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LOCATION BEHAVIOUR AND PERFORMANCE OF FLEMISH ACADEMIC SPIN-OFFS

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Stephen Bothuyne

Foreword

I would like to thank everyone who has supported me during the writing of my master's dissertation and especially throughout my education at Ghent University. This project was a true learning experience which has given me insights to build my future career. Especially the independence and freedom given to complete this thesis in a full year were really satisfying.

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Table of Contents

List of Used Abbreviations

Abbreviation	Full term
ASO	Academic spin-off
IP	Intellectual property
IPR	Intellectual property rights
Km	Kilometers
KU Leuven	Katholieke Universiteit Leuven
M&A	Mergers & Acquisitions
NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne
NUTS	Nomenclature of Territorial Units for Statistics
ROA	Return On Assets
ROE	Return On Equity
OLS	Ordinary least squares
TTO	Technology transfer office
UAntwerp	Antwerp University
UGent	Ghent University
UHasselt	Hasselt University
USO	University spin-off
VUB	Vrije Universiteit Brussel

List of Figures

List of Tables

1. Introduction

Over the last three decades, universities are being increasingly considered for their assistance in the creation of new ventures, namely academic spin-offs. Academic spin-offs (ASOs), University spin-offs (USOs), or just spin-offs are especially of broad and current interest since recent success stories as *Ablynx* and *Collibra.* Ablynx, a biotech specialized firm, was acquired in 2018 for 3,9 billion euros whereas Collibra, specialized in data governance, was the first Belgian private 'unicorn' – a tech start-up with a valuation of more than one billion dollars. This highlights the changing role of universities from traditional research and education providers to academic entrepreneurship and spin-off creation (Lerner, 2004). The growing relevance of academic spin-offs is also illustrated by the cumulative number of created spin-offs by the KU Leuven, one of the five Flemish universities included in this study:

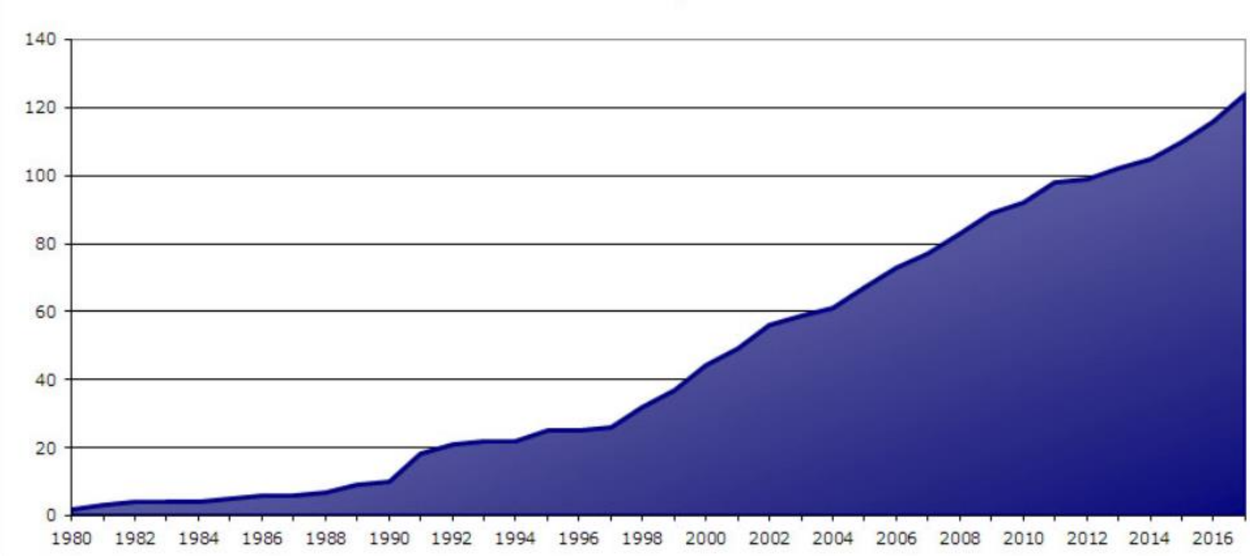

Figure 1 Cumulative number of academic spin-offs created (KU Leuven Research & Development, 2019a)

To date, there is an overall agreement about the positive effect of spin-offs on the economy and society, with the creation of wealth and employment (Clarysse, Heirman, & Degroof, 2001; Czarnitzki, Rammer, & Toole, 2014). This paper focuses on the link between these academic spin-offs and their parent university by targeting their physical location behaviour and the determinants influencing it. It also tries to link the university's research to the performance of the ASOs. This brings us to the two research questions of this paper:

"Are academic spin-offs (AS0s) clustered around their associated parent universities? And **Have R&D initiatives a positive impact on spin-offs' performance?"**

We answer these research questions by using data from two main sources. First, *Orbis*, which is a database containing (financial) data from European companies. We use this data to find the actual location of the Flemish academic spin-offs and retrieve some financial information. After we discussed the actual location of the Flemish ASOs, we asked the founder(s) for the main determinants influencing this location decision. These determinants were retrieved via a survey sent to all founders of the Flemish ASOs. The second research question focuses on the research activities performed at the university which ensured the foundations of the spin-off's creation. This could be easily measured by using the most likely output of valuable research, namely patents. We can obtain the patent information via *Orbis* and try to link this to the performance of the Flemish ASOs.

The aim of this paper is to contribute to the literature about European spin-offs since most studies are focused on the USA's spin-offs (Bigliardi, Galati, & Verbano, 2013). Secondly, we provide an empirical overview of the Flemish academic spin-off's landscape since 2001 by targeting the location behaviour and determine the influence of intellectual property on performance. We also want to contribute to the ongoing debate about the implications of the university's involvement in society.

This paper will be structured as follows. Part 2 consists of the literature review and will distinguish academic spin-offs from related concepts, describe the location behaviour of spin-offs in other studies and explain the importance of patents as the output of university's research and subsequently as the input for the spin-off. The research questions and hypotheses are also formulated in this section. Part 3 will explain our data collection process and methodology. In part 4, the descriptive statistics and statistical results will be described and explained. Part 5 mentions an illustrative robustness check whereas the conclusion of this paper can be found in part 6. Part 7 shortly relates this paper to the existing literature. Some limitations and recommendations for future research are suggested in part 8. Lastly, potential implications for policy makers can be found in part 9.

2. Universities affiliated with New Ventures: ASOs

2.1. The changing role of Universities

Universities have an essential responsibility in society. They are not only seen as the cradle of knowledge production but also as key knowledge transmitters. During the last two decades, it has evident that universities also have a third mission to accomplish: collaborating with the industry (Leydesdorff & Meyer, 2007; Mansfield, 1995). The reasons for the increasing importance of university-industry relations are abundant: it is a driver of economic growth, regional innovation processes, realizing full benefits of R&D investments, knowledge commercialization, job creation, etc. (Atasu et al., 2009; Huggins & Johnston, 2009; Siegel & Zervos, 2002). It is also driven by globalization and increased competition which both reshape the innovation strategies of most companies, focusing on external sources of knowledge (Hagedoorn, Lokshin, & Malo, 2018). This is especially the case in technology-intensive industries as chemistry and biotechnology. Universities play, therefore, a decisive role in the innovation performance of many firms.

In addition, the importance of universities to their surroundings and to economic development in general is annually increasing in relevance. In an era of huge technological advancements, open innovation and globalization, firms cannot afford to rely only on their own knowledge base. Knowledge networks, joint-ventures and university-industry linkages are a fundamental determinant of a firm's success (Bodas, Freitas, & Verspagen, 2017). This increased industry interest answers to the attention of policy makers to tackle the knowledge paradox (i.e., the fact that not all valuable academic knowledge gets translated into marketable products or processes) (Knockaert, Spithoven, & Clarysse, 2010).

Organizations and institutions have a variety of motives to join forces. These motives can substitute or complement each other (Bodas, Freitas, & Verspagen, 2017). Firms wanting to start new product development projects can consult universities searching for knowledge applications. Universities typically focus more on academic basic research while the industry wants a more rapid focus on commercializing the outcomes of basic research.

Generally, university-industry linkages cover a very broad area. There are various possibilities to link a university to a firm such as recruitment of young graduates, part-time professorships, grants for collaborative research, industry-financed laboratories and technology transfer offices which include (the licensing of) patents (Furman, 2007). Technology transfer offices (TTOs) are specialized in transferring knowledge and technology from (several) universities to private and public partners (TTO Flanders, 2019). TTO's fundamentally focus on three ways of explicit knowledge transfer: contractual research, license agreements of Intellectual property rights (IPR) and the creation of spin-offs. This directly leads to regional development concerning knowledge-driven entrepreneurship and innovation (TTO Flanders, 2019). The different interactions of a university to promote their research is commonly called "academic entrepreneurship" (Grimaldi et al., 2011). These interactions may include formal, written methods as patenting, licensing and academic spin-off creation and informal mechanisms as networking, consulting and personal interactions with companies. University-industry linkages can also be specified by focusing on university-industry relationships, as relationships expect a certain continuous effort of both parties to collaborate. Focusing on relationships instead of mere linkages is most important with the creation of spin-offs, because spin-off's success is determined by the intense interaction with the parent institution (Perkmann & Walsh, 2007).

2.2. What are Spin-offs?

In this study, we only focus on the most visible and valuable outcome of university-industry relationships and academic entrepreneurship, namely academic spin-offs. Before we go deeper into the definitions of the different types of spin-offs, we must make the distinction between several closely related terms to spin-offs (Figure 2). The overarching term which captures all companies in their first stage of operations is a **start-up**. These newly established businesses can be founded with the intention to grow via a scalable business model or to remain small (Blank, 2019). Although these start-ups can be regularly established by a certain founder(s) based on a certain business idea, there are distinct names for specific kinds of start-ups. First, a **spin-off** is a "creation of an independent company through the sale or distribution of new shares of an existing business or division of a parent company" (Fontinelle, 2019). The main goal for the creation of a spin-off by a parent company is shifting focus on a particular product/technology and thus streamlining decision making. Secondly, in a **carve-out** "the parent company sells some or all of the shares in its subsidiary to the public through an initial public offering (IPO). Unlike a spin-off, the parent company generally receives a cash inflow through a carve-out" (Picardo, 2018). A carve-out frequently occurs before a spin-off, where a part of the shares is sold to the public and the remaining shares are later distributed to the parent company's shareholders on a pro-rata basis. On the other hand, in a **split-off**, "Shareholders in the parent company are offered shares in a subsidiary, but the catch is they have to choose between holding shares of the subsidiary or the parent company" (Picardo, 2018). The shareholders have to choose between keeping their current shares in the parent company or exchanging them for shares of the subsidiary. Finally, a **spin-out** is an independent venture which could arise of the sale of a part of the parent company's business to another company or through the establishment by former employees of the parent company (Nikolowa, 2014). The main difference between a spin-out and spin-off is the fact that spin-offs get tremendous support from the parent company. The parent company may provide financial, technology or legal services and invests equity in the subsidiary (Fontinelle, 2019).

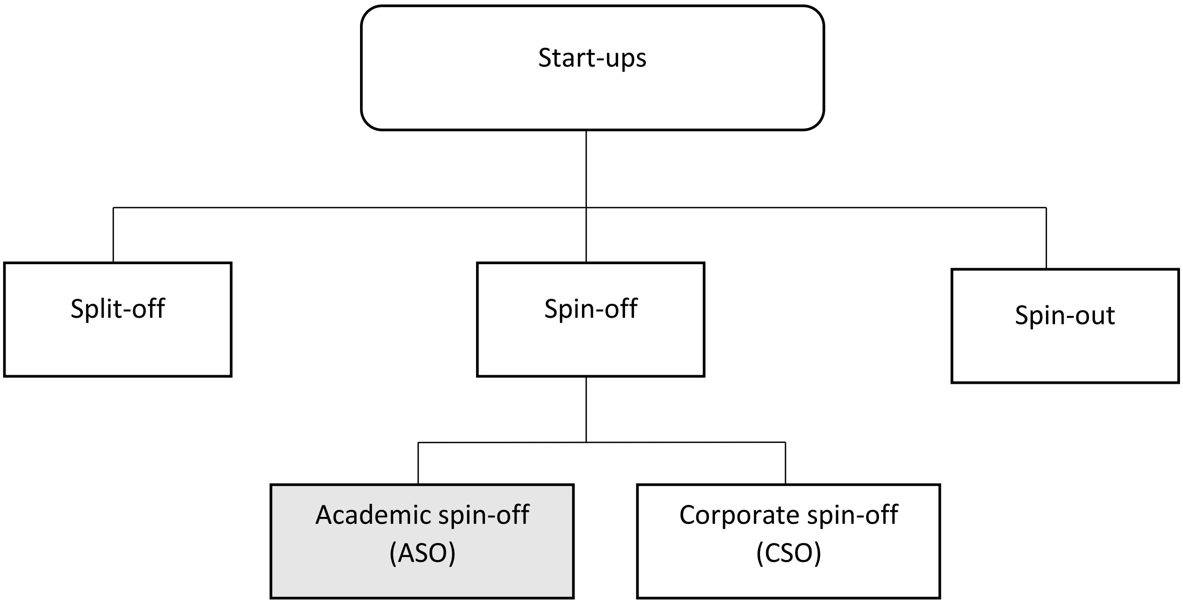

Figure 2 Spin-offs and related concepts

All terms described above are methods to increase the shareholder value of the company (Picardo, 2018). This paper only focuses on spin-offs, more specifically academic spin-offs:

While performing research about the performance of spin-offs, an indication of the type of spin-offs investigated is necessary. Generally, there are two types of spin-offs: Corporate spin-offs (CSO) and Academic spin-offs (ASO). Furthermore, there are several classifications of those two types. In short we define a CSO as ‘a separate legal entity that is concentrated around activities that were originally developed in a larger parent firm; the entity is concentrated around a new business, with the purpose of developing and marketing new products or services based upon a proprietary technology or skill’ (Van de Velde et al, 2006). Lindholm (1994) provides a thorough classification of corporate spin-offs focusing on the transfer of ownership rights. He finds two distinct categories of CSO’s: divestment spin-offs (voting power transferred to another firm) and entrepreneurial spin-offs (no formal transfer of ownership rights) (Lindholm, 1994). Dosi et al. (1988) focus on the nature of the relationship between the spin-off and the parent company, based on resource dependency theory. It states that there are three types of CSO’s: spin-offs developing new technologies, spin-offs serving new markets and restructuring spin-offs (Parhankangas & Arenius, 2003). On the other hand, an academic spin-off or a university spin-off is defined as ‘a new company that is formed by a faculty, staff member, or doctoral student who left the university or research organization to found the company or start the company while still affiliated with the university, and/or a core technology (or idea) that is transferred from the parent organization' (Smilor, Gibson, & Dietrich, 1990). Another definition provided by a very interesting paper by Bigliardi, Galati, & Verbano (2013) formulates an ASO as "Academic spin-offs companies are companies founded by an academic inventor aiming to exploit technological knowledge that originated within a university to develop products or services.". To clarify, the inventor may or may not be a founder of the spin-off or still be affiliated with the university. Finally, The KU Leuven (2019a), one of the five Flemish universities included in this paper, states: "The creation of spin-off companies is one of the technology transfer mechanisms through which knowledge and/or intellectual property are transferred, by which research results are commercially exploited. This implies that the economic activity of a spin-off company is based on scientific knowledge or technological know-how developed within the university. The spin-off company translates these research results in commercial products and/or services.". Academic spin-offs can also be classified into two other, more refined categories: Entrepreneur driven spin-offs and Technology driven spin-offs (UGent, 2019a). Entrepreneur driven spin-offs are, on average, small spin-offs founded by a researcher aiming to get value out of commercial interest in their research. These companies are consultancy and service oriented and often use university facilities to lower the start-up capital. These ASOs license university knowledge instead of being formally transferred to the new company. On the other hand, technology driven spin-offs are based on tremendous breakthrough research that may be the result of many years of costly study. The scale of this new venture is much larger than the entrepreneur driven spin-offs, making it a difficult process to find sufficient funding. The technology is transferred to the spin-off in exchange for royalties and/or shares.

Different types of spin-offs have inherently different properties which make it more or less easy to perform better. Corporate spin-offs (CSO) have the tendency to perform better when forming inter-firm alliances than Academic spin-offs (ASO) (Hagedoorn et al., 2018). This is the result of prior experience, networks and connections of the members of CSO's. Dosi et al. (1988) state that spin-offs serving new markets and restructuring spin-offs are more able to produce prototypes than spin-offs developing new technologies because they have a greater ability to access complementary resources of the parent firm (Parhankangas & Arenius, 2003). The goal and structure of universities and corporations are quite different which rationally leads to different types of spin-offs.

The main resources of academic spin-offs are similar to these of high-tech start-ups: human resources (e.g., founding team, employees), technological resources (e.g., research results, product, patents), organizational resources and financial resources (e.g., venture capital, government grants, bank loans) (Locket et al., 2005). Nevertheless, there are some particularities. The human resources of academic spin-offs are often too homogenous and as a result lack commercial attitude (Wright, Birley, & Mosey, 2004).

The technological resources are generally more generic, new and disruptive compared to the more specific technologies of corporate spin-offs (Danneels, 2004; Marsili, 2002). Furthermore, obtaining sufficient financial funds for new academic ventures is not straightforward. The lack of collateral, track record and cash flow lead to refusals by banks, most venture capital funds are risk averse towards seed capital and business angels are not widely available (Aernoudt, 2017a). This is especially the case in Europe with less openness from investors for high-tech start-ups (Kanniainen & Keuschnigg, 2004). However, recently Europe is keeping up with more advanced venture capital markets like the USA through several initiatives by the European Commission, European Investment bank and the European Fund for Strategic Investments (Aernoudt, 2017b; Winbladh, 2018).

2.3. Relevance

The study of spin-offs is extremely relevant for multiple reasons. First, spin-offs have on average more access to valuable and confidential information compared to regular start-ups. Their main asset consists of the technology transferred from universities or corporations (Clarysse, Wright, & Van de Velde, 2011). Secondly, spin-offs also promote prosperity through knowledge development and employment creation in regions, industry clusters and nations (Parhankangas & Arenius, 2003). The spin-off can have the best of two worlds: combining the entrepreneurship typical of a small company and the large asset base of the more mature parent company. The parent company acts as a failure buffer for the spin-off while administrative responsibilities are transferred to the descendant. Thirdly, spin-offs are also in line with the shortly mentioned TTO's. They transfer technology and knowledge in two stages: first from the university to the company and later from that spin-off to the customers (Bigliardi, Galati, & Verbano, 2013). Nonetheless, TTO's are mostly required to support this process.[1] Fourthly, the amplifying economic importance of spin-offs is mainly the result of the adaptation of the "open innovation" model by many organizations. As stated earlier, increased competition and globalization leave companies no choice to search for additional external sources of knowledge and technology. This external need for knowledge makes small companies with refined scientific expertise very treasured (Bigliardi, Galati, & Verbano, 2013). Fifthly, academic spin-offs are able to involve the initial inventor of the technology in the process of commercialization, which can be vital to obtain a quality product/service to face competition (Hindle & Yencken, 2004). Inventors tend to be more motivated to work in small, new ventures to commercialize their own inventions than in established firms commercializing one of the many inventions (Pinaki,

[1] Although Technology Transfer Offices provide valuable services to support academic entrepreneurship, the efficiency and effectivity is often questioned (Chapple et al., 2005). For example, Knockaert et al. (2016) confirmed that only a minority of researchers is aware of a TTO's existence at their university.

Satyendra; 2014). Given the fact that equity is the most effective compensation tool for enabling inventor involvement, it is also much easier to transfer shares to the new inventor during the creation of a new firm opposed to transferring shares of established firms (Geuna & Nesta, 2006). Sixthly, spin-offs give the possibility to both the university and the researcher to earn more money. The university can potentially receive higher revenues by being a shareholder of the new venture instead of a mere licensing agreement whereas the researcher can earn a higher salary by founding a spin-off and still work for his university (Powell & Owen-Smith, 1998; Bray and Lee, 2000). Seventhly, since large established companies ensure the preservation of jobs, small and flexible companies are necessary to create new employment (Aernoudt, 2017b). Lastly, spin-offs are also fast contributors to the economy due to their more than average growth rates, especially compared to less-technology driven industries (Cooper et al., 1986).

Another reason for spin-off creation is the need for the exploitation of explorations. Universities are typically linked to exploration: a global search for ideas through discovery and innovation (Lehtihet, 2014). To be commercialized and create value, these explorations need to be exploited. This is known as the exploration-exploitation sequence where product development cannot take place if there is no exploration before the exploitation phase (Rothaermel & Deeds, 2004). The main activities of spin-offs are related to the exploitation of ideas that are generated or explored at the parent organization. The parent organization focuses its attention on the knowledge by positioning it in a separate entity. The success of a spin-off is as a result highly dependent on the initial knowledge transferred to the spin-off. To sum up: knowledge is first generated by the faculty members of the university itself (exploration) and later transferred to a spin-off to convert it in a marketable product (exploitation) (Perkmann et al., 2013).

Although this exploration-exploitation sequence is very relevant for academic spin-offs, we also have to mention more recent research which criticizes this linear approach (Sinha, 2015). If the initial explored research by the university is not sufficient to lead to marketable products, additional exploration during the exploitation phase is required. This results in a shift from a linear approach to a more circular approach with the inclusion of a feedback mechanism. Sinha (2015) describes this as ambidexterity, being able to do exploration and exploitation at the same time. Since the universities are still focused on exploration, we can conclude that academic spin-offs exploit this research initially and do additional exploration when needed.

There are multiple successful examples of spin-offs resulting from university's knowledge. Classic cases are to be found in Silicon Valley in the US and Oxford and Cambridge in the UK (Gibson and Smilor, 1991; Kassicieh et al., 1997). However, most research on ASOs is focused in the US while less attention is given to continental Europe. In this study, we focus on ASOs in Flanders, the Dutch-speaking Northern region of Belgium (full discussion below).

