should take advantage of different methods for staff encouragement to innovate. Though there are practices of giving awards and certificates of recognition to innovators, they are not adequate or timely enough to motivate the employees to take up innovative projects. The common view among the staff is that it is not worthwhile to get involved in innovations.

Key findings:

- Radical changes in organisation are mostly pursued rather than incremental changes.
- Factors which influence "incremental" organisational innovations are *firms age* (negatively), *product diversification*, and *firms' capacity of production* (positively).

Source: Soltani and Hosseini (2012)

[1)]For original references used to summarise these findings, please refer to Soltani and Hosseini (2012)

5.2.7 Organisational innovation and competition: trends and evidence in retail

In recent years, one of the major, and most innovative (both technologically and organisationally), areas of change in food retailing has been the **development and investment in a whole new system of distribution**, largely replacing wholesale markets, undertaken by the major retail multiples. Each of them now has a number of regional distribution centres, either in-house or contracted out, with advanced IT systems and dedicated "cross-docking" transport fleets. In terms of product range, service, speed, freshness and quality this new system has little to compare directly with the system it has replaced (Harvey, 2000).

Another fundamental revolution (also, organisationally) in food retailing across Europe over the course of the last two decades is development of different business models: supermarkets and discounters. There is a useful comparison, for example, to be made between German discount superstores, driving supply down a route of high yields of standard products at low prices, where price is the

focus of competition; and the UK supermarkets creating a demand for product differentiation and high value added, where, it is claimed, quality is the focus of competition. But the strategy of discounting, and hence the market in which such firms operate, is quite different from that of the typical UK supermarkets. Product ranges are much smaller, and product differentiation within a product category much more restricted. The emphasis is on price and volume of turnover. UK supermarkets trade in a market which sells higher levels of convenience, greater choice in both price and quality, and in different product ranges (especially chill, own-label, and convenience foods) which are unavailable in discount stores. It is quite possible for supermarkets and discounters to survive, but it is incorrect to assume that they are directly competing with each other in the same market (Harvey, 2000).

Changes characterising the emergence of the distinctive system of retailing in the UK (Harvey, 2000):

- **Re-organising supply – the centralising of buyer power of retailers:** Two main consequences of the centralisation of buying power have been the (a) development of higher levels of own-label produce in the UK than elsewhere in Europe and (b) the emergence of dedicated long-term supply relationships. Both symbolise the extension of control of retailers over food supply. The losers are clearly the branded manufacturers, on the one hand, and the suppliers of fresh produce excluded from partnership and long-term supply relationships with particular retailers, on the other. Wholesale markets have virtually disappeared as channels for getting produce to the consumer. So instead of an industry where producers and suppliers were sharply separated from retailers, the new organisation of the industry is characterised by the integrated supply chain. Large own-label manufacturers, such as Hazelwood or Northern Foods, have separate factories dedicated to the products of each major multiple, one factory producing under a Sainsbury label, another under Tesco, Marks & Spencer, etc. Fresh produce suppliers likewise often enjoy a similar ”own label” status with a particular multiple: in the Canary Islands, for example, a Tesco designed pack of tomatoes leaves the grower with a Tesco label already stamped on it.
- **Revolutionising logistics – the construction of a new logistical infrastructure:** Logistics have become critical in ensuring the expansion of fresh and chilled product ranges, but more generally the centralisation of distribution in regional logistical facilities by all the major retailers has brought about a continuing acceleration of stock flows. There has been a rapid technological and organisational innovation process of a major scale in the process of bringing food to the consumer.
- **Re-configuring innovation strategies of the big food product producers and the supermarkets:** Where the branded manufacturers can be described as ‘conservative radicals', making few but major investments in new products, the own label manufacturers typically produce more than 1,000 new products per year, many with very short life cycles, and so could more appropriately be dubbed ‘variable geometry innovators'. Likewise supply chain organisation affords ‘insider suppliers’ the possibility of a longer-term attitude towards their own retail outlets, and a more coordinated approach to new product development and

marketing. The supply chain is therefore a different innovation environment from a more arm's-length marketplace.

These different aspects of the changes, innovations which are **both technological and organisational**, suggest a long-term dynamic process in which **concentration at the retailing end of the supply chain** has been a key aspect (Harvey, 2000).

Another lesson from food retailing in the UK is that competition is not to be judged in terms of the relationship between prices and costs at a point in time but rather in terms of the capacity to innovate over time leading to longer-term gains in quality, convenience and price. Innovation-based competition is naturally a dynamic process in which one looks for changes in the relative importance of rival firms over time. When we look at the bigger picture of "Who is competing with whom?" and "What is competing with what?" it is clear that major changes have occurred in what the shopping basket is, what shopping is, and the availability and ranges of food products, and not only in prices and costs.
Compared to a period when manufacturers and primary producers predominated, and used their own distribution systems or wholesale markets to get their products to market, we are staring now at a different landscape. This has been a long-term change in the structure of capital invested in the sector. Short-term measures of shopping basket prices at any one point in time are singularly inadequate for understanding the nature of competition or of consumer benefits in this new situation. With a narrow view of competition, it might be questioned whether this change in the nature of shopping, retailing, distribution and organisation of production amounts to competition at all. But, taking a broader view, **one system of economic organisation has replaced (largely) another. And that certainly can be called competition** (Harvey, 2000).

Box 5. Case study – *Analysis of the Organisational Innovation Initiatives in the Supermarkets.*

De Jong et al., (2012) concluded that in successful supermarkets shop assistants adopt innovative and entrepreneurial behaviour that leads to a variety of sustainable improvements in their work environment; in the innovation initiatives we saw that uniform working procedures that are designed by the headquarters do not contribute to innovation. In some cases it even hindered the innovation initiatives; innovative behaviour requires personalised learning processes fuelled by intriguing questions, the felt need for urgency to improve, and active experimenting with developing a new practice. Sharing innovative initiatives across other supermarkets is not self-evident.

Key findings:

Question 1: What innovation initiatives, that aim to improve work processes and procedures, can we identify?

- Most innovation efforts are focused on improving the work environment of the supermarket staff. A smaller amount is focused on the connection with customers and selling more products.
- This could be an indication that the work environment acts as an important lever for innovation, where it is important that people feel respected and happy.

The nature of innovations in the work environment is often characterised by more autonomy, having influence on the way of collaboration, addressing difficult topics, interaction and the quality of the working relationship.

Question 2: What is the contribution of employees, management and the headquarters to the develop-

ment of these innovation initiatives?

