Chapter N 305

**The agri-food products life cycle: the technological dimension role in an open innovation perspective**

**Abstract.** The literature analysis allows to group the main schools of thought on life cycle models into three categories: the marketing dimension (marketing product life cycle), the managerial/engineering dimension (engineering product life cycle), the technological dimension (technology life cycle). However the empirical evidence has revealed an overlap of such models and over time the technological dimension has taken on an increasingly important role in building successful business models. In particular, the open innovation (OI) concept has found more and more application in the agri-food sector through the construction of models based on specific case studies (OI models). The present work aims to carry out a systematic review of the current literature to underline points of contact and deviations between the most accredited models applied in the agri-food sector in order to highlight the success variables underlying the application of each model.

**Keywords.** Open Innovation, Open Innovation Model, Food innovation, Agrifood Sector, Technology Life Cycle, Product Life Cycle.

**Paper type**. Systematic review.

**N.1 Introduction**

**N.1.1 The life cycle and the open innovation perspective**

A multidisciplinary approach to the latest life cycle literature allows the main schools of thought to be grouped into three categories: the marketing dimension (Dean, 1950; Levitt, 1965; Tellis & Crawford, 1981), the managerial/engineering dimension (Day, 1981; Bennett & Cooper, 1984; Westkämper, 2001), and the technological dimension (Tarde, 1903; Rogers, 1962; Chesbrough, 2003). However, the case studies have revealed an overlap of these dimensions, especially the technological one. Hence, this dissertation aims to investigate the role of the technological dimension in an open innovation perspective within the food sector. The technological dimension is crucial: as stated by Schumpeter, economic development is fostered by the continuous emergence of new and more sustainable innovations (Schumpeter, 1934). Consequently, the firm's ability to innovate is fundamental to survive in such competitive environment. Under these circumstances, a system of cooperation between actors is necessary, since companies usually do not have sufficient resources to innovate. In other words, an open innovation approach may be a game changer.

According to the original definition, in an open innovation (OI) process “*… valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well*” (Chesbrough, 2003). In more recent times the definition has been revisited: “*OI is defined as a distributed innovation process based on purposively managed knowledge flows across organisational boundaries, using pecuniary and non-pecuniary mechanism in line with the organization´s business model*” (Chesbrough e Bogers, 2014). Examples of pecuniary and non-pecuniary mechanisms are the following: intellectual property rights, crowdsourcing, crowdfunding, hackathons, collaborations.[[1]](#footnote-1)a Concerning collaborations, the company's ability to build a network (with universities, spin-offs, start-ups, public and private institutions, etc.) allows then to manage a huge flow of information and skills and so to meet the needs of the moment (Tarabella, 2019). In fact, thanks to cooperation, companies not only optimize the flow of information but also increase their profits by ensuring a diversification of their resources (Kranenburg et al., 2004).

**N.1.2 The open innovation approach in the globalized food industry: an essential need**

The food industry is a mature and conservative sector where its profit margins are extremely low and R&D failure rate for new products is high (Bigliardi & Galati, 2013; Tsimiklis & Makatsoris, 2015; Manzini et al., 2016). Furthermore, the food industry has historically given priority to the cost minimization, paying less attention to consumers desires and so to satisfy their needs (Lienhardt, 2004). This approach made the food industry unprepared for the dramatic changes happened during the XXI century. Nowadays, the market is absolutely consumer-oriented, and so an open mindset is essential. These stylized facts show that the food sector can no longer rely on the traditional innovation method: an open innovation approach is needed. Not by chance, in the last decade more and more food companies are looking beyond their organizational boundaries for new opportunities in order to collaborate with potential partners in the supply chain (Tsimiklis & Makatsoris, 2015).

It follows that the open innovation strategy can and must also be pursued in the food sector. In fact, many studies have shown that innovation can become an effective tool, even for mature and traditional industries (Arcese et al., 2015). The main factors that lead food companies to innovate are the following (Arcese et al., 2015):

1. A different nature of food demand;
2. A different organization of food supply;
3. A more differentiated demand from consumers in terms of quality, variety and convenience;
4. A different demand for healthy and eco-friendly food;
5. A different approach to food safety.

Thus, the consumer-oriented approach is fundamental to maintain the competitive advantage.

Nevertheless, new millennium challenges not only concern the change of perspective towards consumers, but also climate emergency. The 2030 Agenda for Sustainable Development explains that innovations along with sustainable and safe solutions represent the main challenge for the agri-food sector (Bigliardi & Filippelli, 2022). After all, the technological dimension is crucial in the agri-food industry. Therefore, an open innovation approach is needed to meet not only the increasing customers needs but also climate challenges. In this respect, the European Commission consider open innovation, education and skills essentials to overcome those challenges (European Commission, 2018).

