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Review

Dynamics of open innovation in the food industry

Soumodip Sarkar[a] and Ana I.A. Costa[b,*]

[a]CEFAGE – Centre for Advanced Studies in Management and Economics, Department of Management, University of Évora, Largo dos Colegiais 2, 7004-516 Évora, Portugal

[b]UNICEE – Research Unit of the School of Economics and Management, Catholic University of Portugal, Palma de Cima, 1649-023 Lisboa, Portugal (Tel.: +351 217 214 270; fax: +351 217 270 252; e-mail: anacosta@fcee.lisboa.ucp.pt)

A growing number of chain actors, together with difficulties in single-handedly meeting the heterogeneous needs of customers, end-users and legislators, is driving the food industry to open up to external sources of knowledge in search of successful new products and technologies. Empirical evidence of food companies engaging in open innovation remains, however, scarce, as do detailed analyses of related business strategies. We review extant literature on open innovation practices in the food industry and analyze their effects on the sector's innovation capabilities and market outcomes. Finally, we draw implications for food innovation and highlight areas where research is needed.

Introduction

The human capital inputs of innovation processes – *i.e.*, the individual skills and knowledge employed in Research and Development (R&D) and commercialisation activities (Romer, 1990) – can be sourced both inside and outside corporate boundaries. Innovation processes in which human capital inputs are sourced mainly within a firm's boundaries have been broadly designated as *Closed Innovation*, as opposed to innovation processes in which such inputs are, to a large extent, purposively sourced outside the firm – a business strategy commonly known as *Open Innovation* (Chesbrough, 2003). The latter is about harnessing the inbound and outbound flows of ideas, technology and skills across a firm's boundaries (which are channelled through its multiple inter-organizational links), with the intent of accelerating internal innovation processes and establishing additional, external paths for the commercialisation of their outcomes (Chesbrough, 2003; Simard & West, 2006). The establishment and management of inter-organizational relationships with customers, competitors, suppliers, public and private research institutions or even seemingly unrelated businesses, with the aim of acquiring additional knowledge and skills for innovation processes, are increasingly seen as an important way for firms to augment their innovation capability (Gatignon, Tushman, Sith, & Anderson, 2002; Hauser, Tellis, & Griffin, 2006; OECD & Eurostat, 2005).

To date, open innovation has been commonly associated with fast-growing, technology-intensive industries, like the information and communication technology sector or the pharmaceutical industry. There is, however, increasing evidence that this concept and associated strategies may also prevail in more traditional and mature industries (Huston & Sakkab, 2006), particularly when certain sets of circumstances arise. Among such circumstances is a high dependence on other entities – be them other firms, public research institutions or end-user communities – for the supply, development and/or commercialisation of new technologies (Chesbrough & Crowther, 2006; Maula, Keil, & Salmenkaita, 2006; Vanhaverbeke & Cloodt, 2006).

Given the high number of actors of different areas involved in food supply as well as their difficulties to single-handedly meet all the heterogeneous (and often contradictory) requirements of intermediate customers, end-users and legislators (Costa & Jongen, 2006; Grunert *et al.*, 2005; Mikkelsen, Kristensen, & Nielsen, 2005), cross-boundary innovation management should thus be a widespread practice in food value chains and networks. Empirical substantiation of food companies engaging in open innovation strategies is, however, scarce (Knudsen, 2007), being mainly limited to anecdotal evidence reported on-line. Accordingly, peer-reviewed literature does not provide much empirical support for open innovation practices in the food sector, although firms in this industry appear to be experimenting in different ways with open innovation strategies (Huston & Sakkab, 2006; Thomke & von Hippel, 2002; Vanhaverbeke & Cloodt, 2006). Most importantly,

* Corresponding author.

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a detailed analysis of these activities, their rationale and market outcome is, with the exception of a few case studies, virtually absent from both academic and practice-oriented peer-reviewed literature. Consequently, the goals of this paper are:

- To review reports on the use of open innovation business models in the food industry;
- To analyze the effects of open innovation strategies on the innovation capabilities and market outcomes of firms in this sector.

The paper is structured as follows. First, we review extant literature on the application of the open innovation concept in the food industry. Next, we analyze the impact of the open innovation strategies employed so far on the sector's innovation capabilities and market outcomes. To this end, we look at changes in firms' innovation effectiveness curves brought about by the use of open innovation business models. Finally, we summarise the conclusions of our analysis, draw implications for the future of open innovation in the food sector and highlight areas where more empirical research is needed.

