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Highlights

- Analysis of three case studies of software ecosystems formed by SMEs
- Hypotheses explaining the dynamics of power in partnerships in a software ecosystem
- Meta-model integrating constructs from software ecosystems and power theories
- Strategies based on power-changing operations to manage power relationships

Strategies for Managing Power Relationships in Software Ecosystems

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Abstract

Building a software ecosystem provides companies with business benefits as well as share risks and costs with a network of partners. The ability to establish successful partnerships with other companies can influence the success or failure of the ecosystem. Companies use power to build alliances and strengthen their position in the ecosystem. However, the inappropriate use of power may create tensions that threaten partnerships. To explore the dynamics of power and dependence in software ecosystems, we conducted three case studies of ecosystems formed by small-to-medium enterprises. As a result, we present a set of hypotheses that explain the effects of power on software ecosystems. As theoretical contribution, we present a meta-model that integrates concepts from s**o**ftware ecosystems literature with constructs from classical power theories. Our practical contribution is a set of strategies that companies can employ to manage power relationships with partners, so that their ecosystems can evolve in a healthy and prosperous manner. By obtaining an understanding of the occurrence of power and dependence, companies can recognise how to exercise power and deal with the power from partners in order to leverage their relationships.

Keywords: Software Ecosystem, Partnerships, Small-to-Medium Enterprises, Power, Strategies.

1. Introduction

Software ecosystems have become one of the key drivers of innovation and growth in the IT industry. A software ecosystem is a group of interconnected companies that work as a unit and interact with a shared market for software and services (Jansen, Finkelstein and Brinkkemper. 2009). Google Android, Apple iOS and Amazon Web Services are examples of successful platform ecosystems. These platforms heavily rely on the active collaboration and expertise of a diverse developer community. Notably, ecosystems are shifting the rules of competition and collaboration in which companies must operate. To ensure sustainable performance, companies are shifting bilateral partnerships to create ecosystems with different players, such as suppliers, complementors, and clients. The survival and progress of companies depend not only on their own business results, but also on the performance of the companies and the entire ecosystem. The foundation of a software ecosystem is based on the notion of interfirm relationship, with companies that co-create value via technological (e.g. new features for an innovative system), commercial (e.g. relevant pool of customers from different segments) and/or intellectual (e.g. new software development skills) complementation. The participation in a software ecosystem enables firms to integrate activities, assets, and capabilities to deliver complex solutions demanded by the market.

To enable a healthy network, companies must strategically govern the software ecosystem by defining appropriate governance mechanisms that amplify the opportunities to attract new players, share benefits among partners, and align activities among participants with complementary assets (Williamson and De Meyer, 2012). The ability to manage relationships with partners can influence the success or failure of the ecosystem. Frequently, companies disregard the potential for conflict and disastrous effects resulting from misaligned strategic interests (Yoffie and Kwak, 2006). For example, companies may battle to access a profitable niche market or implement a strategic software module.

In this setting, the exercise of power allows companies to share benefits, become more attractive and lead partners in their relationships. Companies holding valuable resources, such as money or expertise, can exercise power over partners that depend on such resources. They can also use power as a means to build alliances and strength their position in the network. However, the excessive use of power may create tensions that threaten the evolution of the ecosystem.

In the last years, we have conducted multiple case studies to explore ecosystem partnerships from a power perspective. We are particularly interested in understanding the dynamics of power in ecosystems formed by Small-to-Medium Enterprises (SMEs). Researchers have extensively studied proprietary ecosystems orchestrated by big players (Manikas, 2016). However, it is quite surprising that very limited

research has analysed the relationships among SMEs forming an ecosystem, as this type of company accounts for around 95% of global business (Colomo-Palacios, Biró and Messnarz, 2015).

The current paper builds upon former studies, as described in Figure 1. In (Valença and Alves, 2017a), we presented a substantive theory on the occurrence of power and dependence in ecosystem partnerships, together with illustrative power models from two exploratory cases studies (CSI and CSII). In another paper published at the 43rd Euromicro Conference on Software Engineering and Advanced Applications in 2017 (Valença and Alves, 2017b), we proposed six hypotheses about power relationships.

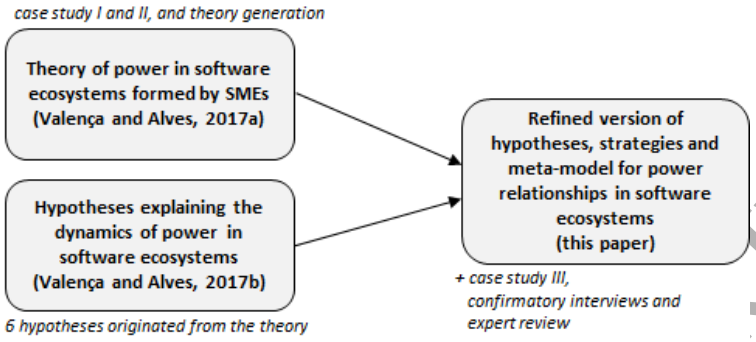

Figure 1. The differences between previous works and this paper.

This paper is an extension of (Valença and Alves, 2017b). Here, we include a refined version of the hypotheses with new evidence gathered from confirmatory interviews. We also add a new case study (CSIII). As novel contributions, we propose a meta-model that integrates concepts of power and software ecosystems. Moreover, we present a set of strategies that companies can employ to establish successful power relationships in software ecosystems. The strategies are based on power-changing operations, which allow a company to adjust power advantage in a partnership. For example, a company may invest on establishing contact with potential partners who can provide it with new clients, reducing its dependence on the customer base of a dominant player. By implementing such power management strategies, companies may improve their own performance and promote the health of the entire software ecosystem. We developed these strategies based on results obtained from multiple case studies. The strategies were created from the analysis of interviews with studied companies and were assessed by means of an expert review. The proposed strategies aim to support companies to obtain a greater understanding on the occurrence of power and dependence, particularly recognising how to exercise power effectively and how to deal with the power from partners in a software ecosystem.

We structured this paper in six sections. Section 2 provides a conceptual background on software ecosystems and power theories. Section 3 details the research method to conduct the case studies. Section 4 illustrates the power model of a case company. In Section 5, we present the meta-model for power relationships in software ecosystems and an extended version of the hypotheses. In this section, we also propose practical strategies to manage power relationships in software ecosystems. Section 6 discusses the results of the expert review. It also analyses research limitations and related studies. Finally, Section 7 presents the contributions for research and practice and proposes directions for future works.

2. Theoretical Foundation

In Section 2.1, we explain relevant concepts of software ecosystems field. In Section 2.2, we describe well-established works on power, which allowed us to examine the dynamics of power relationships among software companies in a comprehensive manner. The ideas introduced by the authors who proposed the classical power theories were widely adopted by researchers from several domains, such as, managerial sciences (e.g. Zhuang and Zhou, 2004; Gaski, 1986) and software engineering (e.g. Milne and Maiden, 2012; Hurni and Huber, 2014).

2.1. Key Concepts in Software Ecosystems

The concept **software ecosystem** establishes a metaphor with natural ecosystems, in which species are part of a food chain and depend on each other. In this setting, a network of actors function as a unit and interact within a shared market for software and services. The relationships among ecosystem participants are generally underpinned by a common technological platform or business opportunities, through the exchange of information, resources and artefacts (Jansen and Cusumano, 2013). In the last

decade, relevant players from the software industry created software ecosystems around their products by opening their platforms via interfaces, allowing external actors to integrate complementary solutions and develop new applications (Che and Perry, 2014). The interactions with external actors allow these players to complement the functionality of existing products as well as expand the offering of systems integration and services (Cusumano, 2004).

Companies in a software ecosystem collaborate and create larger software solutions via integrations of their products in **partnerships**. This intentional strategic relationship between companies enables them to join efforts to achieve goals they could not attain easily in isolation. On the one hand, companies gain access to a myriad of technologies to co-create innovations and enter new markets niches. On the other hand, they strive for common benefits and keep a high level of mutual interdependence.

The network of a software ecosystem is structured on top of business, technical, and social **dimensions** (Manikas and Hanssen, 2013b). The *business* dimension involves elements such as the marketplace, entry barriers and customer base. The *technical* dimension embraces technological and architectural aspects, such as the common software infrastructure and product line. Finally, the *social* dimension considers interfirm relationships, reputation and shared knowledge. In (Valença and Alves, 2017a), we synthesise the core elements of a software ecosystem, which we mapped after performing an exhaustive literature analysis of secondary studies (e.g. systematic literature reviews, mapping studies).

A community of interacting **actors** enables the software ecosystem to create and deliver new solutions (e.g. complete integrations, specific applications) to the market. Such mutually dependent participants often involve a keystone, niche players, value-added resellers, and customers. The *keystone* is a leading actor (in general, a company or independent entity) that guarantees the well-functioning of the network. This player is responsible for running a platform, creating and applying rules, processes and business procedures, setting and monitoring quality standards, and orchestrating actors' relationships. Examples of big keystones are Apple in the iOS ecosystem and Amazon in the Alexa ecosystem. *Niche players* use the central technological infrastructure to produce functionality to address demands from the market. They complement the keystone work and influence ecosystem management. The *value-added resellers* make profit from extending and selling ecosystem solutions to customers, end-users or other vendors. Finally, *users* purchase or obtain an ecosystem solution from a niche player or a vendor to carry out their businesses (Hanssen and Dyba, 2012).