The focus of this paper lies on the factors influencing academic spin-offs performance and location behaviour. Therefore, the distinction between CSO's and ASO's is no further pursued in this study. However, investigating CSO's performance can give important insight into the different factors influencing the respective spin-offs. In the remaining of this research, when referred to spin-offs we mean academic- (ASOs) or university spin-offs (USOs)

2.4. Location Behaviour of ASOs

Before we deep dive in the research about the link between intellectual property and ASO's performance, we first focus on their physical location in relation to their original university. It seems common sense that spin-offs created by a certain institution would locate in the surroundings of that institution. It also appears viable that spin-offs located nearby their associated university would benefit from these close linkages and boost their success potential. As mentioned before, some key regions of university spin-offs as Silicon Valley in the US and Oxford in the UK are known as clustered regions of knowledge transfer. On the other hand, the geographical clustering of new innovative ventures appears paradoxical given the intangible nature of knowledge. This brings us to our first research question:

RQ1: Are Academic spin-offs (ASO'S) clustered around their associated parent universities?

The guidance of our research question to a specific hypothesis is the result of some important literature studies. Empirical examples approve the existence of spin-offs in the close environment of the university (OECD, 2002). Rodriguez-Pose and Refolo (2003) state that Small and Medium-sized enterprises (SMEs) in Italy during a seven-year period (1989-1995) were concentrated in the proximity of universities and research centers. The research performed in local universities is thus not only beneficial for the formation of SMEs, but also for the chances of development and survival of these firms. They find no such relation for larger firms which serves as an indication of the importance of geographical proximity for start-ups such as spin-offs. The importance of geographical proximity is also stressed by Bathelt, Malmberg and Maskell (2004). They use "local buzz" as the collective name of information flows and complex communication in a local area leading to the development of shared values, interactive learning and problem-solving. A survey conducted by Jensen and Thursby (2001) claims the need for intensive interaction between the new venture and the associated university. The new venture needs inventor cooperation to commercialize the mostly embryonic technology licensed from university. Intensive cooperation is assisted by the face-to-face exchange of tacit knowledge which implies the need for geographical proximity to university (Dahl & Sorenson, 2012). Furthermore, entrepreneurs are more likely to stick to their "roots" than employees (Dahl & Sorenson, 2012). The main cause of this geographical inertia is the presence of social capital, which cannot be carried away like human capital. Tacit knowledge is an important determinant of social capital and is difficult to transfer, as a result local proximity lowers transaction costs. This transfer of tacit knowledge is not limited to the early formation of the spin-off but is also instrumental for the upcoming years. After formation, they might still depend on additional research and advice (Egeln, Gottschalk, & Rammer, 2004). Besides informal, tacit knowledge transfer as a key reason for geographical proximity, formal relationships with the university can also have their impact. A formal relationship with the university can generate income through research projects, part-time tutoring by the spin-off's founder or provide an escape route in case of spin-off's failure to work again for the university itself. These relations imply physical presence at the university (Egeln, Gottschalk, & Rammer, 2004). Gittelman (2003) also emphasizes the importance of clustering and social capital and concludes that geographical proximity is beneficial for innovation. Entrepreneurs tend to locate in their home region to have a greater ability to attract resources (raising capital and personnel) in the first place. In addition, this also gives the advantage of being able to spend more time with family and friends. They usually have a higher preference to live near family and friends than employees, but no negative relationship between regional embeddedness and performance has been found (Dahl & Sorenson, 2012). Dahl and Sorenson (2012) find that ventures even tend to perform better in terms of greater profits and cash flows when they are based in regions familiar to their entrepreneurs. Entrepreneurs can reduce the uncertainty of founding a firm by locating in a well-known region. They have the advantage of understanding local laws, language, customs and preferences of the local population. Besides these legal, linguistic and cultural barriers, localizing firms in foreign countries also implies higher transportation costs and possible import restrictions. Entrepreneurs are also enticed to their home region through nonpecuniary compensations as control offered by self-employment and satisfaction from the feeling of accomplishment (Blanchower & Oswald 1998). Certain firms need the infrastructure of their university (e.g., laboratory equipment, high-tech ICT material), some provide services for that university, others are dependent on support from local authorities (OECD, 2001). The use of university equipment lowers the needed investment of the spin-offs and can reduce the cost of personnel by allowing students to do some research in the context of a Ph.D. or master thesis. The employment of PhD-students and researchers in companies is even promoted via grants (Baekeland and Innovation mandates) (Agency of Innovation and Entrepreneurship, 2019). Of course, the most simple and self-evident reason remains the fact that the knowledge is derived from the university and that the entrepreneur already lives in the surroundings of this university. The entrepreneur is attached to his social network which he developed over the years and therefore the social costs, in addition to the costs of relocating itself, can be recognized as too high (Stuart & Sorenson 2003).

Apart from the determinants which favor geographical proximity of the ASO to the university, there could be several comprehensible explanations of why a spin-off would locate elsewhere. First, the new venture is not only dependent on the parent institution, but could also rely on other partners (e.g., industry partners, research centers, scientists) for the wellbeing of their firm. If a firm is hugely dependent on a specific business partner, the venture may be located far away from the parent institution. Second, spin-offs should also lay their eye on sustainable customer relations and favour locating close to the market. Therefore, new ventures are facing a trade-off between locating near their parent or near other relevant partners while considering the input costs (e.g., buying/renting laboratory equipment, transport costs, transaction costs, labor costs) (Egeln, Gottschalk, & Rammer, 2004). Overall, we conclude that geographical proximity to the parent university has a positive influence on academic spin-offs performance, resulting in the first hypothesis:

H1: *The location of a spin-off is clustered around its associated university.*

This first hypothesis can be further refined by focusing on which of all determinants has the greatest impact on the location decision of the new venture. The just-mentioned need for infrastructure seems a vital motive to settle near their parent university. If years of research is being done in the laboratory of the university and additional research is needed after the spin-off foundation, it appears viable to continue using that equipment instead of buying an expensive laboratory yourself. Ndonnzuau et al. (2002) conducted a worldwide field study by visiting universities in several countries like Finland, Belgium and the USA. They witnessed how universities were very flexible in providing access to infrastructure (e.g., laboratories, equipment, test devices, etc.). This is also one of the stimuli mentioned by Ghent University to found an entrepreneur driven academic spin-off, also stressing the reduced capital needed for the start-up phase (UGent, 2019a). The other major Flemish university, KU Leuven, also stresses the available support after foundation by providing infrastructure. They point out the available infrastructure in the university itself or in the surrounding science parks and business centers of Leuven (KU Leuven Research & Development, 2019c). Since the most important science parks of the two most prolific Flemish universities are located closely to the university itself, we can equate these locations:

Table 1

Most important science parks and business centers of 2 Flemish universities (KU Leuven Research and Development, 2019c; UGent, 2019b)

UGent	KU Leuven
Tech Lane Ghent Science Park (+- 4km)	Arenberg science park (+- 3km)
	Haasrode science park (+- 4km

This leads to our second hypothesis:

H2: *The need for infrastructure is positively related to spin-offs locating close to their parent.*

2.5. Literature Overview of other Success-factors

In addition to location as an important success-factor for spin-offs, several other causes can be found in the literature. Vohara et al. (2004) focused on the importance of guidance and training by the university itself by providing a mentor, training and education. Similor and Matthews (2004) proved the straightforward assumption that spin-off's success is dependent on the involvement of the parent institution. This involvement can be unraveled in financial involvement of the parent, competent staff in technology transfer offices, transparency and clarity of support policy and access to qualified entrepreneurial skills. Financial involvement of the parent/university is also one of the mentioned success-factors in studies conducted by Locket et al. (2005) and Scholten (2006). Heirman and Clarysse (2004) highlighted the importance of the degree of innovativeness, stage of development of the technology, ability to patent or in general protect the technology and scope of the technology/patent itself. The availability of resources by the spin-offs and the external environment can also have a decisive influence on their performance. Strong relationships with key clients, research partners and the parent university can facilitate the spin-off's growth pattern (Mustar, 1997). External factors like the specific policy applied by the university can have a decisive impact on the profitability of the spin-off. Clarysse and Moray (2005) found evidence that a changing policy of technology transfer influences the funding of ASOs. They investigated the structured process of venture creation of the Belgium based research institute IMEC. IMEC changed their IPR management to increase new venture's value by using a complex IP strategy instead of the usual license, which is more favorable for investors. Flanders was originally lagging in the creation of spin-offs compared to other European companies but lately managed to catch up. By the provision of intensive coaching and support, as mentioned earlier, they obtained a rather quick turnaround (Flanders Investment and Trade, 2017). The changing policies applied by the government for the stimulation of spin-offs is also a huge determinant for Flanders spin-offs' success. For example, the tax shelter, which gives investors in start-ups a possible tax reduction up to 45% of their investment. This tax shelter is applicable for al private taxpayers in Belgium who have the possibility to invest directly in a specific start-up, invest in a diversified portfolio, invest in a starter fund or invest through a crowdfunding platform. The difference between the diversified portfolio and the starter fund is that the starter fund can change the composition of your fund without your consent (Startuptaxshelter, 2019).

Bigliardi, Galati and Verbano (2013) provided a comprehensive and useful framework of the multiple factors influencing spin-off performance. They identified four classifications of factors derived from a wide range of literature:

Table 2

Factors influencing spin-off performance (Bigliardi, Galati, & Verbano, 2013)

University's characteristics	**Founders characteristics**	**Environmental characteristics**	**Technological characteristics**
Financial involvement	Need for autonomy	Industry	Degree of innovativeness
Formal contact	Risk-taking responsibility	Regional infrastructure	Stage of development technology
Competent TTO's	Career orientation and motivation	Seed and venture capital availability	Ability to patent
Access to qualified skills		**Spin-off's location**	
Training/education		Relationships with key clients, partners	
Relationships with key companies		Government	
		Technology transfer policies	
		Tax shelter	

We follow this framework and add other relevant literature findings in the columns. We can conclude that spin-off's location is definitely a success factor of their performance, but also admit the fact that there are a variety of explanations for beneficial spin-offs with an unfavorable location. This paper focuses on the geographical location of the ASOs and the university related factors which could influence this location decision.

2.6. Performance of Academic Spin-offs

The performance measurement of spin-offs is not straightforward. First, we want to emphasize that this paper is not a study about the performance of ASOs as such or a comparison between the performance of different universities. We need a performance measure to be able to find a possible link between research initiatives and this performance. How we interpret and measure research initiatives is mentioned in the next section. Second, the performance we want to target in this study is pure economic performance (e.g., profitability, job creation). However, we acknowledge the fact that spin-offs, in addition to their financial impact, can also have a technological or scientific effect (Bolzani et al., 2014). The most drastic performance measure is the survival or mortality rate of a company. If a company ceases to exist, the company is labeled as a failure and performance is equal to zero. Bolzani et al. (2004) do not find a substantial difference between the failure rates of spin-offs and other companies. If some claim in either direction is stated, it is mostly conditional. For example, Rothaermel and Thursby (2005) find support that companies with a university link have a lower failure rate, but also find these same companies struggling to survive. They claim that a university link gives a reputation effect, access to strong international patent protection facilities, support in the transfer of tacit knowledge and a strictly planned follow-up. This reputation effect can have a signaling effect on potential investors, simplifying fundraising (Vanacker & Forbers, 2016). On the other hand, this link conceals the often immature and underdeveloped technology and pompous attitude of the inventor.

There is little consensus in the literature about which performance measurement instrument should be applied. The most traditional performance measures like Return On Equity (ROE) and Return On Assets (ROA) are sometimes unreliable for spin-offs. Spin-offs often require large investments needed to develop a marketable product, which may only pay off after certain years (Shane & Stuart, 2002). This results in a sequence of years without a profit. Assessing the performance of all spin-offs based on accounting-based ratios is accordingly biased (John Hagel III, 2010). Especially high-tech spin-offs can have several years of loss-making until a breakthrough has been found and a product has been commercialized. This is known as the famous Death Valley curve (Figure 3). During the Valley of Death, start-ups have the highest chance of going bankrupt due to the continuous stream of negative cash flows. Climbing out of this valley is only possible when revenues start being generated (Osawa & Miyazaki, 2006; Kenton, 2017). On the other hand, traditional measures as ROE and ROA are commonly used in similar studies and better known to the public, making it a benchmark to include in your study (Pagano, Panetta & Zingales, 1998; Anderson & Reeb, 2003; Farre-Mensa & Ljungqvist, 2008). Other measures of performance can be growth in sales, employment growth, turnover and credit ranking (Engeln et al., 2003; Schmelter, 2004; Smith & Ho, 2006). These last-mentioned measures are preferred over pure accounting-based measures to objectively track spin-off's performance. For instance, biotech firms are known as cash burners without realizing a profit for several years. A possible way to evaluate their performance is to trail the employee growth over multiple years. Promising firms can attract additional financing which allows them to attract additional employees to continue the research.

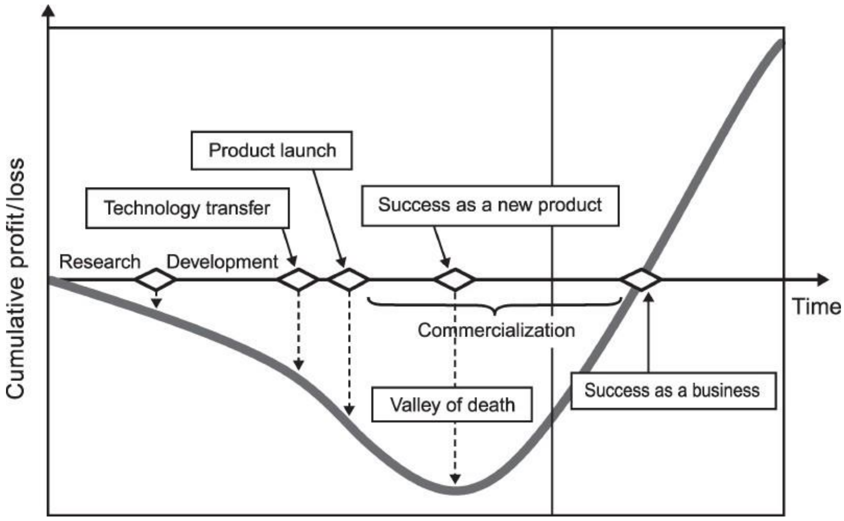

Figure 3 The Valley of death (Osawa and Miyazaki, 2006)

2.7. Linking Performance to University

The goal of this research is not to precisely describe the performance of each spin-off, nor to give an evolution of ASOs performance over time. We want to link the performance of these spin-offs to their parent university. We do this by linking the R&D initiatives undertaken by each university, which initially led to the spin-off being founded and able to grow. This intellectual property (IP) is one of the building blocks of the founded ASOs. We already claimed spin-offs to be the most visible outcome of academic entrepreneurship, we believe patents are the most visible formal input of an ASO's existence. This is the basis for our second research question:

RQ2: Have R&D initiatives a positive impact on spin-offs' performance?

IP Support is one of the most important activities of TTO's. The protection of research results is crucial as it is giving the owner (which in Flanders is mostly the university itself and not the researcher) a competitive advantage in the possible valorization of this initial research (UGent, 2019c; Joos, 2017). Research is, apart from a motivated and capable team to transfer knowledge to the spin-off, the second critical success factor (KU Leuven Research & Development, 2019b). This research can be patented or not, but protected research gives a wide range of benefits. First, it gives the obvious advantage to be the only party to exploit the research, to sell it or to give a license. Second, it strengthens the negotiation position with other firms whether these are firms willing to collaborate or with competitors trying to stay ahead of you. Third, patents advertise R&D activities conducted in the past because they act as a measure to asses a firm's ability to perform valuable research (Stuart, Hoang, & Hybels, 1999). Fourth, it gives a 'freedom to operate' and is good publicity since patenting can be seen as a quality signal (FOD Economie, 2018). The role of patents as quality signals is also confirmed by Czarnitzki et al. (2016), who showed that patents act as a sort of collateral to potential finance providers which mitigates finance constraints. They found that the mere application or mere existence of the patent was sufficient to increase the chance to attract external finance regardless of the quality of the underlying protected technology. Czarnitzki et al. (2016) state that determining the value of patents is very difficult and uncertain for financial institutions, but they evaluate the mere existence of them positively. Their results only apply for small firms who usually face huge information asymmetries due to the lack of a proven track record and have little collateral to offer since they are only in the start-up phase. Since most academic spin-offs are rather small and constantly looking for finance, patents can have a crucial impact on financing the business (Sørheim, 2011; UGent, 2019c). Even when there is doubt about protecting a technology by patents, filing for patents can still be a beneficial decision for small high-tech firms due to the signaling value. Other studies provided similar conclusions with Harhoff (2009) claiming that patents have a signaling function about the quality of the R&D staff and their capability to manage IP-rights. Henderson and Cockburn (1994) focused on the pharmaceutical industry, by using the number of patents as a proxy for the research competencies of the firm. Although there is no doubt about the beneficial impact of patents, there are also some remarks which should temper the pure focus on patents. First of all, not all companies file for patents or are doing activities which require patented technology, especially in the services industry which rely more on trade secrets (Agarwal, Erramilli, & Dev, 2003; Morikawa, 2014). Secondly, filing for patents can be very costly (e.g., filing fees, lawyer fees, drawing fees) which could especially limit young ventures due to their poor cash-flow position in their first years (FOD Economie, 2018; Upcounsel, 2019). Thirdly, most patents are in fact worthless due to the difficulties related with extracting the true value of the invention (Key, 2017). Although only 3% would eventually be worth something, they compensate for the costs for the remaining 97% of worthless patents (Blyler, 2017). If a company does not file for patents at all, they will never have the chance to have a vital patent eventually. For example, Thomas Edison had hundreds of worthless patents whereas only a few led to breakthrough inventions.

Research is the foundation of why spin-offs are created in the first place (Shane, 2004). Since patents are an eventual outcome of this research, this relationship seems trivial. There is a lot of literature proving this relation by considering patents or filing for patents as a proxy for public research (Rodriguez-Pose &

Refolo, 2003; Caldera & Debande, 2010; Fischer & Varga, 2003; Burhan, Singh, & Jain, 2017). Clarysse et al. (2007) went a step further by showing that patents are an indicator of early growth and success of academic spin-offs. However, in another study by Clarysse et al. (2011) no significant relationship between patents and later growth was found, stressing the importance of patents in the start-up phase. A comparable study conducted by Haussler et al. (2012) indicated the necessity of patents for biotech spin-offs to attract venture capital and becoming operational. This patent acts as a certain collateral, a confirmation of previous research and an indication for future successes. These future successes lead to a higher market value of the firm today, with number of stocks being correlated with a venture's market value (Hall et al. 2005). Helmers and Rogers (2011) found that patents lead to a larger growth rate and productivity compared to firms without a patent in their possession, especially for small firms. Levitas and McFayden (2009) focused on the competitive advantage granted by patents by protecting the research results, leading to higher expected profit margins in the future. These patents make sure the firm can manage their liquid assets more efficiently by having easier access to external financing. This reduces the need for a large cash pile to fund future projects and increases the firm's financial flexibility. Cockburn and Wagner (2007) conducted a study on the survival of ICT firms before and after the dot.com bubble in 2001. They suggest that firms unable or unwilling to obtain patents had a lower survival rate.

Technology transfer offices have played a crucial role in increasing awareness and providing support with patent filings. The European patent office received a record of 174 317 patent applications in 2018, which is an increase of 4,6% by last year and even 14,15% compared to 2014, emphasizing the ever-growing relevance of patents (Figure 4) (European Patent Office, 2019). Belgium even experienced an increase of almost 10% in patent filings whereas Ghent University (66) and KU Leuven (35) were both in the top 10 of largest patent applicants (Vlaanderen, 2019).

The overwhelming amount of literature indicating the positive impact of filing for patents or the possession of patents and the increased growth of patent filings brings us to our third hypothesis:

H3: *The number of patents is positively related to the performance of an academic spin-off.*

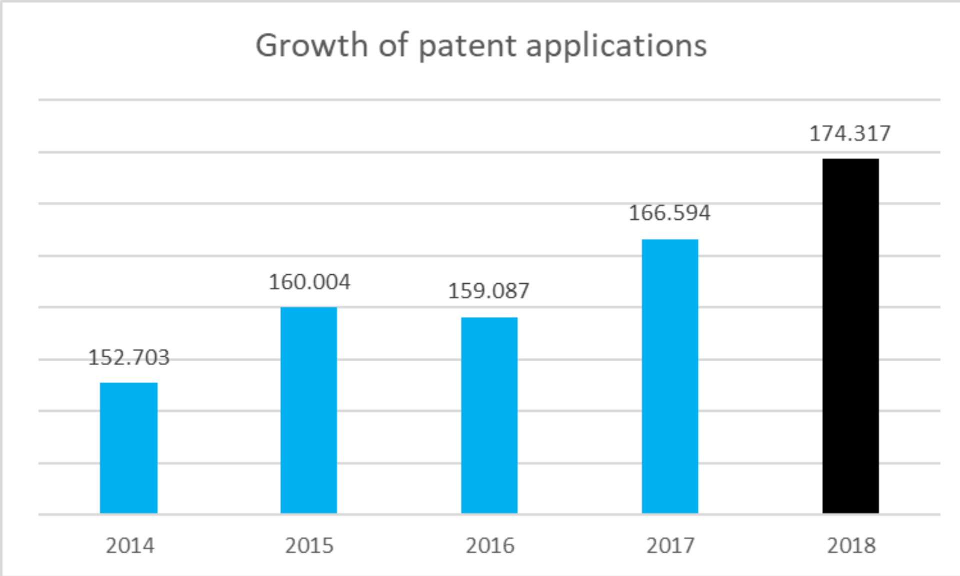

Figure 4 Growth of patent applications (European Patent Office, 2019)

3. Sample Data and Methodology

3.1. Data Collection

In this study, we focus on ASOs in Flanders, the Dutch-speaking Northern region of Belgium. Flanders is a rising high-tech region which is improving its competitive position through converging old and new technologies (Cantwell and Lammarino, 2001). This part of Belgium has five universities: Universiteit Gent (UGent), Katholieke Universiteit Leuven (KU Leuven), Universiteit Antwerpen (UAntwerpen), Vrije Universiteit Brussel (VUB) and Universiteit Hasselt (UHasselt). The VUB is a special case because it is officially established in the Brussels Capital Region but is a Flemish (Dutch-speaking) university (Vlaanderen, 2019; De Tijd, 2013). Officially, there is also a sixth university, namely the Transnational University of Limburg. However, this university is nothing more than an (inter)national collaboration between the University of Hasselt, Maastricht and KU Leuven (UHasselt, 2019). This sixth university is not further included as no academic spin-off is derived from it. On average, these five universities create 3,8 spin-offs each year whereas the European average is only 1,7 (Universitaire spin-offs succesvoller dan ooit, 2015). All nine universities in Belgium combined (also the French-speaking Southern region) created 183 spin-offs over the last five years. This number extensively exceeds the expectations of these universities by nearly 100%. Reasons for this miscalculation and nonetheless positive evolution are twofold: the rather conservative calculations applied by universities due to uncertainty, and the favorable economic environment. This increase is also encouraged by the government which focuses more and more on entrepreneurship, especially in Flanders (De Preter, 2018).

