

Complementary Adoptions and the Diffusion of Information System in Small and Medium Enterprises: An Exploratory Study

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Abstract

The aim of this study is to explore the diffusion of information systems (IS) in small and medium enterprises (SMEs) as a multifaceted and open social phenomenon, by considering the role and effects of complementary adoptions -in terms of other innovations and their adopters- on the adoption of the IS -focal adoptions. We conceptualised adoption as a staged process (agenda-setting, matching, implementing, restructuring, clarifying, routinising and infusion) and used multiple case studies to guide the fieldwork and analysis. We found that the outcome, timing, and flow of the stages of the focal processes were affected by intricate and multilevel systems of mutually dependent complementary adoptions of innovations and non-innovations by a diversity of adopters, which ultimately determined the results of the focal adoptions. Our constructs define an alternative unit of analysis that provides a comprehensive and realistic view of the possibilities of effectively diffusing IS in SMEs. This emphasises the need to rethink the objects of study, agency functions, theoretical frameworks, and research approaches if we are to understand systems and design and implement system interventions, including public policies.

Keywords: Information systems diffusion, Small and medium enterprises, Multiple adoption dependencies, Unit of analysis, Systems of innovation

1. INTRODUCTION

The process and outcome of an innovation -namely, a 'focal' innovation- in society can be explained by the chronological events that complexly connect 'complementary' innovations, innovators, and other actors (Mowery and Rosenberg 1998, Perez 1983). Technical and social components must be systemically linked to unblock and speedup the development, progress, and success of focal innovations, including the organisation of production and distribution (Jagerberg 2005). For example, the creation of the internet depended on the development of complementary innovations including telecommunications infrastructure, packet-switched networks, computer systems, and other interdependent technologies, along with the coordination of multiple stakeholders to agree aims, architectures, standards and basic services that materialised and made its operation feasible (e.g. Ryan 2013).

However, most studies in this area focus on the research and development stage of innovations, rather than the diffusion stage. Rogers (2003, p. 164) himself emphasised that such studies 'do not tell much about the diffusion-adoption phase... investigations of the entire innovation process are needed'. Similarly, Gagliardi et al. (2018, p. 224) stated that 'mainstream innovation diffusion studies rarely admit [complementary innovations] as a fundamental element of their conceptual frameworks'. We agree with this gap in relation to IS diffusion in SMEs. Research in this area, although of great value, has mostly focused on the factors (i.e. barriers and enablers) that affect the earliness, rate, or extent of adoption of an IS (Chitura et al. 2008, Chouki et al. 2020, Consoli 2012, Ghobakhloo et al. 2011, Jeyaraj et al. 2006, Parker and Castleman 2009, Parker et al. 2015, Spinelli 2016, Williams et al. 2009). The activities of other organisations or individuals are included as factors that directly influence the adopters of the IS (Chitura et al. 2008, Choudrie and Culkin 2013, Chouki et al. 2020, Consoli 2012, Ghobakhloo et al. 2011, Jeyaraj et al. 2006, Parker et al. 2015, Spinelli 2016, Williams et al. 2009), for example competitive pressures, the bargaining power of big buyers, and public policies. Clearly, the predominant unit of analysis embraces the specific IS artefact that is to be diffused and a given group of adopters. We conceptualise it as a focal adoption, composed of a focal innovation and its focal adopters. However, we believe that the units of analysis in the research of the diffusion of IS in SMEs can be expanded beyond focal adoptions because diffusion is a multifaceted and open phenomenon that is affected by numerous events and processes that take place outside the organisational boundaries and microenvironments (see Avgerou 2010, Kurnia et al. 2015, Kurnia and Johnston 2000, Currie 2009, Parker et al. 2015). Units of analysis matter because they are the entities that are the subject of study (e.g. Babbie 2009, Silverman and Solmon 1998). We specifically argue that to understand and potentially influence the diffusion of IS, the units of analysis should embrace both focal and complementary adoptions. Therefore, the objective of this research is to explore through case studies the role of complementary adoptions (in terms of other innovations and their adopters) in the context of IS diffusion in SMEs (focal adoptions). Our questions are threefold: What is the nature of the complementary adoptions? How do complementary adoptions affect focal adoptions? And how are these adoptions connected and dependent on each other?

We begin below with a literature review on complementary adoptions, and then move on to developing the theoretical framework for the study. After explaining the research design, we present the case studies, after which we explain and discuss our theoretical constructs. Finally, we reflect on the implications for theory and practice, including agential roles to drive and coordinate multiple adoption dependencies.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Complementary Adoptions in Diffusion Research

As noted, the academic literature on complementary adoptions in diffusion is very scarce (Gagliardi et al. 2018, Rogers 2003). Some research focuses on the analysis and exploitation of relevant quantitative data on complementary adoptions. Within this group of studies, we have identified longitudinal research on the correlation between the diffusion of pairs of complementary innovations in people (Dewan et al. 2010, Niculescu and Whang 2011), such as for personal computers and the internet, and wireless voice and data services. The results are disaggregated, for example by the level of development of the studied countries or the innovativeness of the adopters. Focusing on single innovations, Sundararajan (2008) quantified the mutual effect of adoption by groups of two types of adopters in the diffusion of network goods, for instance in the adoption of an e-marketplace by sellers and buyers. Also, based on extensive data and complex mathematics, some studies have gone a step further by developing computer simulations to model the co-diffusion effects of pairs of complementary innovations (Jensen and Chapin 2014, Lazzati 2020).

Other research is more prescriptive in terms of diffusion strategies. Robertson and Breen (2014) explained how leaders in the toy industry have developed complementary innovations such as new products, services, business models and channels to market, to make their core offer much more appealing. Analysing the entrepreneurial ecosystem of the ceramic industry, Russo (2000) demonstrated how an innovative product needs to have evidence of high levels of demand before convincing other companies to adopt the complementary innovations -for example, a manufacturing method- that could ensure long-term success. Bucklin and Sengupta (1993) went even further in their study of scanners and barcodes, emphasising the need for direct collaboration with other companies in the life cycle of the complementary innovations that work with the focal innovation. Finally, Gagliardi et al. (2018) showed how the success of a focal innovation depends on the development and diffusion of complementary innovations that are dynamic in nature, such as in the case of drugs and their improvable companion tests.

Although the existing studies in the area are useful for introducing oneself to some aspects of the topic, most of the material is about the diffusion of non-IS innovations to individuals or not specifically to SMEs. Also, the focus is often on only one complementary innovation and one or two groups of adopters. Finally, the focus of the literature is either on quantitative relations between innovations or on generic diffusion strategies. All this is a long way from our aim of illustrating and understanding in detail an ontological view about an alternative unit of analysis for future research. This reinforces our exploratory approach to the topic and the research questions.