The **health** of a software ecosystem indicates how the ecosystem is evolving and how effective the managerial strategies are to the sustainability of individual players as well as the whole ecosystem. The overall performance of software ecosystems depends on the actions and decisions taken by each individual player. An ecosystem is healthy when it provides mutual benefits for players (Manikas and Hansen, 2013a). The companies acting in the ecosystem are committed to their own health as well as their partners' health. It means that a win-win approach is needed for the ecosystem to thrive. Hence, the ecosystem as a whole must create opportunities for its participants and those who depend on it. According to Hartigh, Tol and Visscher (2006), the health of an ecosystem is a diagnostic of its strength at a given moment. Three measures are commonly used to assess ecosystem health (Iansiti and Levien, 2004). *Productivity* indicates the ecosystem ability to transform inputs into products and services. One possible metric to measure productivity is the number of applications in a marketplace. *Robustness* means the capacity of the ecosystem to deal with interferences and pressure from competitors. To measure this aspect, we can analyse the survival rate of ecosystem members. Finally, *niche creation* denotes the business opportunities available in the ecosystem, which are obtained via valuable resources and market niches expansion. The number of new players around the platform is a way to assess niche creation.

Ecosystems generally evolve during a common lifecycle encompassing the phases of birth, expansion, leadership, and self-renewal (Moore, 1993). In this paper, we focus on the birth phase to understand how actors leverage opportunities to attract new participants to the ecosystem. Potential partners must recognise the benefits of complementing the core of their products or enriching the product line around the platform. During the emergence of an ecosystem, actors will accomplish this goal via partnerships, acting as complementors and combining their solutions. By gradually sharing their pool of customers and accessing new segments, ecosystem participants increase their dependence and need for convergence (Dittrich, 2014). In case the software ecosystem results from the efforts of multiple partners, a keystone can emerge in this initial stage to orchestrate participants and coordinate development efforts.

2.2. Classical Power Theories

Power is a concept that has been investigated exhaustively by social scientists and philosophers. Recently, power has also be subject of study in managerial research, more specifically on firms' alliances and strategies. Power is not a property of an actor or group, but rather a construct that can be analysed more or less systematically from the viewpoint of the relationships around an actor (Dahl, 1957).

Therefore, to say that an actor has power is vacant, unless we specify over whom. It means the exercise of power and the way the relationship occurs in practice is contingent (Isaac, 1987).

The definition of power from Emerson (1962) is a common operationalisation of this construct in inter-organisational studies (Meehan and Wright, 2012). Different areas adopted Emerson's definition along time, with an increased academic interest for his work in recent years. Emerson related power to the notion of **dependence**, introducing the concept of **power relationships**. The author argued that power generally resides in the other's dependence and involves the control of what the other party values. Hence, a potential influence results from the existing dependence between two actors *X* and *Y*. The dependence of an actor *X* upon an actor *Y* is directly proportional to *X*'s motivational investment in goals mediated by *Y*, and inversely proportional to the availability of those goals to *X* outside their relationship. Therefore, we can understand power is a circumstantial and relative concept, whose exercise involves interdependence between parties (i.e. any form of interdependence between parties gives rise to power). In interfirm relationships, Leonidou et al. (2014) define the notion of dependence as the extent to which an actor *X* needs to keep a relationship with another actor *Y* to acquire resources and accomplish his goals.

In light of the previous definitions, we consider power as the ability of a company *X* to exert some sort of influence in the relationship with a company *Y*, and it is based on the dependence of *Y* upon *X*. The power of each both *X* and *Y* evolves along time (Lawler, 1992). It means the total amount of power in their relationship is not fixed, but variable. Shifts in the power of *X* or *Y* generate a redistribution of power, which shows the importance of analysing the process of power exercise. We can perform such analysis by understanding the unique power capabilities of each participant in a structured relationship.

The term **power capability** (PC) expresses an ability of a power holder to exercise power based on specific assets owned by the actor (Gaski, 1986). Examples of power capability are a company's expertise in a novel technology or ability to provide access to a profitable customer market. Each PC represents a potential for power use, as an action where an agent may use its power source(s) (Lawler, 1992) (Kim, Pinkley and Fragale, 2005) (Leonidou et al., 2014). According to Lawler (1992), unions negotiating with management have some structurally based capability to apply leverage (e.g., workers difficult to replace), for instance. These PCs vary among the firms and denote a specific power type.

French and Raven (1959) proposed a taxonomy of **power types**, which is one of the most adopted conceptualisations of power (Elias, 2008). Their power theory is widely adopted across several disciplines due to its loose conceptual framework. The understanding of power as a set of forms is suitable to analyse this construct in several domains. Their work aims to classify power in a precise manner. The proposed power taxonomy comprises five power types, which we describe in light of a relationship between two given companies *X* and *Y*:

- *Coercive power* is the perception of *Y* that *X* has the ability to punish it. For instance, threats by *X* to punish its partner *Y* by reducing profit margins if *Y* fails to comply with requests.
- *Expert power* is the perception of *Y* that *X* has some special knowledge or expertise. For instance, the specialised and unique knowledge possessed by *X*, which is needed by its partner *Y*.
- *Legitimate power* is the perception of *Y* that *X* has the right to prescribe behaviour over Y. For instance, the belief by *Y* that *X* has the right to affect its operation due to internalised values or formal processes in their relationship.
- *Referent power* is the identification of *Y* with *X*, translated in a feeling of oneness of *Y* with *X* or desire for such identity (if *X* is an attractive group, *Y* will have a desire to join in). For instance, *Y* feels pride to define a partnership with *X*, as it admires the status of *X*.
- *Reward power* is the perception of *Y* that *X* has ability to provide rewards in their relationship. For instance, the belief by *Y* that *X* can mediate rewards such as better credit terms or new joint sales.

We highlight that such forms of power may affect each other in a positive or negative manner, as well as transform over time (Wrong, 1980; Williams and Moore, 2007). For instance, once an actor exercises *coercive power*, it may directly cease its *reward power* or no longer hold the same degree of *referent power*. In other situations, the exercise of *expert power* by a firm denotes for its partner that it is able to hold *legitimate power* in their relationship (Gaski, 1986; Valença and Alves, 2017a).

We observed further developments of this taxonomy in the reviews of Raven (1993) and Elias (2008). However, their extensions proposed punctual refinements of the power types instead of presenting novel issues or paradoxes in their structure. Hence, we relied on the original taxonomy and considered relevant advances from recent literature, such as contributions from the IMP Group[1], e.g. Leonidou at al. (2014).

The diverse types of power originate from a **power source**. According to Dahl (1957), this notion is also part of a precise description of a power relationship. Power sources are tangible or intangible resources that an actor can exploit to affect the behaviour of another actor. In business relationships, possible power sources are strong reputation, large customer base or intellectual property. We highlight

[1] Industrial Marketing and Purchasing Group: international group that develops knowledge in B2B marketing and purchasing.

that one shall only consider the two sides of the relationship to identify the power types and respective sources utilised. Although companies operate in a software ecosystem, we must explore each specific partnership between two parties to identify these elements.

In a power relationship, actors may have different levels of dependence, which entails different levels of power. Since the exercise of power is circumstantial and relative, such levels may vary between parties. Emerson (1962) introduced four operations to promote structural changes in power relationships by altering the power advantage between two actors. These **power-changing operations** revolve around the idea of dependence, e.g. increase the degree of dependence of the partner on the company, or decrease the degree of dependence of the company on the partner. Such operations enable a company to deal with the power of a partner by exploring its power capabilities. We propose the power-changing operations with examples as follows, as well as illustrate their impact in Figure 2.

- *Withdrawal* occurs when *X* reduces motivational investment in goals mediated by *Y*. Hence, *X* gains power by absorbing the dependence on *Y* (A. in Figure 2). For instance, *X* neglects the complementation from *Y* by internally building the product feature previously supplied by *Y*.
- *Extension of power network* occurs when *X* cultivates alternative sources for gratification of the goals mediated by *Y*. Hence, *X* gains power by reducing its total dependence on Y and relying on other players (B. in Figure 2). For instance, *X* obtains the technical complementation previously offered by *Y* from one or more partners, which provides *X* with relationships that are more flexible.
- *Attachment* occurs when *X* mediates goals that increase the motivational investment of *Y* in the relationship. Hence, *X* gains power by increasing the dependence that *Y* has on their relationship, given new benefits provided by *X* (C. in Figure 2). For instance, *X* provides *Y* with new commercial benefits such as new customers or a wider profit margin in a joint project.
- *Coalition formation* occurs when *X* establishes coalitions that prevent *Y* from accessing alternative sources of resources to achieve its goals. Hence, *X* gains power by making *Y* more dependent on their relationship, given a reduction in the options for alternative partnerships (D. in Figure 2). For instance, *X* forms coalitions with other companies (including competitors) to deny *Y* to define substitute partners, who could offer similar commercial benefits to *Y*.

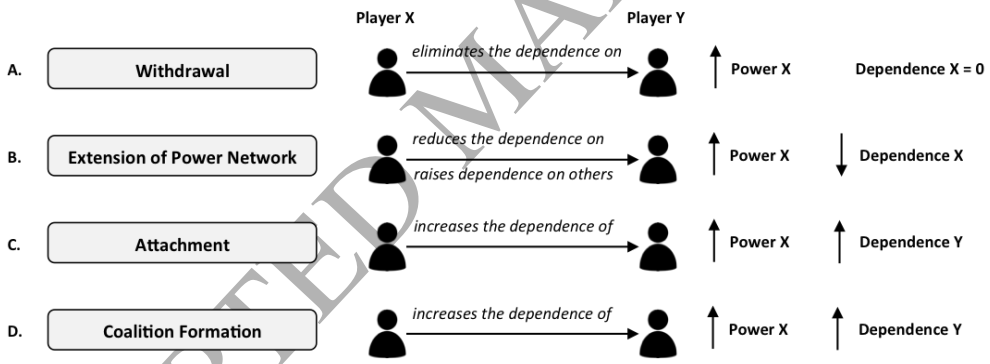

Figure 2. Effects of power-changing operations in a partnership between two software ecosystem partners.