The available data of Flemish spin-offs is derived from these five Flemish universities' websites itself and by using *Orbis*. The *Orbis Europe* database composes annual balance sheet, income statement and social balance sheet data of around 19 million companies across Europe. The standardization of data makes it extremely suitable for research purposes (Bvdinfo, 2019). The *Orbis* database is assembled by Bureau van Dijk (BvD), one of Europe's leading electronic publishers of business information. Bureau van Dijk processes and controls financial statements registered to the responsible public authorities (e.g., the National Bank of Belgium) and afterward makes them available to the public. The process to link the companies on the respective websites to the companies in *Orbis* is relatively straightforward: by directly searching for the companies, which are mentioned on the universities' website, on *Orbis*. In case of doubt, we visit the companies' website itself and use the unique firm identifier (i.e., the firms' Value Added Tax code). Although a wide range of data can be retrieved (e.g., financial data, patent information, owners' data), not all data is publicly available on *Orbis.*

This limited data is the result of no mandatory disclosure for some key financials, which are represented in *Orbis* as not available (n.a.) or not specified (n.s.). Belgian corporate law gives freedom to small and medium-sized enterprises to disclose some key (financial) data (e.g., number of employees, turnover). Therefore, we can only fully rely on data disclosed by most of the entities. We tackle this issue by including data-related questions in our survey, which will be discussed in detail at the end of this section.

We also emphasize that all financial figures of these ASOs combined only reflects a tiny fraction of total entrepreneurial activity. For example, in 2015 only 0,6% of new ventures were spin-offs (Department of Economy, Science and innovation, 2016; Startersatlas Unizo, 2016). Nonetheless, the growing importance and presence of spin-offs make this research interesting for future purposes (Wim De Preter, 2018).

The dataset contains almost all academic spin-offs founded in Flanders during 2001-2017. We do not include founded spin-offs in 2018 due to the unavailability of data at the time of writing. We retrieve 196 spin-offs founded by those five universities, but only retrieve data of 194 firms (one firm has his headquarters in Canada which exceeds the scope of *Orbis Europe* and the other is not findable, caused by early bankruptcy). We also need information about the survival of the different spin-offs and thus need to know if a company failed or was involved in an M&A during the given time frame. Therefore, we checked "mergers & acquisitions deals" information on *Orbis,* universities' websites, companies' websites, *Staatsbladmonitor* and press releases. Before consulting *Orbis,* financial data via the *National Bank of Belgium* was also collected to confirm if a company was inevitable an ASO.

The collection of sector data of each spin-off is again retrieved via *Orbis.* We use the widely recognized NACE Rev. 2 (Nomenclature Statistique des Activités économiques dans la Communauté Européenne – counterpart of the US SIC industry coding system) as industry standard classification system. This classification has four hierarchical levels whereas only level 1 (21 sections identified by alphabetical numbers) is used in this research (EC Europe, 2010). The sections-level provides already plentiful detail and is used in most recent corporate finance research when industry classifications are needed (Ferrando & Mulier, 2015; Siqueira et al., 2017). We additionally need the geographical location of ASOs in our dataset which we retrieve via Orbis and the companies' websites. In this case, we use the NUTS (Nomenclature of Territorial Units for Statistics) as our territory classification system. This classification has three subdivisions of which we use subdivision two (NUTS 2). Subdivision one (NUTS 1) is, when applied to Belgium, the complete Flemish region which is too broad. NUTS 2 provides information about the Flemish provinces and Brussels which is optimal since each university is located in a separate province. Therefore, we focus on NUTS 2 (EC EUROPA, 2018).

The calculation of the distances between each spin-off and its parent university is done by integrating the addresses captured by *Orbis* and the companies' websites and by using *Google Maps/GPS Visualizer.* We could not calculate this via *Orbis* itself*,* and also not via *Belfirst* (the Belgian counterpart of *Orbis*), which initially provides such a service, but was inaccessible for our subscription. Therefore, we consulted *Google Maps* and put every single entity on the map and calculated the distances with the built-in 'Distant Measure'.

After we had obtained detailed information about the population of Flemish ASOs via the universities and *Orbis*, we contacted every single firm for some additional information. We did this by using a survey conducted in April 2019. This survey approach provides us the opportunity to directly ask founders which motives led them to locate their company at their specific location. Since the literature review on location behaviour and determinants gives a wide range of reasons, we want to understand which determinants played a decisive role in the minds of entrepreneurs in (mainly) Flanders. The online survey approach has the advantage to retrieve unavailable information directly from the founders without geographical dependency. The most important disadvantage of this technique is the self-reported information by the respondents which cannot be verified. The respondents can first of all simply choose to not respond to the survey leading to non-response bias or survey response fatigue (Debois, 2019). Even if they respond, survey taking fatigue can lead to a low completion rate. In addition, the respondents may not feel encouraged to provide accurate answers (De Franzo, 2012). *Qualtrics* was used as survey software, which is an easy-to-use software to create surveys and export them to *SPSS* for analysis. The *Qualtrics* survey asked for the name of the spin-off (since these surveys are anonymous), the affiliated university, the number of FTE's and turnover (to tackle missing data in *Orbis*) and a last question where we asked founders on the determinants of their location decision. (Attachment 1).

The survey was conducted via e-mail invitation or via *LinkedIn* on April 9, 2019, and a reminder e-mail was sent one week later. The survey closed on April 21, 2019. The e-mail addresses were retrieved from the companies' websites and could be general company e-mail addresses and/or specific e-mail addresses of founders/employees. The *LinkedIn* information was retrieved by searching for the company on *LinkedIn* or by searching for the name of the founders directly by using press releases.

Consequently, this paper provides a unique approach by combining data from a database with data retrieved from a survey. However, there are potential concerns related to using surveys to obtain data (e.g., typing errors, misunderstanding a question), but since this was the only option to know non-disclosed financial data we believe it is extremely useful (Campello, Graham, & Harvey, 2010).

3.2. General Regression Model

This part starts with a description of the different variables used in the regression model and their respective calculation methods. Afterward, the regression function is derived from these variables.

3.2.1. Variables

We measure new venture financial performance based on traditional accounting variables. The availability of accounting data via *Orbis* and the frequent application of accounting measures in literature offset the related disadvantages. Additionally, some alternative measures (e.g., sales growth, employee growth, turnover) are very difficult to calculate as a result of non-disclosure by the spin-offs.[2]

Our primary performance measures are Return On Assets (ROA) and Return On Equity (ROE). They are both computed in two ways. In one approach, we use earnings before interest and tax (EBIT) divided by the book value of total assets/shareholder funds. In the second approach, we use net income scaled by the book value of total assets/shareholder funds. The difference between both approaches is the exclusion of taxes and mainly interest payments. Providing both approaches makes us distinguish the effect of debt financing on profitability, ignoring the capital structure of the ASO.

$$ROA\ (using\ EBIT)_{ASO} = \frac{EBIT}{Total\ Assets}$$

$$ROA\ (using\ Net\ Income)_{ASO} = \frac{Net\ Income}{Total\ Assets}$$

$$ROE\ (using\ EBIT)_{ASO} = \frac{EBIT}{Shareholders\ funds}$$

[2] Although we included turnover questions in the survey to have an additional measure, we were not able to incorporate this in this research since only a limited number of firms provided this confidential information.

$$ROE\ (using\ Net\ Income)_{ASO} = \frac{Net\ Income}{Shareholders\ funds}$$

Our independent variable is the number of patents which serves as a proxy for university research (Rodriguez-Pose & Refolo, 2003). This information is easily retrievable via *Orbis.*

$$Patents_{ASO} = Absolute\ number\ of\ patents$$

We use various control variables in our study. First, we control for **firm age**, i.e. the number of years that the spin-off subsists as an independent entity (Mosakowski, 1993). Different companies can perform differently at various points in time. As mentioned earlier, high-tech spin-offs often suffer severe losses after creation during their development of marketable products. Second, larger companies tend to have a higher probability to attract more customers and employees (Heirman & Clarysse, 2007). Therefore, we include the number of employees as a proxy for **firm size**. We do not use total assets or total sales as a proxy for firm size following several reputable authors (Becker-Blease, Kean, & Etebari, 2010; Clarysse, Wright, & Van de Velde, 2011). One of the best proxies for firm size is added value, clearly preferable to total sales due to the complexity of organizations. Primarily because we have to focus on the value of the firm's contributions, not on the value of the output. However, considering the simplicity and the straightforward availability of the number of employees we prefer this measure over value added per employee. After all, both measures are very similar, which makes this a logic choice (Kumar, Rajan, & Zingales, 1999). Using number of employees as a proxy for firm size also has as a long intellectual tradition (Pashighian, 1968). We use the natural logarithm of the number of employees in order to account for the fact that the median number of employees is examined less than the mean (Evers, Bohlen, & Warren, 1976). The **sector** is also included as a control variable, but solely focusing on the main section of the NACE classification system. The inclusion of the sector conforms with traditional new product development literature (NPD) (Balachandra and Friar, 1997). Since the companies in our dataset are spread over 13 sectors, which are analyzed at the nominal level, we should include 12 dummies to include every sector in our analysis (Table 3). However, this is unfavorable due to the small number of companies in most sectors. Therefore, we only use 3 dummies corresponding with 4 sectors (Manufacturing (C), Information and communication (J), Professional, scientific and technical activities (M) and an Others categories grouping all other sections (O)). Finally, we also include one dummy for every dependent variable to deal with extreme values. We set the threshold of extreme values on the arbitrary values of 1 and minus 1. An ROE and ROA exceeding these thresholds mean the company is making more profits or losses in one year than the total value of assets/equity. This can be the result of a quick turnaround or because the company is heavily financed with debt (Palepu, Healy, & Peek, 2016).

Age_{ASO} = Number of years since Date of Incorporation

$Size_{ASO}$ = Ln (Number of employees)

Sector = 3 dummies corresponding with the NACE-section (level 1), Manufacturing is the reference category:

$$ICT_{ASO} = Information\ and\ communication\ sector$$

$$PST_{ASO} = Professional, scientific\ and\ technical\ activities$$

$$Others_{ASO} = Other\ sectors\ (different\ from\ Manufacturing, ICT\ and\ PST)$$

$ExtremeValue_{ASO}$ = dummy with value 1 if ROE or ROA is < -1 or > 1 and value 0 if > -1 and < 1

Table 3

Number of ASOs per sector during 2001-2017

NACE Level 1 (section)	Number of companies	Percentage
A - Agriculture, forestry and fishing	1	0,52%
C - Manufacturing	22	11,34%
Credit needed	1	0,52%
F - Construction	1	0,52%
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	8	4,12%
J - Information and communication	55	28,35%
K - Financial and insurance activities	1	0,52%
M - Professional, scientific and technical activities	89	45,88%
N - Administrative and support service activities	5	2,58%
P - Education	1	0,52%
Q - Human health and social work activities	7	3,61%
R - Arts, entertainment and recreation	2	1,03%
S - Other service activities	1	0,52%
Total	194	100,00%

3.2.2. Estimation Strategy

If we want to test our third hypothesis about the influence of number of patents on financial performance, we have to use four different Ordinary Least Square (OLS) regressions. The main reason for this is because the dependent variables are continuous as they are based on traditional accounting measures. We perform one OLS for each dependent variable:

$$ROA\ (using\ EBIT)_{ASO} = \beta_0 + \beta_1 Patents_{ASO} + \beta_2 Age_{ASO} + \beta_3 Size_{ASO} + \beta_4 ICT_{ASO} + \beta_5 PST_{ASO} + \beta_6 Others_{ASO} + \beta_7 ExtremeValue_{ASO} + \varepsilon$$

$$ROA\ (using\ Net\ Income)_{ASO} = \beta_0 + \beta_1 Patents_{ASO} + \beta_2 Age_{ASO} + \beta_3 Size_{ASO} + \beta_4 ICT_{ASO} + \beta_5 PST_{ASO} + \beta_6 Others_{ASO} + \beta_7 ExtremeValue_{ASO} + \varepsilon$$

$$ROE\ (using\ EBIT)_{ASO} = \beta_0 + \beta_1 Patents_{ASO} + \beta_2 Age_{ASO} + \beta_3 Size_{ASO} + \beta_4 ICT_{ASO} + \beta_5 PST_{ASO} + \beta_6 Others_{ASO} + \beta_7 ExtremeValue_{ASO} + \varepsilon$$

$$ROE\ (using\ Net\ Income)_{ASO} = \beta_0 + \beta_1 Patents_{ASO} + \beta_2 Age_{ASO} + \beta_3 Size_{ASO} + \beta_4 ICT_{ASO} + \beta_5 PST_{ASO} + \beta_6 Others_{ASO} + \beta_7 ExtremeValue_{ASO} + \varepsilon$$

Or shortly:

$$\boldsymbol{Performance_{ASO} = \beta_0 + \beta_1 Patents_{ASO} + \beta_2 Age_{ASO} + \beta_3 Size_{ASO} + \beta_4 ICT_{ASO} + \beta_5 PST_{ASO} + \beta_6 Others_{ASO} + \beta_7 ExtremeValue_{ASO} + \varepsilon}$$

We use the Manufacturing sector (C) as the reference group and consequently have three dummies referring to the other two major sectors and the “others” category.

3.2.3. Deviations from this General Model

This general regression model will be used to test our third hypothesis. In addition, the data analysis section will also include two other OLS regressions. One will relate the distance between each ASO and its parent with the answers of the survey. The other will be the same as the general regression model but replacing the dependent variable with the cash flow on the balance sheet total. Since these estimation strategies are similar and use the same control variables, these will not be elaborated in this section. They will be thoroughly explained in the respective subsections.

4. Data-analysis

4.1. Survival Rates

Before we try to answer both research questions, we apply the most severe performance measure on the spin-offs' dataset, the so-called "survival rate" or its opposite "mortality/failure rate" (Bolzani et al., 2014). The survival rate is the rate of number of enterprises that survives one or more years after being founded. It provides useful insights about the average survival of start-ups, in this case academic spin-offs. This is in line with the literature claiming the increasing relevance of ASOs recently.

The survival rate can be constructed by including or excluding the survival by takeover-cases. These are firms where the legal entity itself ceased to exist, but their activities are taken over by another legal entity. We construct the survival rate including and excluding survival by takeover (Entrepreneurship at a Glance, 2012). These results are reported in Table 4 and 5. In Table 4, information is provided about the number of founded companies per year, the number of companies which survived or ceased to exist per founded year, the number of companies which ceased to exist per year and the number of active companies per year. As of April 2019, 161 are still active whereas 35 ceased to exist. The number of founded companies increased dramatically since 2010 with an average spin-off creation of 15 per year compared to only 5,44 per year for the 2001-2009 period. In Figure 5, the evolution of the number of founded spin-offs since 2001 is displayed. We can see a huge increase in this number since 2007 and later on. Even during the financial crisis (2008-2012), spin-off creation was omnipresent.

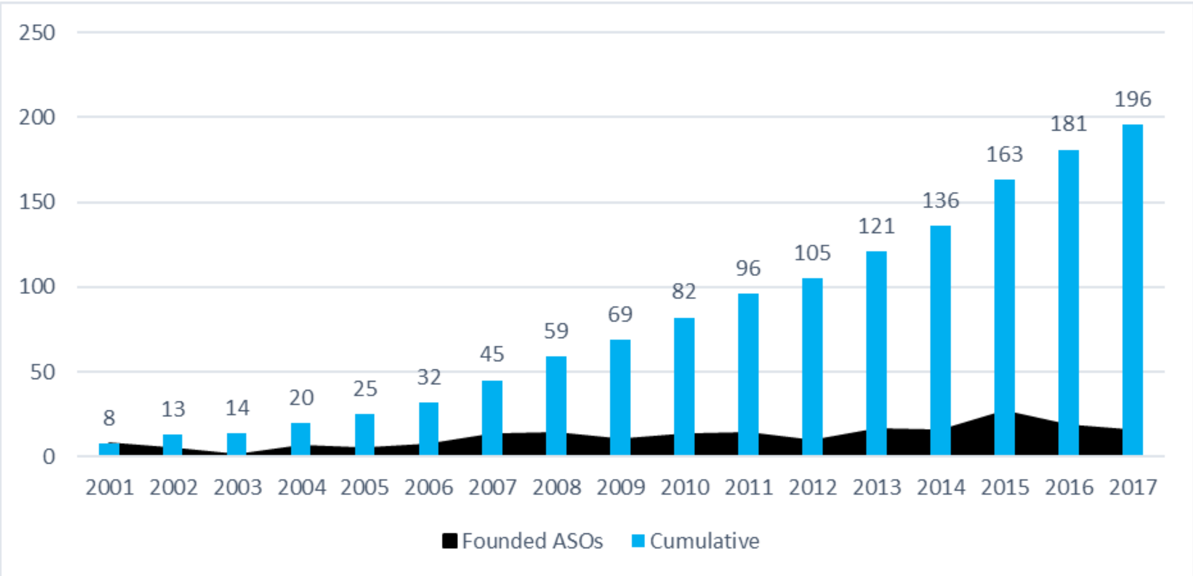

Figure 5 Evolution number of ASOs (2001-2017)

Of the total population of Flemish ASOs during 2001-2017 (n = 196), only 3,06% failed (n = 6) and 14,80% was involved in a merger or acquisition (n = 29), which results in a survival rate of 82,14%. If we include the M&A-cases into the survival rate ("survival by takeover"), we obtain a survival rate of 96,94%. However, this survival rate is calculated considering all the available information until April 04, 2019, and thus includes also M&As finished in 2018 (n = 6) and the first 3 months of 2019 (n = 2). If we only focus on the available information during our original period (2001-2017) we get a survival rate, excluding survival by takeover logically, of 86,22%.

Table 4

Amount of founded and terminated ASOs per year and per yearly cohort during 2001-2019

Year	Founded ASOs	Founded and survived in yearly cohort	Founded and terminated in yearly cohort	Terminated per year	Operating per year
2001	8	6	2	0	8
2002	5	4	1	0	13
2003	1	0	1	0	14
2004	6	4	2	0	20
2005	5	4	1	0	25
2006	7	5	2	0	32
2007	13	10	3	1	44
2008	14	10	4	1	57
2009	10	7	3	1	66
2010	13	10	3	0	79
2011	14	13	1	1	92
2012	9	7	2	1	100
2013	16	14	2	1	115
2014	15	15	0	7	123
2015	27	27	0	3	147
2016	18	18	0	4	161
2017	15	15	0	7	169
2018	/	/	/	6	163
2019	/	/	/	2	161
Total	196	169	27	35	

Table 5

Survival rates of ASOs including and excluding survival by take-over

Considered Information	Founded ASOs	Bankruptcy	M&A	Survival rate (including survival by take-over)	Survival rate (excluding survival by take-over)
2001-2019	196	6	29	96,94%	82,14%
2001-2017	196	6	21	96,94%	86,22%

The majority of the companies that failed or were involved in an M&A experienced this event between 2014 and 2019 (29 out of the 35 companies). Of the 35 companies that ceased to exist, 34% was located in East-Flanders, 23% in Flemish Brabant and 17% in Antwerp (Table 6). The finished companies mainly operated in information and communication (31%) and professional, scientific and technical services (40%) (Table 7). This is not surprising since 70% of the founded spin-offs are active in these two sectors as well (Table 3).

Table 6

Ceased ASOs during 2001-2019

NUTS 2	Companies ceased to exist
Antwerp	6
Brussels	3
East-Flanders	12
Flemish Brabant	8
Hainaut	1
Limburg	2
Namur	1
Noord-Holland	1
West-Flanders	1
Total	35

Table 7

Sectors of ceased ASOs during 2001-2019

Industry	Companies ceased to exist
C - Manufacturing	6
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	2
J - Information and communication	11
M - Professional, scientific and technical activities	14
Q - Human health and social work activities	1
S - Other service activities	1
Total	35

The mortality rate of ASOs of 3,06% seems rather low, given the newness and uncertainty accompanied with these new ventures. We can compare this with the available failure rates of Belgian companies in 2015, provided by credit information provider Graydon (Graydon, 2015):

Table 8

Failure rates per company form (2015)

Company Form[3]	Failure rate
Starters-BVBA	8,67%
BVBA	1,74%
NV	0,91%

Starters-BVBAs have the highest failure rate, which is credible due to the newness and few (financial) obligations this legal entity has (Unizo, 2019). BVBAs and NVs have lower failure rates given the more established nature of these firms.

This low failure rate (high survival rate) is in line with data retrieved from *Eurostat*, the EU's statistical bureau, which demonstrates that Belgian start-ups (thereby also ASO's) have the highest survival rate of Europe (Flanders Investment & Trade, 2017). Almost 62% of Belgian start-ups launched in 2009 were still active after five years (Figure 6). The rather conservative attitude of Belgian entrepreneurs and therefore thorough preparation before eventually founding a company is mentioned as a possible explanation

[3] BVBA and NV are the Belgian equivalents of respectively a private limit liability company and a public limited liability company.

(Flanders Investment and Trade, 2017). In our dataset, 80% (n=8) of Flemish ASOs founded in 2009 were still active after five years whereas the other two spin-offs were acquired. This even exceeds the already high survival rate of Belgian start-ups. We can conclude that the failure rates of Belgian ASOs are positively low.