- Shop assistants are directly involved in all but one of the innovations efforts. They appear to be the main innovators. It is clear that they take ownership and show entrepreneurship.
- In about half of the cases it is the shop assistant who takes the initiative for an innovation. In the other half, the store manager takes the initiative. The head office manager takes initiative in no cases, and is even not involved in any of the observed innovations.
- When the store manager takes initiative, he almost always involves shop assistants in the further development of the innovation.
- External parties are only involved in one case.
- When it comes to selling more products, the shop assistants always take the initiative first. When the store manager takes initiative it mostly deals with improvements in the work environment. Innovations focused at the customer are initiated both by shop assistants and store managers.
- When shop assistants take the initiative, they mostly invite direct colleagues first, instead of involving the store manager.

Question 3: To what extent have these innovations been shared with others inside and outside the context in which the innovation was developed?

- Most of the observed innovations became regular practice in the supermarket where they emerged.
- Out of the 26 cases, nine innovations have been implemented and observed in other supermarkets as well. However, it is not clear whether and how the learning process supporting the implementation took place. It is even doubtful whether a deliberate implementation process took place, especially when the large number of employees involved in other stores is observed
- Among the best spread innovations are those initiated by shop assistants and by store managers. Apparently, both types of actors are important for bringing the innovation process into the third phase, the phase of dissemination.
- We could observe innovations spread to other stores that were originally initiated by shop assistants. And, the other way round, there are also innovations initiated by store managers that were only a one-time action. In short, it seems that the successful development of an innovation effort does not depend on the hierarchical position of the initiator.
- The innovations focusing on selling more products often stay local practices that are not shared with other stores.

Headquarters stimulate a uniform approach with respect to the presentation of products in the different supermarkets. At the same time, successful innovation initiatives often do not comply with this uniformity. And, because the innovation initiatives are quite often conflicting with the national approach as imposed by headquarters, local shops are not motivated to share their innovation ideas with respect to selling more products. This might be an explanation for the fact that not many innovation initiatives are shared among shops.

Reflection on alternative assumption 1. All employees who actively work on improvements and innovations in their day-to-day-work environment can be regarded as knowledge workers.

The analysis of 26 innovation efforts in 17 supermarkets supports the assumption that regards shop assistants as innovators. In about half of the cases shop assistants take the initiative for an innovation. Shop assistants are involved in all innovation efforts, except for one. They are able to take ownership and have a leading role when it comes to signalling problems, active experimenting, consolidating the results of successful experiments in the day-to-day work practice.

Reflection on alternative assumption 2. Knowledge workers develop improvements and innovation in their work, in a step-by-step process that show characteristics of developmental design. In this process three phases can be distinguished: (a) experimenting with new approaches; (b) developing sustainable improvements and innovations; (c) sharing these improvements and innovations with other contexts.

The results support the assumption that innovation should be regarded as a step-by-step developmental process instead of a predictable process that can be deliberately implemented. The first two phases could be clearly observed in the supermarkets. It is not easy to recognise the third phase. We found similar innovations in more than one context. However, it was not clear whether the various shops adopted

these innovations by learning from each other. It is likely that shops experiencing similar problems independently came to similar solutions.

- Some innovation initiatives remain singular changes that never evolve into a sustainable and renewed work practice, while others do.
- In none of the cases, the headquarters played a role in the observed innovations. We did not see local mangers actively rolling out new work procedures. Moreover, innovation efforts aiming at increasing turnover were not shared with other shops.
- It looks as if shop assistants need local freedom to act when it comes to developing viable innovations. Here, imposed measures from the headquarters seem not to be effective.

Reflection on alternative assumption 3. For every change, no matter how big, small seeds or successful examples can already be found in the workplace. By sharing these innovations within one context and across other contexts innovation initiatives can further develop and have more impact.

The first part of the assumption seems to find support in practice. An appreciative inquiry of what is already there reveals many local innovation efforts: some in an initial phase, others are already well developed. The supermarket staff experienced the inquisitive and appreciative uncovering of these initiatives as stimulating and encouraging. As for the second part of the above assumption, sharing innovative initiatives between contexts does not appear to be self-evident. This might indicate that innovation requires an individualised learning and development process. It seems that one cannot simply transfer what is successful in place A to place B (see also Dixon, 2002). There is a need to experience an intriguing question, to feel the urgency for finding a solution and then collaboratively experiment with developing a new practice. Achieving high impact from innovations shared among different contexts then might need deliberately facilitated learning processes where participants from various contexts meet and engage in exploring similar intriguing questions, searching for existing initiatives, and share their experiences. Then adaptation, adoption and successful local implementation might occur.

Source: de Jong et al., 2012

Box 6. Take outs – Highlights on economic factors of organizational innovation.

- An organisational innovation is the implementation of new organisational methods in business practices, workplace organisation or external relations
- Organisational innovation is ultimately driven by economic motivations: improving firm performance, productivity, and (international) competitiveness.
- Research on organisational innovation is still highly dispersed, and empirical findings are hardly comparable.
- There are two perspectives on the occurrence of organisational innovation: 1) it emerges in the course of process or product innovations, and 2) it can be a necessary precondition for technical innovation.
- There are no organisational innovations that produce best results concerning all performance criteria: single organisational innovations and knowledge management practices represent best practice only with respect to one criterion; they cannot be characterized as “generic best practices”.
- Organisational innovations and new knowledge management practices are often introduced together with new organisational elements: knowledge capture, extended group model, organisational support of individual and collective learning.
- **General factors**: which factors (in all sectors) are more important for organisational innovation?
  - R&D has a positive effect on product innovation in manufacturing, while it is less relevant for organisational innovation;
  - ICT is particularly important for organisational innovation: the introduction of information technology is combined with a transformation of the firm, investment in intangible assets, and a change in the relation with suppliers and customers;
  - Other factors include: 1) a firm's structural characteristics (size, workforce, education level of work forces, market-geographic scope), and 2) the search for new knowledge (from internal sources, market sources, professional sources);
  - The institutional context may moderate the performance results accrued from organisational inno-

vations.

- **Specific factors**: which factors are more important for stimulating organisational innovation in food industry and food retail?
- The four main factors are firm characteristics, managers' characteristics, inter-organisational ties, and intra-organisational ties;
- Drivers of organisational innovations are: reorganisation of the management, possibilities of collaboration (suppliers, retailers, customers), and vertical integration;
- Barriers to organisational innovations are: low trust levels, pressure of retailers, costs, differences in expectations, vertical integration, and the regulatory environment.