To illustrate the application of power-changing operations, we can consider the same partner companies *X* and *Y*. In their relationship, *X* uses the large dependence of *Y* on its pool of customers to control the relationship. For instance, *X* can specify the roles and duties of suppliers in a joint project, select the strategic requirements that it will implement or establish the percentage of profits that partners will receive (Valença et al., 2014). In this scenario, *Y* can alter the power relationship by considering one or more power-changing operations. For instance, *Y* can apply *withdrawal* operation and neglect the existing dependence on *Y* by strengthening its relationship with customers or prospecting new customers in a new market niche. *Y* could also adopt the *attachment* operation by implementing a new cutting-edge technology in an integrated product, causing *X* to depend on this innovation. In these situations, *Y* can (i) exercise power capabilities that were not used in the relationship with *X* or that can be used in a different manner, or (ii) develop new power capabilities derived from other elements of the software ecosystem used as power sources. Once adopting one or more power-changing operations, *Y* ultimately undermines or changes actions in the relationship. For instance, in light of a new benefit offered to *X* (*attachment* operation), *Y* gradually changes its role in the ecosystem or increases its participation in overall decisions.

Originally, these operations were presented as means to eliminate the power advantage of a given partner by creating an ideal situation of balance, i.e. the degrees of power and mutual dependence are equal. However, Lawler (1992) showed that there is no such perfect correlation between the power capabilities of *X* and *Y*. It means that, by using a power-changing operation, *X* may gain power and *Y* may

keep its power, or *X* and *Y* may both gain power at the same time, for instance. In addition, power is rather variable. At a given point in time, *X* may gain power and balance the relationship. However, all of the sudden, *Y* may gain power and change the alleged balance of the relationship. Therefore, in this paper, we do not discuss the use of these operations as means to necessarily achieve balance, as we believe that such balanced situation is hard to achieve because it is transitory or even unnecessary.

3. Research Method

This research involved four phases, as represented in Figure 3. Between 2012 and 2017, we conducted **three exploratory case studies** with companies in emerging software ecosystems. We describe each case study in Section 3.1. The case studies encompassed the first three phases of the research, whose main results were companies' power models (Phase 1); a theory of power in ecosystems formed by SMEs (Phase 2); hypotheses explaining the dynamics of power in software ecosystems (Phase 2); and strategies to manage power in software ecosystems (Phase 3). In 2018, we concluded the research with an **expert review** to assess the proposed strategies (Phase 4). We detail these phases in Section 3.2.

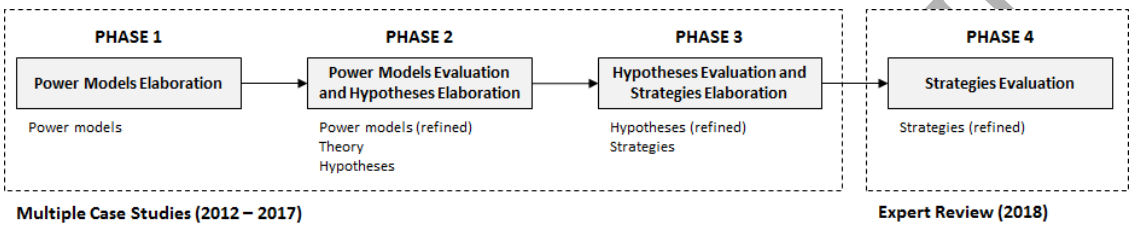

Figure 3. Research phases

3.1 Multiple Case Studies

We conducted three case studies of ecosystems formed by SMEs to investigate the partnerships among participating companies. To select the cases for this research, we considered small-to-medium sized software companies following a market-driven business model and complementing their products via partnerships by creating an emerging software ecosystem. This definition is aligned with the characteristics of a software ecosystem (cf. Section 2.1). It is worth noting that all case studies were undertaken in a sequential manner following the same research protocol. Table 1 gives an overview of CSI, CSII and CSIII, highlighting the companies and respective participants in Phases 1, 2 and 3.

Table 1. Data collection phases and respective participants from CSI, CSII and CSII.

Research phases	Phase 1 – power models elaboration	Phase 2 – power models evaluation and hypotheses elaboration	Phase 3 – hypotheses evaluation and strategies elaboration
CSI	**Company A –** project manager, business analyst, system analyst **Company B –** product manager, project manager, release manager, integration team leader, business analyst, system analyst 1, system analyst 2, tester **Company C –** services manager, project manager, business analyst **Company D –** product manager, project manager, solutions architect, system architect, system analyst **Company E** – operations and deployment director	**Company A** – project manager **Company B** – operations director **Company C** – configuration manager, innovation manager **Company D** – project manager	**Company B** – operations director **Company D** – project manager
CSII	**Company F** – sales director, marketing manager, product owner, business analyst, system analyst **Company G** – marketing manager **Company H** – operations director	**Company F** – sales director	**Company F** – sales director
CSIII	**Company I** – CEO, developer **Company J** – CEO **Company K** – CEO		**Company I** – CEO

In Table 2, we present general information about the companies involved in the case studies, such as domain and solutions developed, as well as age and number of employees.

Table 2. Software companies investigated in the multiple case studies.

Case study companies		Domain and products developed	Age	No. of employees
CSI	**Company A**	ERP with modules focused on retail chains, distributors and wholesalers markets.	32 years	100
	Company B	ERP with modules focused on several market niches.	45 years	180
	Company C	Information system with modules for pharmacies.	28 years	100
	Company D	Information systems for hospitals.	27 years	150
	Company E	Web portal for electronic quotations.	16 years	15
CSII	**Company F**	Information and management solutions with modules for hospitals and laboratories.	30 years	N/A
	Company G	Information systems for laboratories.	34 years	70
	Company H	Tools and services to modernise software systems in diverse markets.	22 years	50
CSIII	**Company I**	Functional modules, toolbox and connectors for Microsoft Dynamics CRM.	18 years	30
	Company J	Accounting and industry system.	33 years	N/A
	Company K	Insurance system.	31 years	180

3.1.1 Case Study I (CSI)

CSI involved 5 software companies based in Recife/Brazil, which are named here as Companies A, B, C, D and E. **Company A** has a portfolio of software solutions for retail chains, distributors and wholesalers markets. It defines integrations around its main product, an ERP with modules for stock supply, inventory management and tax review. In its turn, **Company B** provides around 15 software products, with an emphasis on enterprise information systems. This vendor addresses the needs from market niches such as oil and gas and logistics through an ERP, whose main module involves financial accounting and tax compliance features. **Company C** is specialised in different solutions, such as mobility and cloud computing. One of its main products in an information system for pharmacies, with storefront functionalities. In 2010, a Brazilian leader in retail management software for diverse vertical markets acquired this company. **Company D** offers an extensive product portfolio that embraces radiology and laboratory software solutions. It focuses on developing software systems for hospitals and clinics. A key module of these systems includes an electronic medical record. In 2011, a foreign

healthcare group with over a century of experience acquired this company. Finally, **Company E** supplies the healthcare market (hospitals and patient service centres) with an electronic quotation web portal that enables e-procurement and supply contract management.

Company A complements the ERP from Company B with stock supply, inventory management and tax review features. In its turn, Company B integrates the financial accounting and tax compliance features from its ERP with the information systems from Company C that automates services for pharmacies. Hence, these companies offer a complete suite for their customers. Company B also provides these features for the radiology and laboratory software solutions from Company D. Finally, Company E complements the solutions from Company D with its electronic quotation web portal. In this network, Company B and Company D are important players due to their ability to constantly involve partners in new business deals, through their representation or recommendation for customers. In particular, Company B occupies a leadership position in local IT industry. Therefore, Companies B and D are potential keystones, considering their leadership and capacity to promote co-creation of value among participants. This type of player is essential for an emerging ecosystem to thrive. In Figure 4, we represent the partnerships among these companies.

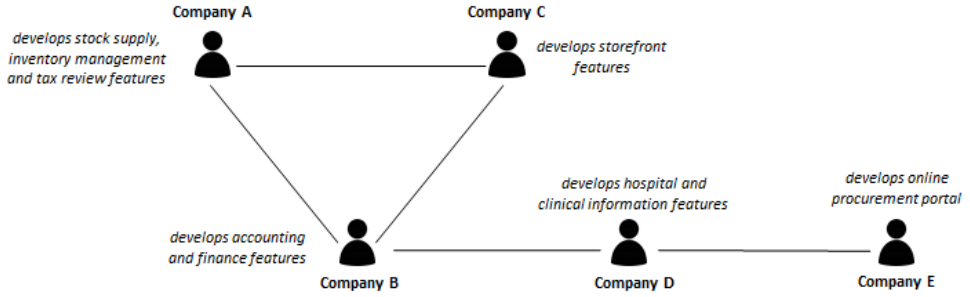

Figure 4. Partnerships between software companies from CSI.

3.1.2 Case Study II (CSII)

We performed CSII with 3 software companies here called Companies F, G and H, which are based in Recife and São Paulo/Brazil, as well as in Lisbon/Portugal. **Company F** is responsible for healthcare information management solutions for public hospitals and health insurance firms. The company offers around sixty core features including reception, billing, inventory, costs, business intelligence, clinical and laboratory areas, among others. Based in São Paulo, **Company G** operates in the diagnostics market, with a focus on laboratories. Its portfolio involves twenty information systems for laboratories. Moreover, it pioneered the development of interfacing software for integrating hospital management systems with laboratory machines in Brazil. Its portfolio embraces twenty software solutions for laboratories. Finally, **Company H** is based in Lisbon/Portugal, but has a relevant branch office in Brazil, among others in Spain, UK and USA. It develops modernisation tools for banks, insurance and healthcare firms, governments and software vendors. It is expert in solutions and services to analyse, optimise and modernise software solutions.

