
# Knowledge and capabilities for products/services development: The UK spin-off firms context



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# Knowledge and capabilities for products/services development: The UK spin-off firms context

**Abstract**

**Purpose** – This article explores and proposes the skills and capabilities required in developing products and services within UK university spin-offs (USOs) by considering the model of products/services development (Verona, 1999).
**Design/methodology approach** – mixed methods of 20 in-depth interviews and questionnaire survey with 204 founders of USOs.
**Findings –** The findings contribute in filling the literature gap by proposing key knowledge and capabilities required to develop products/services within the unique and non-commercial context, in which USOs are created by academics who do not necessarily have entrepreneurial or business experience.
**Originality/value** – This research contributes to studies of product/service development by proposing a modification of elements within the existing theoretical model to be applicable to the specific firm and country context, such as USOs in the UK. Further, the study extends knowledge on the interplay between knowledge management and product development. The applications of the findings are that they can inform academic entrepreneurs on the capabilities significant in the development process. They can also act as indicators to Technology Transfer Office (TTOs) in what is needed for the provision of appropriate support and training to academic founders/entrepreneurs in order to foster and enhance other entrepreneurial activities.
**Keywords** *Knowledge capabilities; product and service development; knowledge management; university spin-offs*
**Paper type** *Research paper*

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## 1. Introduction

Interaction or knowledge transfer activities between universities and industry have been widely observed (Agrawal, 2001; Bekkers and Freitas, 2008; Azagra-Caro et al. 2017). An important category of technology transfer is academic entrepreneurship, which includes commercial exploitation of technologies by academic entrepreneurs through company set ups (Perkman, and Walsh, 2007). With unique and hybrid characteristics, these university spin-offs (USOs) are considered to be an economically compelling subcategory of high-tech start-up firms (Shane, 2005). Since 1960s, a number of studies have looked at mechanisms in transferring university research and technology through firm creation and in some cases survival (Landström, 2007; Djokovic and Souitaris, 2008; Bramwell and Wolfe, 2008; Rasmussen and Borch, 2010; Perkmann et al., 2013, Fini et al. 2016, Prokop et al. 2019 ). However, the majority of research into university spin-offs tends to focus on the infrastructural perspectives that support the creation of USOs rather than on the firms' innovation practices and their technological offerings.

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We have added some more studies in the bracket.

Generally, the effective development of products and services requires various quality skills and competencies embedded in a firm much more than a series of instruments and systems (Tidd and Bessant, 2009; Sousa and Rocha, 2019). Based on the conceptual model proposed by Verona (1999), the combination of functional (i.e., *technological* and *marketing*) and

integrative (i.e. *external and internal*) capabilities are highlighted as having an influence on the efficiency of the development process as well as the effectiveness of the products/services in terms of product quality and fit to market's demands. However, USOs are significantly different to corporate spin-offs with regard to the time taken in developing product/service, and degree of modification of products and services (Löfsten and Lindelöf, 2005). The processes of converting academic knowledge and invention into a product demands capabilities and resources that are typically lacking by academic entrepreneurs (Bathelt *et al.* 2010). There are gaps in the knowledge about the transformation from academic research to the development of a market-driven product/service (Barr *et al*., 2009) including what management capabilities are employed by USOs in developing products and services. Therefore, the central research question is: *What management capabilities are used by USOs to develop new products/services?*

The findings of this research expand the knowledge of the existing studies of USOs by presenting new perspectives on firm-level capabilities required by USOs in developing products/services. Additionally, this study also builds and extends upon the extant literature in product/service innovation by adapting and modifying elements within the theoretical model by Verona (1999) to be applicable to the USO context. This has demonstrated that the model can be expanded and applied to small emergent firms beyond just large and structured corporates. In addition, the findings suggest the importance of knowledge capabilities and knowledge management embedded in the product/service innovations.

The paper is structured with a discussion of the capabilities-based model by Verona (1999) as a conceptual framework for this study including its limitations. Then, the discussion moves to the insights derived from the in-depth interviews, which provide a foundation in which we propose the management capabilities applicable to the USO context. Then, the findings from the survey together with Principal Component Analysis (PCA) are discussed to address the research question outlined above. Finally, the article concludes with a proposed adjustment of the conceptual model in the light of the analysis and highlights its contributions.

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Taken on the comments from the 1st reviewer, we try to avoid the term "model development"

## 2. Theoretical Background

### 2.1 The role of capabilities in product and service development

In addition to resources outlined in the 'Resource-based View' (RBV) concept, capabilities are the skills or knowledge that allow the implementation and ensure appropriate exploitation of resources (Barney and Mackey, 2005; Ferreira and Fernandes, 2017). Competitive companies, particularly in high-tech sectors, demand a range of key resources and capabilities to facilitate the development process of products and services. Further, the technical, physical, and knowledge-based activities are regarded as a key in establishing product development routines (Cardinal et al., 2011).

During product or service development, a company's abilities to achieve are located within its capabilities (Sirmon *et al.*, 2007; Teece, 2018) to continually develop, extend, elevate, protect, and update the firm's unique asset base (Teece, 2007). In addition to capabilities, knowledge and knowledge management can also be considered the important elements on the product/service innovation process, since knowledge helps facilitate a transformation from an idea into tangible products (Menezes Ferrari, and Carlos de Toledo, 2004). In the complex process like product/service innovation, knowledge can be employed as a resource to reduce this intricacy. Hence, managing knowledge as a resource will be of significance (Du Plessis,

2007). Verona (1999) has proposed a conceptual model that links functional and integrative capabilities with the proficiency and effectiveness of product/services.

The functional capabilities enable a company to develop and expand its technological knowledge (Kleinschmidt *et al.* 2007). The integrative capabilities captivate crucial knowledge and information from outside and combine various technical skills established in different divisions inside the firm (Teece *et al.*, 1997). This means the capability of the firm to integrate internal and external knowledge into the organisation's repository (Du Plessis, 2007). The existence of functional and integrative capabilities is clearly linked with the proficiency of the product and service process. Technological capabilities together with external and internal integrative capabilities contribute to the efficiency of the product/service development process, while marketing, external and internal integrative capabilities affect the effectiveness of products and services (Verona, 1999). *See Figure 1*.

*Insert Figure 1 here*

**2.2 The scarcity of resources and capabilities within the university spin-off context**

USOs, unlike private enterprises, are created within a non-commercial environment. Mustar *et al*. (2006) cited that USOs are confronted with barriers to development because the university environment often lacks resources and capabilities that encourage commercial activities. Vohora *et al.* (2004) also pointed out that the inability of USOs to prevail over each critical stage occurs because of an inadequate level of capabilities and social capital. Developing innovations within the USO context occurs in an iterative and non-linear manner (Druilhe and Garnsey, 2004; Vohora *et al*., 2004; Mathisen, and Rasmussen; 2019). In addition, the knowledge platform of high technology industries, in which the majority of USOs operate, is usually in its initial stage, evolving and highly complicated (Carayannis *et al*. 2017). The processes required in converting academic knowledge and technologies into a marketable product/service require knowledge and capabilities, which are lacking in the majority of universities and academic entrepreneurs (Bathelt *et al.* 2010). Further, it is also noted that many Technology Transfer Offices (TTOs) are deficient of resources and capabilities to aid a successful commercialisation of academic technologies and ideas (Siegel and Wright, 2015; De Silva, 2015).