6 Food waste reduction possibilities along the food supply chain through innovation

6.1 Technological drivers causing food waste

FUSIONS work on food waste drivers (Canali et al., 2014) has identified a number of technological drivers contributing to food waste generation. These technological drivers of food waste can be described being connected to material objects, equipment and methods, rather than human beings or their relations. These drivers have been grouped into three main categories as follows: (a) drivers inherent to the characteristics of food, and of its production and consumption, where technologies have become limited, (b) drivers related to collateral effects of modern technologies, and (c) drivers related to the suboptimal use of, and mistakes in the use of food processing technology and chain management.

The majority of technological drivers can be found in category (c). Access to modern technology will obviously limit losses due to mechanical damage during harvest, handling, logistics and storage although this is less of an issue for advanced regions such as the EU (Gustavsson et al., 2011). Inadequate systems of control in production and processing are one of the most frequently cited drivers leading to food waste. This occurs across all sectors of the food processing industry. Examples include slaughtering and processing losses in the meat industry (Whitehead, 2011), cutting and trimming losses (Somsen, 2004), losses due to production errors and rudimentary control measures (Parfitt et al., 2010; Stuart, 2009; Svenberg and Torgå, 2007), processing waste e.g. pastry trimmings, overfilling losses (Ridgeway et al., 1999), and failure of the heat seal on packaged food (Whitehead, 2011). Suboptimal operation and ease of use of equipment, and production planning are other drivers which can result in losses due to production errors, product changeover losses and over-production losses (Mena and Yurt, 2011; Brook Lyndhurst, 2010a). Food is wasted as a result of spoilages caused by poor storage handling and conditions, and damage created during transport. This is coupled with cold chain inefficiencies occurring during transportation of materials throughout the food supply chain. Suboptimal use of packaging and labelling is another important driver in creating food waste. Packaging defects and errors can, in turn, lead to broken and damaged food items and the food cannot be sold if the packaging is mismarked or mislabelled (Mena and Yurt, 2011). The packet size and material must also be optimal for the consumer to avoid waste in the household (Williams et al., 2012). Food waste due to suboptimal management at home can be improved through the use of technology such as fridge / freezer temperature and door open alerts (George et al., 2010), suitable storage containers / systems (WRAP et al., 2011; WRAP and French-Brooks, 2012) and internet / mobile apps. Drivers inherent to the characteristics of food are mostly seen in the primary production and processing of farm staples segments, where food waste and loos occurs due to storage and microbiological quality issues (HGCA, 2011) or due harvest loss & damage. Processing methods for potatoes, tubers and vegetables, such as mechanical

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peeling and handling, can cause very high amounts of waste (Willersin et al., 2015, Ahokas et al., 2012). Soft fruits and vegetables are rather vulnerable to damages during automated harvest and handling which leafs to losses and waste. Climate change was also identified as a driver contributing to increased losses due to moisture and moulds, as well as increased contamination in harvested crops.

The example of a driver related to collateral effects of modern technologies was non-selective fishing, where trawl fishing and non-selective gears produce by-catch which is not utilised (Brook Lyndhurst, 2010b; Kelleher, 2005; Diamond and Beukers-Steward, 2011). This may reflect the advanced nature of technology utilised in European food production systems.

Box 7. Take outs – Food waste reduction possibilities through technological innovation.

Technological innovation can help reduce food waste through the following practices:

- The development of better selective instruments in the primary sector (e.g. selective fish gears),
- Improved storage technologies,
- Development of farm facilities,
- Access to modern equipment and techniques,
- Better measurement systems,
- Electronic ordering systems and automatic ordering.

6.1.1 Possibilities to reduce food waste by technological improvements/innovations

FUSIONS work on food waste drivers (Canali et al., 2014) has identified the possibilities to reduce food waste by technological improvements and innovations along entire food supply chain. For **primary production** the role of technological improvements is related to technology e.g. better storage, better breeding, improved fishing gear. For *food processing* segment access to modern equipment and techniques' has been found to be the main technological driver related to the possibility of a reduction in food waste.

The need for advanced packaging materials was identified as a main driver contributing to food waste reduction at **Wholesale and logistics**. The assumption is that advanced packaging could save food from spoilage as long as necessary to bring the food item in best quality to human consumption. The use of new packaging material can bind oxygen, may kill microbes, absorb ethylene or regulate moisture of the content. Although these technological improvements are developed by research and have to be implemented by producers, the trend could be fostered by request from the wholesale and logistics companies. Nevertheless, it should be born in mind that food products are also thrown away although they are fine to eat and if it is the goal to wrap every food item into packaging material. Thus, advanced packaging material could only be part of the solution for pre-processed food or specific food items. The use of innovative technologies such as 'time temperature indicators' could contribute to major food waste reduction occurring during the logistics. It aims to enable the tracking of tempera-

ture changes of food products, facilitating the identification of those areas where food spoilage occurs.

Modern and electronic store management systems can greatly improve waste efficiency in stores. These systems can automatically order new products when they are sold. This removes the human error of over- or under-ordering and the stock should stay at the optimal level. Electronic ordering systems exist today but coming more popular in the future can decrease food waste generation.