The partnership with Company G allows Company F to integrate its health management system with health equipment in hospitals and laboratories, considering the expertise of Company G with connectors. Finally, certifications from players such as Microsoft, IBM and Oracle enable Company H to improve the system, software architecture and development process from Company F. Company H provides services for code sanitisation and migration for Java technology. Company F is a fast growing healthcare vendor, with operations in Latin America and Africa. It gradually created an ecosystem through initiatives such as a partnership model and an initial health platform to attract small players that can leverage its system with complementary functionalities. Hence, Company F acts as an initial keystone by sharing business opportunities with partners. By collaborating with Company F, Company G can serve new clients in Brazil and abroad. In its turn, Company H depends on this partnership to grow its customer base in Brazil. Figure 5 represents the relationships among these companies.

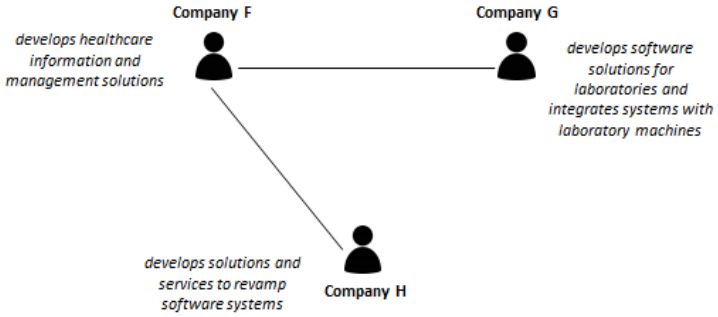

Figure 5. Partnerships between software companies from CSII.

3.1.3 Case Study III (CSIII)

CSIII involved 3 software companies based in the Netherlands, which we call Company I, J and K. **Company I** serves customers from IT and financials markets in Benelux by acting as a value-added reseller of Microsoft Dynamics CRM. Through this business model, it adapts Dynamics CRM to different verticals. It offers functional modules ('templates'), a solution to build such templates ('toolbox') and solutions that enables data exchange between Dynamics CRM and other systems ('connectors'). In its turn, **Company J** is a market leader for cloud business software in Benelux. It maintains a portfolio of accounting and industry software in the cloud for SMEs. Finally, **Company K** develops a cloud-based and modular SOA insurance system, with special policy and claim handling modules. The company offers this solution in markets from Netherlands, UK, Belgium and South Africa.

Company I has partnerships with Companies J and K. It relies on a Microsoft certification to fuel the partnerships with software integration via connectors, acting as an important niche player. Company J has an expanding network around its solutions, with a wide customer base. Company I figures as an app centre partner in this ecosystem, supplying players with extensions in the form of connectors. Company J offers these solutions in an online marketplace for customers. Finally, Company K has a platform around its insurance solution. It recommends some partners by presenting their complementary features for customers. We represent these partnerships in Figure 6.

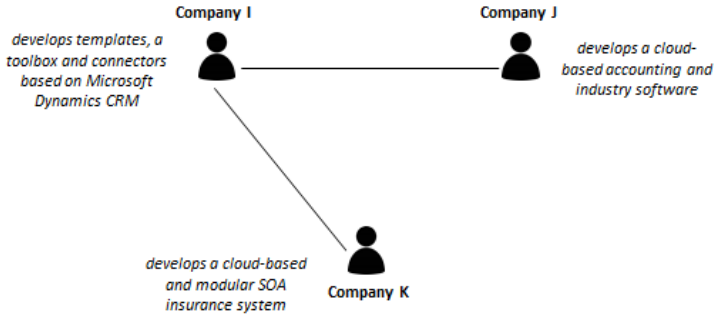

Figure 6. Partnerships between software companies from CSIII.

3.2 Research Phases

Phase 1 – Power Models Elaboration

In September 2012, we started an analysis of software ecosystems literature to map central concepts and develop the conceptual framework to adopt in our multiple case studies (cf. Section 2.1). Then, we structured the data collection protocol for the case studies, which was largely based on interviews. To select the companies and partnerships to examine, we used a snowball sampling strategy. We asked interviewees to suggest companies (and professionals, if possible) with which they collaborate in joint initiatives, such as systems integration projects. Hence, we identified participants of the ecosystems and respective relationships.

Between October 2013 and December 2015, we conducted 31 semi-structured interviews in 11 companies. Since these interviews were exploratory, we defined 40 questions embracing business, social and technical issues of partnerships. The interview protocol is available at the Appendix of (Valença and Alves, 2017a). The interviewees were professionals from technical (e.g. business analysts, developers, testers) and managerial roles (e.g. product managers, directors) (cf. Table 1 – first column). In particular, we agreed upon a nondisclosure agreement to keep data anonymously. We asked interviewees to present internal documents (e.g. requirements specifications and project management artefacts) used in system

integration projects and other joint initiatives with their partners. Besides, we explored (i) the websites of the companies to obtain information about their product portfolios and partnerships, as well as (ii) IT news portals that provided market information about companies.

Two researchers examined this dataset using thematic analysis (Cruzes and Dybå, 2011). The information was organised in themes, such as 'benefits of partnerships', 'motivation to collaborate' and 'contribution for innovation'. By verifying patterns within data, we perceived that *power* and *dependence* were relevant aspects cited along the themes. Hence, we adopted these constructs to explain the relationships among ecosystem partners. Then, we formulated the following research question (RQ1): ***how power and dependence occur in partnerships among SMEs in a software ecosystem?***

To answer this question, we studied theories from power literature to select relevant concepts to support data interpretation. We analysed the collected data from the three case studies to identify the main power capabilities of each company, which translate situations of power exercise by one party and dependence by another. We subsequently constructed *power model*s as graphical schemes that express the use of power by a company. While the first perspective of power models presents the main interactions among the power capabilities associated with a specific power type, the second perspective indicates the software ecosystem elements used to obtain power sources. All power models are available at the website https://sites.google.com/site/powerinsoftwareecosystems/. Finally, we integrated the power models of the studied companies to represent the power exercise in a software ecosystem. It is worth noting that the case studies were conducted separately and in a chronological order.

Phase 2 – Power Models Evaluation and Hypotheses Elaboration

Between December 2015 and May 2016, we evaluated the completeness and correctness of power models with studied companies from CSI and CSII. We performed confirmatory semi-structured interviews with 6 professionals from 5 companies (cf. Table 1 – second column). This phase focused on interviewing managerial roles, which generally have a global understanding of the company and engage in strategic interactions with external players. Therefore, the participants were able to identify mismatches between the created power models and their company's reality, such as omission of important power capabilities or unforeseen impacts among them (e.g. neglecting that the exercise of a given power capability promoted the exercise of another).

The confirmatory interviews aimed at evaluating the power models of each studied company as well as obtaining new information about the partnerships to deepen our understanding of power relationships. Hence, we defined a second research question (RQ2): ***what are the origins and effects of power in partnerships among SMEs in a software ecosystem?*** As a result, we derived six *hypotheses* explaining the dynamics of partnerships from a power-dependence perspective. The initial hypotheses were previously published in (Valença and Alves, 2017b).

To generate these findings, we executed the same thematic analysis procedure, codifying the data as previously done in the initial data collection. In Phase 1, we initiated the cross-case analysis among companies from CSI and CSII based on a theoretical foundation on power and software ecosystems. In Phase 2, we concluded the analysis by evaluating the final power models to generate our *Theory of Power in Emerging Software Ecosystems Formed by Small-to-Medium Enterprises* published in (Valença and Alves, 2017a). We derived the theory from CSI and CSII, and later aligned with the results of CSIII.

Phase 3 – Hypotheses Evaluation and Strategies Elaboration

Between September and October 2017, we evaluated our proposed hypotheses with the studied companies. We conducted another round of confirmatory interviews with 4 professionals from 4 companies (cf. Table 1 – third column). This investigation also involved professionals from executive roles. In particular, we sought to maintain the same participants interviewed in Phase 2, given their familiarity with the research context. Hence, we performed an incremental evaluation process by discussing the evolution of our findings with the participants.

In Appendix A, we present the interview guide used in Phase 3. In the first part of the interviews, we presented the five main power types, together with examples. In this way, we aimed to ensure that participants would interpret the hypotheses correctly. Then, we described the six hypotheses and provided rationale on how we generated them. For instance, we explained how we concluded that *expert power* was a trigger of other power types or why we recognised *reward power* as a key power type for partnerships to thrive. In Company I (CSIII), we started the interview by discussing the power capabilities aggregated in a power model. Then, we moved to discuss the hypotheses generated from the power models. This approach was needed since we did not manage to involve companies from CSIII in Phase 2.

During the interviews, we asked the opinion of participants about each hypothesis. Based on their feedback, we made necessary adjustments in the hypotheses. Interviewees also provided us with new episodes of power exercise in their partnerships, which enabled us to illustrate the hypotheses with new

evidence. For instance, Company B intends to collaborate with IBM to evolve its ERP with artificial intelligence features. Evidence such as the following reinforced our conclusion that *expert power* is a premise for the growth of partnerships (cf. H_1 in Section 5): *"we went after cutting-edge technology related to artificial intelligence; Watson is emerging in the market in several segments; so, we want to update the ERP to say it has this technology"*, explained the operations director. Section 5 presents the six hypotheses that were evaluated with participants from the case studies. For each hypothesis, we describe a few representative situations of power exercise and include excerpts of confirmatory interviews. The situations reported in the hypotheses present positive or negative outcomes of power use in partnerships.