2.2 Research on IS Diffusion in SMEs and Theoretical Framework

2.2.1 Adoption process

We required a framework that would guide us to comprehensively investigate most of what happened throughout focal adoptions with the aim of detecting complementary adoptions and grounding theoretical concepts about them. We decided to use the *innovation adoption process (AP)* in organisations (Rogers 1983, 2003) as an exploratory tool and the initial constituent of the theoretical framework. The AP is composed of a sequence of interdependent and non-linear *stages* -agenda-setting, matching, redefining/restructuring, clarifying, and routinising- which organisations pass through when they adopt innovations. These stages cover the full life cycle of adoption, from initial needs to the point where the innovation is used fully and properly and provides the expected benefits. As the AP is an abstract model for any organisational adoption, we adjusted it according to our study focus on IS.

Cooper and Zmud (1990) were the first to adapt the AP stages to the context of IS. We expanded their framework to obtain more comprehensive guidance for most events during the life cycle of IS adoption. The result is shown in table 1. The contextualisation of the AP goes beyond expressing the stages in IS terms. It considers the division of the redefining/restructuring stage into two to distinguish the activities related to the IS artefact from the organisational activities. Another difference is the expansion of the scope of the redefining stage, which is now termed implementing, by adding the in-house creation and maintenance of innovations to the modification of externally generated innovations. Finally, there is the infusion stage, which is about innovations that are adopted gradually with no guarantee of full use.

Table 1. Stages of the AP for IS (adapted from Cooper and Zmud (1990))

AP stages	Explanation
Agenda-Setting	Study of the strategic situation of the organisation and scanning of different types of IS
Matching	Technical, organisational, and financial analysis to agree the investment of resources for the implementation and use of a specific IS
Implementing	The IS is developed, acquired, or rented, possibly installed, possibly adapted to the organisational processes, and maintained

Restructuring	The organisational structure, processes, internal and external relationships, and/or boundaries are modified, and personnel are trained. All as requisite to make the IS operative and valuable
Clarifying	The personnel of the organisation are induced to use the IS
Routinising	The use of the IS is encouraged as a normal activity
Infusion	Extent of use of the IS in terms of number of users, quantity of total transactions, types of transactions, and/or quantity of transactions per type

The adoption stages have been practically untouched by research on IS diffusion in SMEs (Parker et al. 2015, Parker and Castleman 2009, Salim et al. 2015). Most studies focus on the binary decision to adopt or not to adopt, or else they differentiate between adoption, implementation, or use, mostly to measure factors rather than to explain processes (see Currie 2009, Ghobakhloo et al. 2011, Salim et al. 2015). As Rogers (2003) has stated, nor does most diffusion research make use of the AP. This is in clear contrast to the study of *factors of adoption*. However, the fact that the process stages are affected by a diversity of factors opens opportunities to combine them within single studies (Kurnia and Johnston 2000, Mustonen-Olilla and Lyytinen 2003, Salim et al. 2015).

2.2.2 Factors of adoption

The technology, organisation, and environment framework (TOE) (DePietro et al. 1990) and the diffusion of innovations (DI) (Rogers 2003) are two of the most frequently used theories to study factors in the diffusion of IS in firms (e.g. Kurnia et al. 2015, Oliveira and Martins 2011, Salavati et al. 2013)¹. These and other frameworks classify factors into groups with the aim of making better sense of them for research and practice. For example, DI considers as meta-factors the characteristics of the internal organisational structure, of the leader, of the innovation, and of the openness to the external environment. TOE contemplates three types of factors, namely the organisational, technological, and environmental ones.

TOE and DI overlap and complement each other (e.g. Arpaci et al. 2012, Oliveira and Martins 2011). For instance, both develop the organisational dimension by considering the degree of centralisation of power, knowledge diversity in employees, interconnectedness among functional areas, firm size, and slack resources. Regarding leaders, DI includes the analysis of adoption champions and different categories of innovators, whereas TOE, as part of its organisational context, addresses the role of top managers in fostering and supporting change.

The technological context of TOE includes the existing technological infrastructure and practices in firms which could support the life cycle and realisation of the benefits of adoption. Although practices are to some extent connected to the organisational aspects of DI, the infrastructural component contrasts with the external focus of DI on the attributes of innovations. Unlike DI, TOE also encompasses relevant environmental forces, such as industry and market structures, external support networks, and government regulations. DI basically considers the internal mechanisms that facilitate the interaction with the external environment, as TOE also does. In addition, DI explains the social side of diffusion, including communication networks, opinion leaders and critical masses.

Researchers have tested these and other theories, either individually or in combination, to assess their components in different diffusion scenarios (e.g. specific IS in target SME populations) (see Jeyaraj et al. 2006, Kurnia et al. 2015, Wymer and Regan 2005). The results have been twofold: firstly, a context-dependent list of relevant factors; secondly, their useful reclassification into diverse groups according to the views of the researchers (see Jeyaraj et al. 2006, Wymer and Regan 2005). For instance, Al-Qirim (2004) and Thong (1999) proposed similar frameworks specifically for IS in the SME sector, which are composed of the characteristics of the SMEs, decision-takers, IS, and the external environment. These dimensions do not only resemble a good combination of TOE and DI (Arpaci et al. 2012), but they also represent a wide-ranging summary of most of the factors found in the literature about IS diffusion in firms (c.f., Jeyaraj et al. 2006).

¹ Major theories about diffusion factors in individuals include the technology acceptance model (Davis 1986), the theory of planned behaviour (Ajzen 1991) and the unified theory of acceptance and use of technology (Venkatesh et al. 2003).

Thus, we decided to use the classification of Al-Qirim (2004) and Thong (1999) as a guide, since we found it comprehensive, clear-cut, and easy to understand. Table 2 presents several examples of factors for each group.

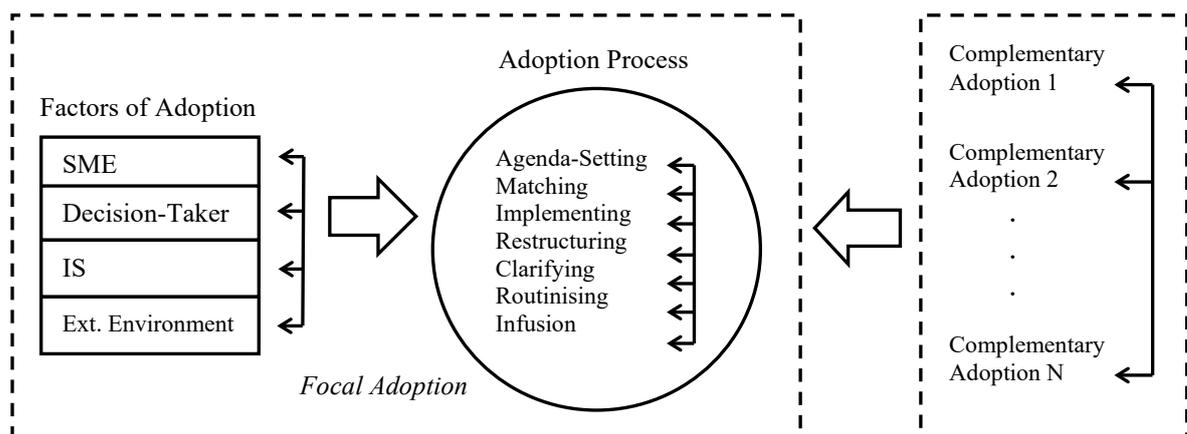
Table 2. Factors of IS adoption in SMEs

Groups	Examples of factors
SME	Centralisation, technical expertise, creativity following recognition of opportunities, formal planning, and external links
Decision-Taker	Strategic thinking, IS knowledge, IS management focus, role in IS initiatives, and attitude towards risk and change
IS	Business benefits, technical complexity, pace of change, ease of use, and compatibility with current practices
External Environment	Customer power, industry characteristics, mutual trust, competitor initiatives, and public policies