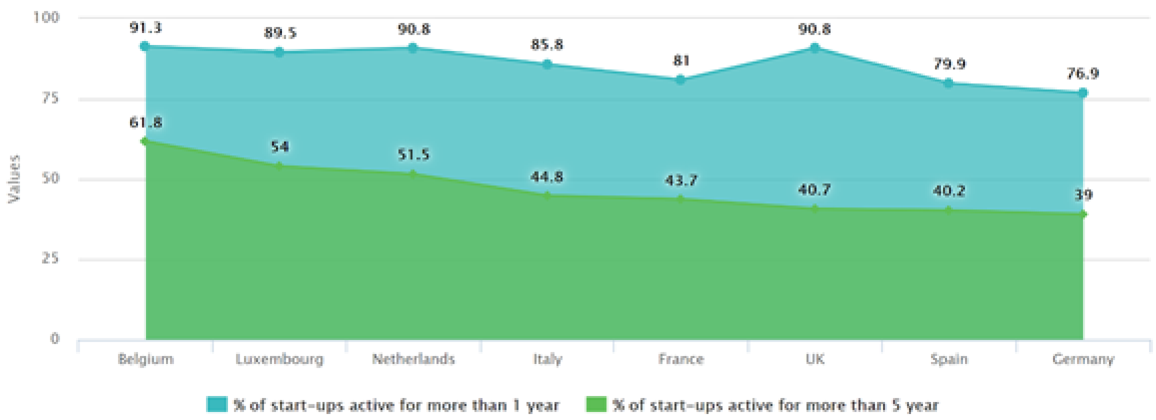

Figure 6 Survival rate of European start-ups founded in 2009 (Flanders Investment & Trade, 2017)

4.2. General Descriptives of ASO Location

The survival rate and the associated tables already prove the increasing importance of spin-offs in Flanders. Subsequently, we want to answer both research questions, starting with the actual location characteristics of the different ASOs. The five Flemish universities created 196 spin-offs during 2001-2017, of which financial data is available for 194 of them[4]. First, we found evidence of 205 created spin-offs because some ASOs are started with the support of multiple (Flemish) universities. If we delete the seven double- and one triple counts, we obtain the 194 original firms (Table 9).

[4] There is no data available in *Orbis* of two firms: *ESPACE* and *Fluent.ai.* The former is not available in *Orbis* (missing value), the latter is a Canadian firm whereas only European firms are included in the *Orbis* database

Table 9

ASOs with multiple affiliations

Companies with more than one parent university	Affiliated universities
Aelin Therapeutics	UGENT; VUB; **KUL**
Epilog	**UGENT**; UA
Aphea.Bio	**UGENT**; KUL
Elmedix	UGENT; **UA**
Algonomics	**UGENT**; KUL
IcoMetrix	UA; **KUL**
ADxNeurosciences	**UA**; KUL
Fluent.ai	UA; KUL; University of Toronto
Imageens	UGENT; University of Sorbonne; University of Paris
Textkernel	UA; University of Tilburg; University of Amsterdam
Loci Orthopaedics	KUL; National University of Ireland Galway

Most of our examined spin-offs are founded by Ghent University and KU Leuven, representing 37% and 33% respectively whereas Hasselt university only represents 5,10% of ASOs population (Table 10 and 11). If we control for size by calculating the number of ASOs per 1000 students, we see no difference between the universities except for the KU Leuven which has a slightly lower percentage compared to its peers. In Table 3, an overview was provided of each section of the NACE classification system with their number of corresponding ASOs. There are two sectors responsible for over 70% of the companies. ASOs are mostly concentrated in professional, scientific and technical activities (M) with an attendance of 46% and the information and communication sector (J) with more than 28% of the companies included. Companies offering professional, scientific and technical activities are mostly consulting firms specialized in research or research supporting services. The distribution per sector for every Flemish university shows the same domination of those two sectors (Figure 7). A χ^2-test found no significant difference between the universities and the sector of their spin-offs (Pearson χ^2 with p=0,088 and Phi=0,542). Lastly, there are currently no spin-offs listed on the stock exchange.[5]

[5] There was one spin-off listed on the stock-exchange, namely *Ablynx*, but they were delisted after acquisition by *Sanofi (see Example below)*

Table 10

Number of ASOs per university during 2001-2017

Flemish university	Founded ASOs	% of total population
Ghent University (UGent)	73	37,24%
Katholieke universiteit Leuven (KU Leuven)	65	33,16%
Vrije Universiteit Brussel (VUB)	26	13,27%
Antwerp University (UAntwerp)	31	15,82%
Hasselt University (UHasselt)	10	5,10%
Total	205	/
Consider ASOs affiliated with multiple Flemish universities	196	100%

Table 11

Number of ASOs per university and per 1000 students during 2001-2017

Flemish university	Founded ASOs	Number of students	ASOs per 1000 students
Ghent University (UGent)	73	44000	1,66
Katholieke Universiteit Leuven (KU Leuven)	65	58930	1,10
Vrije Universiteit Brussel (VUB)	26	15865	1,64
Antwerp University (UAntwerp)	31	20812	1,49
Hasselt University (UHasselt)	10	6262	1,60
Total	205		
Consider ASOs affiliated with multiple Flemish universities	196	145869	1,34

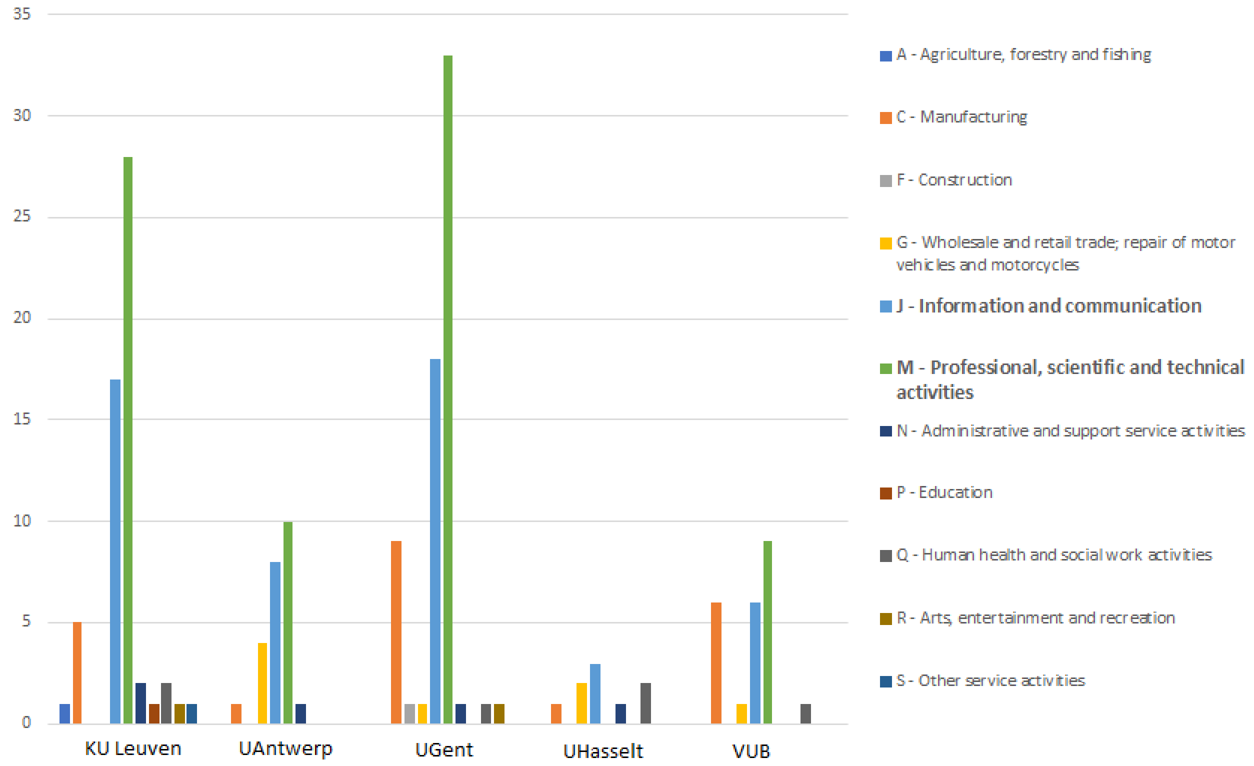

Figure 7: Distribution of ASOs per sector (NACE classification: section)

Example: The success story of Ablynx, a bio-tech company built on llamas and camels.

Ablynx is one of the 196 ASOs which were founded between 2001-2017 at a Flemish university, more specifically at the Vrije Universiteit Brussel (VUB) in 2001. The company is based on research of the blood of *Camelidae* (e.g., camels and llamas) which has specific properties for applications on humans (Ablynx, 2019). Research is being done to use the nanobodies of the llamas' blood in molecules of rare blood diseases, conditions including inflammation, respiratory orders and cancer (Babas, 2018). Initially, this first discovery happened by accident by VUB-professor Raymond Hamers, who gave dromedary blood to his students due to their anxiousness for hiv in human blood (VUB Today, 2018) . They started in 2002 with 5 million euros of seed financing provided by a public investment firm GIMV, followed by multiple financing rounds over the years. Ablynx, as a bio-tech company, should not be measured in the early phase of its existence by parameters like turnover and profit. Instead, the amount of cash a company is able to attract and 'burn' is more relevant, as cash is needed to continue their R&D activities (De Groote, 2017). A good measure of performance for Ablynx is, in according to their cash 'burn' amount, the growth in employees over the years (from 2 in 2001 to 450 in 2018) (Ottevaere, 2017). In 2017, the *European Commission* granted *Ablynx* the permission to bring their blood clotting agent brand *Cablivi* on the European market. *Cablivi* is a drug against the rare but life-threatening, autoimmune-based blood clotting disorder. Ablynx held its IPO on the *Euronext* Brussels in 2007 followed by a stock issuance on the American *Nasdaq* in 2017. The promising research of *Ablynx*, with proven results, increased the interest of more established firms and *Ablynx* became a take-over target during 2017. Danish *Novo Nordisk* first did an attempt in acquiring the Flemish spin-off but their offer of 2,6 billion euros was refused. Eventually, French based *Sanofi* announced the acquisition of *Ablynx* for 3,9 billion euros on January 2018 (Sinnaeve & Vanlommel, 2019). *Ablynx* transformed from a small, accidental experiment at the VUB to a massive company, part of one of the biggest pharmaceutical companies in the world.

4.3. Location Behaviour of Academic Spin-offs

We have the location of the five Flemish universities, the 196 spin-offs and are able to calculate the distances by using *Google Maps'* 'Distance Measure', making the mapping relatively straightforward. However, some spin-offs are affiliated with multiple universities which makes some distance calculations between universities and spin-offs biased. For example, *Algonomics* is affiliated with Ghent University and KU Leuven making it impossible to be situated near both universities. If a spin-off has more than one parent university, the distance to the nearest parent institution is used (Egeln, Gottschalk, & Rammer, 2004). If an ASO has a parent university which is not one of our five examined Flemish universities and is located closer to a foreign parent university than to a Flemish one, it is not used in our analysis. In Table 9, all eleven companies with multiple affiliations were listed. The first seven companies have only Flemish connections, including them in the analysis (the closest parent is indicated in bold). Five of these seven spin-offs are located less than 5 kilometers away from one of their parents and, in addition, they are all established in a research park or incubator indicating the closer relationship with one of both parents. Since the location of these spin-offs reveals the closer ties to one of the parents, we do not include the distances to the other affiliation. The last four companies have foreign parents and are localized abroad which excludes them from our dataset. Our future calculations would be extremely biased when including them (e.g., *Loci Orthopaedics* is 984,58 kilometers away from KU Leuven). Our final dataset for the location behaviour consists consequently of 192 ASOs.

To make the following discussion about the location of all 192 ASOs visualizable, Figures 8-13 provide several maps including all ASOs for the complete region of Flanders and per Flemish university. Range rings are included with a radius of 25km, 50km and 75km to scale the map, these rings will be discussed at the end of this section (Egeln, Gottschalk, & Rammer, 2004).

Figure 8: Concentration of Flemish ASOs

Figure 9: Location of UGent ASOs. Range rings are included following the typology of Egeln et al. (2004).

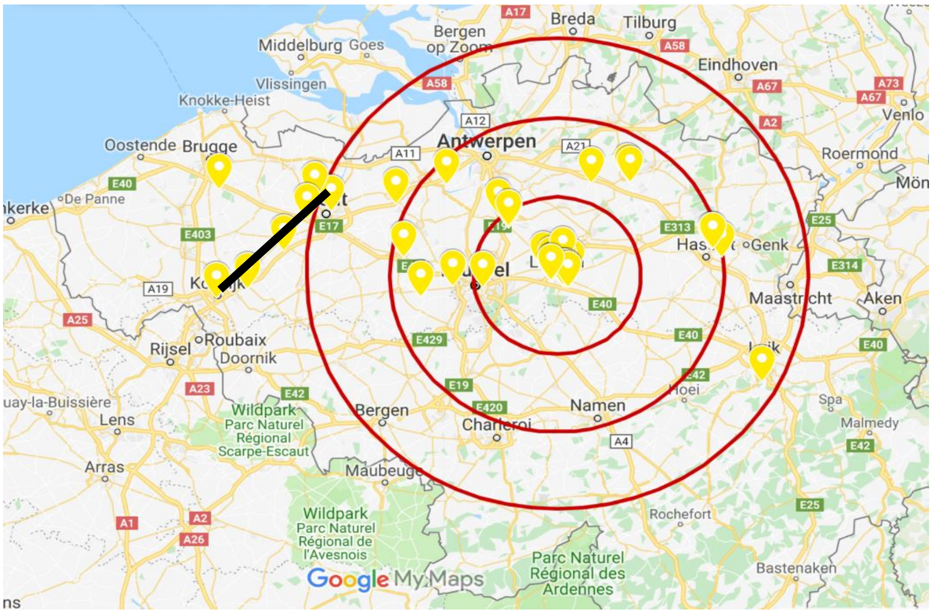

Figure 10: Location of KU Leuven ASOs. Range rings are included following the typology of Egeln et al. (2004). The black line is the Kortrijk-Ghent axis.

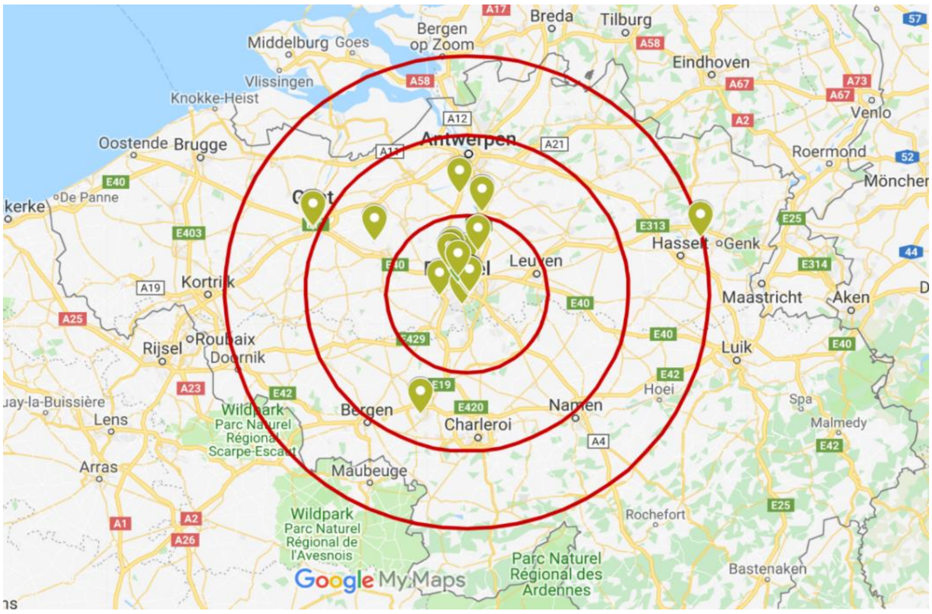

Figure 11: Location of VUB ASOs. Range rings are included following the typology of Egeln et al. (2004).

Figure 12: Location of UAntwerp ASOs. Range rings are included following the typology of Egeln et al. (2004).

Figure 13: Location of UHasselt ASOs. Range rings are included following the typology of Egeln et al. (2004).

First, Table 12 describes the NUTS 2 subdivisions of the five parent universities. Each university is established in the capital of a province (Brussels is strictly not a province but is an equivalent NUTS 2 region). In Table 13, we can already find our first evidence to support Hypothesis 1. The matrix table gives an overview of how many ASOs are located in a certain NUTS 2 region and their university they are affiliated with. For example, 93% of all new ventures in the Brussels Capital Region are originated from the VUB. If we look at the absolute numbers, Ghent University is affiliated with 56 of the 70 spin-offs in East-Flanders. Even in Limburg, Hasselt University has affiliations with 47% of all universities. This lower percentage is common sense given the fact that UGent and KUL are in absolute numbers by far the largest ASO-creators in Flanders. We can also prove the association between an affiliated university and the location (NUTS 2) by looking at the asymmetric measure *lambda,* which has a significant value of 50,8%.

Table 12

NUTS 2 and 3 subdivision of parent universities

Flemish university	NUTS 2
UGent	East-Flanders
KU Leuven	Flemish Brabant
VUB	Brussels
UAntwerp	Antwerp
UHasselt	Limburg

Table 13

Number of ASOs per NUTS 2 region per university

NUTS 2/Universities	UGent	KU Leuven	VUB	UAntwerp	UHasselt	Total	Percentage
BE23 - East-Flanders	56	7	5	2		70	80,00%
BE24 - Flemish Brabant		36	3	3		42	85,71%
BE10 - Brussels-Capital Region		1	14			15	93,33%
BE21 - Antwerp	6	6	2	18	1	33	54,55%
BE22 - Limburg	1	5	1	2	8	17	29,41%
BE25 - West-Flanders	6	4		1		11	/
BE32 - Hainaut				1		1	/
BE33 - Liege		1				1	/
BE35 - Namur	1					1	/
NL41 - Noord-Brabant					1	1	/
Total	70	60	25	27	10	192	/

Table 14 provides the average distance of a spin-off to his affiliated university. The minimum average distance is between the UGent and their spin-offs (13,31 km) and the maximum average distance between the KU Leuven and their spin-offs (23,06 km). These average distances of all five Flemish universities seem quite the same which is also the result of our Kruskal-Wallis (Attachment 2) test which shows that there is no statistically significant difference in distance between the different universities, $\chi2(4) = 4,623$, $p = 0,328$.[6]

Table 14

Average distance of ASO to his parent university

University	Average of Distance (in km)
UGent	13,31
KU Leuven	23,06
VUB	19,82
UAntwerp	21,65
UHasselt	13,58
Total Average	18,39

If we apply the same typology as Egeln et al. (2004) to classify the ASOs based on four distance groupings, we obtain Table 15. The categories of this table are the same as the range rings included in Figures 8-13. Almost 72% of all academic spin-offs derived from a Flemish university are geographically located less than 25 kilometers away from their parent. Only a mere 5% are located further than 75 km away, with a maximum distance of only 118,75 km.

This 5% of ASOs is already a limited number, but in reality, this number is probably even smaller. Of all nine ASOs which are located outside the 75km range, six are affiliated with KU Leuven. During this entire research, we focused on the distance between the core of KU Leuven (Oude Markt 13, Leuven) and the respective spin-offs. However, KU Leuven is a 'national' university which has smaller hubs in diverse cities across Flanders. All six out-of-range spin-offs are situated along the Kortrijk-Ghent axis (Figure 10). Presumably not by coincidence due to the fact that KUL has hubs in both Kortrijk (*Campus Kulak)*, Ghent (Campus Sint-Lucas and Technologiecampus Ghent) and Bruges (Here only one ASO is situated) (KU Leuven, 2019). Overall, our evidence supports Hypothesis 1, the location of a spin-off is likely to be clustered around an associated university.

[6] We used the Kruskal-Wallis test because the normality assumption (of dependent variable distance) of ANOVA was not met, even after data transformations. (Rahman, 2015)

Table 15

Classify distance of ASOs according to Egeln et al. (2004)

Distance between ASO and parent university	UGent	KU Leuven	VUB	UAntwerp	UHasselt	All ASOs	All ASOs (percentage)
<25 km	55,00	39,00	16	20,00	8	138	71,88%
25-49 km	10,00	12,00	4	2,00	1	29	15,10%
50-74 km	4,00	3,00	5	3,00	1	16	8,33%
≥75 km	1,00	6,00	0	2,00	0	9	4,69%

4.4. Determinants of Location Behaviour

Now we have found evidence in favor of Hypothesis 1, we can analyze which factors have an essential impact on the choice to locate nearby parent universities. Therefore, an analysis of the answers to the last question of our survey is necessary (Attachment 1 – Q7). First, we assess the minimum sample size to come to statistically relevant conclusions. Since we sent our survey to the entire population of 196 spin-offs, this sample size is not an a priori requirement. We calculate the sample size by following this formula (Select, 2019):

$$n \geq \frac{N * X}{X + N - 1} \quad where\ X = \frac{Z^2 * p * (1-p)}{MOE^2}$$

With $n = sample\ size$

$Z = critical\ value\ of\ the\ normal\ distribution\ for\ a\ confidence\ level\ of\ 95\%$

$p = sample\ proportion\ (50\%)$

$MOE = Margin\ of\ error\ (5\%)$

This leads to a minimum sample size of 131.[7]

A sample size of 131 implies in our case a response rate of at least 66,84% which was impossible to expect given the average response rates in similar external executive studies are around 5-15% (Hitchman, 1995; Campello, Graham, & Harvey; 2010; Surveygizmo, 2019). This is especially the case since we need responses of persons who have a very time-consuming business life. We stopped the registration of

[7] $(n \geq \frac{196*X}{X+196-1} \quad where\ X = \frac{1{,}96^2*0{,}5*(1-0{,}5)}{0{,}05^2})$

responses after two weeks including one reminder e-mail. At the end of this period, we had 87 responses resulting in a 44,39% response rate. However, since 32 responses are incomplete and therefore (completely) useless for our study, our response rate dropped to 28,06%.[8]

Although this is a more than acceptable response rate, our absolute responses are too low to generalize our conclusions to the population. This is a major flaw in this research since no statistical validation can be given. Our final sample size leads to a margin of error of 11,53% with a confidence level of 95%. However, our conclusions are still informative and can be a guideline for future studies.

Table 16 gives an overview of the descriptives of our 9 determinants of location behaviour. Since we used a 7-point Likert scale, all values are between 1 and 7. We can immediately see that *Place of Residence, Need for infrastructure* and *Greater ability to attract resources* have the highest average and, therefore, seem to be the most important factors. We repeat our second hypothesis:

H2: *The need for infrastructure is positively related to spin-offs locating close to their parent.*

[8] Most incomplete responses consist of only the company name and the affiliated university. The informative questions were mostly ignored. Probably because these questions asked for some research from the respondents.