The synthesis of a number of studies within the academic entrepreneurship discipline has highlighted that USOs clearly lack capabilities that allow them to gain competitive advantage. *See Table 1*. The only capabilities that give a competitive edge to USOs are 'technology capabilities' owing to the nature that the firms are created from research and scientific applications. A lack of capabilities in USO context is significant in their developmental processes. Therefore, a central question emerges:

*What management capabilities are used by USOs to develop new products/services?*

To investigate this question, the conceptual model proposed by Verona (1999) is used as the main theoretical framework. However, this model holds certain assumptions that are more applicable to large and well-structured companies, such as within integrative capability, incentives and rewards for staff or integration throughout the organisation are outlined. Certain elements within the capabilities assume innovation is routinised and the process is formalised (Berends *et al*. 2014). Due to the limitation of this model in relation to the applicability to the USO context, both functional capabilities (e.g. technological and marketing) and integrative capabilities (e.g. external and internal) are explored and adjusted to be applicable to the USO

context through exploratory interviews and then the adjusted model is proposed through the PCA analysis to address the central question.

*Insert Table 1 here*

## 3. Methodology

The aim of this study is to explain the capabilities used by USOs to develop products/services, but first the exploration of capabilities applicable to USO context is required. A mixed method research approach was undertaken. The qualitative method, i.e. in-depth interviews with USOs' founders, was employed to ascertain the capabilities utilised when developing products/services. This stage enabled the adjustment of some capabilities to be appropriate to USOs' context. Subsequently, the quantitative method, i.e. a web/postal survey, was used to confirm the results from qualitative stage and allow the proposal of a model, based on the Verona (1999) model as discussed in the previous section.

### 3.1 The Sample

*The population*

The population in this study involved USOs in the UK that are still active across all industries. According to the report by HEFCE 2010-11, the number of three year-old or older spin-off companies in the UK was approximately 1,000. The definition given by the Higher Education Funding Council (HEFCE)[1] was followed, but the scope was more focused on spin-offs firms that have been established by academic or university staff (whether the university owns the Intellectual Property-IP or academic entrepreneurs own the IP).

*The development of the UK USOs database*

The sampling frame or database of this study was drawn from public websites of universities in the UK. The list of 133 universities was obtained from the Universities UK (http://www.universitiesuk.ac.uk), the central organisation supporting all universities in the UK. The database of UK USOs was constructed by searching through the universities' business and innovation centres as well as departmental websites. Since some universities do not provide a list of spin-off firms on their public website, the contacts were made to universities' staff at the business and innovation centres to ensure that there was no omission of any USOs. In order to ensure that these were USOs from academic or university staff, the names of company directors were checked against the university's website to see if they were affiliated with the university. From 1356 spin-off companies in the database, 844 USOs were active in operation. The database included the firm's demographic information as well as founders' contacts, i.e. name, e-mail and telephone number.

### 3.2 Data Collection Methods

The data were collected through two phases: qualitative and quantitative stage.

*a) Qualitative stage*- For the qualitative stage, the purpose of this stage was to explore the applicability of the Verona (1999) model. Therefore, in-depth interviews were conducted with 20 founders of USOs. The sampling approach adapted was purposive with selected respondents, selected from the UK USOs database, aiming to represent the various sectors,

[1] the definition set in the Higher Education Business-Interaction (HEBCI) surveys for Higher Education Funding Council (HEFCE) is broad and expansive by embracing new legal entities and enterprises created by the Higher Education Institute or its staff to allow the commercialisation of knowledge from academic research. The universities may or may not have a stake in these firms. In addition, the term "spin-offs" includes start-up firms established by university staff and students beyond the exploitation of IP



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firms, size and different regions in the UK. The respondents were selected based on the following criteria:

- being a founding member of a USO
- owning equity in the firm
- used to/or currently hold an academic position when establishing the company
- having product/service offerings in the market.

Convenience also played a secondary role in the selection process, i.e., how easy was it to get access and to get an agreement from the founders to set up a 30 to 45 minute interview. See *Appendix1* for summary of USOs and the respondents' profiles.

The interviews were mainly conducted via the telephone; face-to-face interviews were carried out only with academic founders of firms located in London. The majority of the firms were categorised as micro with only 1-10 employees; only one was a medium-size firm (with more than 50 staff). Additionally, 14 founders in the sample maintained their academic position. The interviews were semi-structured. This allowed probing questions to be asked which provided detailed and in-depth information.

The transcriptions of the recorded interviews were first manually coded according to the four capabilities (i.e., technological, marketing, external, and internal), which contributed to the success in product/service development as proposed by Verona (1999). Then, during the second coding round, the common themes emerged from the 20 respondents. Then, in the third coding, the themes were organised according to the categories based on the headings above. Despite the manually coding method, this offered some benefits in understanding the underlying context and to prevent any mistakes or misinterpretations (Howitt and Cramer, 2010), the possibility of human errors and bias was recognised. To mitigate the bias that might have occurred, transcripts were separately coded by other researchers. Then coding results were compared and adjusted accordingly.

The details of what the respondents viewed as applicable to the university spin-off context under each capability were coded and highlighted. Subsequently, these details were mapped against the original model to allow the deletion of some variables under each capability that were not relevant to the USOs. In the same way, details of new variables that were applicable to the university spin-off context were integrated into the model. This adjusted model was later tested at the quantitative stage. Based on evidence from in-depth interviews with 20 founders of university spin-offs, some adjustments and additions of variable to Verona (1999) model were proposed to improve the applicability to the USO context.

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*b) Quantitative stage*

The self-administered survey was conducted both on-line and paper-based with USOs' academic founders. The academic founders were targeted for the survey since they usually own the broad knowledge on the firm's history (Carter *et al*., 1994). The whole population (n=844) was sampled to ensure that sufficient and representative response rate received for the following reasons: 1) the population of interest was small and finite; 2) surveys to small business firms, in which most of USOs are categorised, have particularly high non-response rates (Dennis, 2003).

*Questionnaire development*

The survey questionnaire was divided into three parts: 1) demographic information, 2) product/service portfolio, and 3) capabilities employed in product/service development. The observed variables were derived from the qualitative stage. The self-completed survey

questionnaires were pre-tested through discussion with 15 founders and product development managers of USOs prior to the distribution.

*The survey process*

The structured questionnaire was built on an on-line survey platform. Then, an e-mail with a web link to the online survey was sent to respondents. In addition, a paper-based questionnaire was developed since some firms do not publish e-mail address of founders and staff on the website. Both online survey and paper-based questionnaires were sent to 844 USOs altogether; out of 844 firms, 322 firms were sent paper-based questionnaires by post. For the online survey, 6 e-mails bounced back and another 20 firms stated that they had no interest in doing the survey. In total, the total completed questionnaires received for this study were 204 and the response rate was 24%.