2.2.3 Final framework

Figure 1 shows the interaction of processes and factors. Each factor may affect one or more stages of the focal AP (e.g. Robey and Farrow 1982, Sabherwal and Robey 1995). For example, flexible organisation structures favour the initial innovation stages, but mechanistic structures are more convenient for the last stages (Zaltman et al. 1973). Also, each factor may indirectly affect the effects of other factors (e.g. Sabherwal and Robey 1995). For instance, the dominance of either IS personnel or end users in projects may trigger conflicts and biases, which could be attenuated by the involvement of top management (Doll 1985, Newman and Sabherwal 1991). Finally, the outcome of an adoption stage may influence the outcome of other stages (e.g. Mohr 1987, Sabherwal and Robey 1995). For example, the early definition of a proper project scope would lead to successful IS outcomes (Swanson 1988). We designed this analysis to identify complementary adoptions at the societal level and provide a first step in understanding their nature and how they affect focal APs and each other.

Figure 1. Framework to explore complementary adoptions



To conclude, as our objective is to detect complementary adoptions, we need to define what an innovation is. The complementary innovations could be of any type, not only IS. This required using a comprehensive definition of innovations to be aware of them during the exploratory study. Accordingly, we used the classification of Schumpeter (1954), which posits five types of innovations: new goods or services, new methods of production or commercialisation, new sources of supply, the exploitation of new markets, and new ways to organise the business. We extended this by adding

organisational and technological process innovations for improving internal operations (Meeus and Edquist 2006). Finally, since our research is contextual to the adopters, we also considered that ‘an innovation is an idea, practice or object that is perceived as new by an individual or other units of adoption’, even if the items ‘are not objectively new’ (Rogers 2003, p. 12).

3. RESEARCH DESIGN

We followed a hybrid approach to carry out this exploratory research (Corbin and Strauss 2014), starting with a theoretical framework as a lens to do the fieldwork. Accordingly, our constructs were developed from the data to supplement the initial framework. The AP stages and the adoption factors initially guided the fieldwork, but issues related to complementary adoptions emerged during the interplay between data, theoretical framework, and theory building.

We used multiple case studies of IS adoption by SMEs in England. Case studies are defined as ‘an empirical investigation of a particular phenomenon within its real-life context’ (Robson 2002, p. 178). Yin (2009, p. 16) added that ‘the boundaries between phenomenon and context may not be clearly evident’. In our research, the phenomenon is the focal adoptions, and the context is composed of the factors of adoption, which we expected to be in some instances the manifestation of complementary adoptions. As the aim of the research is to expand the unit of analysis, we also expected to reconceptualise the phenomenon under investigation by considering both the focal adoptions and part of the initial context, specifically the complementary adoptions.

We opted for an arrangement of collective cases (Stake 2005), in which the researcher defines the specific interest within the phenomenon -in our study, complementary adoptions- and from there works with a varied and balanced group of cases which are believed to offer the greatest learning potential. This is vital in an exploratory study. Our cases include SMEs from diverse industrial sectors and various IS applications with different levels of difficulty for the adopters. We used 5 case studies until we reached theoretical saturation (Corbin and Strauss 2014), which proved to be very helpful to complete and illustrate our constructs in detail.

The cases involved very small companies or micro enterprises, the segments of the SME sector with the fewest employees per firm. The factors of adoption tend to be more pronounced in these companies (e.g. Barba-Sanchez et al. 2007, Karjaluo and Huhtamaki 2010, Wolcott et al. 2008), which helped us to recognise the needs and characteristics of complementary adoptions. For example, the main decisions in micro enterprises are normally centralised on the owner-manager (e.g. Ott and Laumer 2012, Wolcott et al. 2008), and key individual employees are usually in charge of several activities under demanding time constraints (e.g. Jones et al. 2011, Karjaluo and Huhtamaki 2010). These characteristics create barriers related to knowledge and skills (e.g. Jones et al. 2011, Wolcott et al. 2008) that are difficult to overcome since these firms do not have specialised IS departments (e.g. Jones et al. 2011, Oni and Papazafeiropoulou 2014), nor do they have enough slack resources or the willingness to invest in education and training (e.g. Jones et al. 2011, Karjaluo and Huhtamaki 2010). In line with the constraints in this sector, the studied SMEs received public-funded consulting services to support IS adoption.

We employed diverse sources and methods to triangulate information (e.g. Denzin 2012, Patton 2014), including semi-structured interviews with SME and programme personnel, SME and programme documents such as assistance proposals and evaluations, emails between different participants, internet research on the SMEs, commercial and technical information about the IS, and observations on the use of the IS by employees. We also had access to relevant documentary information on the participation of some of the SME decision-takers in a leadership training programme. Our interviews were with important SME decision-takers -three managing directors, one project development manager and one production director- and programme personnel -two programme consultants who directly assisted the SMEs in their adoption process. We recorded the interviews and guaranteed confidentiality to the participants.

Finally, we analysed the case studies using the data display and analysis method (Miles et al. 2019). We initially reduced the data by summarising the interviews and writing self-memos about all the pieces of information. We then tried to represent the complex relationships among focal and complementary adoptions graphically. We did several iterations of this exercise jointly with a written explanation of each case until we obtained clear and comprehensive conclusions on multiple adoption dependencies. In sections 5 and 6 we present relevant parts of the material used in the analytical process (explanations of the cases and graphs of our constructs).

4. CASE INFORMATION

In this section, we give summary information about each case through a chronological narrative (Yin 2009). This format is convenient not only because the APs developed in complex and distinctive ways, but also to better appreciate the cross-case constructs explained in the next section, especially the dynamics of the AP dependencies. We use pseudonyms to identify the organisations that participated in the study.

4.1 JVentureCo

The firm launched the first e-marketplace for the building supplies sector. The company was a joint venture formed by the SMEs Archard and Intech. Apart from its directors, who were also the directors of the parent companies, it had 2 full-time employees. Archard was a distributor of architectural hardware, a specific segment of the building supplies sector, while Intech had expertise in internet IS. Archard was a brick-and-mortar company, which partnered with Intech to fulfil a need for IS expertise to develop its new initiative.

The e-business model was based on resale agreements with traditional building supply shops. The shopping basket of each client in the e-marketplace could include products from different shops. However, delivery to the client was to be made directly from the warehouses of the supplying shops. In addition, delivery times and charges to customers varied for each shop.