Table 16

Descriptives Determinants of location behaviour

Determinants of location behaviour	*N*	*Mean*	*Std. Deviation*	*Minimum*	*Maximum*
"Roots" - Birthplace of founder(s) (1)	*55*	*3,53*	*2,17*	*1*	*7*
Place of residence (at date of incorporation) (2)	*55*	*4,36*	*2,07*	*1*	*7*
Need of infrastructure (e.g., laboratory) from University (3)	*55*	*4,29*	*2,32*	*1*	*7*
Transfer of tacit knowledge/Face-to-face interaction required (4)	*55*	*3,71*	*2,11*	*1*	*7*
Formal contact with University (e.g., research projects, part-time tutoring) (5)	*55*	*3,96*	*2,16*	*1*	*7*
Greater ability to attract resources (Personnel/Capital) (6)	*55*	*4,45*	*2,03*	*1*	*7*
Dependent of support from local authorities (7)	*55*	*2,58*	*1,56*	*1*	*7*
Providing services for university (8)	*55*	*2,53*	*1,63*	*1*	*7*
Support of University (TTO) to commercialize knowledge (9)	*55*	*2,29*	*1,55*	*1*	*7*

This gives already an indication in favour of **Hypothesis 2**. First, we use a chi-square test to prove the representativeness of our sample in relation to the population of spin-offs. This is explained in Attachment 3.

We use a repeated measures ANOVA to statistically validate our hypothesis. In this test, we test if the founders of the ASOs find all location determinants equally important or not. Since this is a parametric test, we have to meet certain assumptions which are discussed in Attachment 4.

Since the assumptions are (partially) met, we continue our research by assessing if the distribution has equal or non-equal variances. We do this with the Mauchly's test of sphericity which is significant at the 0.01% level , leading to the assumption of non-equal variances (Attachment 5). We therefore use the multivariate tests which all four have a p-value below the threshold (p = 0,05) (Attachment 5). We can conclude that the repeated measures ANOVA determined that the means of the 7-point Likert scale differed statistically significant between the nine location behaviour determinants ($F(8, 47) = 10{,}543$; $p < 0{,}005$). Post-hoc tests using the Bonferroni correction revealed that *Dependence of support from local authorities, providing services for university* and *support of TTO for commercialization knowledge* are less important than the other 6 determinants, except for *"Roots"* which has only a significant difference with *support of TTO for commercialization* (Attachment 5). At this moment we can conclude that determinant 2-6 are of more importance than determinant 7-9, but we cannot accept our second hypothesis yet. Therefore, we have to conduct a one-sample t-test for each determinant with a test value equal to 3,5 (arbitrary average of 7-point Likert scale). These 9 one sample t-tests are statistically significant for all determinants except for *"Roots", Transfer of tacit knowledge* and *Formal contact with university* (Attachment 6). As a result, the most important determinants of location behaviour are *the place of residence of the founders, need of infrastructure (e.g., laboratories)* and *a greater ability to attract personnel and capital.* Specific for our hypothesis we find that *Need for infrastructure* is statistically significantly higher than our test value, $t(54) = 2{,}525$, $p = 0{,}015$. Therefore, we could conclude that the need for infrastructure is positively related to an academic spin-off locating close to its parent. This tends us to confirm **Hypothesis 2**. However, we also want to incorporate our dependent variable *Distance* and the various control variables. Including these variables makes it able to link the location determinants to the actual location of the company, especially since the survey analysis is completely dependent on self-reported data. Including the actual location will act as a control mechanism to evaluate if these determinants actually influence the eventual location choice. This will be analyzed in the next section.

We end this part of location behaviour determinants by interpreting the answers on Q8 of our survey (Attachment 1 – Q8). These answers have no statistical power but give interesting insights about the thought process before establishing at a certain location and unfortunately also revealed some improvements for future questionnaires.

Other decisive factors mentioned to influence location behaviour:

-"The beauty of the city of Ghent, which is valued by our visiting customers and employees from abroad" – AM-Team

-"Being close to the airport since the distance between Leuven and the airport is 12 minutes by train" – Biorics NV

-"Power-Link (located at GreenBridge Ostend) is the Ghent University platform for energy transition projects. The Argus project started from within Power-Link and the director found it viable to commercialize the project (via StarTT) into a UGent spinoff. The GreenBridge incubator was focused on renewable energy & energy optimizations (now it changed focus to Blue Cluster), so we were located in the middle of a very strong network of energy-minded companies." – Argus Technologies

-"a strong and compact "ecosystem" - CellSine

-“center of the country” – Double Pass -“Proximity to major train station: we have a strong culture of not wasting time in traffic jams” - Elimity -“Availability of train station and parking space for staff” - Elmedix -“compromize - compromize - compromize ... a start-up is full of compromizes, this was one of them. The geometric "point of gravity" of the places of residence of the founders” – Luceda Photonics -“As a full time working mother of 3 I felt very discriminated against by the toxic masculine culture in academia. I therefore decided to become an independent consultant and start my own firm so I could work from home, which made life much easier to combine work and family life. So the fact that my company could be based in my house was very important.” – Nesma consulting -“Supplied by investor/business angel” - Triphase

Future questionnaires should definitely include “*Availability of public transport*” to address the importance of train stations, airports, taxis, etc. in the surroundings of the office. Another option could be “Dependent on potential financers” to incorporate the location of the finance providers who often intervene in the new venture’s operations (Vanacker, Seghers, & Manigart, 2012).

4.5. Linking Location to Location Determinants

We already discussed the pure location behaviour of ASOs based on the typology of Egeln et al. (2004) and distinguished the nine location behaviour determinants of our survey. In this section, we will link both the actual distance and the possible location determinants by using an ordinary least squares regression (OLS) because the dependent variable is continuous (Baggaley & Hull, 1983; Maurer and Pierce, 1998; Sullivan & Artino, 2013). The regression model elaborated in the data-analysis section will be discussed in the next section where we focus on the link between patents and performance. Since we already described all variables which will be used, the regression function can be derived easily:[9]

$$Distance_{ASO} = \beta_0 + \beta_1 Q7_1 + \beta_2 Q7_2 + \beta_3 Q7_3 + \beta_4 Q7_4 + \beta_5 Q7_5 + \beta_6 Q7_6 + \beta_7 Q7_7 + \beta_8 Q7_8 + \beta_9 Q7_9 + \beta_{10} Age_{ASO} + \beta_{11} Size_{ASO} + \beta_{12} ICT_{ASO} + \beta_{13} PST_{ASO} + \beta_{14} Others_{ASO} + \varepsilon$$

The dependent variable $Distance_{ASO}$ reflects the distance, measured in kilometers and log-transformed, between each ASO and its parent university; The nine independent variables *Q7_** reflect the nine location determinants of our survey (Attachment 1*); Age_{ASO}* reflects the number of years since the date of incorporation for each ASO; $Size_{ASO}$

[9] In line with the limitation regarding the small sample size of our survey, we also have to mention that our sample size of 55 is seen as too small for testing all our predictors. There are various rough rules of thumb to indicate this issue. For example, Green (1991) suggests a minimum sample size of 104 + k, where k is the number of predictors. In our case this would require a sample size of at least 118.

reflects the size of the ASO and Is based on the number of employees; *ICT_{ASO}, PST_{ASO}* and *$Others_{ASO}$* are the three dummies reflecting the 4 categories of sectors

Although we found self-reported evidence of the second hypothesis, this additional regression is extremely relevant as mentioned in the previous subsection. The main disadvantage of drawing conclusions of this regression, in addition to the remark in footnote 6, is the smaller data sample used for this analysis. Since we only had 55 valid responses on our survey, which serves as the source of our independent variables, we can only perform this regression for 55 ASOs and not the complete population of 194 ASOs. The values of our dependent variable are displayed in Table 17:

Table 17

Descriptives Distance

Dependent variable	N	Mean	Std. Deviation	Minimum	Maximum
Distance	55	11,79	14,82	0,68	53,48

The boxplot of *$Distance_{ASO}$* (Attachment 7) could imply the need for a transformation of our variable to correct for outliers. However, the correction for outliers seems unnecessary since the maximum value for *Distance* of 53,48 km does not exceed the maximum of the mean + 3 * standard deviation (EPM Information Development Team, 2012). In the end, we still need a transformation of our dependent variable to deal with the right-skewness of our variable to simplify the analysis (Attachment 7). We use an *ln (x+1)* transformation because many values are below 1, resulting in negative values when performing the traditional *ln(x)* transformation (Deng, 2012). Furthermore, we take the natural logarithm of the number of employees as already explained in the sample data and methodology section.

After the description and preparation of the dependent and independent variables for the regression analysis, we only need to describe the control variables before conducting the linear regression. The industry classifications and associated ASOs are already portrayed in part one of this section (Table 3). In Table 18 and 19, an overview is given of the descriptives of firm age and number of employees per affiliated university. Since not all companies have to disclose their number of employees, we only have this information for 134 companies. This is already more than publicly available because we integrated our survey responses of question 4 in our dataset (Attachment 1 – Q4). The average age of an ASO in Flanders is 6 years and it has between 4 and 7 employees (median). The older age of ASOs affiliated with UHasselt is probably due to the small sample of which three spin-offs are founded before 2010. The larger mean of employees for the VUB is largely created by the 480 FTE's of Ablynx. Since we already take the natural logarithm of employees and the maximum age is only 18, no further winsorizing is needed or desirable (G. Verleysen, personal communication, April 24, 2019).

Table 18

Descriptives control variable Age

Flemish university	N	Mean	Median	Minimum	Maximum	Std. Deviation
UGent	65	6,11	5	0	18	4,45
KU Leuven	58	6,60	6	0	16	4,53
VUB	23	5,61	5	1	16	3,99
UAntwerp	24	6,38	6	1	15	4,21
UHasselt	9	9,33	9	6	16	3,12
Total	179	6,40	6	0	18	4,35

Table 19

Descriptives control variable Size (number of employees)

Flemish university	N	Mean	Median	Minimum	Maximum	Std. Deviation
UGent	49	10,03	5	0	50	11,96
KU Leuven	46	15,63	7	1	140	27,92
VUB	17	42,18	6	1	438	105,26
UAntwerp	16	8,97	4	1	69	16,35
UHasselt	6	4,25	4	0	11	4,19
Total	134	15,64	5	0	438	42,33

Before we analyze the results of the multiple regression, we have to make sure the assumptions of OLS are met. This is discussed in Attachment 8 with associated SPSS-output. Afterward, we performed the regression via SPSS. Regression coefficients and standard errors can be found in Table 20:

Table 20

Regression results Location determinants

	OLS
Constant	0.56 (0.65)
"Roots" - Birthplace of founder(s) ($Q7_1$)	-0.02 (0.06)
Place of residence (at the date of incorporation) ($Q7_2$)	-0.03 (0.06)
Need for infrastructure (e.g., laboratory) from University ($Q7_3$)	0.13 (0.09)
Transfer of tacit knowledge/Face-to-face interaction required ($Q7_4$)	0.11 (0.08)
Formal contact with University (e.g., research projects, part-time tutoring) ($Q7_5$)	-0.36 *** (0.10)
Greater ability to attract resources (Personnel/Capital) ($Q7_6$)	0.05 (0.08)
Dependent on support from local authorities ($Q7_7$)	-0.10 (0.08)
Providing services for university ($Q7_8$)	-0.09 (0.10)
Support of University (TTO) to commercialize knowledge ($Q7_9$)	0.50 *** (0.11)
Age	0.08 ** (0.03)
Size	-0.10 (0.10)
ICT[1]	1.08 ** (0.41)
Professional, scientific and technical services (PST)[1]	0.86 * (0.38)
Others[1]	1.65 *** (0.46)
Observations	52
F value(7,126)	3.30 ***
Adj. R^2	0.38

Note: Standard error in brackets. The symbols °, *, **, *** denote the significance levels at 10%, 5%, 1% and 0.1% respectively. There are no signals of problems with multicollinearity since all Variance inflation factors (VIFs) are below the critical threshold of 10 (the maximum is 4.10) and tolerance scores above 0.2. The correlation table is shown in Attachment 9.

[1] Manufacturing is the reference category for the sector dummies.

The regression model is significant at the 0.01% level. The adjusted R-squared of 38% means that 38% of the model explains the regression. The adjusted R-squared is lower compared to the R-squared of 55% due to the punishment of independent variables which do not affect the dependent variable. We find for *Formal contact with university (Q7$_5$), Support from university to commercialize knowledge (Q7$_9$), ICT*, *PST, Others* and *Age* coefficients statistically different from 0. This means that for a one-point increase (7-point Likert scale) of the value for *Formal contact with university,* the distance between the ASO and its parent is expected to decrease with 30%, holding all the other independent variables constant (UCLA, 2019). If the value for *Support of university to commercialize knowledge* increases with one point, the distance is expected to increase with 64%, holding all the other independent variables constant. Especially this last finding is in line with our previous conducted repeated measures ANOVA which also stated that *Support of university to commercialize knowledge* was less important than the other determinants. However, we find no statistically significant coefficient for our second hypothesis variable, namely *Need of laboratory infrastructure (e.g., laboratories) (Q7$_3$).* The three sector dummies have also coefficients significantly different from zero at the 5% level. ASOs in the ICT sector are on average located 194% further away from their parent compared to ASOs in the manufacturing industry. Firms in the professional, scientific and technical activities sector are on average located 135% further away from their parent compared to their peers in the manufacturing industry. Firms in the "others" category are on average located 419% further away from their parent compared to the firms in the manufacturing industry. Lastly, if the age of a company increases with one year, the distance to its parents is expected to increase with 8%.

To conclude: Although we found evidence that *Need of infrastructure* was an important location determinant via a repeated measures ANOVA and independent t-tests, we find no such evidence for our multiple regression. Since we attach more importance to the actual location itself than on the self-reported answers of the founders, this result makes it impossible to confirm **Hypothesis 2.** A possible explanation could be that not all university's infrastructure such as laboratories is located at the university itself. For example, the earlier mentioned Tech Lane Ghent Science Park has its own laboratories in the bio-incubator. This explains why infrastructure is reported as an important location determinant but is not found significant when including the distance to the core of the university itself. On the other hand, we can conclude that support from the university or its TTO to commercialize research is not important for the actual location. This could be partially caused by the doubtful efficiency and effectivity of TTOs in general and because only a minority of the researchers is even aware of its existence (Chapple et al., 2005; Knockaert et al., 2016). We can also conclude that formal contact with the university is an essential factor to influence the actual location decision. This is understandable since part-time lecturing and performing research requires the physical presence of the founder at the university.

4.6. General Descriptives of ASOs Patent Possessions and Performance

The 194 spin-offs of which data is retrievable in *Orbis* possess 462 patents. In Table 21, patent information is provided per university. Although a quick calculation would suggest an average of 2,38 patents per ASO, the Table shows that this number is highly inflated by specific cases. The clearest example are the 160 patents in the possession of the VUB spin-off *Ablynx* which represents 35% of all 462 patents and even 88% of all VUB affiliated ventures. Furthermore, the median of patents is 0 since only 63 ASO's own at least one patent. We will deal with these influential cases by winsorizing the number of patents at the 5th and 95th percentiles, changing the four outliers to 19,5 patents (Ghosh & Vogt, 2012).

Table 21

Descriptives Patents

Affiliated University	Total Number of patents	Max of Number of patents	Min of Number of patents	Average of Number of patents
UGent	111 (24%)	45	0	1,56
KU Leuven	122 (26%)	20	0	2,00
VUB	181 (39%)	160	0	7,54
UAntwerp	28 (6%)	13	0	1,00
UHasselt	20 (4%)	17	0	2,00
Total	462	160	0	2,38

Now we have checked for outliers for the independent variable, we move on with the analysis of the four dependent variables. We retrieve data of all companies in their last available year, which is for 94% of the companies 2017. The other companies have older data due to M&A's or liquidations. First of all, we have to eliminate companies with no available data (n.a.) for the respective ratios. All four foreign companies have no valuable data for our analysis and are subsequently removed. The same goes for nine companies founded in 2017 with no data available yet. Lastly, we have to remove two other companies because no relevant data is available.[10] In the end, 179 firms are included in our database with at least the valuable financial data (ROE/ROA) available.

Although we find 179 valuable results for the ROA, we have to deal with missing values of ROE. This is the result of negative equity for 31 companies which makes the interpretation of ROE inapplicable (Palepu,

[10] *The Forge (founded in 2014 but no data available) and Ciblis (Failed in 2017 and only a new entity founded in 2017 could be retrieved).*

Healy, & Peek, 2016).[11,12] All other values can be calculated and are given a value 1 for the *ExtremeValue* dummy if the ROE/ROA is below -1 or above 1.

Table 22 provides the descriptives of the dependent variables. All means for all 4 variables are negative whereas the medians are also low to negative. This finding is not surprising given our relatively young sample of high-tech firms. *Table 23* illustrates the same variables but excluding values below -5 or above 5. We only exclude 4 cases for ROE and 2 cases for ROA, but the results are quite different. The averages improve significantly while the standard deviations are also much smaller. To conduct the regression analysis, we also winsorize the dependent variables at the 5 and 95 percentiles to deal with these outliers.[13]

Table 22

Descriptives performance indicators (ROE/ROA)

Dependent variable	N	Mean	Median	Minimum	Maximum	Std. Deviation
ROE (Net Income)	148	-69%	2%	-6400%	500%	5,51
ROA (Net Income)	179	-30%	-4%	-1093%	448%	1,24
ROE (using EBIT)	148	-68%	1%	-6400%	500%	5,57
ROA (using EBIT)	179	-29%	-4%	-779%	95%	0,95

Table 23

Descriptives performance indicators excluding 6 outliers (ROE/ROA)

Dependent variable	N	Mean	Median	Minimum	Maximum	Std. Deviation
ROE (Net Income)	144	-14%	5%	-300%	500%	0,95
ROA (Net Income)	176	-17%	-3%	-304%	448%	0,62
ROE (using EBIT)	144	-13%	2%	-300%	400%	0,94
ROA (using EBIT)	176	-19%	-3%	-297%	95%	0,55

[11] *All 31 companies have a negative equity value whereas 24 of them have a negative Net Income and 26 a negative EBIT. Although it is considered more positive to have a positive Net Income/EBIT and negative equity than the other way around, the inclusion of these companies makes the interpretations of the following regressions more difficult. In our research, they are therefore excluded.*

[12] *Unfortunately, the exclusion of these 31 companies makes the regression of ROE biased. Excluding the companies with negative equity, is in fact the same as excluding the worst performing companies. The analysis of ROA where we have values of all 179 companies partially compensates this error.*

[13] Another approach to deal with outliers and normalize data is the log-modulus transformation (John & Draper, 1980). This transformation is derived from the normal log transformation and helps incorporating negative values. Eventually, we did not apply this method because it makes data interpretations murky (Wicklin, 2014).

Since we already described and analyzed the control variables Industry, Age and Size in previous sections, we can directly shift to the regression analysis.

4.7. Regression analysis linking Patents to Performance

We specified the variables for the regression analysis and prepared the data to perform an ordinary least squares regression (OLS) because the dependent variables are continuous as they are based on traditional accounting measures. We repeat the estimation strategy:

$$\boldsymbol{Performance_{ASO} = \beta_0 + \beta_1 Patents_{ASO} + \beta_2 Age_{ASO} + \beta_3 Size_{ASO} + \beta_4 ICT_{ASO} + \beta_5 PST_{ASO} + \beta_6 Others_{ASO} + \beta_7 ExtremeValue_{ASO} + \varepsilon}$$

The dependent variable $Performance_{ASO}$ reflects the performance based on traditional accounting measures (ROE and ROA); $Patents_{ASO}$ reflects the absolute number of patents in the possession of an ASO[14]; Age_{ASO} reflects the number of years since the date of incorporation for each ASO; $Size_{ASO}$ reflects the size of the ASO and Is based on the number of employees; ICT_{ASO}, PST_{ASO} and $Others_{ASO}$ are the three dummies reflecting the 4 categories of sectors; $ExtremeValue_{ASO}$ is a dummy with a value 1 if ROE or ROA is <-1 or >1 and value 0 if >-1 and <1.

First, we had to make sure a linear multiple regression is permissible. We have tested the assumptions of linear regression for all 4 regression functions. This is discussed in Attachment 10 with associated SPSS-output.[15] Afterward, we extracted the 4 regressions via *SPSS*. Regression coefficients and standard errors can be found in Table 24.

The adjusted R-squared varies between 31% and 52%, expressing the percentage each model respectively explains from the regression. Although our models are statistically significant at the 0,01% level, we only find the dummy variables for extreme values to be statistically significant (i.e., $p < 0,05$). For example, an extreme value for *ROA (using EBIT)* is associated with a decrease in ROA of 1,30 (130%), holding all the other independent variables constant. Since this dummy variable is only a mere classification of our dependent variable, the added value of these coefficients is very low. Furthermore, we can indicate that the independent variable *Patents* approached the borderline of significance for *ROA (using EBIT)* and *ROA (NetIncome)* (i.e., $p = 0,09$ and $p = 0,07$ respectively). Therefore, we conclude that there is a weak statistically significant relationship (at only the 10% level) between the number of patents of an ASO and

[14] We repeat that this absolute number of patents has been winsorized at the 5th and 95th percentiles. We also did the same regression analysis with a log transformed independent variable. This did not change our initial conclusions.
[15] We would like to thank Gregory Verleysen, statistical consultant at Ghent University for his constructive feedback.

its performance measured as ROE and ROA. For example, an increase in the number of patents by 1 is associated with a decrease in ROA *(using EBIT)* of 0,01 (1%). We cannot fully confirm **Hypothesis 3**.

Table 24

Regression results Patents-Performance

	Model 1 – ROA-EBIT	Model 2 – ROA-Net income	Model 3 – ROE-EBIT	Model 4 – ROE-Net income
Patents	-0.01 °	-0.02 °	0.01	-0.01
	(0.01)	(0.01)	(0.02)	(0.02)
Age	0.00	0.00	0.01	0.00
	(0.01)	(0.01)	(0.02)	(0.01)
Size	0.02	0.01	-0.09	-0.02
	(0.03)	(0.03)	(0.06)	(0.05)
ICT[1]	-0.11	-0.08	-0.30	-0.26
	(0.11)	(0.10)	(0.27)	(0.22)
PST[1]	-0.07	0.00	-0.21	-0.20
	(0.10)	(0.09)	(0.24)	(0.19)
Others[1]	-0.02	0.01	-0.43	-0.20
	(0.12)	(0.11)	(0.28)	(0.23)
ExtremeValue	-1.30	-1.12	-1.11	-1.46
	(0.11) ***	(0.10) ***	(0.16) ***	(0.14) ***
Constant	-0.04	-0.09	0.39	0.22
	(0.11)	(0.11)	(0.27)	(0.22)
Observations	133	133	109	109
F value	21.43 ***	20.11 ***	8.12 ***	16.55 ***
Adj. R^2	0.52	0.50	0.31	0.50

Note: Standard error in brackets. The symbols °, *, **, *** denote the significance levels at 10%, 5%, 1% and 0.1% respectively. There are no signals of problems with multicollinearity since all Variance inflation factors (VIFs) are below the critical threshold of 10 (the maximum is 3.10) and tolerance scores above 0.2. The correlation tables are shown in Attachment 11.
[1] Manufacturing is the reference category for the sector dummies.