Concerning Europe, the food and drink industry represents the largest manufacturing sector in the EU. This sector is the main contributor to the European economy. In particular, more than 294,000 companies are involved, 99% of which are SMEs (FoodDrinkEurope, 2018).

However, SMEs actions are limited since they have few resources and capabilities (European Commission, 2009; Dima et al., 2022). In most cases, SMEs have difficulties with bank financing. Nonetheless, the recent sharing economy growth makes it easier to SMEs to receive credit financing. Anyway, many SMEs don't ask for FinTech financing (Najib et al., 2021).

Turning to other food industry challenges, companies have to face the shortened life product cycles, the competitive time-to-market race, and the cluttered retail shelf space (Bellairs, 2010). This implies that digital technologies exploitation (e.g. IoT, big data, blockchain, artificial intellinge) is unavoidable (Saguy, 2016). To put it more simply, digital technologies not only connected the entire world, but also changed all sectors, including agri-food sector (Tarabella et al., 2021).

Potential outcomes are enormous. Further examples relate to greenhouse monitoring, intelligent farm machines, drone-based crop, supply chain modernization, social media (for open innovation), food quality assessment (spectral methods and sensor fusion) and food safety through gene sequencing and blockchain digital traceability (Misra et al., 2022).

Nevertheless, changing mindset is difficult, since open innovation oriented SMEs experience several barriers such as low absorptive capacity (Spithoven et al., 2010), scarce financial resources for R&D, limited human resources and competences and small market power (Saguy & Sirotinskaya, 2014). Overcoming these internal barriers would allow agri-food companies to develop new open innovation models in order to exploit digital technologies potential.

In conclusion, the food industry contribute to global economy amounts to 4 trillion dollars every year (Arcese et al., 2015). It follows that the exploitation of open innovation practices can foster not only the entire sector but also global economy.

**N.2 Methodology**

The literature analysis started with the Scopus database. The following query has been entered: TITLE-ABS-LEY (“open innovation” and “food” or “agrifood”). Thus, Scopus identified 682 articles. A careful reading of the abstracts made it possible to thoroughly examine the literature concerning food open innovation models. In order to observe further conceptual links, a bibliometric analysis was carried out using the VOSviewer software. This software creates two-dimensional maps. Those maps show the correlation of items through the number of frequencies they share. In this case, the VOSviewer map is based on the keywords provided by the authors.

The Figure 1 displays a co-occurrence map for author keywords on the topic of open innovation in food companies. The goal was to obtain an overview of the present literature in order to identify additional food open innovation models. The term “open innovation and food or agrifood” had to appear in the title, abstract or keywords.