Encouraged by promising initial results, the company decided to use loans to expand its operations. Its success proved only temporary because the increase in sales volume was not sustained, which ultimately affected the recruitment of more supplying shops. The managing director of Intech explained it as follows:

“We developed alliances with some suppliers, developed the platform itself and did some testing... A life test, actually generating revenue and sales... The initial results were pretty good, and then it allowed us to get external funding to expand the activities... [But] the business growth that we had anticipated based on the initial results didn't materialise.”

To overcome this problem, the company received support in strategy and marketing from a government programme. However, the managing director remained sceptical about making costly changes to any aspect of the business, such as designing a navigation structure based on product categories or shops or defining a more attractive delivery charge scheme. The programme consultant who supported the company commented:

“The navigation changed slightly, but they haven't implemented all our recommendations and those which were implemented they didn't implement the core, just bits... [Also,] it was a huge issue [not to implement the advice on uniform delivery charges].”

The venture launched various promotional initiatives, but these were clearly unsuccessful, mainly due to a lack of knowledge and business intelligence on the wider building supplies sector. The managing director criticised this situation:

“[Archard] had knowledge of a very small part of the building supplies industry [architectural hardware]... It's that kind of marketing knowledge you can't expect an advertising agency to have... [JVentureCo] needed to have the industry knowledge.”

The venture was advised of the need to develop a trusted brand to produce a competitive advantage in the relevant and demanding building contractor segment. Although this suggestion was accepted, the firm's personnel acknowledged that it was a very difficult challenge.

Unfortunately, the low volume of transactions made the e-marketplace unattractive even for its current users. JVentureCo could not cope with its financial situation and had to close down. The venture was sold and successfully re-launched by a firm with a well-known and diversified online and offline presence in the sector, which was also in a better position to absorb new operating costs.

4.2 RecruConstCo

This company is a recruitment agency specialising in the construction sector. The managing director had a broad background in human resources but very limited knowledge of IS and project management. He also practised a markedly centralised management style:

“I'm the company, I'm the face of the company and people come to the company because of me... This is why [the company operates in this way], because of my idea of the way we should work... It isn't the way everybody else sees the work, other people want short term gains, making money on commissions.”

The aim of the IS initiative was to support the growth plans of the organisation. RecruConstCo wanted to develop a portal-based internet system to give employers and candidates access to the company's recruitment services. The system would automate functions such as employer profiles, job

opportunities, and uploading and downloading curricula vitae and reference letters. It would also provide construction news, careers advice, and information on working overseas.

The managing director determined the functional requirements of the system and contracted a systems integrator to represent them in the selection of suppliers and products, and the management of the project. Unfortunately, at the end of the project, the response time of the system proved to be very slow, the session manager software randomly collapsed, and the operational cost was too high. The managing director expressed his frustration as follows:

“The systems integrator misrepresented me... They sold me hardware and project management, knowing that there could be a problem... None of the companies that worked here was prepared to say, ‘it’s my fault’... I need to move away from the solution I got because it’s crap, it doesn’t work, and get my money back.”

Even though the managing director had recently taken leadership training and the company had received public assistance in marketing and strategy to grow the business, RecruConstCo decided to reduce its personnel from six full-time employees to only the director and a part-time worker in charge of administrative tasks. This was in sharp contrast to what the managing director had written in his application form for the leadership training course:

“[I see the company] as the first choice for the construction industry in the north of England for any recruitment and human resource requirement. I’ll have offices that will allow the north-east of the country to be covered along with Scotland and the Midlands. I’ll also be in a position for a move into the South East. Each of the regions will be running with unit managers.”

The central reason for this drastic change of plans was that the managing director was not willing to share his databases of employers and candidates with his employees. He believed that these assets were at risk and could be used by any good employee to start their own business. Also, he claimed, profitability increased after the cuts, despite having less work.

The IS project was finally abandoned because the managing director believed that such a small company had no need for a significant web presence, even if the system had been correctly up and running. He said that he might opt to grow the business in the future but would use a service diversification strategy, for example incorporating people management services.

4.3 RecruTrainCo

RecruTrainCo is a regional company which offered recruitment and some training services. It operated exclusively in the construction sector, with its main source of income being the running of publicly funded programmes in disadvantaged areas. After a careful strategic analysis, the 22-employee company planned an aggressive diversification to grow by 400% in a 5-year period. Now the company offers a cross-industry portfolio of services, including benchmarking of employees and candidates, coaching, and management development programmes. RecruTrainCo implemented this strategy through a radical business transformation, as the owner-manager stated in an application form for a training course in leadership:

“We have restructured the company into business units. We have strengthened our skills base, improved our team performance, and modified our reporting and monitoring systems as well as the financial structure.”

In line with the new direction and the goal of growing the business, the SME also decided to expand its IS. The IS initiative embraced the incorporation of functionality into the firm’s internet presence, including facilities to submit vacancies and apply for positions, job alerts, an online training forum, and a payment service for employers.

The initiative was charged to the project development manager, who seconded another employee as his assistant. Both had little expertise in IS but important backgrounds in projects, the selection of suppliers and contract management. Also, the company itself focused on the management and delivery of public programmes. In contrast, the company did not even have an IS area.

Coincidentally, RecruTrainCo received public support for the initial analysis of the functionality. This was used in the requirements of a public tender launched by the company to select a systems integrator to implement the initiative. The selection process was meticulous:

“We sent out the tender to 10 companies and we received 6 back, and out of these 6 we went back to 3 to present to us, and [the systems integrators pre-selected] were the ones that really read the information we had given to them and did quite a good preparation before the meeting.”

During the implementation phase, RecruTrainCo also interacted well with the systems integrator. We observed the systems up and running as well as correctly used by employers, candidates, and the company personnel. The project development manager was delighted with the work of the systems integrator:

“The systems integrator stood out for their willingness to go the extra mile in fulfilling the requirements... They asked a lot of questions, but nothing was too much for them... By taking time to develop a thorough understanding of our objectives, they devised an effective solution which accurately presents us as a forward-thinking specialist company.”

4.4 LanguagesCo

This company is a one-stop language shop for different types of services such as translation, interpreting and voice over. The business model is based on the linking of companies that provide language services to clients. Out of eight employees, the production director was the only employee with IS expertise, including a basic self-taught knowledge of programming languages and experience with enterprise system implementation.

The company had an intranet system for the administration and coordination of service providers and clients, which was developed in Access by the production director himself. He emphasised that the application was built based on a badly designed database. The system was evolving over time according to business requirements and was suffering from improvised modifications in functionality and database files. The application was diminishing in consistency and speed as the volume and types of operation grew.

As a result, an IS initiative was designed to replace the intranet system with an application developed around a proper database structure. The new application had to be relatively easy for the company itself to maintain. LanguagesCo twice received the support of a public programme to design and develop the system.