There could be several factors disturbing this relationship as already partially mentioned in the literature review. First, since only 63 out of the 194 firms possess at least one patent, the necessity of patents to generate earnings is limited. For example, many firms active in the service sector do not file for patents because their activities do not require patented technology or because they do not want to disclose their technology (Agarwal, Erramilli, & Dev, 2003; Morikawa, 2014). The latter is related to a major disadvantage of patents, namely the fact that patents are made public which provides information to (potential) competitors. Successful patent applications require enablement, which means that the filer should give a detailed description of the invention (Lobel, 2013). This detailed description can give your competitors the possibility to reverse-engineer it. This is not the case when you do not disclose your invention and keep it as a trade secret. Although trade secrets are less protected in case of infringement, they do not have expensive filing procedures and can benefit the company longer than the average patent protection period of 20 years (e.g., Coca-Cola's receipt is a trade secret since 1876). An example of an R&D-driven service ASO is *Biogazelle*, active in biotech. The founder of Biogazelle, Jo Vandesompele, prefers trade secrets over patents to protect the firm's research results. He mentions the fact that exercising control over patent infringement is difficult and costly which is not the case when the research is kept as a trade secret (J. Vandesompele, personal communication, May 10, 2019).

Secondly, we could have underestimated the costs of filing for patents. It is difficult to estimate the precise cost for a patent application since it depends on the amount of work for the patent attorney, the level of protection required for the patentee, the country of filing, etc. On average a Belgium patent costs between 4000 and 5000 EUR whereas a European patent costs between 14000 and 17000 EUR (Patenthuis, 2019). These costs could be enormous for just established ASOs, especially for firms who already have considerable cash drains as a result of their R&D expenditures.

Thirdly, companies can have difficulties with the commercialization of the patented inventions. There are various reasons which impede companies to bring their product to the market. Patent law encourages investors to file their patents as soon as possible (Cotropia, 2009; Sichelman, 2009). Although this provides protection to the inventor in an early stage, there is still a lot of research and investment needed to develop the knowledge into a marketable product. In this case, a protection period of, on average, 20 years could not be sufficient to protect the owner. Therefore, many patents of our ASOs could still be in a very early stage of development. Another reason is the result of the "reward theory" which dominates the patent law. This theory focuses on the protection of the invention itself without focusing on the following protection of the costly and risky commercialization process.

Another possible reason for the difficulties in extracting value from patents could be the focus of ASOs on quantity rather than quality (Cox, 2018). In line with the commercialization problem, firms tend to focus on solely protecting their current research instead of on thinking in the long run. Especially medical and pharmaceutical companies tend to patent "everything" to hinder competition and speculate on a few success stories (Gold et al., 2010).

4.8 Regression analysis linking Patents to Cash flow.

The results of the previous section and associated factors which could have possibly disturbed the relationship between patents and performance make it impossible to confirm **Hypothesis 3**. It is even more surprising that the statistically weak relationship between the number of patents and the performance measured via ROA is a negative relationship. Although this relationship is too weak to be statistically significant at the common 5% level and the subsequent decrease in ROA is also negligible, it is completely in contradiction with our hypothesis.

Since return and cash flow are linked to each other, the impact of patents could also be examined on cash flow.[16] This relates back to the discussed Death Valley curve. This negative cash flow known for start-ups is partially created by the costs of obtaining and maintaining patents. These patents are then the result of enormous R&D expenditures which also negatively affect the cash flow. We contacted the TTO of Ghent with our findings and asked for their opinion on these findings. They were not surprised by the non-existing relationship between patents and performance and indicated that there could be a negative impact of the number of patents on the current cash flow of an ASO (P. Vankwikelberge, personal communication, May 27, 2019).

We perform the same OLS regression as in the previous section but use as a dependent variable *Cash flow/Total Assets*.[1] We can use the same estimation strategy with the different dependent variable:

$$\frac{\boldsymbol{Cash\ flow}}{\boldsymbol{Total\ Assets}}_{\boldsymbol{ASO}} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1 Patents_{ASO}} + \boldsymbol{\beta_2 Age_{ASO}} + \boldsymbol{\beta_3 Size_{ASO}} + \boldsymbol{\beta_4 ICT_{ASO}} + \boldsymbol{\beta_5 PST_{ASO}} + \boldsymbol{\beta_6 Others_{ASO}} + \boldsymbol{\beta_7 ExtremeValue_{ASO}} + \boldsymbol{\varepsilon}$$

The dependent variable $\frac{\text{Cash flow}}{\text{Total Assets}}_{ASO}$ reflects the cash flow or cash drain of an ASO in relation to its balance total; $Patents_{ASO}$ reflects the absolute number of patents in the possession of an ASO; Age_{ASO} reflects the number of years since the date of incorporation for each ASO; $Size_{ASO}$ reflects the size of the ASO and Is based on the number of employees; ICT_{ASO}, PST_{ASO} and $Others_{ASO}$ are the three dummies reflecting the 4 categories of sectors; $ExtremeValue_{ASO}$ is a dummy with a value 1 if $\frac{\text{Cash flow}}{\text{Total Assets}}$ is <-1 or >1 and value 0 if >-1 and <1.

Table 25 provides the descriptives of the dependent variable. The mean and median are also pulled down by some outliers. Therefore, we winsorize the dependent variables at the 5 and 95 percentiles to deal with them.

Table 25

Descriptives Cash flow/Total Assets

Dependent variable	N	Mean	Median	Minimum	Maximum	Std. Deviation
Cash flow	165	-0,20	0,02	-8,39	0,79	0,91

Linear regression is also permissible, the tested assumptions can be found in Attachment 12. Regression coefficients and standard errors are shown in Table 26.[17]

[16] Net cash flow can be estimated via the following formula: NCF = Net result + depreciation + provision (Aernoudt, 2017c).
[17] We do not include *Cash flow/Shareholders funds* to avoid the analysis problems experienced in the previous section (e.g., negative equity).

The regression model is significant at the 0.01% level. The adjusted R-squared is 48%. We find for *Patents* and for *ExtremeValue* coefficients statistically different from 0 (i.e., p < 0,05). For example, if a company holds one patent more in its possession, the cash flow on total assets is expected to decrease with 2%, holding all the other independent variables constant.

Table 26

Regression results Patents-Cash flow

	OLS
Constant	0.02
	(0.11)
Patents	-0.02 **
	(0.01)
Age	-0.01
	(0.01)
Size	0.03
	(0.03)
ICT[1]	-0.11
	(0.11)
Professional, scientific and technical services (PST)[1]	-0.06
	(0.10)
Others[1]	-0.01
	(0.11)
Extremevalue	-1,25 ***
	(0.11)
Observations	129
F value(7,122)	17,92 ***
Adj. R^2	0.48

Note: Standard error in brackets. The symbols °, *, **, *** denote the significance levels at 10%, 5%, 1% and 0.1% respectively. There are no signals of problems with multicollinearity since all Variance inflation factors (VIFs) are below the critical threshold of 10 (the maximum is 2.90) and tolerance scores above 0.2. The correlation tables are shown in Attachment 13.
[1] :Manufacturing is the reference category for the sector dummies.

This negative relationship pictured in the Death Valley curve (Figure 3) is present in the dataset of Flemish ASOs when relating the cash stream to the patents of an ASO. This indicates that the costs of patent applications and especially the R&D expenditures which are related to patent applications are detrimental for the cash position. Since the dataset consists of recently founded ASOs, this result is in the end not so surprising. Young, R&D intensive companies need several years of research before actually commercializing a product and subsequently earn profits. Although this leads to cash burns in the short run, this is necessary to make profits in the future (Osawa & Miyazaki, 2006; Aernoudt, 2017b; Kenton, 2019).

Overall, we can conclude that we cannot find evidence of a positive relationship between the number of patents and ROA, ROE or cash flow. The relationship between patents and cash flow is even negative, indicating the cash drain related to R&D expenditures. The long term positive effects of R&D expenditures (measured via patents) cannot be found whereas the short term cash drains which should lead to these positive effects are present.

5. Illustrative Robustness Check Location Behaviour

The determinants of location behaviour were questioned by our survey (Attachment 1). These results can be partially compared to the results of earlier research conducted by *The Belgian Science Policy Office (Belspo)* in 2016 (Attachment 14).[18] They created a survey to collect data on the R&D activities of Belgian companies with the inclusion of a subsection, asking questions about the influence of certain factors on their location. However, this robustness check consists of two important limitations. First, only 95 of our original 196 ASOs filled in this questionnaire, with only 47 valid responses on the question about the factors influencing the location. Second, not all possible determinants overlap between the two surveys with some determinants only partially matching with two options from the 2016-survey. For this robustness check, we match the following possibilities:[19]

Table 27

Matching statements from both surveys

Survey used in this paper	Belspo's 2016 Survey
Need for infrastructure (e.g., laboratory) from University.	-Presence of a higher education institution and/or research institution (centers, laboratories) -Presence of infrastructure (transport, grounds)
Greater ability to attract resources (Personnel/Capital).	-Availability of educated personnel -Financially attractive business conditions
Dependent on support from local authorities.	-Possibility to receive grants -Local regulations

[18] This report is not publicly available in detail, but with the support of A. Spithoven I was able to compare my dataset with the one used in this research.
[19] To match the statements, a translation of the original Dutch sentences to their English counterparts was required.

In Table 28, the descriptive statistics of our three factors and the six Belspo's factors can be found. Since the data of our own survey is measured via a 7-point Likert scale and the Belspo's survey via an ordinal 3-point scale, this data is normalized.[20]

Table 28

Descriptive statistics determinants location behavior (Our survey + matched determinants of Belspo's 2016 survey)

Determinants of location behaviour	N	Mean	Std. Deviation	Minimum	Maximum
Need of infrastructure (e.g., laboratory) from University (Q3)	55	0,55	0,39	0	1
Presence of a higher education institution and/or research institution (centers, laboratories)	47	0,31	0,37	0	1
Presence of infrastructure (transport, grounds)	47	0,57	0,39	0	1
Greater ability to attract resources (Personnel/Capital) (Q6)	55	0,58	0,34	0	1
Availability of educated personnel	47	0,26	0,39	0	1
Financially attractive business conditions	47	0,69	0,34	0	1
Dependent of support from local authorities (Q7)	55	0,26	0,26	0	1
Possibility to receive grants	47	0,49	0,42	0	1
Local regulations	46	0,76	0,36	0	1

The comparison of this data via statistical tests is not recommended since there are too many differences between both surveys. The distributions are not normally distributed which makes a t-test inappropriate, the distributions of the differences are also not symmetrically which discards the Wilcoxon signed rank test. Of course, the most important reason to neglect statistical tests is the fact that different respondents took part in both surveys. Obviously, the non-response between both surveys did not overlap, with only

[20] The data normalization technique used: $\frac{(x_i - \min)}{range}$

12 companies correctly filling in both surveys. Therefore, this robustness check is no robustness check after all. However, we can still use the descriptives of Table 28 to indicate the conformity between both surveys. If we focus on the means, the two surveys neither confirm nor contradict each other. Only the relation between *Dependent of support from local authorities* and *Possibility to receive grants-local regulations* seems reversed.

There could be several explanations for the differences in responses between both surveys. First, the scale of both surveys is different, resulting in fewer possibilities to diversify an opinion on a 3-point scale than on the 7-point scale. The central tendency effect could lead people to the middle of the 3-point scale. Second, the survey conducted by Belspo questioned the respondents to explain the location decision of the R&D activities whereas we asked the respondents on the factors determining the location decision of the company itself. This could not be the same place for every ASO. Third, as mentioned earlier, there is no perfect overlap between the options of both questionnaires. For example, in our questionnaire *Need for infrastructure* specifies the need for laboratories and R&D centers with no focus on general infrastructure like public transport or grounds when in fact the other survey makes this distinction. Fourth, since only 12 companies filled in both surveys, the comparability of both surveys is limited. Fifth, the Belspo survey was part of a very extensive survey with 36 questions while our survey was much shorter. This could lead to boredom called "respondent fatigue bias" (Porter, Whitcomb, & Weitzer, 2004). Overall, we cannot draw conclusions from this robustness check due to all the limitations. Therefore, this is only included as an illustration that a more standardized approach would make it able to compare different reactions through time.

6. Conclusion

In this paper we analyzed the research questions: "**Are academic spin-offs (ASOs) clustered around their associated parent universities?"** and **"Have R&D initiatives a positive impact on spin-offs' performance?"**. In order to evaluate the location and determinants of location behaviour, we used the dataset of *Orbis* and a survey conducted with the founders of Flemish ASOs. For investigating the influence of the number of patents on performance, we used the dataset of *Orbis* which contains the number of patents in each ASO's possession and its information from the annual accounts.

An academic spin-off is a company founded by someone affiliated with a university to commercialize research results into marketable products or services. These spin-offs are geographically located in the surroundings of their respective parent university. Approximately three out of four ASOs have their headquarters less than 25 kilometers away from their parent whereas the maximum distance between an ASO and its parent is only 119 km. The determinants influencing this location are not straightforward. If we solely focus on the responses given by the founders of the ASOs (response rate of 28%), the most important determinants are the place of residence of the founder, the need of infrastructure (e.g., laboratories from university) and a greater possibility to attract personnel and capital. If we relate these responses to the actual location, age, size and industry of the ASO, we draw other conclusions. We only find a statistically significant relation that the need of formal contact with the university decreases the actual distance between an ASO and its parent and that support from the university to commercialize knowledge is not considered important. We cannot find evidence that the need for infrastructure such as laboratories has a significant impact on the actual location. This could be partially explained because not all infrastructure is located at the university itself but in the surrounding science parks where many ASOs are located.

Lastly, we studied the relation between the number of patents in an ASO's possession and its performance. These patents act as a proxy for R&D output and thus as an indication of the impact of research initially conducted at the university. We used the traditional measures ROA and ROE to capture performance. We could only find a weak relation between the number of patents and the ROA captured performance, but this was not statistically significant at the 5% level. After consulting the Ghent TTO, we conducted an additional test to link the number of patents with the cash flow of the ASOs. This resulted in a statistically significant relationship indicating the negative effects of patents on the cash flow, leading to cash drains. This is in line with the famous Death Valley curve which emphasizes the subsequent cash drains of start-ups in their early years.

7. Contributions to the Literature on Academic Spin-offs

This paper provides descriptive evidence of the actual location, determinants influencing this location and a link between intellectual property and performance of Flemish academic spin-offs. Therefore, we used a dataset containing all the spin-offs founded at a Flemish university during 2001-2017. This research about ASOs performance in Flanders is in line with previously conducted studies focusing on a specific region or country (e.g., Finland (Parhankangas and Arenius, 2003); Flanders (Clarysse, Wright, & Van de Velde, 2011); and Italy (Bolzani et al, 2014)). Since most studies in literature targeted USA's spin-offs, this paper helps to fill this gap by focusing on Flemish ASOs (Bigliardi, Galati, & Verbano, 2013). The calculated survival rates emphasize the increasing importance of academic entrepreneurship for universities and the impressive survival possibilities for ASOs. Flemish ASOs are currently performing better than their European peers in terms of spin-off creation. The overview of the actual geographical location of all Flemish ASOs during 2001-2017 and the founders' opinion with regard to the determinants influencing this location also contributes to economic geography or spatial economy. The section about the link between the number of patents in an ASO's possession and its performance contributes to the theory related to intellectual property and the debate between the different types of intellectual property (e.g., patens vs trademarks).

8. Limitations and Areas for Future Research

There are multiple opportunities to extend this research or to address some limitations. First, as already addressed by Clarysse, Wright and Van de Velde (2011), the study of Flemish spin-offs is exhaustive but is limited to one geographical region. This has the advantage to reduce the influence of non-measured variance and variation between different cultures but also limits the scope of this paper. We believe Flanders is comparable to other developing high-tech regions in Europe, but the further we move away from Flanders, the further we move away from our initial setting. Compared to the United States, Flanders is still trailing in successful spin-offs indicating the different environment (e.g., intellectual capital, financial capital, risk and failure aversion in EU vs the USA) (Torcello, 2015). For example, Clarysse et al. (2011) mention the different career path of Ph.D. students in Flanders (directly from undergraduate to Ph.D. studies, lacking essential business experience). Additional research in similar geographical regions or comparative analysis between regions/countries is definitely worthwhile. Furthermore, different countries have also different institutions, laws and policies. This can relate to intellectual property protection, access to government grants, different quality of TTOs, which policy measures with regard to ASOs are applied, etc. Additional research on each of these determinants can give interesting insights.

Second, by investigating ASOs with mainly pure data, we looked at the most visible determinants of ASOs' success. Further research on the transfer of tacit knowledge between universities and spin-offs, the network created per university and social capital transferred between both parties can provide a different perspective on ASOs' performance (Gittelman, 2003). Each university can accommodate their spin-off differently (e.g., assistance with setting up the business, IP protection, financial support, investing in equipment), making interuniversity research in Flanders also interesting.

Third, part of our research was only based on linking the performance of ASOs to their parent by focusing on the input of patents. We did not include the initial capital structure of the new venture. Certain finance providers can maybe give an early competitive advantage which increases the ASO's growth and performance (Munari & Toschi, 2010). Particular venture capital providers specialized in a certain industry (e.g., biotechnology) can guide the entrepreneurial team in achieving certain milestones (MacMillan, Kulow, & Khoylian, 1989).

Fourth, we needed to contact the initial founder(s) of the ASO to obtain non-publicly available information. However, since our valid response rate was approximately 28%, we blame this on the unwillingness/inability to answer but also on the unavailability to contact the right persons. We tried to contact the owner via the official e-mail address of the company and via *LinkedIn*. There are various possible reasons of why we could not eventually reach the right person: no *LinkedIn* account, no activity on the *LinkedIn account,* the official e-mail address of company reaches the wrong persons, the company ceased to exist leading to an inactive e-mail address, etc. A company even responded that the initial founder was sick and therefore unable to fill in our survey.

Fifth, we used, in line with previous studies, patents as a proxy for university research. However, as only 63 of our 194 firms' data sample were patent owners further research is required. In some cases, firms can have very valuable research without the incentive for filing a patent due to the costs for filing a patent and the uncertain outcome, the limited duration of patents and in some cases confidentially is preferred upon patenting (Pitchfork, 2007; FOD Economie, 2018). Additional research could identify the impact of other knowledge transmitters on performance.

Sixth, in accordance with the previous remark, we only focused on patents which were owned by the respective firms. However, many firms license patents from other firms or the university itself. This is not included in our database because this data is simply not available in *Orbis.* We contacted *Orbis* to possible retrieve this information via another channel, but this is not possible yet. This information should be included in *Orbis* from 2020 onwards (K.W. Rimaux, personal communication, April 18, 2019). The inclusion of the number of patents on the date of incorporation could not be included for the same reason. Replicating this study in one or two years with this additional data could lead to different conclusions.

Seventh, we used ROE and ROA as performance measures. Despite the inclusion of two different calculations to mitigate the effect of interests and taxes, there are still some flaws with these ratios. First, since 31 of our 179 examined spin-offs had negative equity (shareholders' funds), the ROE ratio was not meaningful in these cases. Negative equity is the result of negative cumulative retained earnings (caused by reductions in the value of intangible assets, currency swings, etc.) and can create a positive ROE when net income/EBIT is also negative, this situation should by all means be avoided. Second, alternative measures should also be considered (e.g., growth in sales, employment). However, the unavailability of sufficient data through non-disclosure limits these other ratios. Since most of these firms are not obliged to report turnover and employee information, the available data would get too small. It is nearly impossible to retrieve all this missing info via surveys as our research indicated. The low response rate to surveys together with the response bias (e.g., are the self-reported numbers correct, typing errors) makes this a complicated assignment. Third, these ratios can vary extremely year by year for start-ups depending on the achievement of certain milestones (Furhmann, 2019). A potential solution could be to take the averages of several years of financial data.

9. Implications for Practitioners and Policy makers

Academic spin-offs tend to locate close to their parent university. Since 72% of the ASOs in our study are geographically located less than 25 km away from their parent and a maximum average distance between a Flemish university and its spin-offs is only 23 km, the importance of geographical proximity is omnipresent. Especially since the regression analysis showed that formal contact with the university (e.g., research projects, part-time tutoring) is crucial for the founders. This study further informs policy-makers and university's TTOs about the need for suitable locations for spin-offs close to the university. This is also emphasized by the current success of clustering spin-offs via science parks and business centers (e.g., Tech Lane Ghent Science Park, Arenberg Science Park, Haasrode Science Park) (Luyten, 2018; KU Leuven Research & Development, 2019c). Currently, they are already expanding the Tech Lane Ghent Science Park with an additional business center specifically focused on biotech. This is an investment of 25 million EUR with the ultimate goal to create new successful biotech start-ups such as Ablynx and Argenx.

We did not find a significant impact of the number of patents in an ASO's possession and its performance. We already mentioned a variety of possible explanations of this finding in the discussion section and encourage further research on this topic. A potential route that governments could consider for stimulating patent filing, is subsidizing or supporting the actual filing for patents since these costs are not negligible. However, this can lead to perverse effects in which too many patents are filed, just for the obtainment of grants (Cox, 2018). Furthermore, the repeated measures ANOVA and the related regression analysis both showed the limited impact of the support of the TTO to commercialize knowledge. This is also in line with the explained "reward theory" that companies can experience difficulties with the commercialization of patented inventions. Further research is necessary to conclude if additional support or focus is needed by the university or its TTOs.

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11. Attachments

Attachment 1 – Survey asking the founder(s) for the determinants influencing the actual location of the ASOs (and some additional information).

Location behaviour and spin-offs' performance

Start of Block: Default Question Block

Q1

Dear Sir,

Dear Madam,

In view of my Master dissertation at Ghent University, the Department of Economics, I am looking for your motive(s) for location and additional information about the spin-off you are currently working for and/or which you founded.