All the variables derived from the qualitative stage as presented in the adjusted model (*see Figure 2)* provided the basis for the development and design of questions for the survey questionnaire. The questions related to capabilities were divided into two sections: the capabilities contributed to the efficiency of the development process and the effectiveness of the products/services (See *Appendix 2* for the list of observed variables). There are a number of variables under each capability. To determine the dominant capabilities for process efficiency and product/service effectiveness, PCA was employed to extract the main components of each capability. The findings from the survey are reported in the following section.

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## 4. Findings

*Knowledge or technological capabilities*

Most academic founders recognised knowledge and technological capabilities as very strong and unique to the USOs context since USOs are in general established based on IP or new technologies and knowledge. These capabilities, thus, come naturally in the case of USOs. Such technological capabilities can bring competitive advantage to USOs as noted by Kock *et al.* (2011) that new products/services created by technological innovations are often designated as being important to a firm's competitiveness and future success. This means, technological innovation is expected to drive the success of the new product/service since new knowledge/technologies bring better performance and advance benefits to customers (*see Table 2*).

*Insert Table 2 here*

According to Verona (1999), knowledge and technological capabilities include, '*previous experience in running research and development firms*'. However, it can be noted that the majority of USOs in this study were founded by academics, holding a full-time position within a university. This variable is not quite relevant to the USO context. Additional variables are included instead as a replacement as a result from the in-depth interviews, i.e., '*IP*', '*an ability to apply and translate technology to product*'.

*b) Marketing capabilities*

The views of academic founders about marketing capabilities were conflicting; some believed that marketing is necessary and critical for product/service development, but some viewed that it has had little impact on their products/services because of the nature of niche markets, in which most of the USOs operate. Nevertheless, there have been common views among respondents that marketing capabilities are not a strong point among USOs because companies

are spun off from academic and university environments, where marketing or marketing activities are not common practice. Even though academic entrepreneurs have some ideas about market or customers' demands, they do not necessarily have expertise in executing different marketing tools. Therefore, marketing expertise is frequently brought in from external sources. Marketing activities, including promotion of products, has been undertaken in collaboration with partners. Alternatively, word-of-mouth is used to promote their products/services.

With regards to market research, understanding customers' needs was highly regarded; this is considered the initial and fundamental element in developing products/services. However, getting customer information was achieved informally through either staff or prototype testing. This confirms the study by Marion *et al*. (2012) that, in small firms, prospective customers are not usually engaged in the design process. Marketing research is undertaken mostly within firms. Market information or ideas for product/service features are based on experience and expertise of founders or team members (*see Table 3*).

Hence, adjustments of the marketing capabilities were made by simplifying the term market research and explained as '*understanding what the market wants and needs*' instead. Since university spin-offs seldom conduct upfront market research, the variables of '*exploratory and exploitative market learning*' originally outlined in the model were not applicable to the university spin-off context. In addition, detailed variables were incorporated to reflect the actual context of university spin-offs, e.g. '*perception of business opportunities*', '*decision on USP (unique selling proposition)*', and '*marketing through partners and networks*'.

*Insert Table 3 here*

*External integrative capabilities*

Evidence from the interviews showed that networks and collaboration are recognised as being important in the success of product/service development. As many studies have confirmed, due to resource limitations, it is inevitable for small firms to collaborate or network with external partners to tap into resources or knowledge that develop new products/services (Avermaete *et al.,* 2004; Li and Atuahene-Gima, 2001). Additionally, a few features relating to external capabilities have emerged from interviews, such as '*maintaining networks with academics*', '*building trust and relationships with partners*', and '*recruiting staff with capabilities to network*'. These elements are included as variables in the model.

Under the external integrative capabilities of the original resource-based model, the variable on "*incentives and rewards to encourage external network*" is not applicable to the context of USOs. As evidenced from the interviews, there has been a general acknowledgement that networks are important to USOs' product/service innovations as well as their success. They have endeavoured to build and extend business links beyond the academic networks. Hence, incentives and rewards to encourage external networks are not necessary in the case of USOs. This variable is removed from the model. See *Table 4* for the summary of external integrative capabilities from in-depth interviews.

*Insert Table 4 here*

*Internal integrative capabilities*

Based on the evidence from interviews, a few variables are proposed to be included i.e., '*brainstorming sessions, financial systems*', '*staff training*', '*systems for tracking how much*

*time and investment into the development of a product/service*', '*simple management structure and minimal bureaucracy*', and '*teams with different skill sets and capabilities*' (*see Table 5*). In the original model, a number of variables under internal integrative capabilities deemed irrelevant to USOs, such as, '*career paths for staff across the organisation*', '*incentives and rewards*', '*combination of various internal sources for technical knowledge*', and '*cascade of the integration throughout the company*'. These elements represent reality in much larger and more structured firms whereas USOs have small teams of a few members of staff. In addition, these variables contradict the findings from the interviews on the point that complex company structures and bureaucracy are unnecessary since small companies (like USOs) benefit more from integration. As a result, these variables are removed from the adjusted model. Figure 2 summarises the adjustments and additions made to the original model.

*Insert Table 5 here*

*Insert Figure 2 here*

*The capabilities contributed to the efficiency of the development process*

Three capabilities contributed to efficiency in the development process including technological, external and internal. The results shown in *Table 6* show that the combination of these three capabilities contribute to efficiency in the process in developing product/service innovations. Within technological capability, only the use of *scientific or technological knowledge* and *IP* is regarded as having an impact on the efficiency in the development process. Likewise, within internal integrative capability, the variables: *communications and interaction among team members*, *knowledge integration sharing*, *brainstorming session*, *joint problem solving*, *team with different skill sets*, and *organisational value and shared vision* are regarded as important towards process efficiency in developing products/services. All the variables within the external integrative capability, i.e., *systems to integrate external knowledge in products/services development*, *maintain networks with academics*, *building trusts and relationship with partners*, and *staff with capabilities to network*, are viewed as contributing to the efficiency of the development process.

*Insert Table 6 here*

*The capabilities contributing to the effectiveness of products/services*

Marketing, external and internal integrative capabilities are the three important capabilities, which contributed to the effectiveness of products/services (Verona, 1999). The main components of each capability were extracted (*see Table 7*). When analysing further detail the capabilities (marketing, external and internal integrative), the proposed construct of marketing capability for the effectiveness of products/services within the USO context including: *perception of business opportunities*, *decision on USP (unique selling proposition)*, *marketing collaboration with partners and networks*, *pricing policy, supply chain or distribution, advertising or promotion or word-of-mouth*.

Again, within external integrative capabilities, variables, *building trust and relationships with partners* and *staff with capabilities to network* contribute to the effectiveness of products/services. Almost all internal integrative variables are regarded as important to the

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We avoid the term "model development" or the effect of capabilities towards the efficiency of the development process. We do recognise the limitation of the PCA technique and noted on the limitations.

effectiveness of products/services, except the variable *simple management structure*. The construct of internal integrative capability for the effectiveness of products/services within the university spin-off context is: *communications and interaction among team members, knowledge Integration sharing, brainstorming sessions, administrative support, financial systems, joint problem solving, staff training, system to track how much time and investment into the development of a product/service, team with different skill sets and capabilities, and organisational value and shared vision*.