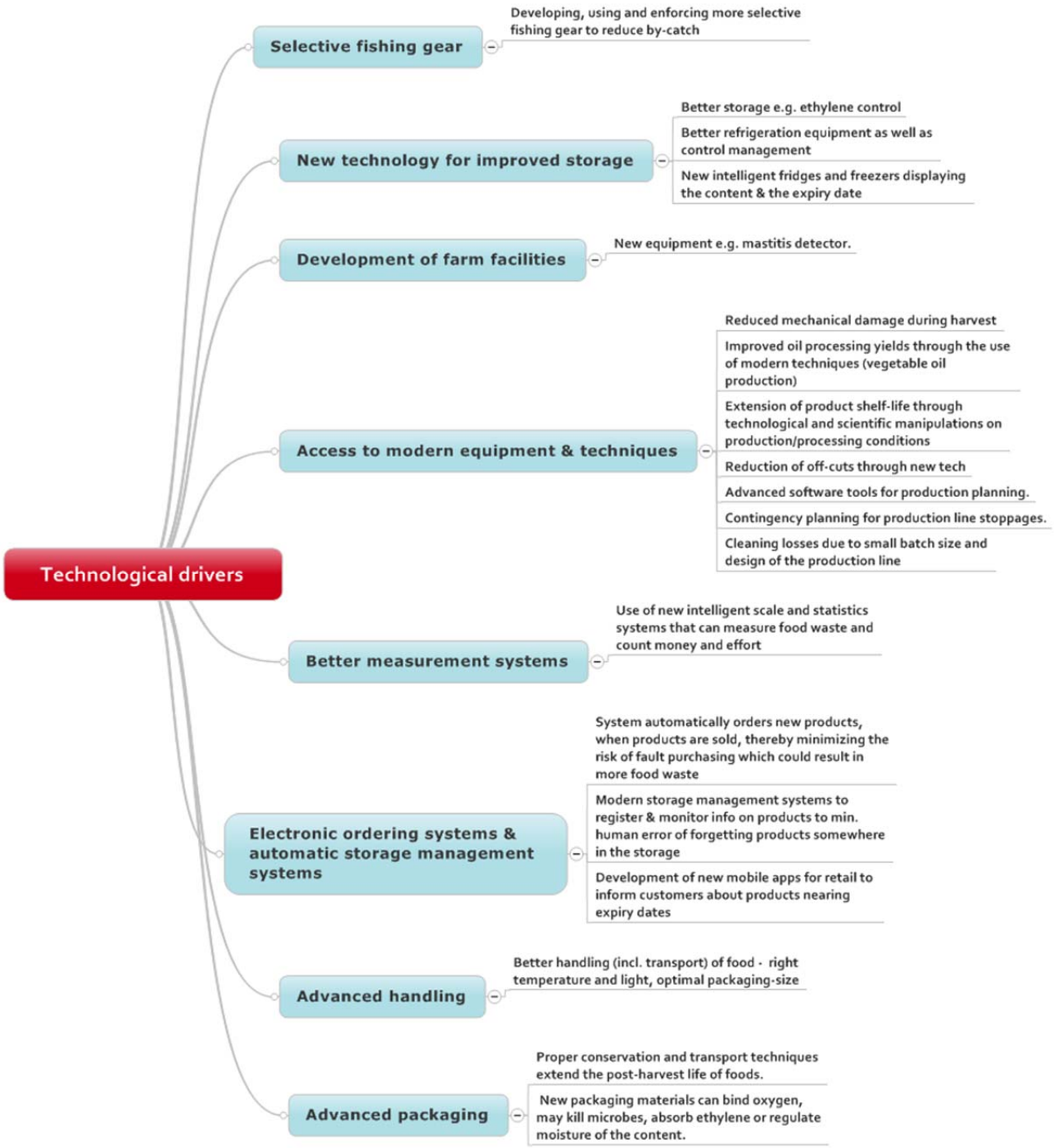
When it comes to **Retail sector** better inventory management can help retailers minimize food loss. They have to take account various indicators influencing the shopping behaviour of the consumer, e.g. weather, season, offer of the week, personal attitude. This can make ordering the right amount tricky and retailers usually over order to meet the full shelf expectation of the consumer. New and better refrigeration equipment can improve the shelf-life of products and help to buffer the changes in fluctuating demand.

At **Food Services** the suggested new service system for hospitals and workplace canteens where customers order the food themselves in advance so that they have the amount and food that they want could help reduce food waste.

At **Households** ordering from home and having smart appliances to monitor the foods already in the home (in cupboards & the fridge / freezer) can help decrease food waste by improving meal planning.

Food waste drivers affected by technological innovation and possibilities to prevent and reduce food waste are summarised using a system presented below (Figure 5).

Figure 5. System map on technological food waste drivers



6.2 Organizational drivers causing food waste

FUSIONS work on food waste drivers (Canali et al., 2014) has identified a number of business-related drivers contributing to food waste generation. These drivers have been grouped into three main categories as follows: (a) drivers that identify causes of food waste which may be addressed through management solutions applicable within the single business units, (b) drivers that identify causes of food waste which may be addressed through management solutions coordinated among different business units/operators of the food supply chain, and (c) drivers that identify causes of food waste which are related to wide economic and structural variables, not readily addressable by management solutions at the level of the food supply chain

The drivers that may potentially be affected by organisational innovation can be grouped in (a) and (b) categories; especially for food processing, wholesale and logistics and retail levels of the chain. The implementation of a new organisational method in the undertaking's **business practices**, **workplace organisation** or **external relations** may potentially limit food waste generated due to business-related drivers. The relevant drivers are summarized in Table 2 below (Canali et al., 2014).

Table 2. The business-related food waste drivers that may potentially be affected by organisational innovation

	Business-related food waste drivers	Category[1)]	Related examples of current causes of food waste
Food processing	Production of sub-standard food due to errors in processing;	(a)	• Production losses caused by inappropriately prepared ingredients, incorrectly run processes, the production of off-specification products; Recalls due to consumers' complaints: The producer has supplied something to the market that is not right, and the consumer detects a discrepancy in taste, and if the complaints system has logged multiple complaints for this product, it will be recalled.
	Food contamination due to errors in processing;	(a)	• Inefficient cleaning of equipment which leads to product contamination
	Damages to packaging during processing	(a)	• Damages in packaging with or without affecting the safety, taste or nutritional value of the food;
	Errors in labelling	(a)	• Incorrect labelling or packaging;
	Grading and sorting of products	(a)	• Grading & sorting losses;
	Contracts/agreements	(b)	Contracts in the chain: wastes and by-product wastage caused by own-label manufacturers not being able to redirect overproduction to different customers in keeping with their contractual agreements with the retailers
Wholesale and logistics	Mishandling and improper storage conditions (temperature, moisture, and light)	(a)	• Wrong handling and storage: Mishandling of food – for example food not being stored at the right temperatures or in the wrong light.
	Physical or damages to fruit and vegetables due to mishandling	(a)	• Rotten fruit in the deck infect the surrounding fruit. This is a common reason for food waste in the wholesale sector. Mishandling can both lead to physical damage and bacterial damage on the products
	Improper stock rotation methods leading to product rejection by retailers	(a)	• Disregarding first-in first-out principle: If the storing system is insufficient and staffs are not properly instructed, newly delivered products may be put onto the shelf instead of those from storage. This leads to older products being rejected by the retailer
	Supply chain/cold chain inefficiencies	(b)	• Waste occurring because of logistical management mistakes and/or lack of proper logistic management processes and systems. Insufficient