The first attempt failed to satisfy the production director due to the intention to develop the system in PHP. He had a meeting with the programme director, which led to the original consultant being replaced by another who was willing to develop the system in Access. The production director then took an active role in designing the functionality of the application. The programme consultant who developed the system pointed out:

“[The system] was developed to the production director’s specifications. We worked with him adding many features... He was quite involved in the design process, he developed his own system previously, he knew a little bit about Access development.”

The programme delivered a system based on a well-designed relational database but with bugs. Therefore, the SME still had to debug the system and pass the historical data from the old files to the new database. Despite this, the production director was satisfied with the application:

“[The consultant] produced a good working prototype with a lot of very useful stuff in it... There wasn’t time to solve those bugs and there wasn’t time to provide the documented model of how it works... given it was free, they did very well in terms of telling me what I could do and building me a model that I’d like to use.”

However, after assessing the difficulties of completing an application that he had not developed and the complexity of data migration, the production director decided to modify a copy of the old system based on the improvements in the new system:

“What I’m really doing is taking elements of the [new] design [to the old system], so for example, going from the single supplier table to the modular supplier tables, linked supplier tables, and I take that and build it into our database... I’m not taking the code; I’m taking the design.”

He was doing this work in his spare time, but he finished only a minimal part of it. Regrettably, no relational design was used by LanguagesCo within three years after the programme intervention.

4.5 FuelCo

FuelCo distributes, installs, and provides technical service for liquefied petroleum gas conversions for truck diesel engines. The firm had two full-time and two part-time employees, and it outsourced the conversion of engines and technical service to two suppliers. With the objective of helping sales generation, the managing director decided to provide externally audited and funded trials for one or two trucks from the fleets of potential clients to compare fuel consumption and costs. This was done in partnership with sector consultants and financial institutions. The managing director explained the difficulties of introducing this technology to the market:

“This isn’t like selling mobile phones to millions of people. We’re selling something very specific... For example, we wouldn’t use telemarketing because there is a lot of knowledge involved. Customers are concerned that if someone is going to do something with their trucks, and the trucks cost 50,000 pounds, or if it breaks down in the middle of a contract.”

To implement this plan, the firm wanted to adopt a database to compare the numerical indicators and show the results in tables and graphs. FuelCo also intended to log the fuel consumption of fleets

with the expectation of commercialising aggregated data to interested parties, for example breaking down fuel consumption by a combination of vehicle make, model, age, route, month, or owner.

For reasons of validity, the data capture from the fleets had to be done automatically, using sensors in the trucks, telemetric systems, and interfaces with the database. This is an extract from an e-mail in which the managing director detailed an alternative to this component:

“We’ve a candidate for the automation of data collection – ‘Canbus’ [a telemetric product]... This is a data-acquisition unit for collecting data from external sensors. These sensors would be load cells, fuel monitoring, GPS navigation and even wind-speed and temperature. The central unit can then relay that information to a PC into a database.”

Even with the support of a public programme, FuelCo only finished the database system because the research and development of the automation of data entry was too complex. In another email, a programme consultant responded to FuelCo regarding this requirement:

“[The automation of data collection] is an expensive option... This automation may be problematic to fully automate... Just for your information, the Engineering department in a University uses Canbus on several projects... If you were at all interested in talking about telemetry with someone there, I would be happy to introduce you.”

Also, after four years of the operation, the company only had one customer, so it would have been impossible to populate the database with substantial data. Regrettably, as the automatic data capture system was not developed, the database by itself did not give any meaningful added value over an old spreadsheet that the company had been using with the same aim. As a result, FuelCo never used the new development. The production director tried to show us the new system, but he could not remember how to operate it.

5. THEORETICAL CONSTRUCTS AND DISCUSSION

This section is structured around the three research questions. We start by discussing the nature of the complementary adoptions, after which we explain their impact on the stages of the AP of the focal adoptions. Finally, to gain a comprehensive view of the complexity of this unit of analysis, we analyse the diversity of dependencies among the complementary adoptions and focal APs.

5.1 The Nature of Complementary Adoptions

We found that *all the focal adoptions needed one or more complementary adoptions to be successfully completed*. Table 3 shows the focal adopters, their activities and sectors, the IS that they tried to adopt in the focal adoptions, and whether they succeeded. Except for RecruTrainCo, all the focal adoptions had negative results. The unsuccessful cases were very useful to clearly recognise the need for complementary adoptions. Accordingly, in table 4 we present some relevant adopters and the items that they adopted or should have adopted to help the focal adoptions.

Table 3. Focal adoptions

Focal adopter	Activity and sector	IS (focal adoption)	Was the IS a success?
JVentureCo	Intermediary for building supplies	An e-marketplace for the sector	No
RecruConstCo	Human resource services in construction	A portal-based, self-service application for employers and candidates	No
RecruTrainCo	Cross-sector services in human resources	Improvement of website functionality and appearance, including an online training forum	Yes
LanguagesCo	Intermediary in language translation services	An intranet application to manage interaction with language service providers and clients	No
FuelCo	Representative of manufacturers of truck parts	A database to graphically compare consumptions of fuel and costs	No

Using the innovation definitions of Schumpeter (1954) and Rogers (2003) (see section 2), we can appreciate that the complementary adoptions were not always about innovations. As table 4 shows, there were items that could have been considered innovations by some, but not all the adopters. For

instance, the exploitation of the whole building supplies sector was indeed an innovation for JVentureCo because the commercial expertise of Archard had been as a distributor in a niche market, namely architectural hardware. The venture did not have any acquaintance with diversification strategies. This complex challenge should have implied a full AP in itself, including: an early acknowledgement of the issue; evaluation of courses of action, resources and risks; a gradual implementation; some restructuring of the partners to facilitate operations; and a review of and consolidation in the sector. New knowledge and skills would have been relevant factors for accomplishing all this.

Table 4. Complementary adoptions and their impact

Focal adopter	Who were or should have been the adopters in the complementary adoptions?	What items were or should have been adopted in the complementary adoptions?	Was the item an innovation?	Impact on the focal AP²
JVentureCo	JVentureCo	Exploitation of a new market: The whole building supplies sector	Yes	<i>Agenda-setting, restructuring and infusion</i>
	JVentureCo	New technological process: Business intelligence to generate knowledge about the whole sector	Yes	<i>Agenda-setting, restructuring and infusion</i>
	Supplying shops	New method to commercialise: With the e-marketplace	For some adopters	<i>Restructuring and infusion</i>
	Clients	New source of supply of products: More suppliers in the e-marketplace	For some adopters	<i>Restructuring and infusion</i>
RecruConstCo	Managing director	New way to organise the business: As a result of a growth strategy	Yes	<i>Agenda-setting and clarifying</i>
	Managing director	New services: e.g. People management	Yes	<i>Agenda-setting and clarifying</i>
	Employers	New organisational process: e.g. The management of people	For some adopters	<i>Agenda-setting and clarifying</i>
	Managing director	New organisational process: The project management life cycle	Yes	<i>Agenda-setting, matching and implementing</i>
	Employers	New source of supply of services: More candidates via the portal	For some adopters	<i>Restructuring and infusion</i>
	Candidates	New method to commercialise: The portal	For some adopters	<i>Restructuring and infusion</i>
RecruTrainCo	RecruTrainCo	New way to organise the business: Business units as a growth strategy	Yes	<i>Agenda-setting</i>
	RecruTrainCo	New services: Benchmark of employees and candidates, coaching, online training, etc.	Yes	<i>Agenda-setting</i>
	Employers	New organisational and technological processes: e.g. Coaching and online training	For some adopters	<i>Agenda-setting</i>
	Employers	New source of supply of services: More candidates via the new internet presence	For some adopters	<i>Restructuring and infusion</i>
	Candidates	New method to commercialise: The new internet presence	For some adopters	<i>Restructuring and infusion</i>
	LanguagesCo	Production director	New organisational process: The design and maintenance of relational databases	Yes

² This column is explained in section 5.2, Effects of Complementary Adoptions on Focal APs.