A review of open innovation practice in the food industry

Conceptual background

The food processing industry is typically described as a relatively mature and slow-growing area of business, which displays a relatively low level of R&D investment and is quite conservative in the type of innovations it introduces to the market (Costa & Jongen, 2006). This sector perceives its end-customers to be, to a large extent, wary of radically new products and changes in consumption patterns. Such perceived wariness, together with the necessary stringency of legal requirements related to safety, transforms food product and process innovation in a highly complex, time-consuming and risky endeavour, and hence one not to be lightly undertaken. However, recent important changes in the nature of both food demand and supply, coupled with an ever-increasing level of competitiveness, have rendered innovation not only an unavoidable corporate activity, but also one that is increasingly vital for overall agribusiness profitability.

Contemporary consumers demand unique flavours and singular foods, guilt-free convenience in cooking and eating, and an increasingly health-promoting diet closely tailored to their individual needs and preferences (Costa, Dekker, Beumer, Rombouts, & Jongen, 2001; Costa, Schoolmeester, Dekker, & Jongen, 2007). Such demand requires a kind of product development that necessarily entails creating, or at the very least adopting, innovative technological solutions and new business models. On the other hand, recent general advances in areas like biotechnology, nanotechnology and preservation technology offer an unprecedented number of opportunities for added-value applications in the food industry, many of which have the potential to adequately meet modern consumer demand (Juriaanse, 2006).

Unavoidable as it may be, innovation remains a highly challenging and complex process for the food processing industry to manage. The number of actors of different sectors involved in food production, together with their difficulty to single-handedly meet all the heterogeneous (and often contradictory) requirements of intermediate customers, end-users and legislators, determines that innovation activities must be carefully coordinated. This in turn compels innovation processes to be managed both within and across organizational boundaries along the value chain (Costa & Jongen, 2006; Grunert *et al*., 2005; Mikkelsen *et al*., 2005). Moreover, many of the emerging technologies that can potentially sustain (or complement) a wave of successful new food applications (e.g. nanotechnology) are being developed outside the processing industry. In order to leverage these on-going innovation processes, food industry actors must therefore enter into more or less formal arrangements with other entities in the innovation system. Formal agreements are likewise required for the adoption of externally developed novel technologies (Maula *et al*., 2006). Last but not least, the establishment of close relationships with regulatory bodies, intermediate and end-users throughout the innovation process is essential to improve public acceptance of emerging food technologies and the commercial success of the products thereof (Costa & Jongen, 2006; De Jong, van Kleef, Frewer, & Renn, 2006; Vanhaverbeke & Cloodt, 2006).

All of the above implies that innovation in the food industry is likely to increasingly rely upon the decisions and activities of other entities in the innovation system. As such, the sector should exhibit a significant number of open innovation strategies, the purpose of which could range from merely securing access to external sources of human capital to actively taking part in the creation of inter-organizational knowledge and skills.

Empirical evidence

In spite of enough theoretical support for the widespread adoption of cross-boundary innovation management in the food area, empirical evidence of food companies engaging in open innovation strategies remains scarce. Knudsen (2007) analysed the results of a survey on the employment of inter-organizational relationships in product innovation by European manufacturing and service firms active in the Food and Beverages sector. She observed that all surveyed companies ($n = 132$) had partnered, on average, with at least one other organization for the development of their last important product innovation. Additionally, survey results indicated that these companies would rather cooperate with customers, suppliers and competitors than with private/public research organizations or consultants, and preferably at the initial research stage rather than during technical development. Finally, she was also led to

conclude that food companies allied preferably with organizations in their own sector, probably due to the high degree of overlapping between their knowledge-bases. The latter was believed to facilitate inter-organizational interactions and thereby increase the chances of innovation success.

Huston and Sakkab (2006) described the successful development and launch of a new type of Pringles' potato crisps (printed with words and images), driven by the application of the open innovation concept. The authors reported on how Procter & Gamble (P&G) was able to lower product development costs and time-to-market for the new line through the in-sourcing of a technology for printing edible images on cakes and cookies. This technology had been primarily developed by a baker in Italy and was discovered through the global network of potential sources of ideas and know-how that P&G maintained as a part of its open innovation program.