*Insert Table 7 here*

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## 5. Discussion

The findings from the survey and the PCA analysis allow the proposed adjustment of the model as presented in the Figure 3. The findings have also shown that, within technological capabilities, only *scientific and technological knowledge* and *IP* are perceived to be contributing to the efficiency of the development process. This is not a surprise because these two capabilities are regarded as unique and very significant to USOs. Product/service development is an intricate and knowledge-intensive process that entails specific methods to encourage learning and transfer knowledge; it consists of both explicit and tacit knowledge (Goffin and Koners, 2011). In addition, it involves an application of knowledge that allows the organisation to create value (Nguyen et al., 2019). It is also noted that the firms' ability to seize, transfer, and distribute knowledge can create competitive advantage (Lawson *et al.* 2009). Hence, *scientific and technological knowledge* and *IP* coupled with external (e.g., *systems to integrate external knowledge in products/services development* and *maintain networks with academics)* and internal capabilities (e.g. *knowledge integration sharing* and *communications and interaction among team members*), which involve the organising and sharing of knowledge, can potentially engender the efficiency of the development process.

*Insert Figure 3 here*

Only three variables within marketing capabilities are perceived as important to the effectiveness of products/services, i.e., *perception of business opportunities*, *decisions on the USP (unique selling proposition)*, and *marketing collaborations with partners and networks*. Marketing capabilities considered important to the effectiveness of products/services relate more to a strategic marketing policy (e.g. defining competiveness of the products/services, or recognising market opportunities) than on promotion, pricing or distribution. It is interesting that marketing activities done in collaborations with networks are found important in the university spin-off context. This point resonates with research by Aarikka-Stenroos and Sandberg (2012) which shows that small firms like USOs may be deficient in financial resources and branding reputations that would help them attain target customers through traditional advertising and promotions. Hence, the way to create market demands is by channelling products/services and resources through developing relationships with partners and networks. Network relationships often present multiple complementary resources for marketing and maximise opportunities for adoption of innovative products/services.

However, understanding customers' wants and needs is not regarded as significant to the effectiveness of products/services. USOs in the sample, categorised as small to medium firms, tend to be similar to small firms in general when developing products/services by relying on

their own clients' knowledge and information as well as market analyses rather than commissioned market research (Berends *et al.*, 2014). The minimal upfront market research is likely to be driven by resources constraint and its desire to get the product/service into the market quickly (Marion *et al.*, 2012). This can possibly explain why *market research (to understand market wants and needs)* does not appear to be contributing to the effectiveness of its products/services.

In model proposed by Verona (1999), it is assumed that all the variables within the internal integrative capability have contributed to both process efficiency and the effectiveness of products/services. This is not the case in the UK USOs context. The findings show that most of the variables under internal integrative capabilities proposed have contributed to the efficiency and effectiveness of product/service innovations, except the variable "*simple management structure and minimal bureaucracy*". However, the difference of variables within internal integrative capabilities contributing to the efficiency of the development process and the effectiveness of products/services has been observed. For instance, only a set of variables: *communications and interaction among team members*, *knowledge integration sharing*, *brainstorming session*, *joint problem solving*, *team with different skill sets*, and *organisational value and shared vision* are considered important to process efficiency, whereas almost all variables within the internal integrative capability, except *simple management structure*, contribute to the effectiveness of products/services. The findings have proposed the modification of the original conceptual model by underlining the distinction of the use of internal capabilities between process efficiency and products/services' effectiveness. Further, these findings are also aligned with the study by Pitt and MacVaugh (2008) on a holistic integrative idea of knowledge management that permit the flow, creation and recombination of information and create positive impact towards products/services processes. As also noted by Singh Sandhawalia and Dalcher (2011) cutting edge technological knowledge is insufficient in developing effective products/services, especially in fast moving contexts; knowledge management skills is therefore necessary to develop and support development practices and routines.

In addition, all of the external integrative capabilities contributed to the efficiency and effectiveness of product/service innovations. However, the difference has been observed for the efficiency of the development process and the effectiveness of products/services. All of the external capabilities variables (i.e., *systems to integrate external knowledge in products/services development*, *maintain networks with academics*, *building trust and relationship with partners*, and *staff with capabilities to network)* are regarded as important to the efficiency of the process, while only a couple of external variables, such as *building trusts and relationship with partners*, and *staff with capabilities to network,* are viewed vital to the effectiveness of the products/services. It can be argued that products/services development processes contain steps or cycles intended to provide useful commercial value to customers or end-users (Harmancioglu *et al.* 2007). The development process can be long, unwieldy and possibly full of errors and mistakes. Therefore, networking or partnering with external firms may result in saving budgets and shortening time spent in development (Knudsen, 2007). The efficiency of the development process, noted in the model by Verona (1999), involves the reduction of lead time and an increase in productivity. Thus, the combination of external capabilities, such as *systems to integrate external knowledge in products/services development*, *maintain networks with academics*, *building trust and relationship with partners*, and *staff with capabilities to network,* are more likely to enable the efficiency of the development process.

From a different perspective, the effectiveness of product/service encompasses fits with the market needs and increased product quality. Building trust and relationships with partners and having staff with abilities to network could help USOs receive market feedback that is beneficial to develop market-oriented products/services. As noted by Lawson *et al*. (2009), comprehensive engagement and contribution from partners in the design and products/services development process have been linked to product feature improvements. Building trust and shared understanding with partners allow knowledge sharing, which is important in developing quality products/services. In addition, a high level of trust between firms generates the environments for developing successful products/services (Bstieler, 2006).

This study proposed the key capabilities employed to develop products/services within the UK USO context. The data have expanded the knowledge of the organisational configuration and resources required by university to assist in the establishment of USOs. New angles are offered on firm-level capabilities required by USOs to develop successful products/services, including the efficient development process and products/services that fit to market demand. This research contributes to studies of product/service innovation by proposing an adaptation and modification some elements within the theoretical model proposed by Verona (1999) to be applicable to the USO context.

The paper also highlights the significance of knowledge capabilities and knowledge management towards the efficiency and effectiveness of product/service development. With high-tech start-ups, like USOs, knowledge/technological capabilities are the backbone for innovations and value creation activity like product/service development. Additionally, this research has supported the interplay between knowledge management and product/service development discipline (Prieto et al., 2009). It extends the knowledge on the combination of knowledge capabilities and the management of knowledge for the efficiency and effectiveness of products/services, e.g. the combination of technological capabilities and external capabilities contribute to the efficiency of the development process.

## 6. Implications to academic entrepreneurs, Technology Transfer Offices (TTOs) and universities

The research suggests a better understanding of the capabilities contributing in developing products/services to academic entrepreneurs, since they do not necessarily have these skills and knowledge enabling the development of commercialised products as well as the growth of USOs (Fernández-Alles, et al., 2015). Certain capabilities do not occur naturally among academic founders, especially those in science and engineering disciplines. Skills, such as marketing, networking and financial capabilities are foreign to typical academic cultures and environments. Besides, the practice of capabilities/knowledge management has been demonstrated, such as a system to incorporate knowledge from external sources or communications and knowledge sharing. This practice will allow the flow and integrate internal and external knowledge to facilitate the development process.