FuelCo	FuelCo	New method to commercialise: Externally funded and audited trials to clients	Yes	<i>Agenda-setting and restructuring</i>
	Clients	New technological process: The converted engines	Yes	<i>Agenda-setting and restructuring</i>
	FuelCo	New organisational process: The research and development of the automatic data capture system	Yes	<i>Matching, restructuring, and infusion</i>
	Clients	New service: The automatic data capture in the trucks of the fleets	Yes	<i>Infusion</i>

In contrast, adoption of the e-marketplace would not have been an innovation for some of the supplying shops. Although the JVentureCo initiative was the first e-marketplace in the sector, whether it was an innovation depended on the knowledge, skills, and experience of each supplier in similar types of commercial decisions, as well as with the logistical processes and technical requirements for materialising the adoption. Importantly, if an item is not considered an innovation by an adopter, the complementary adoption will not necessarily be guaranteed because *there might be similar products or services in the market, or the adopter might have other strategic priorities*. Thus, some forms of interventions would be needed for the adoption to happen.

We also appreciate that complementary adoptions should ultimately affect other adoptions just *as factors of adoption do, since complementary adoptions create factors, that is, barriers and enablers*. We will use the cases of RecruConstCo and RecruTrainCo to exemplify these connections. Both SMEs tried to adopt similar internet systems to connect employers and job seekers, and both had a similar barrier, namely a lack of knowledge about IS. Thus, each decided to contract a systems integrator to select, coordinate, and assess the work of various suppliers of products and services.

The crucial difference was that RecruTrainCo had expertise in projects and contract management. It used this enabler in its public tender and throughout its project to take control of its initiative and ensure the commitment of suppliers. In contrast, RecruConstCo had to abandon its initiative due to a very poor development of its project. Clearly, the personnel of RecruConstCo should have properly *adopted* the practice of project management before embarking on any IS business initiative. Instead, the lack of this complementary adoption *created another barrier in itself*, which spoiled the focal AP. A successful adoption could have generated an enabler to break the barrier of lack of IS knowledge and favour the focal process.

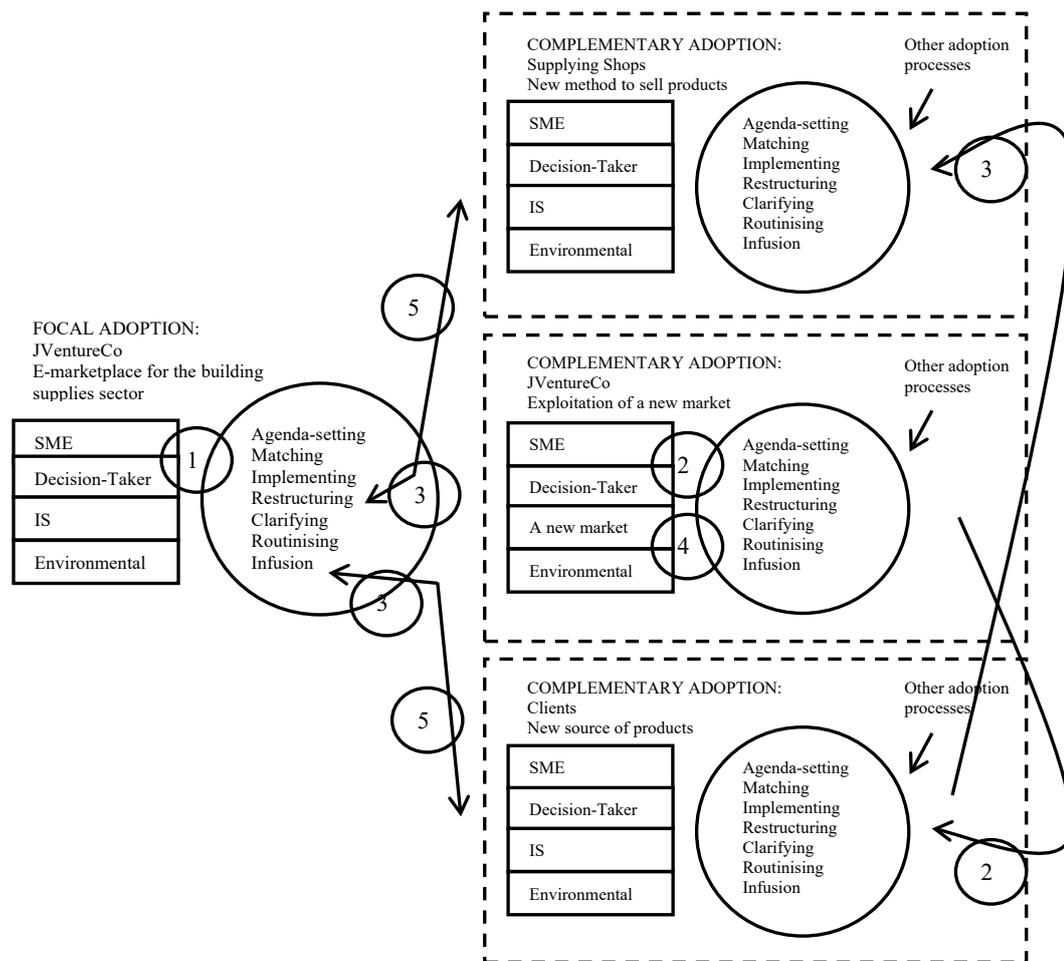
Similarly, the production director of LanguagesCo would have needed to do a full AP of the relational database technique to acquire the necessary skills to conclude the adoption of the intranet application for the administration of providers and clients. The company should have developed this knowledge-related enabler to overcome the underlying barrier represented by the future dependence on external agents for the maintenance of the system. The clients of FuelCo should also have adopted the automated data capture system as a technical enabler to justify the adoption by FuelCo of the database to compare fuel consumption and costs in fleets. The barrier was the reduced benefits of the focal innovation as a stand-alone database, which would have prevented the input of large volumes of valid data without human intervention.

Summarizing, when complementary adoptions involve innovations, adopters must perform complete complementary APs. If the adoptions were not about innovations, they may still not be carried out as there may be similar alternatives in the market or competing internal priorities for adopters. In the end, complementary adoptions create factors which affect focal APs as enablers and barriers.