			communication with the market and retailers leads to wrong deliveries and returns. Management root-causes (practices): waste management responsibilities, information sharing, promotions management, forecasting, performance measurement, packaging, cold chain management, quality management and training. • Damage during transport due to temperature. Extreme changes in temperature during shipment can spoil or shorten the shelf life of food products. Meat and fish products are particularly sensitive to temperature conditions during transportation. Also other refrigeration problems during transport may occur, e.g. for chilled food.
	Forecasting of stocking /ordering due to lack of cooperation along the supply chain	(b)	• Miscalculation of market request; improving forecasting and working in partnership with suppliers could result in reductions in costs and waste generated throughout the supply chain. Seasonal variations are not sufficiently focused on but primarily, it has to be said, knowledge of the customer is crucial. • Retailers' service level requirements. Wholesale overstock to prevent penalties as the time to react on orders from retail is not enough for later orders at production.
	Contracts/agreements	(b)	• The sell-by date, the allocated time supplied to the manufacturer, has been exceeded. Retailers will refuse to take product with insufficient shelf-life remaining. This is in part because customers prefer fresh product over those with only a short shelf-life remaining. • Natural surplus of products during season: Mainly fruit and vegetables which mature very quickly during good weather conditions have to be sold very quickly after harvest during season to avoid spoilage. • Requirement of 75% remaining shelf life: When retail takes over products from wholesale or producers in most cases the remaining shelf life has to be 60-75 %. The wholesalers have taken initiatives to keep these products past the "internal best before date" from being wasted • Wholesale packaging size: Often the ordered products cannot be sold by the best before date as the wholesale packaging size which is offered by the producer is too large. Has to be implemented in cooperation with wholesale/ producers and retail.
Retail	Mishandling of products by untrained staff in the retail units	(a)	• *Untrained staff: Retail has a high share of part-time employees, frequently shelf support (filling the shelves with new products) has been outsourced. In addition, retail does not want to invest a lot of money in education of staff as there is a high rate of employee turnover. Thus,

		skilled staff may be lacking, leading to the wrong handling of food products and wastage.
Rejection of delivery/returns	(b)	• Poor quality delivery from the wholesale to the store: The routine of producers taking back unsold products without charging for them (depending on contract) will not encourage the staff to order the right amount of the product. Furthermore, the cost for the waste may be passed to the supplier. Thus, retail has no incentive to reduce the return flow. But prevention measures have to be implemented at both levels.
Power and trust, transparency, communication, and information sharing	(b)	• Coordination producer-retailer: Production companies sell as much as possible to retailers without taking into account if the products really can be sold within the shelf life of their product. Better coordination between retailers, distributors, wholesalers and manufacturers can reduce food waste and avoid it being shifted across the supply chain.
Relationship between food suppliers and redistributors	(b)	• Lack of trust/knowledge in redistribution: Destroying consumable products rather than donating them because of lack of trust in charity organisations; destroying products because of lack of information on how/where to donate, reluctance to donate food because of fears of litigation should a charity beneficiary fall ill.

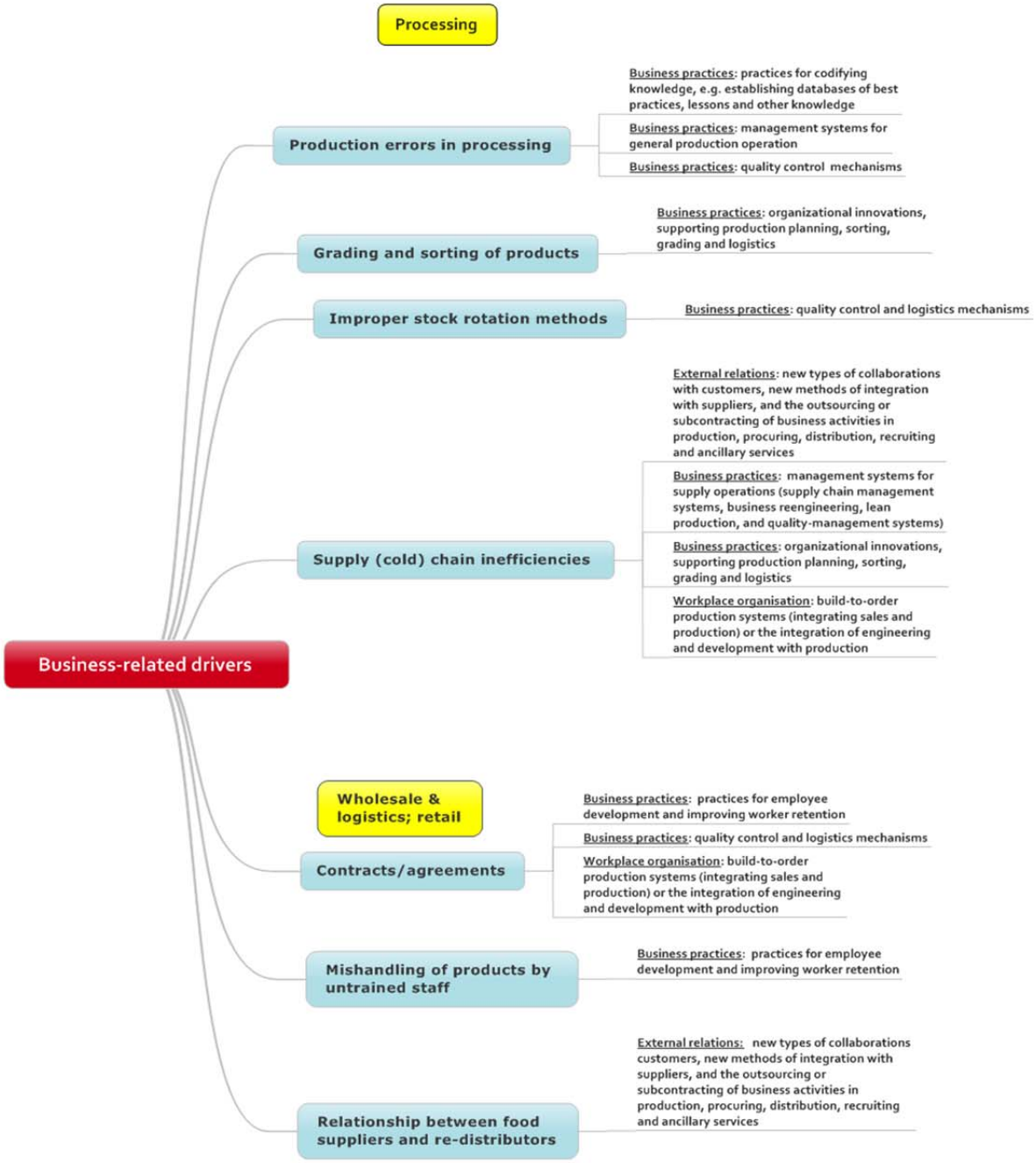
[1)] (a) drivers that identify causes of food waste which may be addressed through management solutions applicable within the single business units; (b) drivers that identify causes of food waste which may be addressed through management solutions coordinated among different business units/operators of the food supply chain.