I contact every spin-off founded at a Flemish University between 2001 and 2017 to get some insights about these specifics. Filling in this (very short!) questionnaire will be highly appreciated as it is a necessary requirement to complete my research and yield valuable output.

Responses will be treated in absolute confidence and all individual information will only be mentioned in an aggregated way per university.

Afterward, I will send my finished dissertation to all respondents.

If you have any further questions, please don't hesitate to contact me. Please feel free to call me on (+32 499608634) or contact by (stephen.bothuyne@UGent.be), if you require any further information.

A tremendous thank you for filling in this form!

Stephen Bothuyne

Student Business Economics - Master Corporate Finance

If you sense, before or during the completion of this survey, that others are more suitable to fill in this questionnaire, feel free to forward this survey or let me know.

End of Block: Default Question Block

Start of Block: Block 2

Q2 What is the name of the Flemish academic spin-off you founded/work at/acquired?

If you founded multiple Flemish academic spin-offs, please fill in this survey twice or let me know via mail.

____

Q3 This company is a spin-off of which Flemish universities?

- ▢ Ghent University (UGent) (1)
- ▢ Katholieke Universiteit Leuven (KU Leuven) (2)
- ▢ Vrije Universiteit Brussel (VUB) (3)
- ▢ Antwerp University (UAntwerp) (4)
- ▢ Hasselt University (UHasselt) (5)

End of Block: Block 2

Start of Block: Block 1

Q4 How many Full-Time Equivalent (FTE's) were employed at your/this spin-off in 2017?

____

Q5 What was the turnover of your/this spin-off in 2017? (if not available e.g. M&A, latest available turnover + year of latest turnover)

____

Q6 What was the turnover of your/this spin-off in 2016? (if not available e.g. M&A, latest-1 available turnover + year of latest-1 turnover)

____

End of Block: Block 1

Start of Block: Block 3

Q7 Several possible explanations for the geographical proximity of the academic spin-off to their university are mentioned. Please score the following motives on applicability for your firm.

	Strongly Inapplicable (1)	Inapplicable (2)	Somewhat Inapplicable (3)	Neither Applicable nor Inapplicable (4)	Somewhat Applicable (5)	Applicable (6)	Strongly Applicable (7)
"Roots" - Birthplace of founder(s) (1)	○	○	○	○	○	○	○
Place of residence (at date of incorporation) (2)	○	○	○	○	○	○	○
Need for infrastructure (e.g., laboratory) from University (3)	○	○	○	○	○	○	○
Transfer of tacit knowledge/Face-to-face interaction required (4)	○	○	○	○	○	○	○
Formal contact with University (e.g., research projects, part-time tutoring) (5)	○	○	○	○	○	○	○
Greater ability to attract resources (Personnel/Capital) (6)	○	○	○	○	○	○	○
Dependent on support from local authorities (7)	○	○	○	○	○	○	○
Providing services for university (8)	○	○	○	○	○	○	○
Support of University (TTO) to commercialize knowledge (9)	○	○	○	○	○	○	○

End of Block: Block 3

Start of Block: Block 4

Q8 If there are some other possible determinants which influenced the location decision, please mention them here. If you have some additional remarks/comments, feel free to add them as well.

____

End of Block: Block 4

Attachment 2 – Kruskal-Wallis test on average distances between ASOs and parent universities

University	N	Mean rank
UGent	70	90,72
KU Leuven	60	94,58
VUB	25	104,18
UAntwerp	27	113,93
UHasselt	10	82,2
Total	192	

Test statistics	
Kruskal-Wallis	4,623
df	4
Sig.	0,328

Attachment 3 – Representativeness of sample to the population of ASOs (grouped per university)

First, we use a chi-square test to evaluate the representativeness of our sample in relation to the population of spin-offs. In the following table, the observed N counts the number of academic spin-offs per affiliated university. We compare this number with the population percentages obtained in Table 10 via a chi-square test. Since the p-value of 0,492 is higher than the threshold (0,05), we can conclude that the distribution of the sample is the same as the distribution of our population. This increases the generalizability of our results.

Affiliated University	Observed N	Expected N	Residual
UGent	26	19,6	6,4
KU Leuven	15	17,5	-2,5
VUB	6	7	-1
UAntwerp	6	8,3	-2,3
UHasselt	2	2,7	-0,7
Total	55	55	

Test Statistics	
Chi-Square	**3,405**[a]
df	**4**
Asymp. Sig.	**0,492**

[a] 1 cells (20,0%) have expected frequencies less than 5. The minimum expected cell frequency is 2,7**.**

Attachment 4 – Testing assumptions for repeated measures ANOVA

First, our dependent variable should be measured at the continuous level. Since the applicability of the nine different location determinants is surveyed by using a 7-point Likert scale, we can assume our variable is measured at the continuous level (Baggaley & Hull, 1983; Maurer and Pierce, 1998; Sullivan & Artino, 2013). Secondly, we have listed nine different location determinants to the same respondents, creating the need for a dependent parametric test. Thirdly, there are no outliers because al responses can only take values between 1 and 7. Fourthly, the dependent variable should be normally distributed for every factor. We do not apply the Shapiro-Wilk test because this test is very sensitive for minor deviations from normality. Therefore, we use the Normal Q-Q Plots to test for normality (Laerd Statistics, 2019). These Q-Q Plots indicate no strong deviations from normality. This finding, together with the fact that a repeated measures ANOVA is robust to deviations from normality, we confirm this assumption as well. Lastly, the variances of the differences between all combinations of levels of the factor must be equal which is known as sphericity (Laerd Statistics, 2019). This last assumption only determines which further test are applicable.

Attachment 5 – Mauchly's test of Sphericity, Multivariate tests and pairwise comparisons (repeated measures ANOVA) – Determinants of location behaviour

Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
factor1	0,13	103,03	35	0,000	0,69	0,78	0,13

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
factor1	Pillai's Trace	0,64	10,54	8	47	0,000
	Wilks' Lambda	0,36	10,54	8	47	0,000
	Hotelling's Trace	1,80	10,54	8	47	0,000
	Roy's Largest Root	1,80	10,54	8	47	0,000

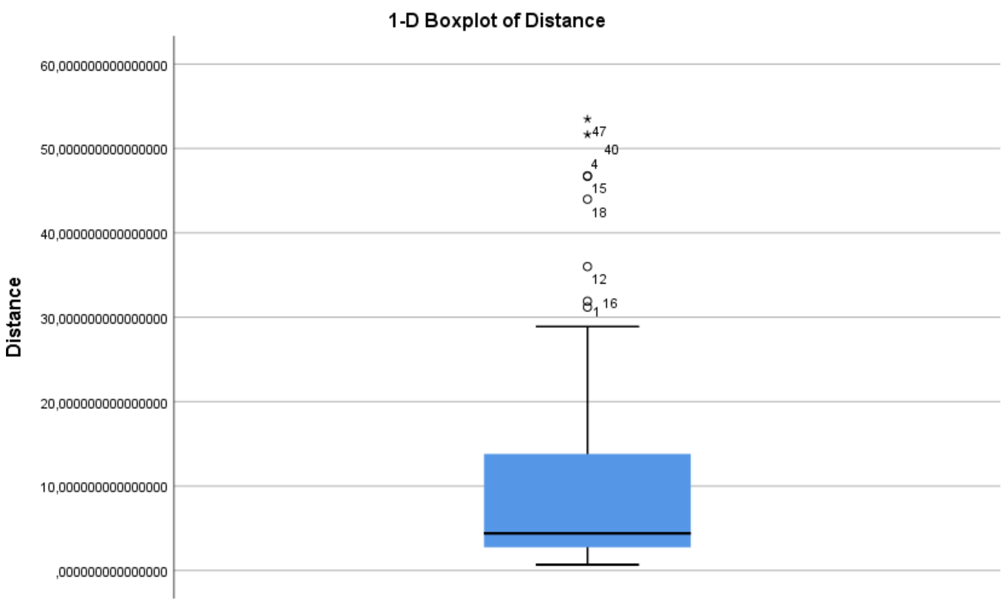
Pairwise Comparisons				
(I) factor1	*(J) factor1*	*Mean Difference (I-J)*	*Std. Error*	*Sig.b*
1	*2*	*-0,836*	*0,37*	*0,995*
	3	*-0,764*	*0,38*	*1*
	4	*-0,182*	*0,349*	*1*
	5	*-0,436*	*0,357*	*1*
	6	*-0,927*	*0,347*	*0,358*
	7	*0,945*	*0,339*	*0,261*
	8	*1*	*0,324*	*0,115*
	9	*1,236**	*0,33*	*0,016*
2	*1*	*0,836*	*0,37*	*0,995*
	3	*0,073*	*0,423*	*1*
	4	*0,655*	*0,424*	*1*
	5	*0,4*	*0,397*	*1*
	6	*-0,091*	*0,409*	*1*
	7	*1,782**	*0,381*	*0,001*
	8	*1,836**	*0,329*	*0*
	9	*2,073**	*0,35*	*0*
3	*1*	*0,764*	*0,38*	*1*
	2	*-0,073*	*0,423*	*1*
	4	*0,582*	*0,258*	*1*
	5	*0,327*	*0,209*	*1*
	6	*-0,164*	*0,367*	*1*
	7	*1,709**	*0,321*	*0*
	8	*1,764**	*0,323*	*0*
	9	*2,000**	*0,312*	*0*
4	*1*	*0,182*	*0,349*	*1*
	2	*-0,655*	*0,424*	*1*
	3	*-0,582*	*0,258*	*1*
	5	*-0,255*	*0,24*	*1*
	6	*-0,745*	*0,318*	*0,821*
	7	*1,127**	*0,295*	*0,012*
	8	*1,182**	*0,283*	*0,004*
	9	*1,418**	*0,267*	*0*
5	*1*	*0,436*	*0,357*	*1*
	2	*-0,4*	*0,397*	*1*
	3	*-0,327*	*0,209*	*1*

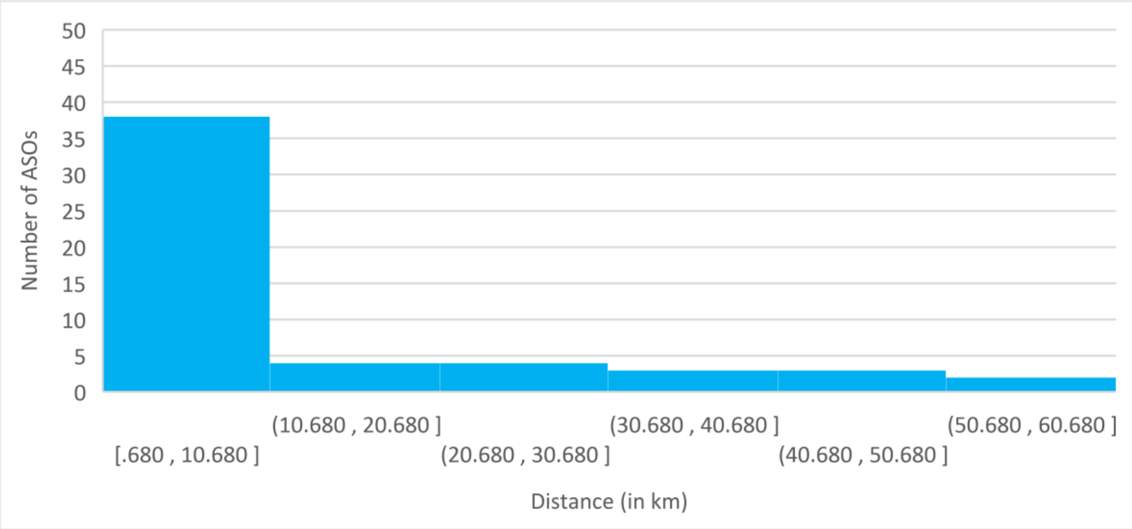
	4	0,255	0,24	1
	6	-0,491	0,343	1
	7	1,382*	0,318	0,002
	8	1,436*	0,26	0
	9	1,673*	0,249	0
6	1	0,927	0,347	0,358
	2	0,091	0,409	1
	3	0,164	0,367	1
	4	0,745	0,318	0,821
	5	0,491	0,343	1
	7	1,873*	0,307	0
	8	1,927*	0,332	0
	9	2,164*	0,337	0
7	1	-0,945	0,339	0,261
	2	-1,782*	0,381	0,001
	3	-1,709*	0,321	0
	4	-1,127*	0,295	0,012
	5	-1,382*	0,318	0,002
	6	-1,873*	0,307	0
	8	0,055	0,261	1
	9	0,291	0,247	1
8	1	-1	0,324	0,115
	2	-1,836*	0,329	0
	3	-1,764*	0,323	0
	4	-1,182*	0,283	0,004
	5	-1,436*	0,26	0
	6	-1,927*	0,332	0
	7	-0,055	0,261	1
	9	0,236	0,168	1
9	1	-1,236*	0,33	0,016
	2	-2,073*	0,35	0
	3	-2,000*	0,312	0
	4	-1,418*	0,267	0
	5	-1,673*	0,249	0
	6	-2,164*	0,337	0
	7	-0,291	0,247	1
	8	-0,236	0,168	1

Attachment 6 – one sample t-tests - Determinants of location behavior

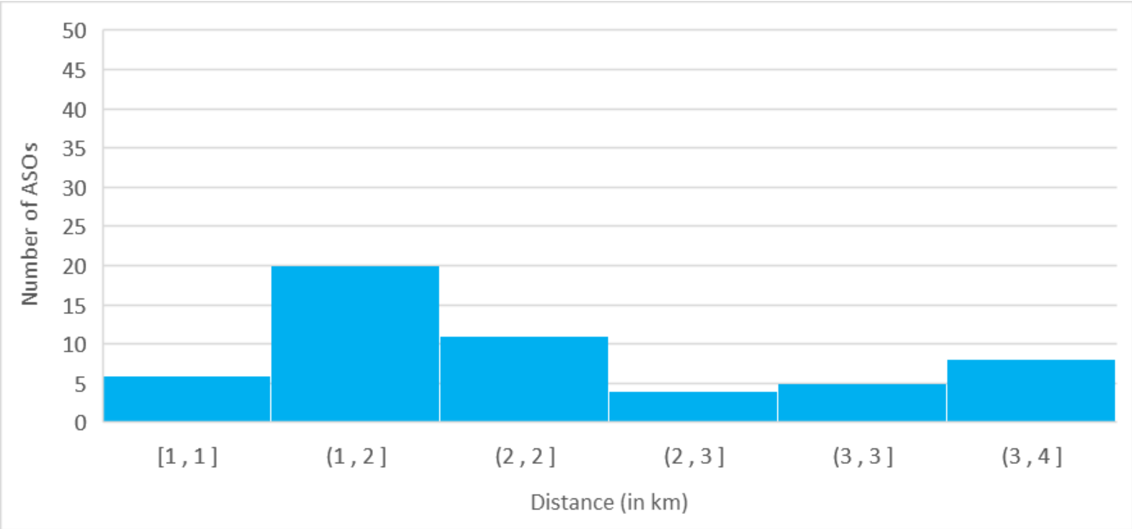
Determinants of location behaviour	t	df	Sig. (2-tailed)	Mean Difference
"Roots" - Birthplace of founder(s) (1)	*0,093*	*54*	*0,926*	*0,027*
Place of residence (at date of incorporation) (2)	*3,099*	*54*	*0,003*	*0,864*
Need of infrastructure (e.g., laboratory) from University (3)	*2,525*	*54*	*0,015*	*0,791*
Transfer of tacit knowledge/Face-to-face interaction required (4)	*0,733*	*54*	*0,466*	*0,209*
Formal contact with University (e.g., research projects, part-time tutoring) (5)	*1,592*	*54*	*0,117*	*0,464*
Greater ability to attract resources (Personnel/Capital) (6)	*3,494*	*54*	*0,001*	*0,955*
Dependent of support from local authorities (7)	*-4,366*	*54*	*0*	*-0,918*
Providing services for university (8)	*-4,422*	*54*	*0*	*-0,973*
Support of University (TTO) to commercialize knowledge (9)	*-5,794*	*54*	*0*	*-1,209*

Attachment 7 – The need for transforming the dependent variable $Distance_{ASO}$





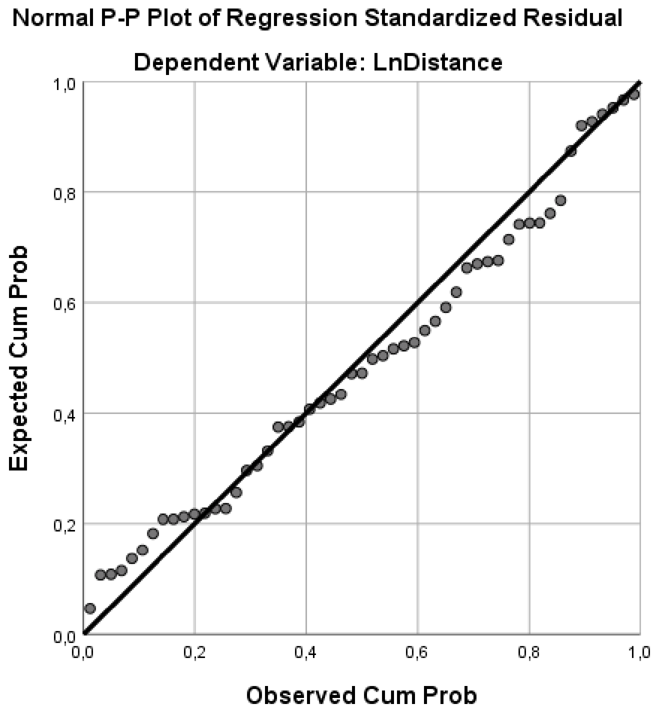
Distribution of ASOs per km

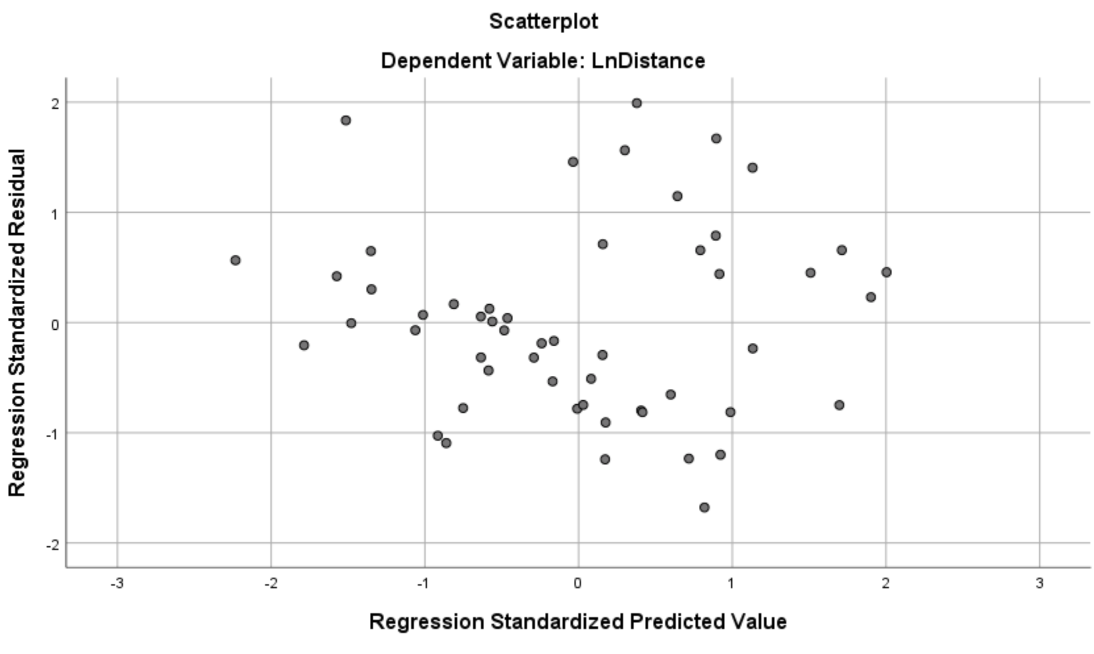


Distribution of ASOs per km (LN)

Attachment 8 – Testing Assumptions for linear multiple regression – $Distance_{ASO}$

First of all, the Cook's distance values are all under one, suggesting no individual cases are unduly influencing the model. Secondly, there is no multicollinearity in the data since the VIF scores are below 10 and tolerance scores above 0,2. Thirdly, the values of the residuals might not be normally distributed. Although the P-P plot indicates a possible violation, only extreme deviations from normality may have a significant impact on our findings. Lastly, the assumption of homoscedasticity is not entirely met. We considered applying a Weighted Least Squares (WLS) regression, which is a common technique to deal with heteroscedasticity. However, we stayed with the OLS given the robust nature of the OLS regression and the disadvantages related to WLS (Engineering Statistics Handbook, 2012; StatisticsSolutions, 2019).