5.2 Effects of Complementary Adoptions on Focal APs

Table 4 shows some complementary adoptions and the stages of the focal adoptions that they should have affected to help the focal APs. The unsuccessful cases were useful not only for spotting missing complementary adoptions but also for noting important characteristics of their effects on focal adoptions. As only RecruTrainCo saw a positive result, what happened in the other cases was somewhat like what is described in table 4. To make sense of this, in figure 2 we present the chronology of the most relevant events and dependencies involved in the failed focal process of JVentureCo. Below, we discuss relevant considerations that could have enabled the case to succeed, including aspects of the adoptions pointed out in table 4.

Figure 2. A dynamic view of the multiple dependencies of an AP



1. The partners designed and implemented the e-marketplace. The IS knowledge of one of them, Intech, was an enabler for quick accomplishment. JVentureCo also agreed the initial participation of a group of supplying shops.

2. JVentureCo tried to approach the building supplies sector, initially having relative success with early adopters.

3. This success positively impacted the initial result of the infusion stage of the focal AP because of the encouraging number of transactions. This, together with the injection of new capital, led to more supplying shops joining the e-marketplace, which positively impacted the temporary outcome of the restructuring stage of the focal AP due to the new external relationships that were managed and serviced.

4. In the medium term, JVentureCo was unsuccessful in exploiting the building supplies sector. Barriers such as low knowledge of the wider sector and a lack of a strong brand name to garner trust with building contractors negatively impacted clients and suppliers. The complete cycle was repeated but with negative effects.

5. The situation of the venture automatically impacted the AP of the clients and supplying shops that wanted to continue using the e-marketplace, causing the end of the focal adoption.

The failure to exploit the building supplies sector was crucial since it directly influenced other complementary APs, which then caused the distortion and failure of the focal AP. It also *indirectly affected certain stages of the focal process* through the other complementary adoptions³, specifically the restructuring and infusion stages. In fact, this complementary adoption ultimately acted like focal factors. We will discuss this further.

Firstly, the adoption was *particularly complex* for the SME. JVentureCo needed to perform many activities: build a strong brand, conduct effective marketing, develop offline sales, and establish

³ In the column 'Impact on the focal AP' in table 4, in italics we present the stages of the focal APs that were indirectly affected by the complementary adoptions.

agreements over delivery times and charges with the supplying shops. However, it did not have the knowledge, presence in the sector, and resources to accomplish these challenges. This explains the positive but short-lived commercial results at the launch of the venture.

Secondly, the evidence indicates that the exploitation of the building supplies sector was not only too complex, but also *started too late*. Archard should have begun to exploit the sector offline well in advance, to trigger and influence the agenda-setting of the focal AP. In fact, the partners only began to operate in that sector with the launch of the e-marketplace. The management of JVentureCo only recognised the challenges of doing this when most of their financial resources had already been consumed. The firm then tried to rely on advice from a public programme, but this was insufficient and ineffective.

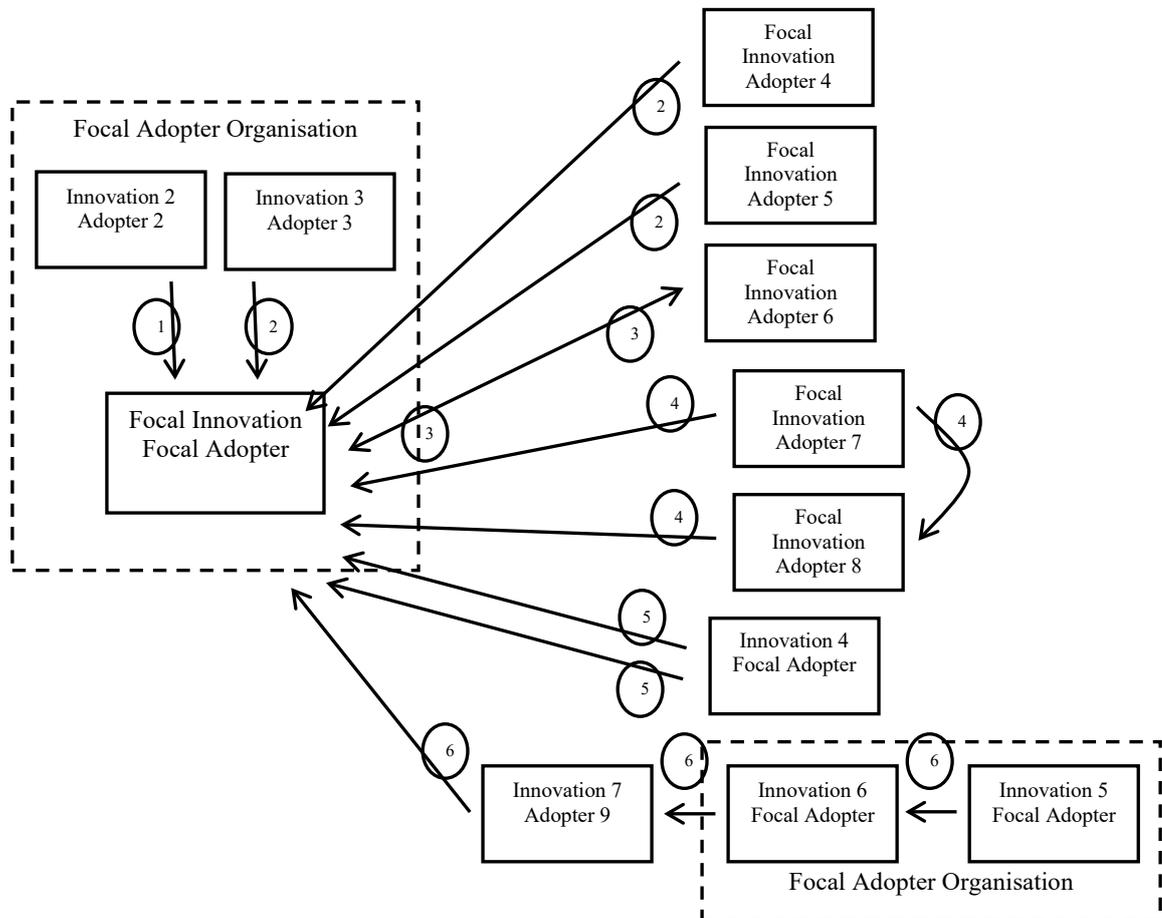
Thirdly, to properly design and accomplish the activities to exploit the building supplies sector, the company should first have found a way to obtain constantly updated knowledge on the entire sector, for example through business intelligence systems or reorganising the business units and relationships of JVentureCo and the partners. This adoption would have directly impacted the exploitation of the sector, thus indirectly affecting the same stages of the focal AP that the exploitation of the sector finally affected, namely agenda-setting, restructuring, and infusion. Despite the relevance of knowledge as an underlying factor, the adoption of a knowledge-generating mechanism was *notoriously missing* from the whole process.