Additionally, the findings of this study can act as initial indicators on what skills are required from academic founders/entrepreneurs and whether TTOs have actually offered support and training that is appropriate and necessary to foster products/services innovations among USOs. Academic entrepreneurs depend greatly on university support and resources to develop and grow (Rasmussen 2011). Setting policy to allow the creation of entrepreneurial opportunities,

i.e. creation of USOs, is important for universities, but ensuring that the offering and accessibility of these entrepreneurial and management capabilities to develop opportunities is equally vital (Rasmussen and Wright, 2015). Where entrepreneurship is regarded as a strategic objective of the university then a policy for supporting these entrepreneurial skills should be established (Hofer and Potter, 2010). Notwithstanding the debate on the extent to which TTOs are able to support USOs beyond their primary establishment (Mosey and Wright, 2007), TTOs may play a critical role in either supplying managerial capabilities (Fernández-Alles, *et al*., 2015) or acting as an intermediary in sourcing such skills and capabilities externally. Hence, there is a need to raise an awareness of these capabilities to university senior management and TTOs.

## 7. Conclusions

Even though USOs has been the subject of study since late 1960s (Landström, 2007), there is a limitation in the knowledge. The majority of research this discipline tends to focus on is the infrastructural perspectives that support the creation of USOs rather than on the firms' innovation and their technological offerings. This study has filled the gap by demonstrating the key capabilities employed to develop products/services within UK USOs' context, as well as the management of knowledge capabilities in the development process. The data can act as indicators to inform academic entrepreneurs, TTOs and university senior management on suitable support, training and development to nurture products/services innovations and entrepreneurial activities.

The scope of this study is the firm-level investigation of the capabilities employed by UK USOs developing products/services. Hence, these only reflect the firm-level capabilities required by USOs in the UK to equip and allow them to undertake product/service innovations. Even though this presents a unique and useful angle to approach the issue, given the qualitative nature of this research, the degree of generalisability of this study is limited. Further research needs to be undertaken to test these propositions to ascertain the relationship between these management capabilities and the effectiveness of products/services and efficiency of the development process.

**Commented [NB10]:** To respond to 1st reviewer's comment: We have recognised and highlighted the limitations of the research and proposed further research.

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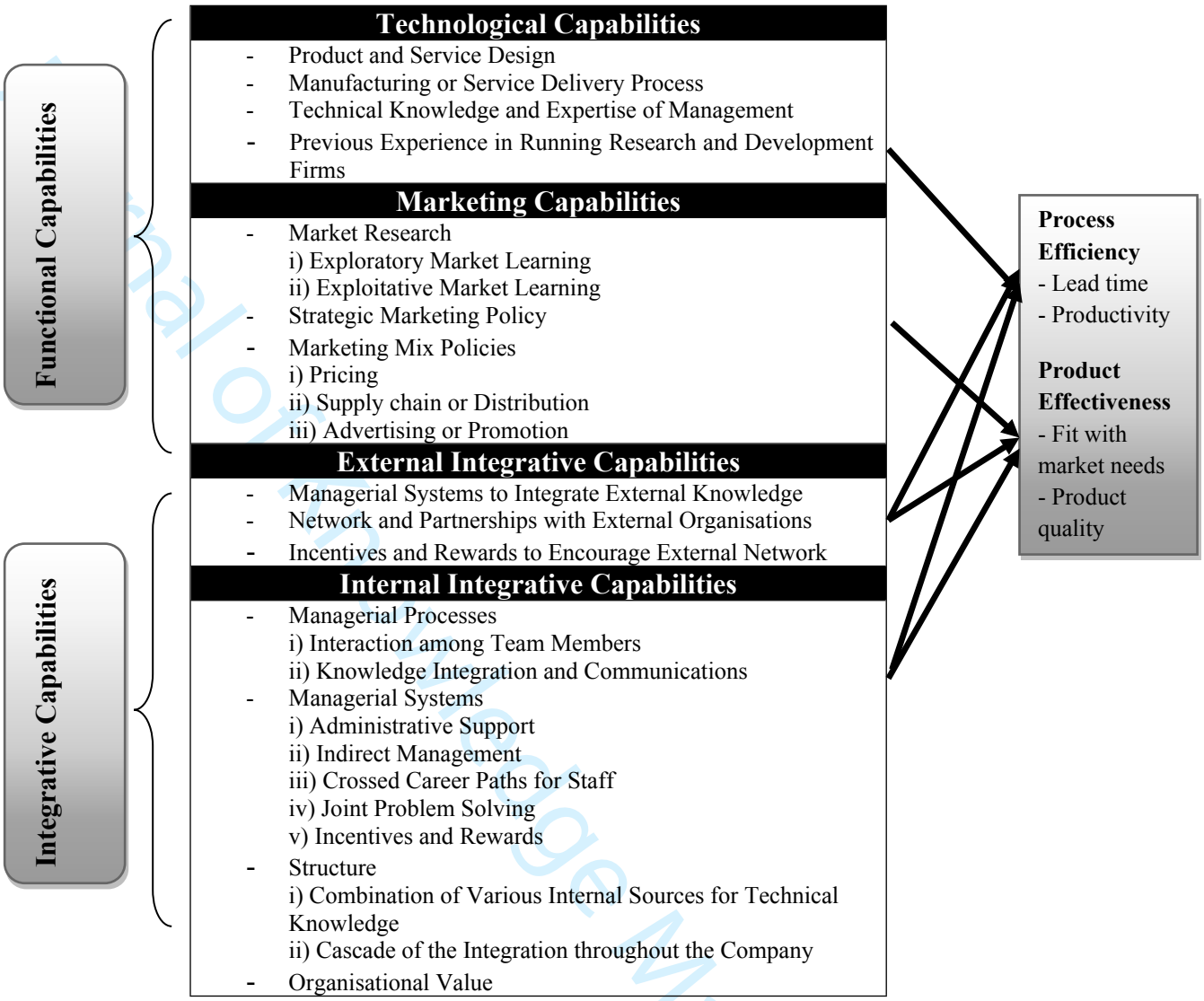
**Figure 1: The resource-based model of product/service development**