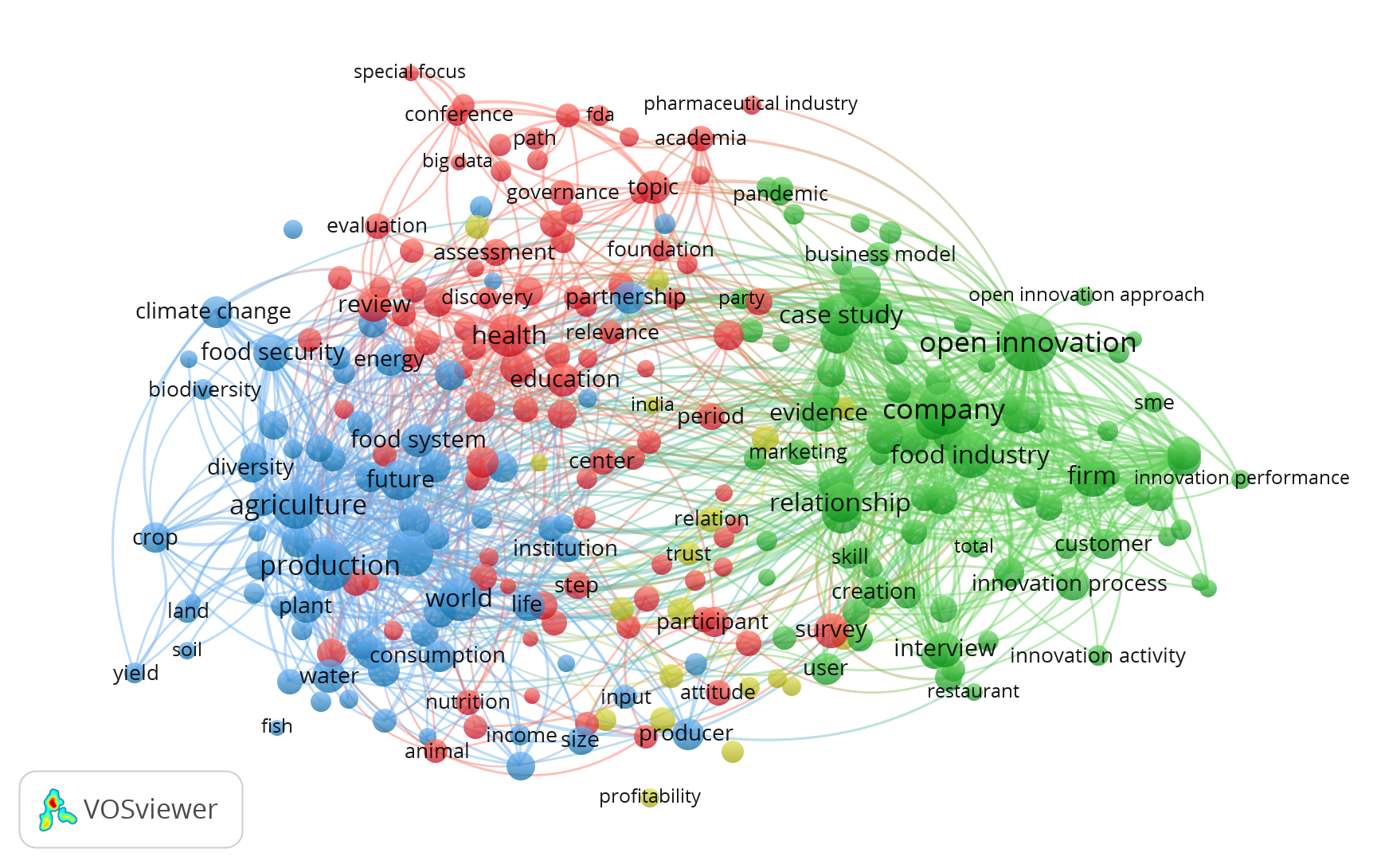


Fig. 1. VOSviewer map visualization of the most frequent keywords.

Source: own elaboration.

21192 terms were observed by VOSviewer and a threshold of 10 occurrences has been selected.[[2]](#footnote-2)b

Thus, 454 keywords meet the threshold. For each of the 454 terms, the VOSviewer default suggestion to select the 60% most relevant terms has been followed. At the end of the process, VOSviewer created a map related to 272 keywords gathered together into 4 clusters.

Each circle represents a keyword. Circle's size reveals how many publications present that precise keyword in the title or abstract. Moreover, keywords that co-occur a lot are placed closed together on the map.

This map revealed some subtopics related to the food open innovation theme. The blue cluster, located on the left, consists of terms related to production agriculture. The red cluster, placed at the top, covers terms that go beyond the interests of this research. On the other hand, the green cluster is the most interesting one: most frequent keywords are “open innovation” and “company”, located close enough to “case study” and “food industry”. It is interesting to note the presence of SME keyword: this should not be surprising since 99% of European food companies are SMEs. In addition, keywords “restaurant” and “interview” are very close. It follows that case studies concerning restaurants are likely to be examined through the use of interviews. Lastly, the pandemic keyword is observed in the green cluster.

**N.3 Literature review**

At the beginning of the XXI century some researcher already highlighted that innovation was the only way to escape from the “spiral of death”. However, most of food companies preferred the cost minimization approach (Juriaanse, 2006). Fortunately, in the last decade open innovation has started to be mainstream in the European food industry: companies such as Cargill, Nestlé, IFF or Mars approached open innovation models (Bigliardi & Galati, 2013). Nevertheless, such improvement is still slow: the switch from closed to open innovation is spreading but at a slow pace. This issue has been already evoked in the literature: nowadays, few research on the food open innovation approach are developed (De Medeiros et al., 2016; Cillo et al., 2019; Sadat & Nasrat, 2020).

On the whole, the diffusion of theoretical food open innovation models is still limited. Table 1 provides a summary.

Table 1 may foster numerous study opportunities for academic researcher. For instance, recent events related to COVID-19 pandemic highlighted global supply chain vulnerability. Moreover, those events put pressure on firms to look for collaborative and more flexible innovation approaches (Chesbrough, 2020; FAO, 2020; Walker et al., 2021). Concerning the pandemic, the social food open innovation model developed by Penco et al. (2021) evaluate the impact of Open Social Innovation (OSI) on the capability of an Italian food bank to overcome the crisis. The study shows

that Covid-19 stimulated the adoption of OSI practices in order to fulfill the food bank social mission. In the matter in question, this case study underlines the role of inbound (acquiring and sourcing) and outbound (selling and revealing) practices to meet food banks goals.[[3]](#footnote-3)c

In conclusion, a further development of food open innovation models is expected in the coming years. In fact, consumers needs related to food are spreading enormously: nowadays consumers choose customized diets that address their desires to eat low-fat foods or to remove ingredients that affect their allergies or personal beliefs (Cillo et al., 2019).