In the second and main part of the interviews, we co-created strategies with participants from the case studies. We adopted the following research question (RQ3): ***how to manage power relationships to promote the health of software ecosystems?*** We started by asking participants if their companies needed to maintain power-balanced or unbalanced relationships with partners. Then, we discussed possible strategies for their companies to deal with partners holding different or similar levels of power. For instance, we analysed whether it was necessary to avoid dominance while collaborating with a weaker partner. To reduce bias, we only explained the power-changing operations (c.f. Section 2.2) after this initial discussion. Then, we examined if the company used one or more operations in a partnership. We aimed to discuss situations in which the power-changing operations were applied.

In this phase, we created a meta-model that integrates concepts of power and software ecosystems to guide the analysis and synthesis of our proposed strategies to manage power relationships in software ecosystems. The meta-model is discussed in Section 5.1. To ensure the rigour of data analysis, one researcher generated the interview transcripts, which were organised with the same coding procedure performed in our previous data collection (cf. Phase 1 – Power Models Elaboration). The themes reflect the key constructs of the meta-model, which are the taxonomy of power types (i.e. *coercive*, *expert*, *legitimate*, *referent* and *reward power*), the power-changing operations (i.e. *withdrawal*, *extension of power network*, *attachment* and *coalition formation*), the notion of power balancing as well as the software ecosystems dimensions (*social*, *business*, *technical*) and health (*niche creation*, *robustness*, *productivity*). Two researchers individually analysed each theme and created memos to register insights, which guided the discussions of findings with the other researchers. During this step, we also selected relevant quotes from interviewees to provide empirical evidence to support the proposed strategies. Therefore, the strategies were generated keeping a chain of evidence.

The strategies reinforce or adjust the decisions of companies about power use in software ecosystems. For instance, we proposed *"$S_{1.2}$ – Rely on the expertise of multiple competing actors"* to address situations such as the following one reported by Company D. This player ceased a representation agreement with Company B and selected an alternative supplier to obtain the same expertise of the previous partner, which was the sole provider of a financial-accounting module in an integrated software solution running in several clients. Section 5 explains the generated strategies to manage power relationships. In total, we identified eleven strategies that were associated to the six hypotheses. The strategies are supported by some quotes from the interviews and enriched with references from the literature that corroborate them.

Phase 4 – Strategies Evaluation

To assess the proposed strategies, we performed an expert opinion study between February and March 2018. Our goal was to use the experience of professionals to judge the potential applicability of the strategies and discuss the effects of power in software ecosystem. In an expert opinion study, participants must to understand the proposal, foresee realistic problem contexts and predict the results (Wieringa. 2014). We designed the study with Google Forms and divided it in three parts: (i) personal information (cf. Table 3); (ii) key concepts on power; and (iii) strategies to manage power in software ecosystems. The second part of the questionnaire explained the notions of power and dependence, while the third one presented the list of hypotheses and respective strategies.

The experts had to indicate their level of agreement with each of the eleven proposed strategies according to a Likert scale ranging from "strongly agree" to "strongly disagree". We also provided an open field in each strategy for participants to comment on the feasibility and completeness of the strategy, as well as to give examples or suggestions for its application. In particular, we asked experts to take a wider viewpoint on software ecosystems while responding by considering their experience with any small or large commercial ecosystem (e.g. Microsoft, SAP, Amazon). This approach allowed us to enrich and amplify the scope of this research, since our three case studies focused on the context of SMEs.

We invited 24 experts based on their contribution to software ecosystems research (e.g. researchers with highly cited papers or frequent involvement in program committees of software ecosystems conferences) and practice (e.g. consultants with courses on software ecosystems, practitioners involved with platform design and market analysis). In the end, 12 experts answered the questionnaire (Table 3).

Table 3. Participants of the expert opinion study.

ID	Country	Highest academic degree	Field of work	Experience with software ecosystems (years)
01	Belgium	PhD	Academia	2
02	Brazil	PhD	Academia	5
03	Brazil	PhD	Academia	2
04	Brazil	MSc	Academia	5
05	Brazil	PhD	Academia	10
06	Canada	PhD	Academia	10
07	Canada	PhD	Academia, Industry	2
08	Colombia	PhD	Academia	5
09	Germany	PhD	Industry	20
10	Netherlands	PhD	Academia	15
11	Sweden	PhD	Academia	5
12	Sweden	PhD	Academia	6

To analyse the scaled responses, we considered the following rationale. We maintained all strategies with more than 50% of acceptance, i.e. sum of responses 'agree' and 'strongly agree'. Similarly, if one strategy received more than 50% of rejection, we removed it from the set of proposed strategies. We examined the comments in the open fields provided by participants, which were organised in themes such as "suggestions for improvement" or "illustrative situations of strategy application". In Appendix B, we present the analysis of the expert review, including all the comments given by the experts. We also discuss the actions taken to address experts' comments. We highlight the strategies described in Section 5 are in their final version, with refinements performed after their evaluation by the experts.

4. Power Model of a Case Company

To illustrate the analysis of power relationships in the studied companies, we present the power model of Company K from CSIII. Company K is a rich example due to its goal to rely on partners to increase its scope of operation in the Dutch competitive software industry. This player tries to leverage partners by increasing the volume of joint sales, but it may also punish them in case of a negative influence on ecosystem performance. Such dynamics denotes that Company K recognises what is valuable for partnerships with complementors: a proper win-win approach.

In Figure 7, we present the different forms of power exercised by Company K in the relationships with partners such as Company I. This scheme shows the first perspective of the power model from Company K, which highlights the positive and negative interactions among power types. It means that each power type may promote/reinforce or hinder the occurrence of other power types. In (Valença and Alves, 2017a), we present a detailed explanation of the power models. The scheme reveals the relevance of *expert power*, which pioneers most power forms exercised by Company K. Once exercised, *expert power* tends to reinforce or give rise to other power types. The partnerships are defined due to the specialised knowledge of Company K in the insurance domain, with an ERP system that holds an established market presence (EX_CK_01).

By investing in *expert power* capabilities, Company K reinforces its strong market position in the insurance domain. It enables the company to reach big customers (EX_CK_02) and share such customer base with partners, due to the creation of new business opportunities (RW_CK_01). *"We provide access to new markets for them"*, explained the company's CEO. During pre-sales phase, Company K enables partners to demonstrate their products to potential customers in specific workshops: *"sometimes we conduct up to 20 workshops; it is a complete process where our partners will be involved"*, explained the CEO of the company. By including players in new business deals, Company K also highlights for them its wide customer base and importance in local IT industry. A negative effect caused by the *coercive power* (CO_CK_01) of Company K is weakening its *reward power* (RW_CD_01). Company K substitutes a partner and stops sharing business deals if the partner may damage the image of the product due to quality issues. It means that restrictions or other negative attitudes of the company undermine its ability to offer benefits.

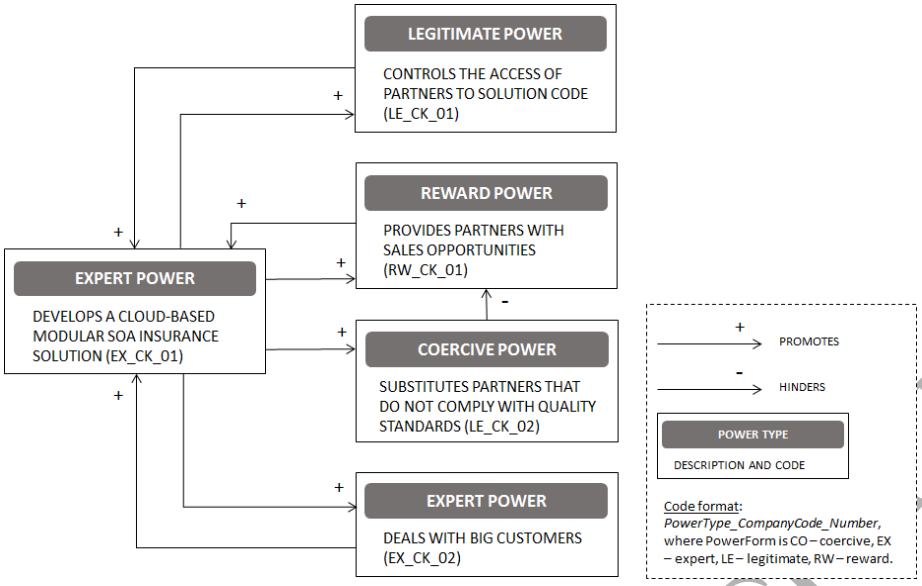

Figure 7. Power model of Company K – first perspective (interactions among PCs).

In Figure 8, we represent the second perspective of the power model from Company K. This scheme presents the main sources of power that the company derives from elements of the business, technical, and social dimensions of the software ecosystem. We provide a complete explanation of these elements in (Valença and Alves, 2017a). We can derive from this scheme that *skill* (EX_CK_01, EX_CK_02) and *technical orchestration* (CO_CK_01, LE_CK_01) are the elements most employed by Company K to exercise power. For instance, Company K uses its expertise and a technical orchestration mechanism to exercise the *legitimate power* of controlling the access of partners to the software code (LE_CK_01). With closer partnerships, the company aims to allow partners to adjust features and business rules of the insurance solution. However, it will restrict access to the back office, as described by the CEO of Company K: *"we are considering (to open) the mid and front end of the solution"*. By sharing this privileged information with partners, the company enables them to improve their contribution as complementors and paves the way for a growing ecosystem.