Alternatively, Thomke and von Hippel (2002) revealed how International Flavors and Fragrances (IFF), a company supplying flavours to the food industry, managed to outsource part of its new product design to customers. IFF developed a customer innovation tool-kit – consisting of an interactive, internet-based application with a large database of flavour profiles – with which it equipped its clients in the food processing industry. This tool allowed customers to design and alter flavour samples at will, enabling IFF to bypass costly market research activities and accelerate the trial-and-error cycles that inevitably accompany product development (PD). By putting customer expertise to use, IFF was also able to expand its knowledge-base and increase the level of customization of its product offer, while lowering its share of the innovation risk.

Finally, Vanhaverbeke and Cloodt (2006) explained how Calgene, a plant biotechnology R&D firm, established a network of inter-relationships with seed companies, farmers, packers, consumers and legislators to access their complementary assets and rally support for the launch of a new, genetically modified tomato for the fresh market. Calgene, a small start-up company, had no choice but to cooperate with other firms and organizations in the innovation system in view of the uncertainties inherent to the development and commercialisation of foods derived from gene technology. Such uncertainties compromised its ability to reap value from the commercial applications of the novel technologies it pioneered. The resulting value network also allowed Calgene to cope better with the high levels of product innovativeness introduced by its gene-modification technology and the consequent low initial levels of public acceptance and consumer adoption (Ram, 1989).

Table 1 summarises the main characteristics of the open innovation strategies employed in the food industry, as described so far. While IFF and Procter & Gamble's open innovation activities are clearly cases of technological process innovations, introduced to increase PD efficiency and sustain new marketing strategies for existing products, the case of Calgene is substantially different. In the latter, a new marketing strategy is implemented, involving the development of new sales channels and promotion tactics, to sustain the successful creation of an entirely new market for a radical product innovation and reduce the associated risk.

Table 1. Main characteristics of the open innovation strategies employed so far in the food industry

	Open innovation in the food industry		
Case study	New Pringles' potato crisps (Huston & Sakkab, 2006)	Design of new food flavours (Thomke & von Hippel, 2002)	Launch of GM tomato (Vanhaverbeke & Cloodt, 2006)
Innovating firm	Procter & Gamble	Int. Flavors and Fragrances	Calgene
External partner	Technology supplier	Customers in the food industry (e.g. Nestlé)	Seed firms, farmers, packers, retailers, consumers, legislators
Type of relationship	Dyad at non-arm's length	Vertically integrated dyad	Network across innovation system
Stage	Process development	Product design	Commercialisation
Strategy	Technology in-sourcing	PD out-sourcing	Creation of value network to sustain market launch
Goal	Reduce PD costs and time-to-market	Reduce PD costs and time-to-market High customization	Ensure acceptance and market success of novel technology
Supporting technology	New printing technology for food	New tool-kit for flavour design	Plant biotechnology
Newness to firm	Really new	Really new	Incremental
End-product	Printed potato crisps for consumer markets	Custom flavours for the food industry	New tomato for the fresh market
Newness to market	Incremental	Incremental	Radical

But whilst the development and commercialisation of a new tomato with enhanced flavour might have been a novel initiative to Calgene and its partners, the basic knowledge of plant biotechnology employed in the process was, nonetheless, not entirely new to them. The following section analyses these cases in more detail, focusing on the impact of the open innovation strategies employed on the sector's innovation capabilities and market outcomes.

Impact of open innovation strategies

On the innovation capabilities of food companies

The impact of open innovation strategies on the technological innovation capabilities of individual food companies can be examined through the analysis of *Innovation Effectiveness* (IE) curves (Kandybin & Kihn, 2004). This type of concave curves represents the marginal return on incremental R&D investment for each company, reflecting the idea that such incremental investments are, in practice, subject to diminishing returns. That is, they reflect the common sense notion that, beyond some point, each additional investment in a new R&D project will generate less and less additional return, given that companies will naturally invest in the most promising projects first.

A company's IE curve can be easily drawn by plotting the Return on Investment (ROI) of each R&D project against the cumulative R&D spending in a given period of time, as depicted in Fig. 1. In this figure, the height of the curve defines a company's overall IE, which increases only (*i.e.*, rotates upwards) when higher returns on R&D spending can be obtained. That is exactly what can be achieved by employing open innovation strategies. When P&G, to sustain the launch of the new printed Pringles, adopted an external, ready-made technology for printing edible images in food (instead of developing it internally from scratch), this company was effectively reducing the development costs and time-to-market associated to this particular market introduction. By being able to expand its product portfolio without additional R&D spending, P&G managed not only to escape the fate of diminishing returns to innovation investment, but also bought itself the option to invest more in innovation while maintaining a high level of return.