Table 1. Food OI models: a literature review

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Food OI model** | **Article** | **Year** | **Authors** | **Methodology** | **Goals** | **Field of application** | **Features** | **Business unit involved** | **Results** |
| **Connect & Develop** | *“Connect and Develop: Inside Procter & Gamble’s New Model for Innovation”* | 2006 | Huston and Sakkab | IT platforms, meetings | First, creating a model that defines problems to be solved; second, let the problems circulate in individual global networks and institutions to find out if anyone in the world has already a solution. | P&G | Technology, radical innovation | R&D unit, production, marketing, purchasing | The C&D model, if seen only as a R&D strategy or as an experiment, is doomed to fail. Hence, it must be guided by the top management. |
| **Share is Winning (SiW)** | *“Creating successful innovation partnerships”* | 2009 | Traitler and Saguy | Data from R&D, universities, companies involved | Co-create value and innovation through partnerships. | Nestlé | Innovation process | R&D unit, clients | Development of the “Innovation Partnerships” strategy and the SiW model. |
| **Food Machinery Framework** | *“Open innovation and supply chain management in food machinery supply chain: a case study”* | 2010 | Bigliardi et al. | Case study with bibliographic review and questionnaire | Evaluate the determining factors (and their extent) for the adoption of the OI paradigm in the food machinery industry. | Companies involved classified | Radical and incremental product innovations | R&D unit, suppliers and clients | Each player in the supply chain perceives innovation as a key factor for surviving in current highly competitive markets. Therefore, he actively participates in the OI. |
| **Living Lab** | *“Organizing information integration in agrifood. A method based on a service-oriented architecture and living lab approach”* | 2010 | Wolfert et al. | Design-oriented case study | Develop a new method in order to organize information integration in the agri-food sector. This will happen through a structure that drives the project towards implementation. | 12 large agricultural Dutch farms | Innovation process | Farmer, supplier, retailer, customer | Important success factors are incremental growth approaches and service-oriented approaches towards processes rather than software. |
| **Want Find Get Manage (WFGM)** | *“The ‘want find get manage’ (WFGM) framework for open-innovation*  *management and its use by Mars, Incorporated”* | 2013 | Garcia Martinez | Application of Slowinski's general model (2004). | Helping companies to effectively implement open innovation strategies. Specifically, the model helps the company to find the best existing technology. If that technology is external to the firm, the model suggest to internalize it. | Mars, Incorporated | Technology | Open innovation team | The model increased the collaborative projects successful rate. It happened because the teams respected the following process: defining the necessary resources, finding them outside the company, looking for potential partners to make a deal, managing the consequences of this agreement. |
| **Controlled OI approach** | *“The tension between traditional innovation strategies and openness: Lindt’s controlled open innovation approach”* | 2013 | Lazzarotti and Manzini | Case study with top management interviewed | Identify the phases where the risk linked to the opening is low, and so exploiting the potential benefits through a technological collaboration;  Identify potential partners, limiting openness only to those with whom it is possible to maintain a long-lasting relationship of trust. | Lindt & Sprüngli  Maitre Chocolatier | Incremental innovation | Marketing unit, R&S, production, expert consumers | Model's adoption allows closed companies to exploit the potential advantages of open innovation without radically changing their business model. |
| **Co-creation of value** | *“Co-creation of value by open innovation: unlocking new sources of competitive advantage”* | 2014 | Garcia Martinez | Case study with interviews | Examine the joint process of co-creation. In this process consumers play an active role within an OI-oriented corporate strategy. | Molson Coors, UK brewing company | Innovation process | Sales unit, production, provision | Consumer role in co-creation of value is crucial in a product-based industry. Such creation can be achieved through consumers participation as partners or co-producers. |
| **Consumer-centric OI framework** | *“A consumer-centric open innovation framework for food and packaging manufacturing”* | 2015 | Tsimiklis et al. | Crowdsourcing[[4]](#footnote-4)d | Making new food products that consumers will buy. At the same time, ensuring that these products will reach the consumer on time and in the right quantity. | Large Spanish yoghurt producer (classified data) | Innovation process | Cross-functional team (production, marketing, logistics, finance, engineering, quality, R&D, food safety, nutrition, purchasing) | Raw materials, planning skills and control systems are needed. This can be achieved through the ability to provide forecasts across the supply chain. Simulations and optimization models allow to define initial risks and manage them effectively. |
| **OI Cereal Scheme** | *“How open is food innovation? The crispbread case”* | 2019 | Grimsby and Kure | Multi-phase (meetings, reports, interviews, quantitative data) | Studying the cereal industry and crispbread success. | Norwegian cereal industry | Product innovation, packaging, transfer of tacit knowledge | Innovation managers | The crispbread case may be an example of successful OI through the export of agriculture-based products from a country with highly subsidized agriculture and a country with the highest labor cost in the world. |
| **Causal loop model of resturant open innovation** | *“Open innovation ecosystems of restaurants:*  *geographical economics of successful restaurants*  *from three cities”* | 2020 | Yun et al. | Case study with interviews and questionnaires | Studying if open innovation is convenient in attracting customers, even for small restaurants. | Four Neapolitan restaurants, one South Korean restaurant, one North Korean restaurant. | Innovation process | Restaurant | OI determines the success of small restaurants. Furthermore, if any small restaurant adopts a closed innovation strategy with respect to an ingredient or recipe or service, it should adopt an open innovation strategy to maintain the competitive advantage over the other restaurants in the neighborhood. An OI platform of any ingredient, recipe or service increases revenue through their sales. |
| **Open social food innovation** | *“Open social innovation for surplus food recovery and aid during COVID-19 crisis: the case of Fondazione Banco Alimentare Onlus”* | 2022 | Penco et al. | Case study | Analyze the role of open social innovation in challenging COVID-19 crisis. | Fondazione Banco Alimentare Onlus (FBAO) | Innovation process | Food bank | COVID-19 encouraged the adoption of open social innovation practices to continue to fulfill the social mission and at the same time to create innovative projects. |
| **Food-Machinery flexibility model** | *“The Thai SME Open Innovation Food-Machinery Flexibility Model: Six Patterns of Coupled Knowledge Flows”* | 2022 | Hongsaprabhas and Parisot | Case study with interviews | Develop a model that takes a leading position for academics and entrepreneurs wishing to develop new products. | 2 Thai food machinery SMEs | Outbound (e.g. insourcing R&D) and inbound (e.g. customer involvement) practices | Food company | The model is divided into 6 sub-patterns with different and unique characteristics. The results of these patterns demonstrate the flexibility of food machinery companies in applying one logical OI or another. In fact, companies do not only practice inbound OI or outbound OI but a mix of them. This agility in adopting various OI logics and practices helps the food machinery company to develop new core competencies along with its production technology. |