*Source: Verona (1999)*

**Figure 2: The adjustments and additions to the resource-based model in products/services development**

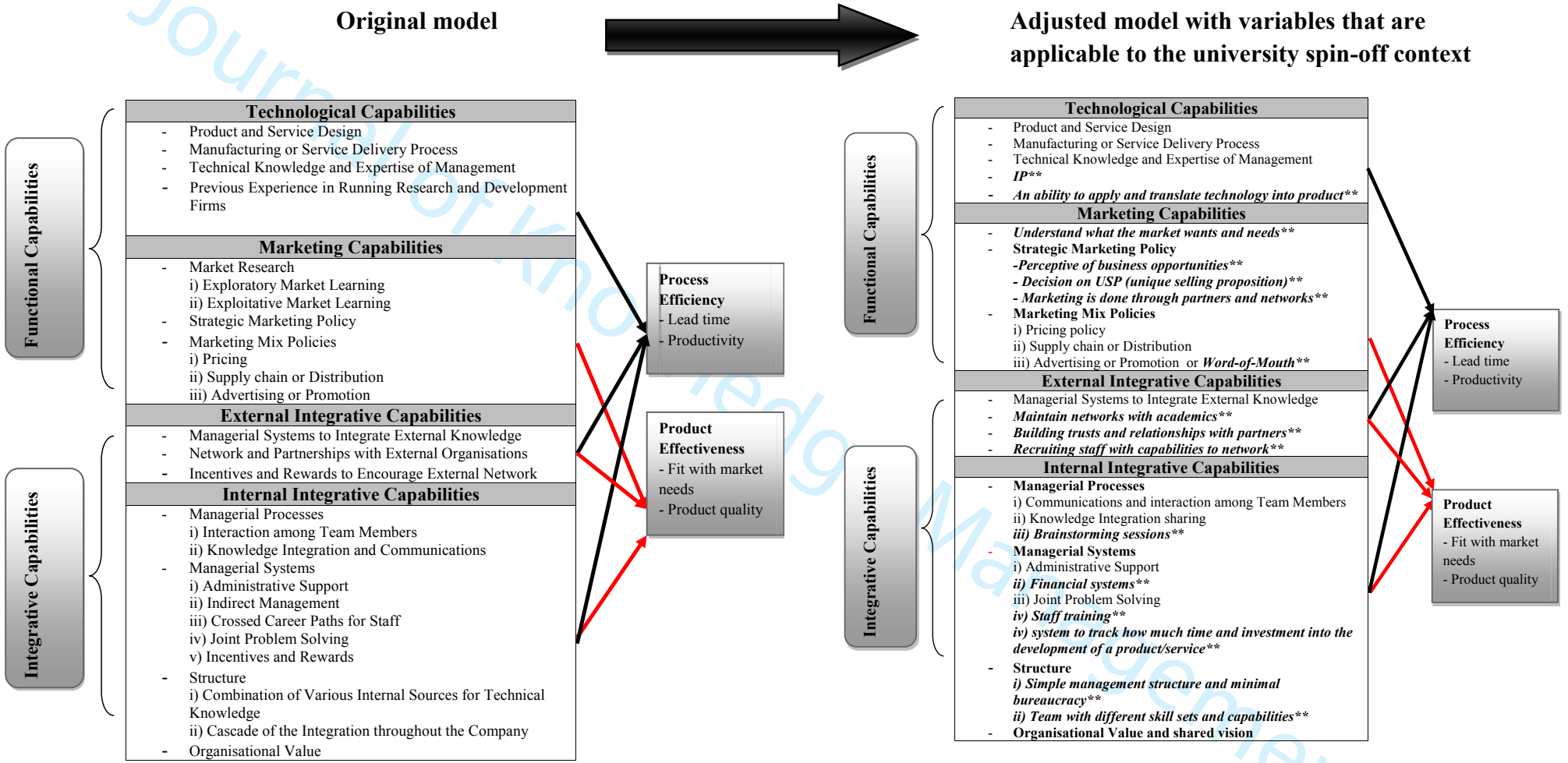


**Figure 3: The factors contributing to the efficiency and effectiveness of university spin-offs product/service development**

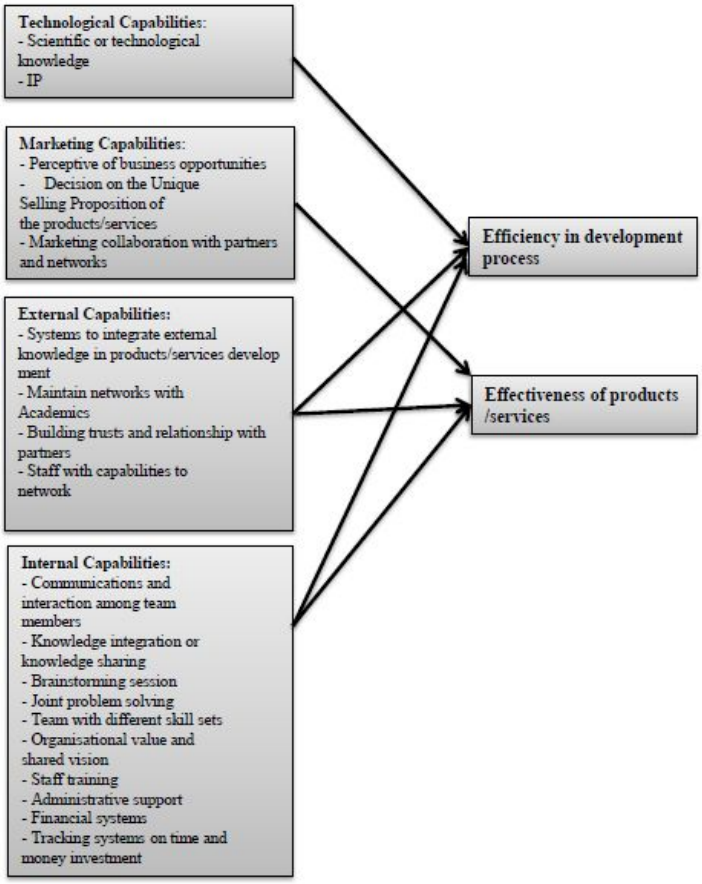


**Table 1: The analysis of capabilities of USOs**

| CAPABILITIES | COMPETITIVE ADVANTAGES | APPLICATIONS TO USOs |
|---|---|---|
| Technology Capability | Enables a firm to provide a particular benefit to customers | Technology resources can be regarded as key distinctive aspects of university spin-offs, which might be a source of competitiveness:<br>a) University spin-offs differ significantly in their novel core technology, which can give them a competitive advantage ( Rodríguez-Gulías *et al*, 2016).<br>b) The technology base developed before the establishment of a firm provides university spin-offs with a stronger competitive position over other firms from the start (Heirman and Clarysse, 2004).<br>c) University spin-offs are different and more flexible in their product-technology. For instance, some spin-off firms develop extensive platforms, which can be used as the foundation to generate numerous products in the future (Meyer *et al.* 1997). |
| Human Resources and Skills/Business routine/Capability | - Set of people and skills that enable a firm to develop and provide a specific benefit to customers<br>- Provides management in an organisation a set of decision choices for generating key productivities.<br>- The identification of a market need and a proposed solution that fills the market gap. | There is a deficiency, generally, in university spin-offs, in the human capital and social capital, i.e., commercial knowledge and previous business skill, since they are found by academics or scientists. Academic entrepreneurs may lack the business knowledge to enable them to set up management routines and processes to properly evaluate business opportunities. This makes university spin-offs different to general start-ups, which may be set up by entrepreneurs that have previous business skills.<br>However, the stock of technology transfer staff with specific skills, such as technical, business, marketing, and negotiating skills are imperative. These skills may be seen as indicators for the new invention to attract external finance (Lockett and Wright, 2005).<br>'Surrogate entrepreneurs' can be alternatively employed from outside the university to work with academics or inventors to perform commercial activities (Franklin *et al*., 2001).<br>The development of routines and commercialisation processes depends greatly upon the experience and skill of technology transfer staff (Lockett and Wright, 2005). |
| Architecture | The network of relationships, contract and alliances | University spin-offs may initially lack business networks because they are set up in the academic setting. Usually, academic founders have well-established alliances, but within academic networks. However, the problem of not being able to establish relationships with external and business partners occurs (Baum et al., 2000).The development of network and strong alliances with a range of partners (customers and suppliers) is noted bringing a benefit to university spin-offs (Hoang and Antoncic, 2003), leading to business improvement and the growth of the company (Perez and Sanchez, 2003). |

| | | |
|---|---|---|
| Reputation | Allows a firm to communicate favourably about itself and products to its stakeholders | University spin-offs share similarities with start-up firms in that they have less strong reputations in the early stage because they are new to the market. The reputation of academic founders can help convey favourably and give confidence to the clients and suppliers.<br>In addition, a university's reputation may help spin offs attract financial investments because investors tend to be more confident and trust in the university's previous capability to accomplish (Di Gregorio and Shane, 2003). |