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: LnDistance
Expected Cum Prob
Observed Cum Prob
0,0
0,2
0,4
0,6
0,8
1,0


Scatterplot
Dependent Variable: LnDistance
Regression Standardized Residual
Regression Standardized Predicted Value
-3
-2
-1
0
1
2
3

Attachment 9 – Correlation table – $Distance_{ASO}$

	Distance	$Q7_1$	$Q7_2$	$Q7_3$	$Q7_4$	$Q7_5$	$Q7_6$	$Q7_7$	$Q7_8$	$Q7_9$	AGE_{ASO}	$SIZE_{ASO}{}^a$	ICT_{ASO}	PST_{ASO}	$OTHERS_{ASO}$
Distance	1														
1 $Q7_1$	-0,049	1													
2 $Q7_2$	-0,161	0,132	1												
3 $Q7_3$	0,003	0,19	-0,065	1											
4 $Q7_4$	0,119	0,247	-0,179	,619**	1										
5 $Q7_5$	-0,005	0,226	-0,015	,753**	,643**	1									
6 $Q7_6$	-0,109	0,219	-0,158	0,186	,324*	0,228	1								
7 $Q7_7$	0,076	0,101	-0,238	,281*	,305*	0,206	0,188	1							
8 $Q7_8$	0,142	0,207	0,121	,289*	,381**	,499**	0,078	0,249	1						
9 $Q7_9$	,366**	0,148	-0,037	,323*	,440**	,538**	0,013	,293*	,689**	1					
10 AGE_{ASO}	0,032	-0,061	0,227	0,014	-0,096	0,056	-0,176	-0,168	0,003	-0,084	1				
11 $SIZE_{ASO}{}^a$	-0,215	-0,035	-0,221	-0,032	-0,069	-0,189	,328*	0,063	-,356**	-0,268	0,023	1			
12 ICT_{ASO}	0,094	-0,083	0,018	0,01	0,124	0,086	,359**	-0,065	0,013	0,088	-0,088	0,025	1		
13 PST_{ASO}	-0,117	0,041	0,215	0,143	-0,054	0,026	-,359**	0,103	0,043	-0,027	0,068	-0,069	-,513**	1	
14 $OTHERS_{ASO}$	,269*	-0,039	-0,166	-,270*	-0,177	-0,127	-0,083	0,071	-0,047	-0,051	-0,097	-0,079	-0,199	-,449**	1

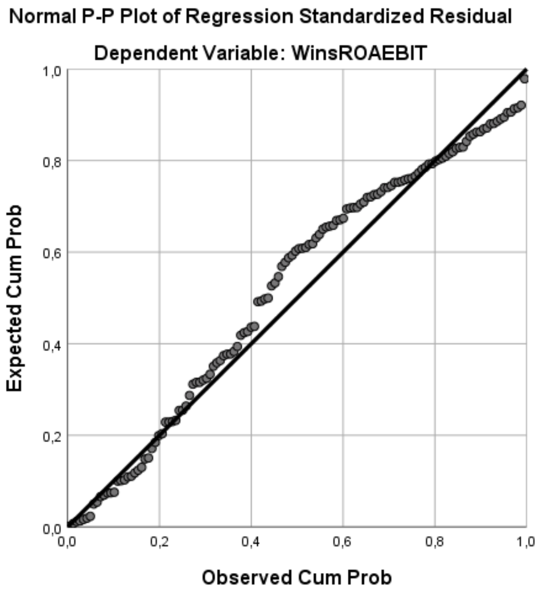
Notes. **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). Variables 12, 13 and 14 are binary; hence, their correlations should be interpreted with care. [a] indicates variables are log-transformed.

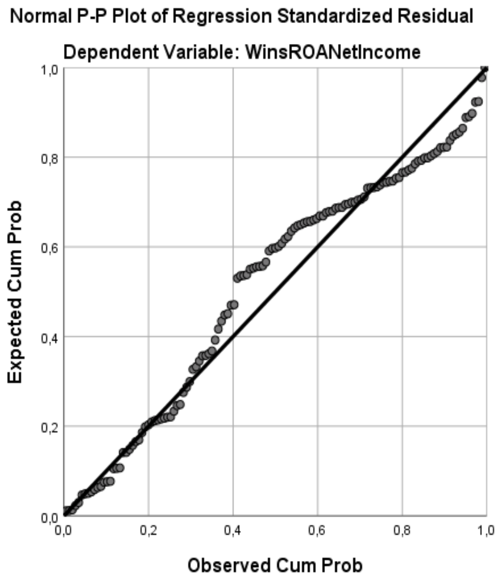
There are no signals of problems with multicollinearity since the Variance Inflation factors (VIFs) are below 10 and above the threshold of 0.2. The correlation coefficients itself indicate also no major problems of multicollinearity since no coefficient is above 0.9 (Dohoo et al., 1997). However, we have to mention that other sources state the presence of multicollinearity when the coefficients are higher than 0.7 (Laerd Statistics, 2015).

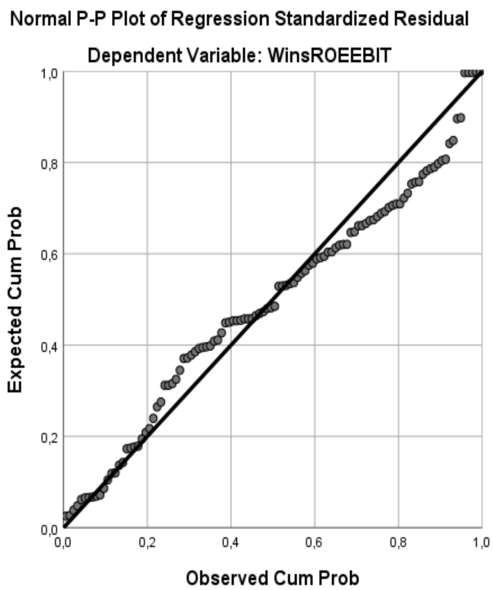
Attachment 10 – Testing Assumptions for linear multiple regression – Patents$_{ASO}$

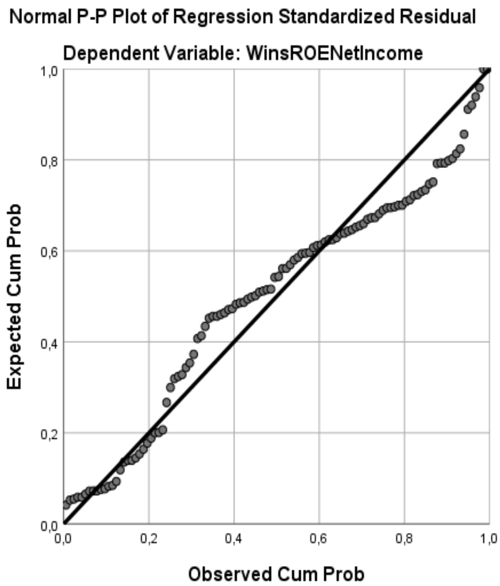
First, the Cook's distance values are all under one, suggesting no individual cases are unduly influencing the model. Secondly, there is no multicollinearity in the data since the VIF scores are all below 10 and tolerance scores above 0,2. Thirdly, the values of the residuals might not be normally distributed. Although the P-P plots suggest a possible violation, only extreme deviations from normality may have a significant impact on our findings. Lastly, we can approve the assumption of homoscedasticity based on the scatterplots.

4 P-P plots (ROA (using EBIT)/(using Net Income) and ROE (using EBIT)/(using Net Income))

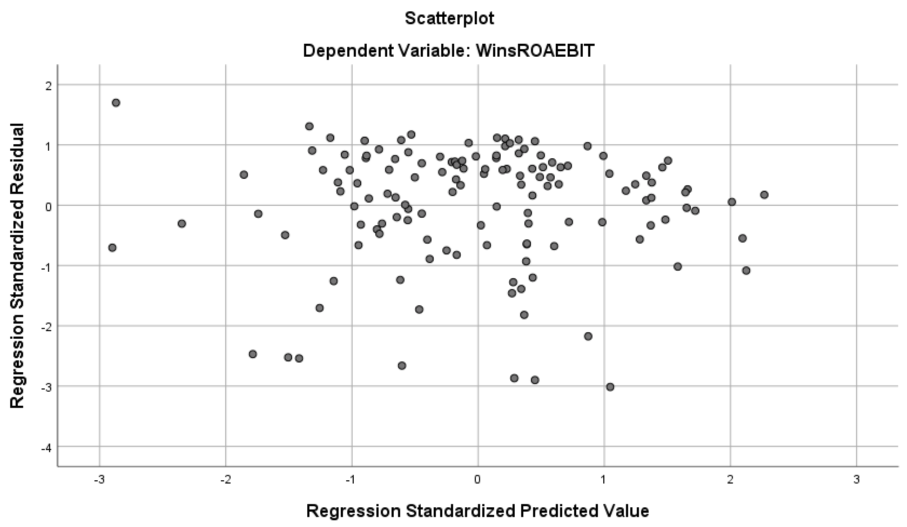


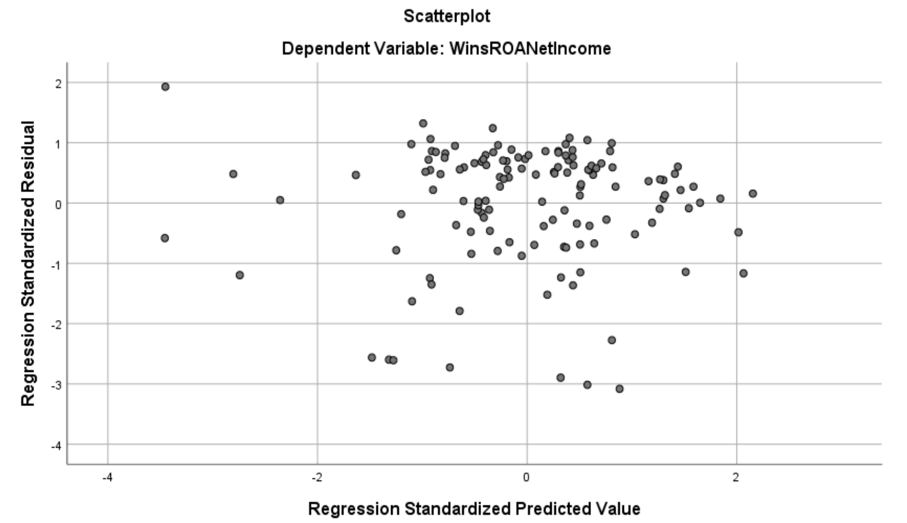


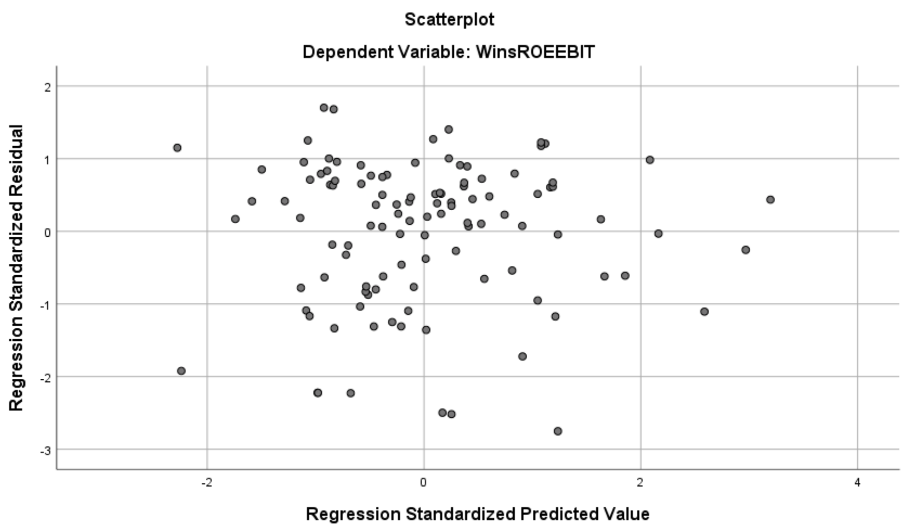


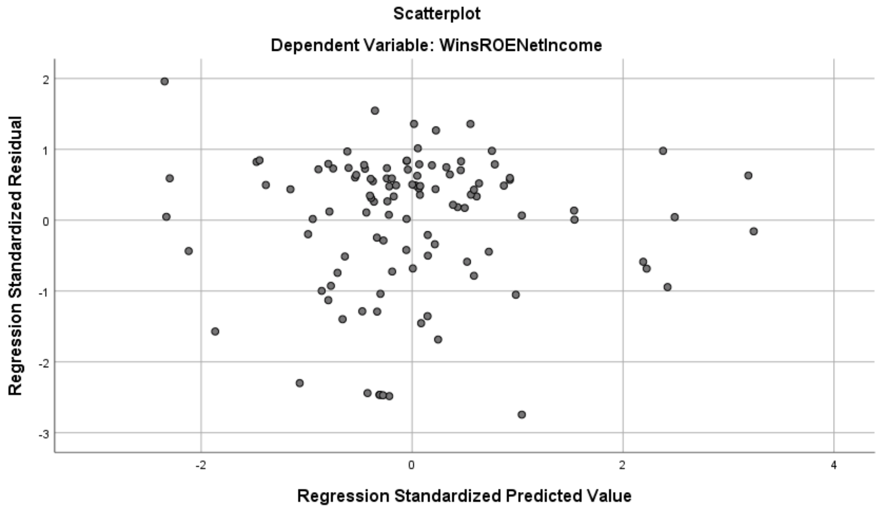


4 scatterplots plots (ROA (using EBIT)/(using Net Income) and ROE (using EBIT)/(using Net Income))








Scatterplot
Dependent Variable: WinsROENetIncome
Regression Standardized Residual
2
1
0
-1
-2
-3
-2
0
2
4
Regression Standardized Predicted Value

Attachment 11 – Correlation table – $Patents_{ASO}$

	ROA (using EBIT)$_{ASO}$	Patents$_{ASO}$	AGE$_{ASO}$	SIZE$_{ASO}$	ICT$_{ASO}$	PST$_{ASO}$	OTHERS$_{ASO}$	ExtremeValue$_{ASO}$
1 ROA (using EBIT)$_{ASO}$	1							
2 Patents$_{ASO}$	-0,118	1						
3 AGE$_{ASO}$	-0,046	0,07	1					
4 SIZE$_{ASO}$[a]	-0,032	,435**	-0,048	1				
5 ICT$_{ASO}$	0,028	0,078	-0,063	-0,006	1			
6 PST$_{ASO}$	-0,069	-,193**	-0,02	0,05	-,575**	1		
7 OTHERS$_{ASO}$	0,069	0,08	0,063	-0,126	-,362**	-,258**	1	
8 ExtremeValue$_{ASO}$	-,742**	0,058	0,05	0,038	-0,011	0,043	-0,057	1

Notes. **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). Variables 5, 6, 7 and 8 are binary; hence, their correlations should be interpreted with care. [a] indicates variables are log-transformed.

	ROA (using Net Income)$_{ASO}$	Patents$_{ASO}$	AGE$_{ASO}$	SIZE$_{ASO}$	ICT$_{ASO}$	PST$_{ASO}$	OTHERS$_{ASO}$	ExtremeValue$_{ASO}$
1 ROA (using Net Income)$_{ASO}$	1							
2 Patents$_{ASO}$	-0,094	1						
3 AGE$_{ASO}$	-0,067	0,07	1					
4 SIZE$_{ASO}$[a]	-0,061	,435**	-0,048	1				
5 ICT$_{ASO}$	-0,072	-,193**	-0,02	0,05	1			
6 PST$_{ASO}$	0,048	0,078	-0,063	-0,006	-,575**	1		
7 OTHERS$_{ASO}$	0,06	0,08	0,063	-0,126	-,258**	-,362**	1	
8 ExtremeValue$_{ASO}$	-,696**	0,099	0,075	0,035	0,013	0,034	-0,071	1

Notes. **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). Variables 5, 6, 7 and 8 are binary; hence, their correlations should be interpreted with care. [a] indicates variables are log-transformed.

	ROE (using EBIT)$_{ASO}$	Patents$_{ASO}$	AGE$_{ASO}$	SIZE$_{ASO}$	ICT$_{ASO}$	PST$_{ASO}$	OTHERS$_{ASO}$	ExtremeValue$_{ASO}$
1 ROE (using EBIT)$_{ASO}$	1							
2 Patents$_{ASO}$	-0,085	1						
3 AGE$_{ASO}$	-0,031	0,07	1					
4 SIZE$_{ASO}$^{a}	-0,147	,435**	-0,048	1				
5 ICT$_{ASO}$	-0,125	-,193**	-0,02	0,05	1			
6 PST$_{ASO}$	0,042	0,078	-0,063	-0,006	-,575**	1		
7 OTHERS$_{ASO}$	-0,006	0,08	0,063	-0,126	-,258**	-,362**	1	
8 ExtremeValue$_{ASO}$	-,530**	-0,026	0,08	-0,078	,157*	-0,095	-0,07	1

Notes. **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). Variables 5, 6, 7 and 8 are binary; hence, their correlations should be interpreted with care. [a] indicates variables are log-transformed.

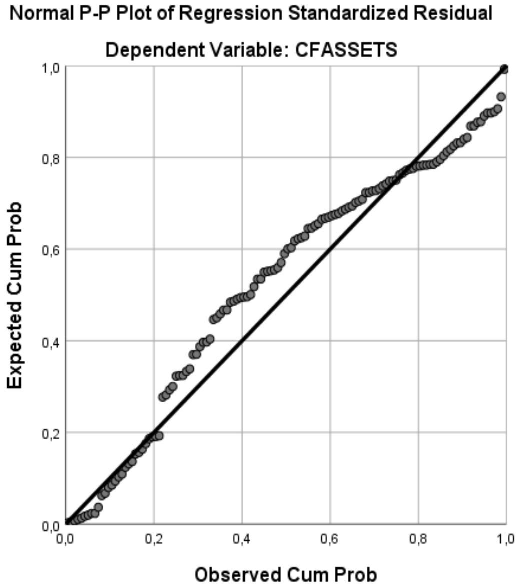
	ROE (using Net Income)$_{ASO}$	Patents$_{ASO}$	AGE$_{ASO}$	SIZE$_{ASO}$	ICT$_{ASO}$	PST$_{ASO}$	OTHERS$_{ASO}$	ExtremeValue$_{ASO}$
1 ROE (using Net Income)$_{ASO}$	1							
2 Patents$_{ASO}$	-0,069	1						
3 AGE$_{ASO}$	-0,068	0,07	1					
4 SIZE$_{ASO}$^{a}	-0,107	,435**	-0,048	1				
5 ICT$_{ASO}$	-0,093	-,193**	-0,02	0,05	1			
6 PST$_{ASO}$	0,024	0,078	-0,063	-0,006	-,575**	1		
7 OTHERS$_{ASO}$	-0,013	0,08	0,063	-0,126	-,258**	-,362**	1	
8 ExtremeValue$_{ASO}$	-,633**	-0,001	0,087	-0,077	0,145	-0,138	-0,013	1

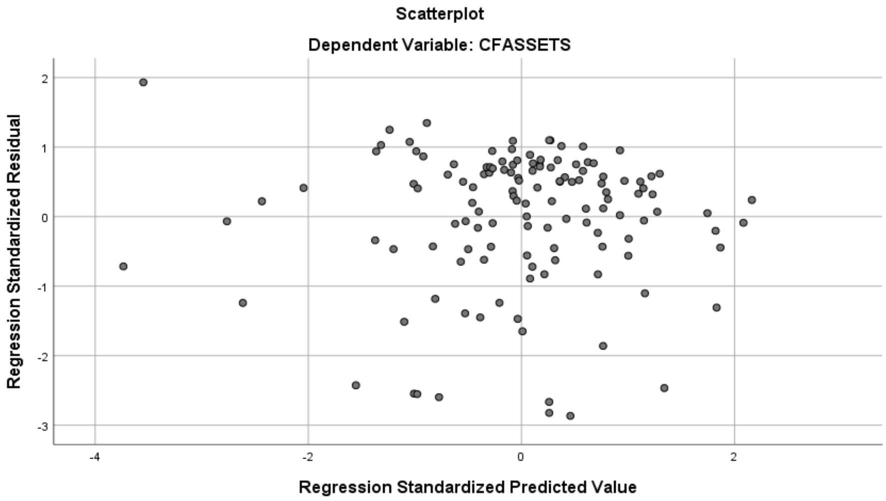
Notes. **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). Variables 5, 6, 7 and 8 are binary; hence, their correlations should be interpreted with care. [a] indicates variables are log-transformed.

There are no signals of problems with multicollinearity since the Variance Inflation factors (VIFs) are below 10 and above the threshold of 0.2. The correlation coefficients itself indicate also no major problems of multicollinearity since no coefficient is above 0.9 (Dohoo et al., 1997). However, we have to mention that other sources state the presence of multicollinearity when the coefficients are higher than 0.7 (Laerd Statistics, 2015).

Attachment 12 – Testing Assumptions for linear multiple regression – $\frac{Cash\ flow}{Total\ Assets}_{ASO}$

First, the Cook's distance values are all under one, suggesting no individual cases are unduly influencing the model. Secondly, there is no multicollinearity in the data since the VIF scores are all below 10 and tolerance scores above 0,2. Thirdly, the values of the residuals might not be normally distributed. Although the P-P plots suggest a possible violation, only extreme deviations from normality may have a significant impact on our findings. Lastly, we can approve the assumption of homoscedasticity based on the scatterplots.





Attachment 13 –Correlation tables – $\frac{Cash\ flow}{Total\ Assets}_{ASO}$

	Cash flow/Total $assets_{ASO}$	$Patents_{ASO}$	AGE_{ASO}	$SIZE_{ASO}$	ICT_{ASO}	PST_{ASO}	$OTHERS_{ASO}$	$ExtremeValue_{ASO}$
1 Cash flow/Total $assets_{ASO}$	1							
2 $Patents_{ASO}$	-0,127	1						
3 AGE_{ASO}	-0,049	0,07	1					
4 $SIZE_{ASO}{}^{a}$	-0,001	,435**	-0,048	1				
5 ICT_{ASO}	-0,068	-,193**	-0,02	0,05	1			
6 PST_{ASO}	0,043	0,078	-0,063	-0,006	-,575**	1		
7 $OTHERS_{ASO}$	0,077	0,08	0,063	-0,126	-,258**	-,362**	1	
8 $ExtremeValue_{ASO}$	-,698**	-0,021	0,045	-0,004	0,059	-0,023	-0,098	1

Notes. **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). Variables 5, 6, 7 and 8 are binary; hence, their correlations should be interpreted with care. [a] indicates variables are log-transformed.

Attachment 14 – Survey conducted by Belspo in 2016 (originally in Dutch)

24. In welke mate waren volgende zaken belangrijk bij het bepalen van waar de O&O-activiteiten plaatsvinden?

Kruis één vakje per rij aan

		Mate van belangrijkheid		
		Groot	*Middelmatig*	*Niet relevant*
a. Beschikbaarheid van geschoold personeel	< LOCA >	1	2	3
b. Aanwezigheid van een hogeronderwijsinstelling en/of onderzoeksinstelling (centra, laboratoria, …)	< LOCB >	1	2	3
c. Nabijheid van uw productieactiviteiten	< LOCC >	1	2	3
d. Aanwezigheid van klanten en/of leveranciers	< LOCD >	1	2	3
e. Aanwezigheid van infrastructuur (transport, terreinen, …)	< LOCE >	1	2	3
f. Lokale regelgeving	< LOCF >	1	2	3
g. Mogelijkheid om subsidies te ontvangen	< LOCG >	1	2	3
h. Aanwezigheid van een cluster van verwante ondernemingen en/of van mogelijkheid tot netwerken	< LOCH >	1	2	3
i. Financieel aantrekkelijke vestigingscondities	< LOCI >	1	2	3
j. Historische redenen	< LOCJ >	1	2	3