Source: Canali et al. 2014

6.2.1 Possibilities to reduce food waste by organisational innovations

The implementation of a new organisational method in the undertaking's **business practices, workplace organisation or external relations** may limit food waste generated due to business-related drivers presented above. Below, the potential application of these forms of organisational innovation to manage the identified business-related drivers is discussed. The identified food waste drivers and potential organisational innovations to address these drivers are summarised in Figure 6.

Figure 6. Business-related Food Waste Drivers and Potential Organisational Innovations Addressing these Drivers



For the food **processing level**, the driver 'production errors in processing' (e.g., sub-standard food; food contamination; damages to packaging; errors in labelling) might be addressed via the following business practices: (a) the implementation of practices for codifying knowledge, e.g. establishing databases of best practices, lessons and other knowledge, so that they are more easily accessible to others; (b) the introduction of management systems for general production operation; (c) the establishment of quality control mechanisms[10]. For addressing the driver 'grading and sorting of products' organisational and management innovations, supporting activities such as production planning, sorting, grading and logistics (business practices) might be used. The establishment of quality control and logistics mechanisms (business practices) are potentially applicable to address the driver "improper stock rotation methods".

Another important business-related driver is supply (cold) chain inefficiencies (e.g., bad forecasting of stocking/ordering due to lack of cooperation), which can be addressed by various forms of organisational innovation; not only by innovations in business practices, but also in external relations and workplace organisation:

- External relations: the implementation of new ways of organising relations with other firms or public institutions, such as the establishment of new types of collaborations customers, new methods of integration with suppliers, and the outsourcing or subcontracting for the first time of business activities in production, procuring, distribution, recruiting and ancillary services;
- Business practices: (a) the introduction of management systems for supply operations, such as supply chain management systems, business reengineering, lean production, and quality-management systems; (e.g., integration of precision agriculture and global positioning systems to improve planting and harvesting efficiencies); (b) the introduction of supporting activities such as production planning, sorting, grading and logistics;
- Workplace organisation: the introduction of build-to-order production systems (integrating sales and production) or the integration of engineering and development with production.

For the **wholesale & logistics and retail** stages, the implementation of practices for employee development and improving worker retention, such as education and training systems (business practices), might positively affect the driver

10 Organizational innovations for low-cost value addition: Producer organizations can play an important role in adding value to and reducing losses of their members' produce through organizational and management innovations, supporting activities such as production planning, sorting, grading and logistics (FAO, 2012). An example of this type of innovation – Reducing post-harvest losses and improving smallholders' income from cassava in Cameroon: The fragmentation of smallholder supplies to the market was identified as one of the bottlenecks that needed to be addressed to improve competitiveness of the cassava chain in Cameroon. Following the establishment of quality control and logistics mechanisms – run by local producer organizations with support from FAO – wholesalers can now use public transport to pick up graded produce and make payments at agreed stops along the Akonolinga-Yaoundé highway. These innovative mechanisms have resulted in improved quality control, fewer product rejections by wholesalers and increased income for both producers and buyers (FAO, 2012).

'mishandling of products by untrained staff'. To address the 'contracts/agreements' driver the following form of organisational innovation might be useful:

- Business practices: (a) the implementation of practices for employee development and improving worker retention, such as education and training systems; (b) the establishment of quality control and logistics mechanisms;
- Workplace organisation: the introduction or improvement of build-to-order production systems (integrating sales and production) or the integration of engineering and development with production.

When it comes to the driver 'relationship between food suppliers and re-distributors', the establishment of new external relations might help food suppliers and re-distributors address this driver. Specifically, the implementation of new ways of organising relations with other firms or public institutions, such as the establishment of new types of collaborations customers, new methods of integration with suppliers, and the outsourcing or subcontracting for the first time of business activities in production, procuring, distribution, recruiting and ancillary services might be useful options.

7 Economic factors effecting the adoption of food waste related innovations

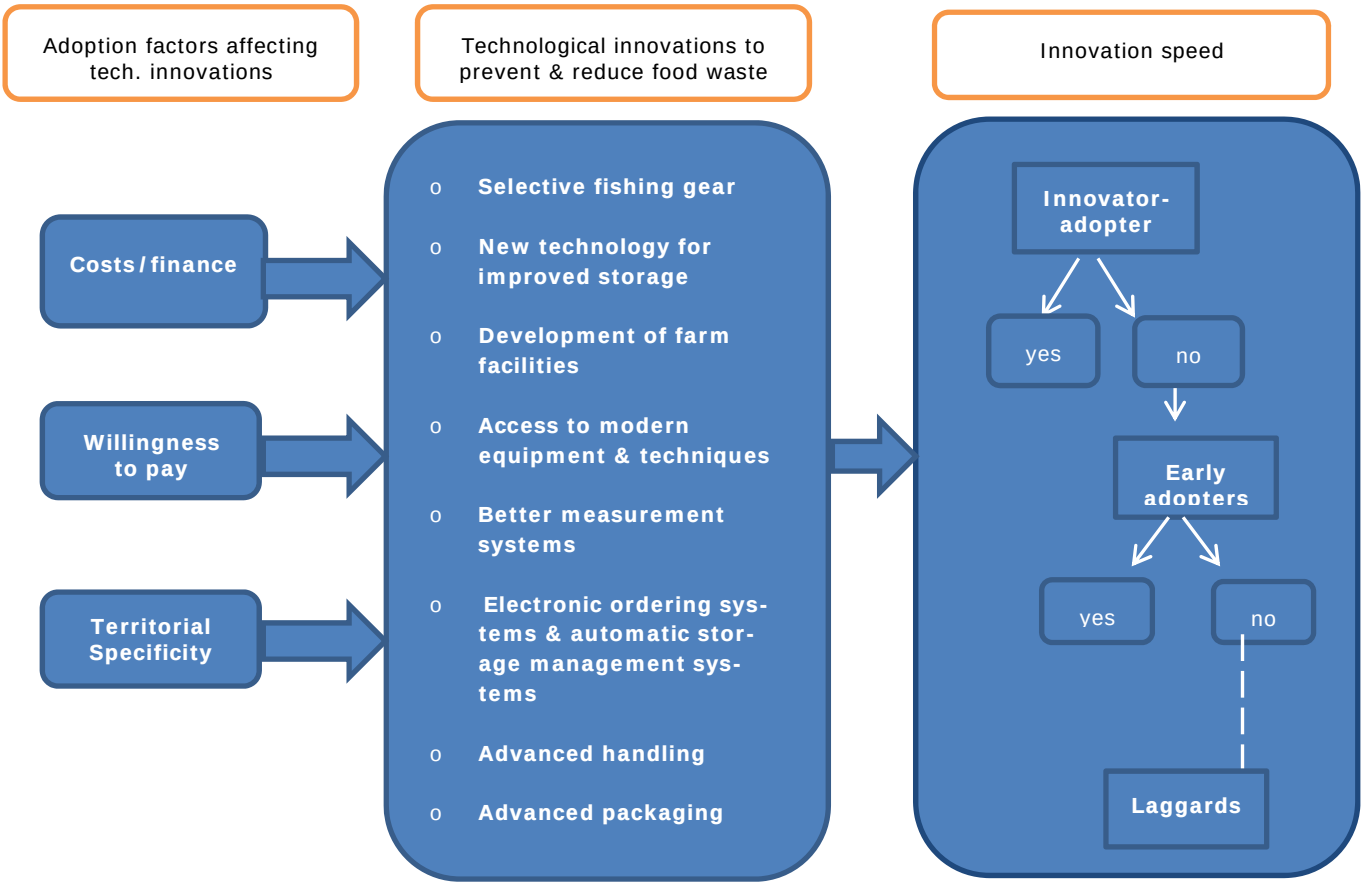
7.1 Technological innovation in relation to food waste prevention and reduction