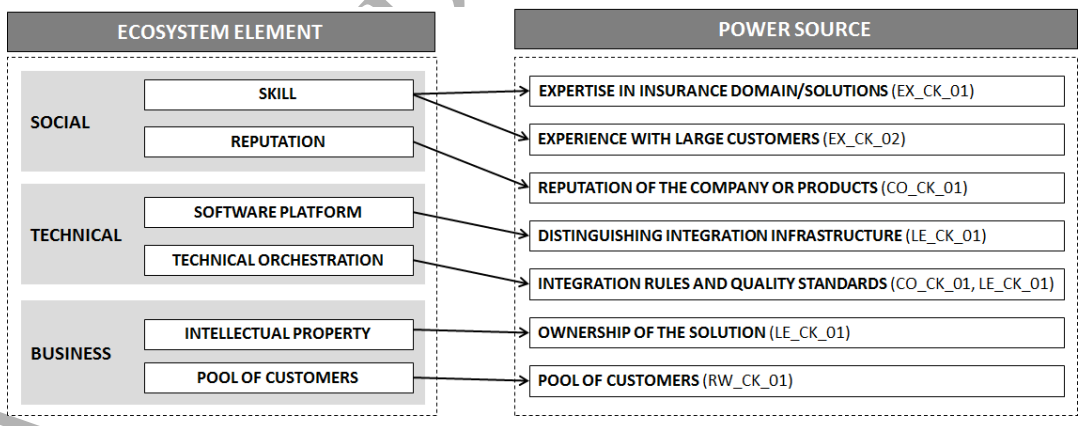

Figure 8. Power model of Company K – second perspective (ecosystem elements used as sources of power).

5. Strategies for the Healthy Exercise of Power in Software Ecosystems

In this section, we describe the findings regarding the dynamics of power relationships in software ecosystems obtained during the execution of the multiple case studies. In (Valença and Alves, 2017b), we presented a preliminary version of the following six hypotheses, which were generated from our rigorous cross-case analysis of the power models of studied companies. These hypotheses synthesise the observed use of the different power forms by companies in emerging ecosystems.

In this paper, we explore the hypotheses in more detail. As a novel contribution, we propose strategies for companies to exercise power in a healthy manner (Table 4). We derived the strategies from empirical evidence (cf. Phase 3 in Section 3.2), and later assessed them via an expert review with professionals

from academia and industry (cf. Phase 4 in Section 3.2). The strategies describe the application of power-changing operations (c.f. Section 2.2). They are supported by quotes from interviewees and inputs from the literature to clarify our arguments. We argue the effective exercise of power fosters the success of partnerships and the prosperous evolution of the software ecosystem.

Table 4. Hypotheses for power exercise and respective strategies to manage power in software ecosystems.

Hypotheses	**Strategies**
H_1 – Expert power enables partners to co-create value via complementation (Section 5.1)	$S_{1.1}$ – Continuously invest in expert power to foster partnership continuity. $S_{1.2}$ – Rely on the expertise of multiple competing actors.
H_2 – Coercive power causes companies migration by weakening partnerships (Section 5.2)	$S_{2.1}$ – Avoid using coercive power to apply severe punishments. $S_{2.2}$ – Anticipate negative actions in contracts and general rules that guide partnerships.
H_3 – Reward power enables partners to jointly satisfy business goals (Section 5.3)	S_3 – Guarantee that business benefits are shared to maintain the value of partnerships.
H_4 – Legitimate power establishes rules and roles in partnerships (Section 5.4)	$S_{4.1}$ – Define agreements that promote the definition of roles in the ecosystem. $S_{4.2}$ – Use authority to reconcile partners' interests and increase their satisfaction.
H_5 – Referent power attracts partners to the ecosystem (Section 5.5)	$S_{5.1}$ – Exercise referent power in combination with other power types. $S_{5.2}$ – Use referent power to influence other companies and orchestrate the software ecosystem.
H_6 – Power is fluid in a software ecosystem of SMEs (Section 5.6)	$S_{6.1}$ – Reinforce capabilities that allow the exercise of diverse power types. $S_{6.2}$ – Take advantage from both balanced and unbalanced power relationships.

5.1 Meta-Model of Power Relationships in Software Ecosystems

In Figure 9, we propose a meta-model that integrates concepts from software ecosystems and power literature. We employed the meta-model as a conceptual framework to elaborate and explain the proposed strategies. The meta-model indicates that a company exercises power over partners at the same time that it depends on other companies in the ecosystem. A company uses power sources to obtain power capabilities that enable it to exercise power in partnerships. The elements of the ecosystem belong to social, business or technical dimensions, and they provide sources of power that a company can utilise. Each power capability is associated with a given power type, which can be classified as referent, coercive, expert, legitimate, and reward power. To manage its position and role in the ecosystem, a company manages its power capabilities by employing strategies based on different power-changing operations, i.e. attachment, extension of power network, coalition formation, and withdrawal. These operations enable companies to modify the current state of power relationships in the software ecosystem. The strategies shall not simply eliminate competition or block particular value channels in the software ecosystem. Ultimately, they aim at increasing the health of the ecosystem, and the health is measured by means of niche creation, robustness and productivity. We highlight that even though a particular company might have a power source, it may not necessarily use it to have a power capability and then exercise power. Similarly, a company may have untapped power sources, i.e. situations in the ecosystem not yet explored to obtain sources of power. In the following sections, we discuss the proposed hypotheses and strategies.

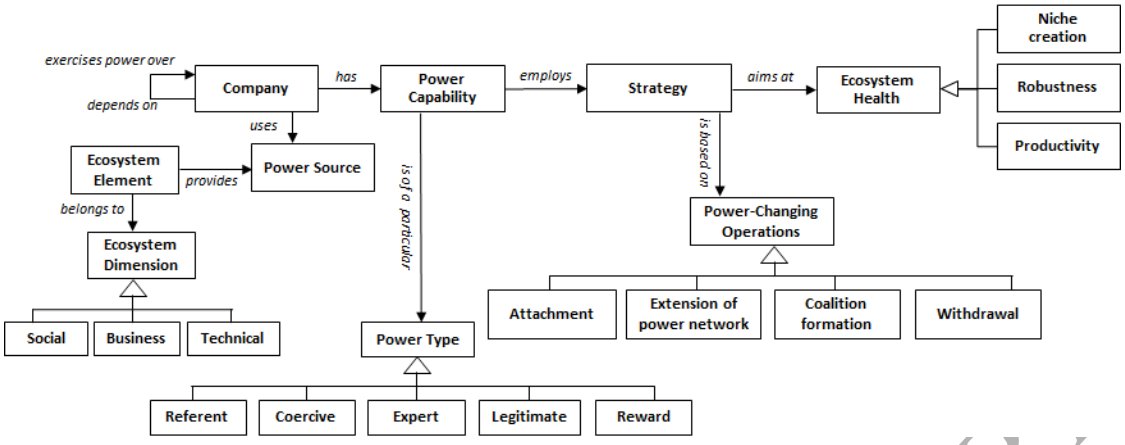

Figure 9. Meta-model describing the relationships among the constructs used in this research.

5.2 H_1 – *Expert power* enables partners to co-create value via complementation

Expert power is the primary form of power that companies exercise in a software ecosystem. By expressing one or more forms of knowledge, such as technological, commercial or managerial expertise, companies raise the trust of other players and promote new partnerships. This power type reflects the elementary motivation for companies to be complemented by partners that have knowledge of a specific system or technology, market domain or type of joint project. Hence, *expert power* acts as a premise for companies to start a collaboration and co-create value. Besides, this power type is the precursor of most power capabilities held by companies in their partnerships. *Expert power* can evolve to other power types, e.g. an actor may transform persuasion (*expert power*) into authority (*legitimate power*) due to formalised expert roles in a partnership. Hence, we observed that *expert power* is responsible for the majority of power transitions in the ecosystems. It denotes the fact that the exercise of a power can be the source of other power types, as observed by Wrong (1980).

As exemplified in Figure 8, *expert power* mainly originates from the skills of a company. Figure 7 shows that it enables a company to obtain simple rights, such as regulating the access of partner to solution code (LE_CK_01). By exercising *expert power*, a company may also pave the way to obtain important prerogatives in the partnership. A company may gain the right to coordinate partners in systems integration projects due to its knowledge (e.g. experience with a client or joint project), in a typical situation of role-based power (Han et al., 2017). We observed an increase or gain of *legitimate power* via *expert power*. Another relevant power transition illustrated in Figure 7 is from *expert power* to *reward power* (RW_CK_01). It shows the capacity of SMEs to share business deals with partners.

Strategies related to H_1

In a software ecosystem, companies must recognise the need to strengthen their skills, as synthesised by the CEO of Company I: *"expert power is the most important; I would call it 'impact power'"*. Players should not only highlight their expertise to impress potential partners during initial conversations. This must be a continuous practice along the partnership. A representative situation occurred in the partnership between Company B and Company D. Company D used to complement its hospital information system with the financial-accounting module of Company B, recommending this partner for clients. *"When we go to the client, we put on the table the option of Company B"*, reported the project manager from Company D. However, Company B did not invest in product quality and customer assistance, with barely any involvement to resolve problems of systems integration. Company B did not recognise its expertise as a pillar of the partnership. Such attitude affected Company B's image as expert. Company B negligence gradually weakened the joint sales process. It forced Company D to cease the representation agreement and invite alternative suppliers to new projects, as the system analyst of the company explained: *"we no longer recommend Company B; (in fact, we) back to recommend only the software from its competitor"*. The CEO of Company I also endorsed this action: *"customers will dump us with authority if we do not sell them the best of the best; (hence,) we need to recommend the best to our customers; otherwise, we lose expert power with them"*.