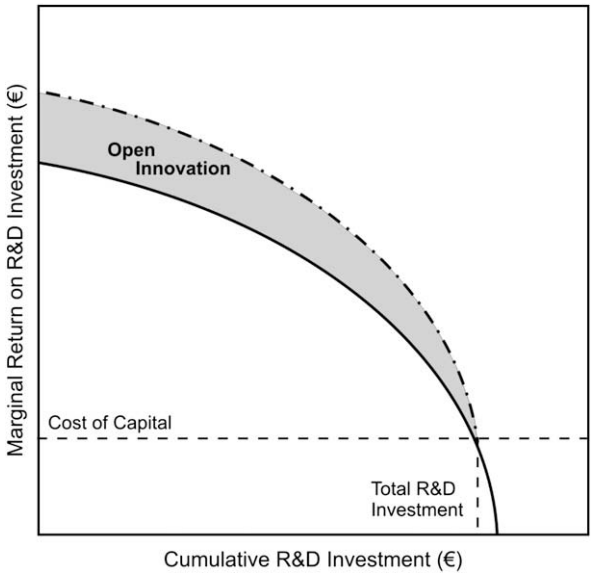

Fig. 1. Impact of open innovation on a firm's Innovation Effectiveness curve (adapted from Kandybin & Kihn, 2004).

The prospect of attaining innovation efficiency gains also played a major role in IFF's move to outsource a great deal of its product design process: the customer innovation tool-kit allowed for a decrease in the costs of creating an additional food flavour. Likewise, Calgene's orchestration of a value network for the launch of a new tomato in the fresh market represented an attempt to increase the ROI derived from plant biotechnology research while minimising the additional costs (and risks) of pioneering a new market on its own within the agri-business sector. Most importantly, Calgene was able to strengthen significantly its dynamic capabilities – *i.e.*, its capacity to capture and assimilate external resources to help configure or re-configure the internal competences necessary in addressing fast-changing technological environments (Teece, Pisano, & Shuen, 1997). This strengthening sustained the competitive advantage the firm enjoyed as a biotech pioneer in the fresh vegetable market and secured it the option of leading future commercial explorations of gene-modification technology in the food area.

On the market outcomes of food companies

The improvement of technological capabilities and R&D effectiveness is, however, not the sole reason leading firms to adopt open innovation. The achievement of higher levels of product differentiation, the improvement of competitiveness and the successful introduction of radical innovations are desirable outcomes associated with this type of business model. The impact of open innovation strategies on market outcomes in the food sector can be examined by looking at the dynamics of the strategy space in an integrated innovation framework (Sarkar, 2005, 2007). In the strategy space (depicted in Fig. 2), outcomes like market share, product sales, ROI or customer satisfaction are linked to the strategic orientation of firms (the degree of product innovation or product differentiation achieved) by *Innovation Pay-Off (IPO) curves,* defined for a given degree of increasing Market Pressure (MP_1–MP_4). IPO curves are upward sloping to reflect the positive relationship existing between the degree of product innovation/differentiation and the associated market outcome, at fixed levels of competitive market pressure. However, and similarly to the IE curves earlier described, IPO curves are concave: beyond some point, additional efforts towards introducing more innovative or differentiated products will generate less and less additional market outcome. Implicit in their construction is the notion of a firm's *overall innovation effectiveness*, *i.e.*, the idea that the incremental investments of innovating firms on both