**Table 2: Summary of knowledge or technological capabilities employed for products/services development from in-depth interviews**

| Theme | Responses from university spin-off' founders |
|---|---|
| Knowledge and technological capabilities are regarded as very strong and unique to university spin-offs since spin-off firms are generally formed based on IP or new technologies and knowledge. These capabilities, thus, come naturally for university spin-offs. | *"technical knowledge was critical, critical to the business, needed to inform all aspects of the product development, performance optimisation, writing to manufacturing processes or managing the intellectual property…."* (Female, biotech spin-off firm in London)<br>*"Knowledge or technological capabilities really are the core of it"* (Female, consulting spin-off firm in Yorkshire)<br>"*if you can generate IP, obviously that's extremely useful*."(Male, pharmaceutical spin off firm in North West England)<br>*"the first is, is to take an education idea and to convert it into or translate it into a form that can be used outside of your own organisation, and this required the…the application of technology."* (Male, software spin off firm in Wales) |

**Table 3: Summary of marketing capabilities employed for products/services development from in-depth interviews**

| Theme | Responses from university spin-off' founders |
|---|---|
| Views about marketing capabilities varied. Some believed that marketing is necessary and critical, but others viewed that it has had little impact towards products/services as university spin-offs operate in a niche market.<br><br>More marketing can potentially be done once a product/service has launched and the company has been substantially established in the market. | *"….if your product is very specific or is, you know, in a particular niche area, then I just…I haven't found anything [marketing] there that's really useful."* (Male, consulting spin-off firm in West Midlands)<br>*"maybe, as we start to grow, that's, you know, we may need it more because there is potential to do more marketing"*<br>(Male, consulting spin-off firm in West Midlands) |
| Marketing capabilities are not a strong point among university spin-offs because companies are spun off from academic and university environment. | *"that is not something that kind of comes naturally to most academics and people from university backgrounds."* (Male, management consulting spin-off firm in London) |
| Marketing activities have been undertaken in collaboration with partners. | *"that (marketing) was the first thing that was brought completely from outside."* (Male, software spin-off firm in East Midlands)<br><br>*"we do marketing through a partner company."* (Male, software spin-off firm in East Midlands) |
| Understanding customers' needs is highly regarded; this is considered the initial and fundamental element in developing products/services. Obtaining customers' information is done informally. | *"But if you think of marketing as em…customer development, like em…as part of our design process, we do a lot of testing with users. So, we made initial prototypes, we went out, we tried them with users, and then we modified the design based on their feedback"* (Male, design/engineering spin-off firm in London) |

| | |
|---|---|
| | *"We don't have any [market research] tools, but we have a VP of Business Development who's always in touch with the customers"* (Male, software spin-off firm in London) |

**Table 4: Summary of external integrative capabilities employed for products/services development from in-depth interviews**

| Theme | Responses from university spin-off' founders |
|---|---|
| Different networks are noted as important to the success of products/services. It is also vital to maintain academic links to keep abreast with new technology and knowledge. | *"We obviously have academic connections; we had the academic link, and we still maintain those academic links"* (Male, management consulting spin-off firm in London)<br><br>*"We still keep very deep ties with them [academics] and we still look at what they're doing in the lab in the academic setting."* (Male, software spin-off firm in London) |
| Expanding networks or contacts to business and industry, e.g. attending industrial conferences is viewed necessary to develop the market for the products/services. | *"there's a different type of networking; it's business network."*<br>*"…if you are already researching and you are collaborating with companies in order to develop a prototype….but, you do need to go to conferences that are targeting industrialists."* (Female, consulting spin-off firm in Yorkshire)<br><br>*"Networking is important, you know,…when you're trying to get feedback to help you develop the product."* (Male, software spin-off firm in East Midlands)<br><br>*"I think the reason why we've been successful and survived so well, despite lack of marketing, is the fact that I'm in so many networks."* (Female, consulting spin-off firm in Yorkshire) |
| Networking skills are regarded as important because these will help in expanding the business and marketing opportunity. | *"You need somebody in the company who can network; you need that network capability. They network and they understand, you know, the field and where we can get clients."* (Female, biotech spin-off firm in North East England)<br><br>*"That is where you need someone, who knows the people, who are already in the industry, typically a marketing person."* (Male, software spin-off firm in East Midlands) |

**Table 5: Summary of internal integrative capabilities employed for products/services development from in-depth interview**

| Theme | Responses from university spin-off' founders |
|---|---|
| Financial and management systems are considered as one of the important factors contributing to the development of products and services. | *"We have systems in place, for example, centralised systems, to manage things like customer relations management, we have systems to manage finances and sales"* (Male, software spin-off firm in Wales)<br>*"the financial support, that's one thing as well, …..when you start the company, there's a huge sort of background of you have to do all the invoices, the accounting, the day-to-day book keeping…you know, keep making sure the bank balance is okay, and all that sort of thing, really, , and this is almost impossible for an academic like myself"* (Female, biotech spin off firm in North East England) |

| | |
|---|---|
| Communications are not considered problematic since university spin-offs are small with only a few staff. Complex company structure and bureaucracy is viewed as unnecessary since small companies (like university spin-offs) have more benefits in having more flexibility to make a decision quickly. | *"You know, if there're only four or five people, there's no point in having lots of bureaucracy and systems and tracking because you can just see what everybody's doing."* (Male, management consulting spin-off firm in London)<br><br>*"So, as a little company, you can do lots of things quickly, and then, if you try to rely too much on the University, which they always work like a corporation in the financial aspect. They have so many restrictions and rules."* (Male, software spin-off firm in East Midlands)<br><br>*"I mean, most university spinoffs, are a few people, not, you know, not tens of people. We've never had problems with communication because there's two of us [laughing]! You know, if you're not communicating with each other, then basically the company are not going to get anywhere at all"* (Male, geography product spin off firm in East Midlands) |
| Employees are also considered as one of the key elements contributing to products/services development. Staff training as well as keeping staff informed on new knowledge/technology are very significant. | *".....Having a good team that actually understands your product and can communicate [to the customers]..."* (Female, software spin-off firm in Scotland)<br>*"the human capital is our biggest resource"* (Male, software spin-off firm in London)<br>*"So the things that we consider internal capabilities include which staff we have and...so that's our biggest one, staff, is our biggest expense."* (Male, consultancy spin off firm in London)<br><br>*"you've got to keep them[staff] trained and up-to-date... knowledge capability and internal capability link together very closely really. But, particularly with a small company"* (Female, consulting spin-off firm in Yorkshire) |