In summary, focal APs depend on complementary adoptions for the outcomes of each of their stages and the timing and flow among the stages. Complementary adoptions affect focal APs both directly and indirectly via other complementary adoptions. Hence, the failure, absence, or delay of any of them could spoil the whole focal process.

5.3 Diversity of Adoption Dependencies

We turn to exemplifying some basic forms in which adoptions depend on and affect each other. This is illustrated in Figure 3 and is then discussed using extracts from the case studies.

Figure 3. Examples of multiple-adoption dependencies



1. A focal adoption may depend on complementary adoptions that *occur only internally within the focal organisation*. Of our cases, only LanguagesCo showed this characteristic. To adopt the intranet application to manage the interaction with language service providers and clients, the production director, who was the person in charge of IS, would have needed first to adopt the technique of relational databases to complete and maintain the application. Although within the focal organisation, both innovation and adopter are different from the focal ones.

2. In the other cases, the focal APs depended on complementary adoptions that *occurred both internally and externally to the focal organisation*. For instance, JVentureCo needed to operate in the entire building supplies market, which represented an additional innovation to the focal e-marketplace. Archad was the entity within JVentureCo in charge of this adoption. In addition, JVentureCo needed supplying shops and clients to adopt the focal innovation to ensure the success of the e-business model.

3. Some cases showed *mutual dependencies between APs*. For example, the successful adoption of the internet system to connect employers and candidates by RecruTrainCo depended on the adoption of this focal innovation by the employers, as external users. At the same time, the adoption by employers depended on the correct adoption of the system by RecruTrainCo itself, including the implementation of useful transactional functions, a proper integration with the back-end databases, and a proper use within the company.

4. Also, we detected the *effects of single adoptions on multiple adoptions*. This happened with the adoption by employers of the new recruitment portal of RecruConstCo. The adoption of the portal by RecruConstCo itself depended on the use of this focal innovation by employers and candidates. Equally, the adoption of the portal by candidates depended on its adoption by relevant employers. Therefore, adoption by employers simultaneously affected both the focal and a complementary AP.

5. Some adoptions may affect *more than one stage of other APs*. This was the case with the adoption of a growth strategy by RecruConstCo, which was vital to trigger the agenda-setting of the focal AP for the recruitment portal. However, as the growth did not turn out as expected, the managing director stopped the AP of the portal at the clarifying stage due to doubts over its value if it served only a few employers and candidates.

6. There were cases of *several serial levels of adoption dependencies*. For example, the correct adoption by FuelCo of the focal database to compare consumption of fuel and costs depended on the adoption of the automatic data capture system by its clients. However, the data capture system would have depended on FuelCo researching and developing it, and the research and development on the success of FuelCo's new way of approaching the engine conversion market. Note that the latter two adoptions should have been accomplished by the focal adopter.

Clearly, a focal AP could be affected by a multilevel combination of these and other types of dependencies as if they were complex systems. Furthermore, the outcomes of the complementary adoptions could change over time through exposure to the varying contexts of their own subsystems. This systemic perspective represents the real structure of adoption, which means that focal APs in many cases depend on *intricate, open, and evolving systems of innovation* (e.g. Edquist 2005, Freeman 2008, Niosi 2018).

6. CONCLUSIONS

The predominant unit of analysis in research on IS diffusion in SMEs has been composed of the specific IS and a given group of adopters (Chitura et al. 2008, Chouki et al. 2020, Consoli 2012, Ghobakhloo et al. 2011, Jeyaraj et al. 2006, Parker and Castleman 2009, Parker et al. 2015, Spinelli 2016, Williams et al. 2009). We have contributed to theory by extending this ontological view to include a systemic structure of complementary adoptions of innovations and non-innovations by a multiplicity of groups of adopters. These directly and indirectly affect the stages, dynamics, and outcomes of focal processes, just as focal factors do.

7.1 Implications and Future Research

A clear theoretical implication is that the theorisation of the diffusion of IS in SMEs should embrace the explanation of the systemic structures formed of both focal and complementary adoptions. From this alternative perspective, future research on diffusion should focus on the composition and outcomes of the structures themselves, either to develop general theories about them or to design interventions to improve their work. It is important to appreciate that the systemic structure (e.g. Freeman 2008, Niosi 2018) of this type of unit of analysis makes the comprehensive investigation of IS diffusion a highly complex task. Not only do focal APs depend on various adoptions and their respective factors, also, at the beginning of such studies the academics, policymakers, or practitioners will not know what the complementary adoptions are, how they are linked, or when and how they will

interact and affect each other. In fact, systemic structures at the societal level are simultaneously both *units of analysis and objects of study* (Edquist 2005, Vega and Chiasson 2019).

There is another critical implication created by the systemic structures once the initiatives for change have been designed: their correct and timely implementation to build working systems. This is clearly dependent on *the role of agents in the evolution of systems* (e.g. Hung and Whittington 2011, Korber et al. 2009). This would require key actors with roles that go beyond those of traditional change agents (those who influence the decisions of adopters (Rogers 2003)) and mediating institutions (those who work with adopters to lower barriers (Damsgaard and Lyytinen 2001)) to become *system builders* (see Hughes 2012). System builders break the status quo, manage diverging interests, influence the activities of several parties, and link and synchronise their work to make technological change happen in society (Howells 2006, Kebede et al. 2014, Klerkx and Leeuwis 2009, Kivimaa 2014, Musiolik et al. 2020). Future research should explain the dynamics of systems with emphasis on why system builders act and their biases, their lobbying and political capacities, their tactics, their knowledge, their access to resources, and how to empower and disempower them.

7.2. Suggestions on How to Research the Extended Unit of Analysis

The multiple adoption dependencies point to the theorisation of not only the state of the structure of systems, but also of their evolutionary character and the role of agents as sources and drivers of change at the highest levels of society. To research this novel, complex and rich unit of analysis, we suggest evaluating *theoretical frameworks that focus on these characteristics*, for instance critical realism (e.g. Vega and Chiasson 2019), complexity theory (e.g. Merali 2006), the morphogenetic approach (e.g. Mutch 2010), and structuration theory (e.g. Jones and Karsten 2008).

We employed a collective case study design (Stake 2005) to learn from varied and balanced cases. This diversity was acceptable for the aims of this exploratory study, in which each case added something to the constructs of the structures. However, it could be interpreted as a limitation in the sense that the findings cannot be generalised to a particular aggregation of companies and IS. An alternative approach could be the use of *surveys* of SMEs of the same sector, geographical area, and adopting the same type of IS, with the aim of detecting factors that could point to complementary adoptions. The results could then be systemically researched through *retroduction* (c.f., Danermark et al. 2019, O'Mahoney and Vincent 2014). This is normally done through comparative studies of cases of similar characteristics (e.g. Tsang 2014, Wynn and Williams 2012), for example, a comparison of regions regarding the diffusion of the same IS in the same sector. This would make it possible to abstract general theory about specific systems by finding the systemic commonalities that could explain the different outcomes of the cases (ibid).

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