However, Company D decided not to eliminate such dependence on a partner in order to keep focused on the healthcare domain, instead of developing extra modules that are outside of its core business. The commercial director of Company F also reinforced this tendency of not eliminating such dependence, given the impact on company operation: *"discarding (a partner product) is more radical, because you will have to be alone (and make the solution yourself)"*. This scenario shows that companies do not

follow a process of independence but rather of complementation, as argued by the CEO of Company I: *"software is part of a chain; you have to excel in one domain; we have to work together; integration is critical success factor*". In light of that, we propose the strategies $S_{1.1}$ and $S_{1.2.}$

- ***$S_{1.1}$ – Continuously invest in expert power to foster partnership continuity.***

We observed that *expert power* is a critical asset for companies to hold in an ecosystem. Once they exercise *expert power* over a partner, the latter will value such knowledge and it will naturally invest in a closer relationship (Maloni and Benton, 2000). Hence, this power type may promote several positive aspects of interfirm relationships. For instance, higher levels of *expert power* are associated with higher levels of trust, satisfaction and coordination (Sahadev, 2005; Leonidou et al., 2014). Moreover, this is a sustainable power type, since companies can nurture it by absorbing knowledge about the product, market or clients on an ongoing basis in the software ecosystem.

We observed that *expert power* is also the basis for companies to provide partners with new benefits on the course of their collaboration. Thereby, actors can apply *attachment* operation whenever they intend to increase their power in partnerships, given a greater dependence of partners on such advantages. Finally, we highlight that a stronger expertise allows companies to define new complements, projects or business models, stimulating niche creation in the software ecosystem.

- ***$S_{1.2}$ – Rely on the expertise of multiple competing actors.***

By relying on the expertise of alternative complementors, companies embrace a safer and productive approach for partnerships. Company D recognised the risks of depending on a noncompliant partner, which could negatively influence the perception of clients regarding its healthcare solution given the seamless boundary between integrated systems. It means that the *expert power* of a partner is certainly a benefit for the collaboration, but holding a high dependence on such knowledge may be imprudent. Hence, Company D also maintained a partnership with a competitor of Company B. Company D applied the *extension of power network* operation and sought companies offering solutions similar to those provided by Company B. This operation is fundamental in case of less tenable relationships. It is also useful when a company concentrates a given expertise and uses it to manipulate other companies in the ecosystem. The presence of alternative vendors creates a productive tension in the relationships by enabling a partner to intimidate this company and reduce its power. Besides, the entrance of new players promotes community growth, strengthening the robustness of the ecosystem.

Frequently, studied companies are not able to apply the *withdrawal* operation when facing situations similar to that of Company D in their ecosystems. For SMEs, discarding a partner implies on the need to gain expertise in other fields, which is something costly, time-consuming and against their strategy to be complemented. The *withdrawal* operation represents an ultimate solution that companies only adopt when they decide to enter the niche market in which the partner acts, i.e. the company starts to see the partner as a predator (Moore, 1993). In general, SMEs consider such dependence on expert companies as positive, since it symbolises the positive complementation that allows joint growth. To avoid risks, companies can invest in the *attachment* operation by mediating additional gains for a partner, regulating the dependence of the other party on shared benefits. Hence, it increases the co-dependence and deepens the bond between partners.

5.2 H_2 – *Coercive power* causes companies migration by weakening partnerships

We observed that Company A, Company D and Company F are the only players able to exercise *coercive power*. They tend to use this power type only when facing recurrent problems caused by a partner, e.g. lack of communication that delays a project, negligence to solve integration issues that affect client satisfaction. These companies stop inviting the partner to integration projects, no longer sharing business opportunities. In this case, they reduce or cease *reward power*. Company D and Company F also noticed their *referent power* affected by the negative attitude involved in the use of *coercive power* due to changes in the perception of partners (e.g. reduce the admiration of partners for the company).

To prompt *coercive power* actions, companies can use their *expert power*. For instance, the need to safeguard its good reputation in the market and the image of its products causes Company K to use *coercive power* over incompliant partners. We conclude that other companies could use such rationale of protecting the image of their product and their own image as suppliers to exercise *coercive power* over partners. In turn, this attitude would weaken collaborations. Hence, holding this power capability is rather a choice of SMEs. To do so, they must consider their degree of dependence on a partner (e.g. need to access the customer base of a partner or need to complement its product). However, the studied companies tend to avoid using *coercive power*, either because they do not hold the sources of *coercive power* or because they attempt to engage in a "nice manner" with partners.

Strategies related to H_2

The operations director of Company B revealed that partners are hardly substituted once systems are integrated, considering the dependence on the external software and, consequently, the negative impact for the clients operation. Supplier change occurs in case of critical technical flaws or due to client requests. The company then tries to substitute the partner in the specific client(s), according to the operations director: *"(if) the system starts to give much trouble, we might remove (the partner) in this case but keep the partnership; if this client complains too much, we put another (vendor), but the partnership continues in other clients"*. Only when Company B decides to end a partnership, it starts to recognise the partner as a competitor again. Thereby, the company defines alliances with customers to change the solution of the partner for that of a different supplier.

Except for such specific cases, companies rarely apply severe penalties over partners. Instead, we perceived an overall sparse and soft exercise of *coercive power*. The rationale for this decision is threefold. First, companies keep a high mutual dependence on their partners, as explained by the project manager of Company D: *"even in face of problems, we try to reach a common place together, because we are always depending (on each other); this is what happens in most cases"*. Second, companies believe they can lose *referent power* when punishing partners, as cited by the commercial director of Company F: *"if I fight with my partners, I create a negative image of Company F in the market"*. Finally, companies recognise that the problems caused by a partner stem from the (i) low maturity of the ecosystem, and (ii) restrictions faced by SMEs that have low availability of financial resources and teams that are not exclusively dedicated to joint projects. *"Sometimes it (partner firm) does not give (attention to an issue) due to lack of resources; for some reason, it cannot offer the attention that the customer is demanding"*, described the operations director of Company B. Based on this context, we propose $S_{2.1}$ and $S_{2.2}$.

- ***$S_{2.1}$ – Avoid using coercive power to apply severe punishments.***

Coercive power is a destructive power type, which may harm the buyer-supplier relationship (Maloni and Beton, 2000). We can easily differentiate it from other types of power because it involves potential punishments (Hunt and Nevin, 1974). The exercise of this power has a negative impact on *expert*, *legitimate*, *referent* and *reward power* (Gaski, 1986). Companies use *coercive power* as penalties that negatively affect the financial support that one party offers to another in a relationship (Etgar, Cadotte and Robinson, 1978). We perceived these facts in practice, since few companies apply *coercive power* by reducing benefits before any ultimate solution for a partnership. Some of them adopt *coalition formation* operation, having customers as allies to gradually remove a partner from the network. Such lack of *coercive power* is the correct approach for SMEs to follow in a maturing ecosystem. This is even more important in the birth phase, when the network is instable and relies on strong relationships to evolve (Moore, 1993). Negative attitudes of a coercive player can damage value co-creation via joint initiatives among partners, decreasing ecosystem productivity. Critical punishments may ultimately cause the migration of partners to other networks, harming ecosystem robustness. A company must invest in collaborations with similar complementors to decrease the impact of problems originated by a partner in joint projects. By adopting *extension of power network* operation, companies assure a safer degree of dependence on a partner. Such pool of suppliers can enable a faster and punctual substitution of a partner.

- ***$S_{2.2}$ – Anticipate negative actions in contracts and general rules that guide partnerships.***

We recommend that companies transform existing sources of *coercive power* into *legitimate power* by defining disciplinary sanctions, which will act as rules to guide partners' interaction. This social orchestration mechanism (Valença and Alves, 2017a) prevents that negative attitudes sound arbitrary, which could cause a player to lose *referent power* once partners regard it as dominator. Eventual punishments could be previously discussed as part of contractual rights and obligations, for instance.

Company B follows this strategy in contracts in which it acts as a value-added reseller. The company figures as a sole supplier for clients and defines partners as hidden complementors. In these cases, a service level agreement allows the company to impose fines for non-compliant partners. We suggest that SMEs avoid economic-related punishment due to the extreme importance of business deals for SMEs to survive. In particular, companies need to recognise the importance of trustful relationships. Rules can be altered in the course of the relationship, with the evolution of the partnership and the ecosystem. Companies must analyse the feedback from the community of partners regarding current rules as well as observe whether such rules are affecting the ecosystem robustness. A decreasing number of participants may denote that overall rules are too strict.

5.3 H_3 – *Reward power* enables partners to jointly satisfy business goals

Companies expect several advantages when collaborating in a software ecosystem (Kude, Dibbern and Heinzl, 2012). Players that directly and intentionally provide such benefits are exercising *reward power*, which is a power type that we perceived in all case studies. Our analysis revealed that most companies use some form of *reward power* in their partnerships, often triggered by their *expert power*. Although the number of *reward power* capabilities per company can be short, their impact is strong. As

illustrated in Figure 7, Company K shares business opportunities with partners (RW_CK_01) through its pool of customers (Figure 8), which is a means for partners to obtain financial gratifications and increase their revenue. Other studied companies benefit partners by offering strategic market information or guidance for product adaptation to a specific field, for instance. In addition, we noticed that power capabilities related to other power types also derive from the exercise of *reward power*. When *reward power* was used, it boosted the *expert power* of Company K. This was due to the perception of partners that the shared pool of customers resulted from the attractiveness of the company in the market.