## Table 6: PCA: Capabilities used for the efficiency in development process

**Rotated Component Matrix[a]**

| | | Component | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Technical Knowledge and Expertise of Management | Knowledge | .103 | .579 | .143 |
| IP | Management | .156 | .546 | -.103 |
| Managerial Systems to Integrate External Knowledge | | .057 | .651 | .005 |
| Maintain networks with academics | Networking | -.028 | .636 | .273 |
| Building trusts and relationships with partners | | .027 | .189 | .789 |
| Recruiting staff with capabilities to network | | .063 | .142 | .591 |
| Communications and interaction among Team Members | Team | .366 | -.153 | .669 |
| Knowledge Integration sharing | Working | .560 | .279 | .247 |
| Brainstorming sessions | | .746 | .068 | -.140 |
| Joint Problem Solving | | .822 | .026 | -.021 |
| Team with different skill sets and capabilities | | .662 | .033 | .117 |
| Staff training | | .498 | .097 | .214 |
| System to track how much time and investment into the development of a product/service | | .377 | .382 | .229 |
| Organisational Value and shared vision | | .584 | .125 | .161 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.
a. Rotation converged in 5 iterations.

**Table 7: PCA: Capabilities used for the effectiveness of products/services**

**Rotated Component Matrix[a]**

| | | Component | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Understand what the market wants and needs | Marketing | -.018 | .211 | .468 |
| Perception of business opportunities | | -.035 | -.037 | .643 |
| Decision on USP (unique selling proposition) | | .113 | .244 | .534 |
| Marketing collaboration with partners and networks | | .034 | .028 | .658 |
| Advertising or Promotion or Word-of-Mouth | | .134 | -.003 | .369 |
| Building trust and relationships with partners | Team Working | .234 | .058 | .518 |
| Recruiting staff with capabilities to network | | .209 | .017 | .578 |
| Communications and interaction among team Members | | .573 | .084 | .117 |
| Knowledge Integration | | .739 | .114 | .173 |
| Brainstorming sessions | | .651 | .033 | -.014 |
| Joint Problem Solving | | .778 | .203 | .104 |
| Team with different skill sets and capabilities | | .651 | .126 | .159 |
| Staff training | System Integration | .228 | .626 | .054 |
| Administrative Support | | .054 | .825 | -.002 |
| Financial systems | | .126 | .852 | .119 |
| System to track how much time and investment into the development of a product/service | | .335 | .580 | .179 |
| Simple management structure and minimal bureaucracy | | .463 | .397 | .128 |
| Organisational Value and shared vision | | .616 | .238 | .125 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation. a. Rotation converged in 5 iterations.

## Appendix 1: Summary of spin-off firms and respondents' profile

| Company | Gender | Typology | Sector | Company location | How the interviews were conducted | size | Maintain academic position |
|---|---|---|---|---|---|---|---|
| Company 1 | Male | product | design/engineering | London | Face-to-face | micro | no |
| Company 2 | Male | service | management consultancy | London | Face-to-face | small | yes |
| Company 3 | Female | software | software | Scotland | Telephone | micro | no |
| Company 4 | Male | product | biotech | London | Face-to-face | small | yes |
| Company 5 | Male | software | software | East Midlands | Telephone | micro | yes |
| Company 6 | Male | service | charity | Scotland | Telephone | micro | no |
| Company 7 | Male | service | consultancy | London | Face-to-face | micro | yes |
| Company 8 | Female | service | biotech | North East England | Telephone | micro | yes |
| Company 9 | Male | software | software | London | Face-to-face | micro | No |
| Company 10 | Female | service | biotech | London | Face-to-face | small | yes |
| Company 11 | Male | product | engineering | London | Face-to-face | micro | yes |
| Company 12 | Male | product | pharmaceutical | North West England | Telephone | micro | yes |
| Company 13 | Female | service | consultancy | Yorkshire | Telephone | micro | yes |
| Company 14 | Male | product | geography | East Midlands | Telephone | micro | yes |
| Company 15 | Male | software | software | East Midlands | Telephone | micro | no |
| Company 16 | Female | product | biotech | South East | Telephone | small | yes |
| Company 17 | Male | software | software | East Midlands | Telephone | micro | yes |
| Company 18 | Male | software | software | Wales | Telephone | micro | yes |
| Company 19 | Male | service | consultancy | West Midlands | Telephone | micro | yes |
| Company 20 | Male | product | engineering | East of England | Face-to-face | medium | yes |

## Appendix 2: Summary of observed variables

| Variables | Measurement scale |
|---|---|
| **Part1: Demographic information**<br>-Years in operation<br>- Number of employees<br>- Annual turnover<br>- Sector<br>- Number of patents<br>- Firm category | <br>- Continuous data<br>- Categorical data<br>- Categorical data<br>- Nominal data<br>- Categorical data<br>- Categorical data |
| **Part 2: capabilities employed in product/service development** | |
| **Technological capabilities (**The importance of technological capabilities to the **efficiency of process** e.g. reduction of lead time production)<br>-Scientific or technological knowledge<br>-Product/service design<br>-Manufacturing or service delivery process<br>-Intellectual Property<br>- An ability to apply and translate technology into product | - Ordinal data |
| **Marketing capabilities** (The importance of marketing capabilities to the **effectiveness of products/services** e.g. fit to market needs)<br>- Market research to understand what the market wants and needs<br>- Hire marketing/business development staff<br>- Perceptive of business opportunities<br>- Decision on the USP (Unique Selling Proposition) of products/services<br>- Marketing collaboration with partners and networks<br>- Pricing policy<br>- Supply chain or Distribution<br>- Advertising or Promotion or Word-of-Mouth | - Ordinal data |
| **External capabilities** (The importance of external capabilities to the **efficiency of process** e.g. reduction of lead time production and the **effectiveness of products/services** e.g. fit to market needs)<br>- Systems to integrate external knowledge in products/services development (e.g. special software to store record or share knowledge retrieved externally)<br>- Maintain networks with academics<br>- Building trusts and relationships with partners<br>- Staff with capabilities to network | - Ordinal data |
| **Internal capabilities (**The importance of internal capabilities to the **efficiency of process** (e.g. reduction of lead time production) and the **effectiveness of products/services** (e.g. fit to market needs)<br>- Communications and interaction among team Members<br>- Knowledge integration or knowledge sharing<br>- Brainstorming sessions<br>- Joint Problem Solving<br>- Team with different skill sets and capabilities<br>- Staff training<br>- Administrative Support<br>- Financial systems<br>- Tracking system on time and money invested into the development of a product/service<br>- Simple management structure and minimal bureaucracy<br>- Organisational value and shared vision | - Ordinal data |