Source: own elaboration.

**N.4) Conclusions**

The food industry is slowly moving towards open innovation models in order to overcome institutional and socio-economic changes (Bayona-Saez et al., 2017). Food open innovation models can complete traditional innovation models, in order to strengthen traditional models weaknesses (Bigliardi et al., 2020). Such goal is unavoidable, since the food sector will soon experience new challenges. However, those challenges could be transformed into opportunities (e.g. Exploitation of digital technologies). Nowadays economic actors live in the open innovation era: it is an undeniable stylized fact. In other words, companies can no longer rely exclusively on traditional open innovation models. Such mindset change requires a huge organizational culture transition. For instance, most of the food companies are afraid to share externally their know-how. Hence, new open innovation models should take into account this psychological issue. In other words, trust cannot be built exclusively through non-disclosure agreements or patents. So, organizational culture must embrace an open mindset. In conclusion, the present research carried out with Scopus can be improved through the integration of additional databases.

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1. a Hackathons represent a new toolkit available in management strategies portfolio. Hackathons are a form of live crowdsourcing where computer programmers develop various prototypes and new ideas in order to innovate (Tucci et al., 2018). [↑](#footnote-ref-1)
2. b The treshold states how many times a keyword have to occur in the dataset to be used in the analysis. [↑](#footnote-ref-2)
3. c Inbound (acquiring and sourcing) and outbound (selling and revealing) open innovation can be practiced through many sub-activities. For instance, company can acquire knowledge through formal networking, cooperation, collaboration, in-licensing. Further examples are customer participation and informal networking (Sadat & Nasrat, 2020). [↑](#footnote-ref-3)
4. d Crowdsourcing can be assessed as a form of outsourcing that engages a group of participants who share work, information or opinions. After the identification of a problem, the group offers solution to that problem: succesful solutions are awarded and developed. [↑](#footnote-ref-4)