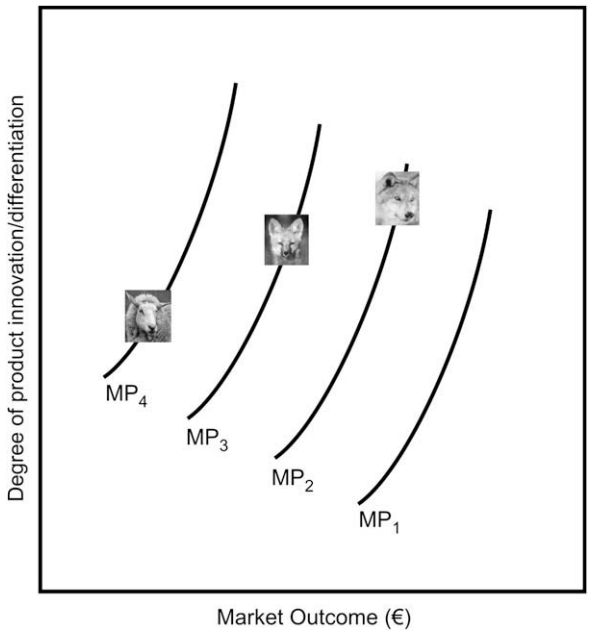

Fig. 2. Innovation Pay-Off (IPO) curves of P&G's Pringles (sheep market archetype), IFF's food flavours (fox market archetype), and Calgene's genetically modified tomato (wolf market archetype). Each IPO curve is defined for a given degree of increasing Market Pressure (MP_1–MP_4).

R&D and commercialisation activities are subject to diminishing returns in terms of the corresponding degree of innovation/differentiation achieved by their new products in the marketplace (Sarkar, 2005, 2007).

In the strategy space depicted in Fig. 2, the positioning of a food company's product line can be represented as a *sheep*, a *fox*, a *wolf* or a *bear market archetype* (Sarkar, 2005, 2007). P&G's Pringles dwell in the highly competitive savoury snacks market (Datamonitor, 2006), where a large number of firms offer product lines of similar characteristics – a *sheep market archetype*. Accordingly, price pressure is high and market shares are relatively small for Pringles and its competitors, implying that costs are highly controlled and product differentiation efforts usually few and feeble. While IFF also dwells in a fairly crowded and competitive marketplace, food flavours are, however, highly differentiated products catering for the varied needs of a large customer base (IFF, 2007) – a *fox market archetype*. Price is thus an important strategic variable, but so is a high degree of customer-orientation. Growth in this industry is highly dependent on the creation and development of new flavours, a complex process that requires the collective effort of a highly qualified workforce with both creative and scientific skills. R&D investment is consequently high, with firms using the protection of trade secrecy to secure the formulae of new ingredients and an adequate return on their innovation effort. Finally, Calgene and its research into the application of plant biotechnology in the development of improved agricultural products (Goldberg & Gourville, 2001) constitute a good example of a *wolf market archetype*. This archetype is characterised by highly innovative products for which there are few, if any, real substitutes. Given that such products are usually the result of large investments in R&D and a high level of technological capabilities and skills, entry costs in wolf markets are quite considerable. Intellectual property is also strongly protected, increasing the likelihood and sustainability of a clear technological supremacy. Consequently, firms in wolf markets have very few competitors, suffer little price pressure and can enjoy high market shares for relatively long periods. The latter, however, must be won first by walking the long and hard path of diffusion of highly innovative products in the marketplace, where the risks of failure are high (Rogers, 1983).

Fig. 3 depicts the impact of open innovation strategies on the market outcomes of P&G's Pringles, IFF's food flavours and Calgene's agricultural applications of plant biotechnology. Given that the technological innovation effectiveness of Pringles (our sheep market archetype) increased due to the in-sourcing of technology to support the launch of a new type of crisps (Fig. 1), its overall innovation effectiveness increased, rotating the corresponding IPO curve outwards in the direction of a higher market outcome. However, because Pringles' printed crisps were the only product originating from the open innovation strategy employed and represented a mere extension of an existing product line, there was very little improvement of the line's degree of product innovation/differentiation. As such, there were few additional market returns to be reaped from the