Technological innovation can contribute substantially to prevent and reduce food waste (Canali et al., 2014). Some examples of such technological innovations are the development of new technologies for storage, refrigerators/cooling, the development of new equipment for harvesting and transporting food along supply chain, electronic ordering systems, advanced packaging etc.

However, several economic factors play a crucial role in business decision to adopt the innovation. One of the crucial factors is investment costs and all sub-factors related to it, such as risks associated to sunk costs, long pay-back periods, high initial investments, poor access to capital, small size of the company with insufficient middles. Another crucial factor is the willingness to pay and/or consumer acceptance of a new technology. Even if the businesses will decide to invest in an innovative technology to reduce food waste, there is still a question whether it will find an adequate response from final users. In case of food waste reduction, it is possible to think of innovative technologies to increase shelf life of fresh products (e.g. use of bio-protective cultures for dairy products), however it is not given that consumers will accept such products. Another important factor affection the adoption and the diffusion of technological innovations is the territorial specificities with legal cultural and economic context. In case of food waste reduction possibilities the adoption and diffusion of technological innovation can have different patterns in different EU countries depending on national policies supporting such innovations (e.g. subsidies for technological innovations to reduce food waste) , economic situations (e.g. economic crises in certain MS may hamper development and or adoption of innovative technologies) and the culture (e.g. culture and thus acceptance of technological innovations in different MS can be rather different). The diffusion of technological innovation depending on the factors described above takes place with different speed. Currently, there are already several technological innovations ready to be implemented in order to prevent and reduce food waste (e.g. electronic ordering systems, apps, new cooling systems); however, the diffusion of these innovation is still in progress. This, of course, is an on-going process and, as with any industry, there will be early adopters of new techniques and those that lag behind.

The results of the analyses regarding the evaluation of technological innovation in relation to food waste prevention and reduction are schematically presented in Figure 7 below. The figure comprises the main factors that can affect the adoption of technological innovation to prevent and reduce food waste by businesses, the main technological innovations to prevent and reduce food waste, and the theoretical speed of diffusion of these innovations.

Figure 7. Evaluation of the economic factors effecting adoption of innovations by businesses to create / reduce food waste

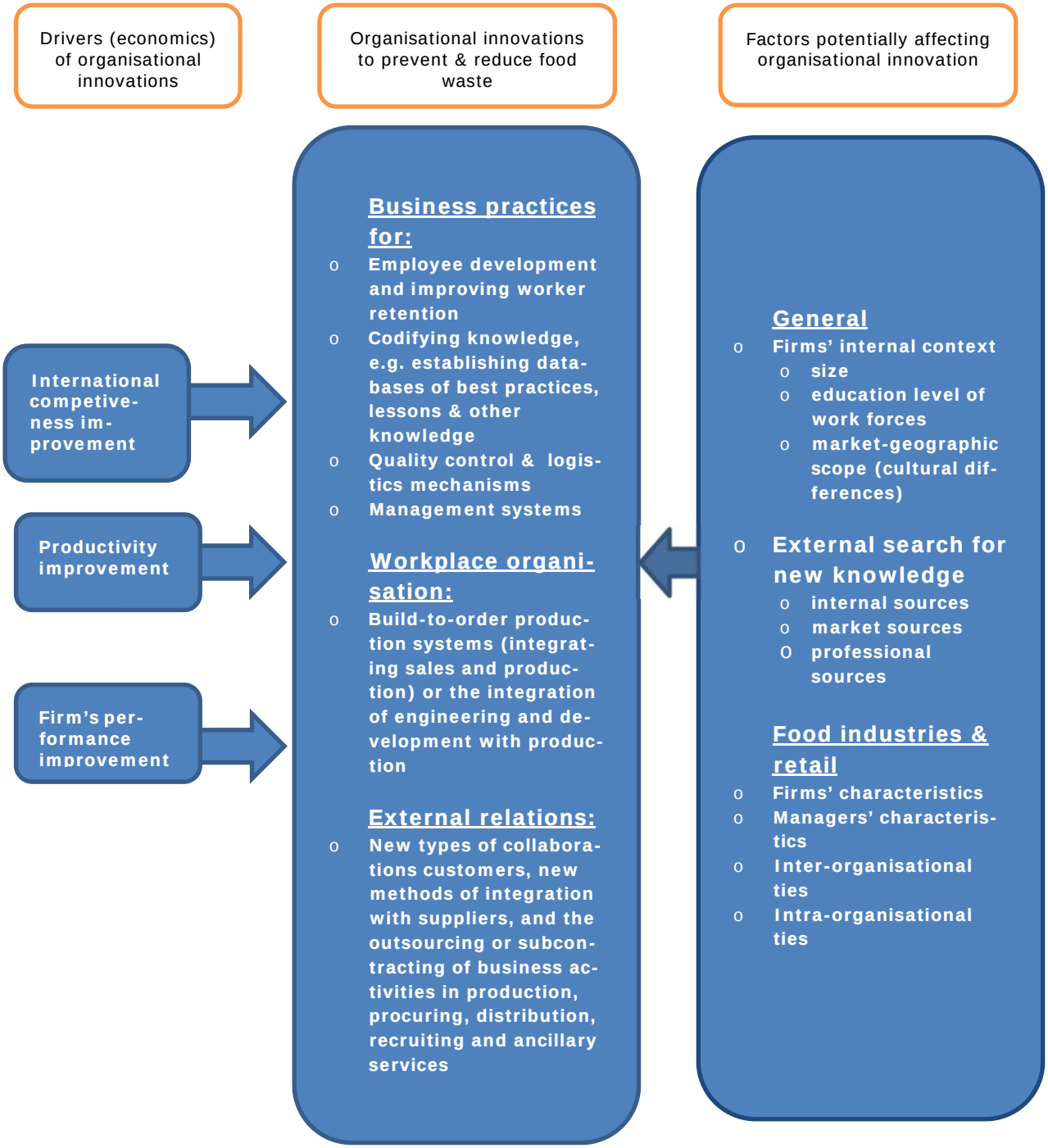


7.2 Organisational innovation in relation to food waste prevention and reduction

The previous analysis showed that organisational innovation has the potential to considerably contribute to the prevention and reduction of food waste, with specific focus the processing, wholesale & logistics, retail.