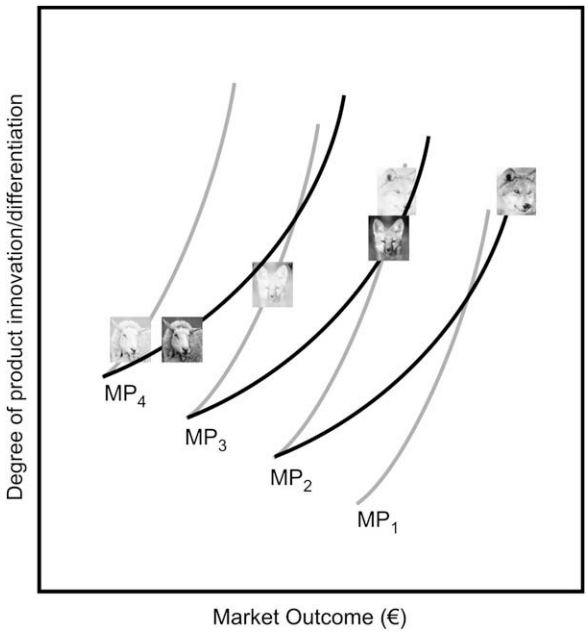

Fig. 3. Impact of open innovation on the Innovation Pay-Off (IPO) curves of P&G's Pringles (sheep market archetype), IFF's food flavours (fox market archetype), and Calgene's genetically modified tomato (wolf market archetype) depicted in grey: overall innovation efficiencies increase and IPO curves shift outwards (depicted in black), resulting in higher market outcomes. For each firm, the corresponding pair of IPO curves (grey and black) is defined for a given degree of increasing Market Pressure (MP_1–MP_4).

innovation effort because there was hardly any shift upwards of Pringles' position in the strategy space.

Customer innovation tool-kits, on the other hand, did more for IFF's food flavours line (our fox market archetype) than merely increasing its technological innovation effectiveness. By allowing for a higher degree of product customization and customer service, they effectively translated into significant improvements of the level of product differentiation. In fact, this type of innovation strategy could have the potential to change the competitive structure of the food flavours' market through the change of IFF's competitiveness. In Fig. 3, we can see that, by significantly increasing both its technological innovation efficiency and the level of product differentiation, our fox archetype might just manage to achieve a competitive advantage and a market outcome worthy of a wolf.

Finally, Calgene's open innovation strategy for the commercialisation of a new, genetically modified tomato also permitted significant market gains, in addition to those resulting from the increase of the firm's technological innovation efficiency (Fig. 1). Such additional gains, however, did not stem from an increase of the product's level of innovation/differentiation – which, given the technology employed, was quite high to begin with – but rather from the capacity to, through the orchestration of an effective value network, speed-up commercialisation and successfully counteract initial customer and public resistance to the new product. This, in fact, increased the rate of market adoption of both the new tomato and its underlying technology, allowing Calgene to benefit from higher market returns than those typical of the initial stages of the life-cycle of radical innovations. Nevertheless, as the value network grew in size and complexity, and became harder to manage, Calgene was increasingly less able to sustain the initial high gains (Goldberg & Gourville, 2001).

Conclusions and implications for future research

In this paper, we reviewed extant literature regarding the application of the open innovation concept in the food processing industry. Moreover, we analysed the impact of the open innovation strategies employed so far on the sector's innovation capabilities and market outcomes. To this end, we looked at changes in firms' innovation effectiveness curves brought about by the employment of open innovation business models.

The first conclusion to be drawn from our review and analysis is that open innovation does take place within the food sector, in spite of this being known as a relatively more traditional and mature industry. Moreover, open innovation strategies come in a variety of forms and, as such, are also met with a wide variety of outcomes. Consequently, there is a clear need for a better understanding of open innovation in the food sector, which should be addressed by the performance of more and more focused case-studies and empirical research.

Secondly, our analysis demonstrated that innovation pay-offs and effectiveness are dynamic, rather than static, concepts, which therefore should be studied as such (Sarkar, 2007). For the food industry, and using once more the market archetype metaphor, this means that a sheep is not doomed to be a sheep as long as it does not act like one. It also means that technological progress need not always to pay off, especially when it is not accompanied by a recognisable (and valued) increment on the product's level of innovation/differentiation in the marketplace. Likewise, even if it costs to be a wolf and it costs to remain a wolf, food companies must increasingly act like one, by generating products that naturally differentiate themselves over and over again in the crowded agri-food markets – because it also pays a lot more to be a wolf. An effective way to achieve this metamorphosis might be, as our analysis demonstrated, to team up with customers, suppliers or other actors inside and outside the value chain to together explore the potential of open innovation business models.

Thirdly, our review and analysis demonstrated that firms stand a better chance of escaping the law of diminishing returns to innovation efforts if they can improve the effectiveness of both their technological and marketing capabilities in a concerted manner. This supports the long-standing call for a higher level of integration between R&D and marketing activities within agri-business companies (Costa & Jongen, 2006). Likewise, when effects on technological capabilities and market outcomes are analysed simultaneously within an integrated framework, research into (open) innovation stands a better chance to become more meaningful to academics and practitioners alike.

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