Figure 8 contains an overview of the results obtained. The figure maps the links between different forms of organisational innovation (potentially applicable for food waste prevention and reduction), economic drivers of organisational innovations, and factors affecting the decision of businesses to adopt these forms of innovation.

Figure 8. Links between Different Forms of Organisational Innovation, Economic Drivers of Organisational Innovation and Factors Affecting Decision of businesses to Adopt these Forms of Innovation



It is important to stress one more time that an **organisational innovation** is the implementation of a **new organisational method** in the undertaking business's practices, workplace organisation or external relations. This implies that the **innovation needs to be new to at least the firm**, and may be developed by the firm itself or by another enterprise (or in collaboration).

The potential organisational innovations identified as useful for food waste prevention and reduction at the processing, wholesale & logistics, retail levels include (Figure 8):

Business practices for:

- Employee development and worker retention improvement.
- Codifying knowledge, e.g. establishing databases of best practices, lessons and other knowledge.
- Quality control and logistics mechanisms.
- Management systems.

Workplace organisation:

- Build-to-order production systems (integrating sales and production) or the integration of engineering and development with production.

External relations:

- New types of collaborations customers, new methods of integration with suppliers, and the outsourcing or subcontracting of business activities in production, procuring, distribution, recruiting and ancillary services.

As discussed above for organisational innovation in general, the ultimate drivers of innovation relate to business economics. Firm performance improvement, productivity improvement, and improvement of international competitiveness are crucial drivers affecting the decision of businesses to adopt organisational innovation. These drivers would definitely affect also organisational innovation for food waste reduction and prevention (Figure 8).

Basically, the organisational innovation identified for food waste reduction and prevention might potentially improve: (a) a firm's ability to learn and utilise new knowledge and technologies, and its ability to innovate; (b) improve the quality & efficiency of work; (c) enhance the exchange of information; (d) reducing administrative costs or transaction costs, costs of suppliers; (e) improving workplace satisfaction (and thus labour productivity). In this way, these innovations might contribute to better performance of the firm. This indicates that there is a potential economic driver for firms to prevent and reduce food waste.

At the same time, it is important to stress the strong interrelations between product and process technological innovations and organisational innovation. Technological innovation requests organisational and marketing changes in order to effectively stimulate productivity and competitiveness. Technological product and process innovations do not have a positive effect without organisational innovation.

Furthermore, the case studies discussed above identified key factors potentially influencing organisational innovation in general, and more specifically in food

processing and retail (Figure 8). These are grouped into general and specific factors.

General factors:

- Firm internal context: size, education level of work forces, market-geographic scope (cultural differences).
- External search for new knowledge (knowledge sources): internal sources, market sources, professional sources.

Factors specific of food industries & retailers:

'+' indicates positive effect; '-' indicates negative effect

- Firms' characteristics: firm age (-), capacity for production (+), product diversification (-).
- Managers' characteristics: managers 'experience (+), management's positioning of the R & D, managers' technical competence.
- Inter-organisational ties: close linkage and cooperation with customers and on various information networks (+).
- Intra-organisational ties (+).

For the innovations to prevent and reduce food waste, intra-organisational ties might be of particular importance. It is certainly necessary for organizations to put together different capabilities and services with the joint goal to prevent and reduce food waste; and through cooperation between suppliers and customers, service providers and scientific institutions to achieve food waste innovations of high quality.

It is, however, important to note that similar to other innovation types (see discussions on technological innovation above), the implementation of new organisational methods is fraught with **uncertainty**. As discussed above, uncertainty can lead firms to hesitate to implement significant changes, even as they face a volatile environment that increases pressures to introduce new products, seek new markets and introduce new technologies, practices and organisational methods into their production processes.

8 Conclusions

The objective of this report was to analyse the economics of innovation and its implication for food waste, namely to evaluate the factors effecting the adoption of innovations to prevent and reduce food waste by businesses. Technological and organisational innovations were considered. These types of innovations may enhance food production efficiency. However, despite their potential role in preventing and reducing food waste, they still have to be economically feasible in order to be adopted by businesses of the food supply chain. Thus, the economical determinants of the adoption of innovations targeting food waste were analysed.

The literature review showed that the adoption of innovations (technological and/or organizational) is ultimately motivated by economic factors, which can be classified as follows: (1) improving firm performance, (2) improving productivity; (3) improving international competitiveness. The cost factors, and the risks associated to these costs, appear to be the most important determinates of technological as well as organisational innovation. Besides, it has been found that product and process innovations do not have a positive effect without organisational innovation, and the combination of both technological and non-technological innovation activities determines productivity gains.

When it comes to food waste prevention and reduction, a good example of combining technological and organisational innovations may be observed in the retail sector. Here, innovative smartphone apps to promote the sale of products nearing their expiration date were developed and adopted through different retailing channels.

Geographic scope (or territorial specificity) appears to be another important determinant of technological and organisational innovations. Cultural differences increase the difficulty of implementing new management practices, especially if the cultural distance is large. Similarly, technological innovations can be quickly adopted and spread in one place, while in other places the adoption and diffusion may be restricted, depending on the enabling environment. In general, innovation is not likely to follow the same path of diffusion in different places, leading to different local outcomes. A good example of this issue is represented by the current development of activities targeting food waste throughout the EU. EU countries can be grouped into innovator-adopters (e.g. UK, Sweden, Denmark), early adopters (e.g. Italy, France, the Netherlands), and lagged (e.g. Eastern European Member States).

Overall, the adoption and diffusion of innovation to prevent and reduce food waste is an on-going process and, like in other sectors, business will divide into adopters of new technologies and organisational innovations, and those that lag behind.

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