Strategy related to H_3

By investing in *reward power*, companies can fulfil each other's expectations. This is particularly important in software ecosystems formed by SMEs, which players have with few customers and limited resources to offer. The operations director of Company B emphasised the relevance of this situation, positioning business advantages as a foundation of any collaboration with another player. *"There must be a reward; we are going to define a partnership to conquer the market; if this is not achieved, the partnership will be undone; there is no reason to collaborate without benefits or results for both parties, even because we do not have enough resources to wait a long time"*. He argued that customer base sharing is a benefit that indeed attracts other companies: *"when they (companies) come to us, what they are looking for is the pool of customers; we can take the partner to those clients"*. The project manager of Company D cited that a particular partner could modify the systems integration protocol because it brought new customers to the ecosystem: *"we had money in front of us, an important (customer) base; so, we thought 'we cannot lose this business (deal) because of that (technical) formalism; we will adapt to the protocol of the other company"*. Therefore, *reward power* addresses the need for a win-win approach. It also provides a company with bargaining power, as stressed by the commercial director of Company F. *"Since we have this power (that is, we have customers in our hands), we are going to demand a fee for companies to access it; they have to bring a benefit for us"*. Therefore, a company that regularly exercises *reward power* can improve its negotiations by increasing the flexibility of partners due to their dependence. Considering this context, we propose the strategy S_3 as follows.

- ***S_3 – Guarantee that business benefits are shared to maintain the value of partnerships.***

The exercise of *reward power* involves offering some sort of compensation (Elias, 2008). Examples of advantages are sharing advertising expenses and providing specialised market data. Nevertheless, the main use of *reward power* arises from an actor's ability to leverage the volume of business opportunities (Blois and Lacote, 2009; Finne, Turunen and Eloranta, 2015). We observed that promoting new sales via a shared customer base is a paramount aspect of interfirm relationships. By involving partners in commercial deals, companies fuel ecosystem economics and positively affect its robustness (Amorim et al., 2017). Moreover, the joint projects enable the development of integrated solutions to access new consumer market segments, which also raises niche creation and productivity in the ecosystem.

While *expert power* is a premise for a partnership to exist, *reward power* is both a pre-requisite and a confirmation of partnership relevance. In the absence of a joint sales process, the collaboration is no longer fruitful. To remain in the software ecosystem, companies (particularly SMEs) expect a steady flow of business rewards in the form of mutual recommendations or representation by partners, for instance. Players who increasingly share business opportunities keep partners closely linked. For instance, Company F understands that it can gain more control over a relationship by adopting the *attachment* operation. It is keen to consolidate its position as main vendor of healthcare solutions for members of the Brazilian Association of Private Hospitals (BAPH). Currently, Company F sponsors all events organised by BAPH. In addition, the company intends to provide the members of the association with new benefits (e.g. automatic integration between the healthcare systems and BAPH database, free offer of an indicator management system, etc.). These benefits facilitate business deals and foster fidelity of big clients.

Rewards are means for a partner to be satisfied with the collaboration. By giving a partner something of value, a company enhances cooperation, productivity, and satisfaction, while reducing conflicts in a relationship (Wilkinson, 1973; Leonidou et al., 2014). On the other hand, rewards enable a company to gain power by raising the dependence of the other party. This situation is a seed for rather imbalanced power relationships, with fertile ground for excessive control and dominance of one player over the others. However, if a weaker company aims to reduce such dependence on the powerholder, it can adopt the *extension of power network* operation to obtain similar benefits from other players. Alternately, it can employ the *withdrawal* operation, neglecting some of the benefits promised by the powerholder partner.

5.4 H_4 – *Legitimate power* establishes rules and roles in partnerships

The notion of *legitimate power* denotes a justifiable right of an actor to request compliance from another actor (Elias, 2008). In particular, the factors underpinning this power type can be specific (e.g. a firm's technological expertise) or diffuse (e.g. the size of the firm) (Blois and Lacoste, 2009). We

identified several situations that *legitimate power* is used in the studied software ecosystems. Many of them are supported by the knowledge of a company. For instance, Company K uses its expertise as a prerogative to establish the level of access of partner to the code of its software solution (LE_CK_01), as shown in Figure 7. *Legitimate power* can be reinforced by the *reward power* of a company who shares business opportunities. In this case, the company's authority emerges as a counterpart of the benefits offered to a partner. Hence, it helps the company to gain leadership and control in the whole ecosystem. In general, all power types can transform into *legitimate power*, which can result from multiple power sources (e.g. expertise in the technology, type of solution or domain; or the reputation of a company or products), as represented in Figure 8.

Strategies related to H_4

The origin of *legitimate power* from multiple sources increases its availability in the partnerships. The frequent presence of legitimate power in the studied companies indicates that this power type is more easily exercised when the SMEs achieve a certain position or role in the ecosystem. Frequently, the importance of the resulting right depends on the power source. Those that are more common or easy to obtain provide players with simple rights, which delineate the rules underlying the partnerships. A company that has knowledge of a specific domain gains the natural right to implement the system requirements for that domain. For instance, Company I has the *legitimate power* to define the roadmap of the solutions provided to the ecosystem due to its specific expertise with connectors and CRM.

However, some power sources are too specific, scarce and valuable. It is the case of a big client or wide pool of customers (when *reward power* promotes *legitimate power*), the robustness of a system with diverse and strategic functionalities (when *expert power* promotes *legitimate power*) or the relevant status of a company (when *referent power* promotes *legitimate power*). Hence, holding such sources of power provides a company with superior competitive advantage. The *legitimate power* generated by these power sources does not provide the company with a simple right. It often grants the company with a position in the ecosystem. Company D and Company F develop healthcare systems with several modules, which occupy a wide scope among IT solutions within hospitals and laboratories. Normally, both companies figure as main suppliers of the health ecosystem they created. The project manager of Company D relate its *expert power*, *reward* power and *referent power* to explain this fact: *"we are a player whose coverage within a hospital is always greater than that of other suppliers; partners seeking Company D serve part of the hospital; for this reason, we always have greater power to decide, impose..."*. In this context, the company holds the right to manage the integration project and coordinate partners. Therefore, its *legitimate power* drives the definition of roles in relationships within the software ecosystem. Considering these facts, we propose the strategies $S_{4.1}$ and $S_{4.2}$.

- ***$S_{4.1}$ – Define agreements that promote the definition of roles in the ecosystem.***

Legitimate power refers to formal or informal agreements between actors (Leonidou et al., 2014). Studied companies that commonly occupy a leading position in the emerging ecosystems have gradually matured their agreements with partners. To exercise *legitimate power* properly, they have developed formal agreements to establish the responsibilities of partners in joint projects. It is the case of Company B in a specific type of contract in which it figures as a value added-reseller. Recently, Company F started to employ such agreements in a strategic manner. It structured a partner certification program, through which players receive a 'powered by Company F' label to denote the compatibility of their products with the solutions of the company. In particular, all partners must go through this certification procedure, which is conducted by the 'integration and partnerships' department of Company F. Hence, partners under the umbrella of Company F are associated with a specific role in the systems integration projects. This is the seed of a wider partnership model, such as the one designed by Company J. This company provides partners with technical support by offering free access to APIs, workshops and developer resources, as well as commercial support by promoting and publishing partners' apps in a marketplace available for its customer base. In particular, smaller companies appreciate these certifications and partnership models because these mechanisms increase their ties with larger players. Consequently, these actions boost the robustness of the ecosystem.

Partnership models also describe the rights and duties assigned to players, translating the scope of their power and creating an organised view of responsibilities. Hence, such models facilitate the collaboration among partners in joint initiatives. These actions are fundamental for the orchestration of players and establish the governance of the ecosystem. Companies can explore agreements to define software development processes and propose innovative business models for the ecosystem, increasing productivity. Moreover, the agreements are a source of predefined and specific advantages for partners, which enable the constant use of the *attachment* operation by the companies. The certification process often related to such agreements requires some sort of investment (time, money, etc.) by the partner, raising not just the dependence on the other party but also the trust and commitment with the relationship

(Chang et al., 2015). Therefore, we perceive that *legitimate power* can be used to specify suitable roles and guarantee their congruence (Zhuang and Zhou, 2004). It is a fruitful power form to coordinate ecosystem value chain.

- ***$S_{4.2}$ – Use authority to reconcile partners' interests and increase their satisfaction.***

The relevance of a leading position lies in the strategic role associated with a company, which is a source of several prerogatives for the powerholder company. In this case, the company derives *legitimate power* capabilities that others in less powerful positions do not hold. Such legitimate authority enables companies to manage potential conflicts and solve unfruitful battles in the ecosystem. However, some players use their authority in a dominant manner, as highlighted in $S_{3.2}$.

Company I faced threats and inflexible attitudes in a joint project it acted as complementor. According to its CEO, the controlling behaviour of the partner, who followed the approach 'my way or the highway', caused Company I to leave the partnership. Company I decided to adopt a software platform from a competing vendor. It clearly employed the *extension of power network* to deal with the negative power exercise of the former partner. The company migrated to Microsoft's ecosystem and currently uses Azure technology to develop its solutions.

The previous example highlights that a hierarchically superior actor can refer to obligations cited in the agreement to force a partner to perform actions against its goals (Leonidou et al., 2014), with negative outcomes for ecosystem health. In this case, *legitimate power* reveals the common interpretation of power as an observable dominance of one actor over others (Wrong, 1980). We stress that companies must recognise the need for cooperation in a software ecosystem, whose network of interdependent players requires the achievement of multiple goals and shared decision-making.

5.5 H_5 – *Referent power* attracts partners to the ecosystem

The reputation or status of a company is the origin of its *referent power*. In our studies, we perceived that this is a very strong power type, which can promote or be promoted by multiple power types, such as *expert power* and *legitimate power*. However, the sources of *referent power* are not accessible for all players, as it requires that companies have a certain level of maturity. Thereby, only a few companies own *referent power*, i.e. Company D, Company F and Company G. For instance, Company D explores its *referent power* when negotiating the leadership of a joint project or defining the integration infrastructure with partners. Instead of solely stressing its expertise with a particular segment or the benefits brought by the business deal shared with partners, the company also uses arguments during negotiations that highlight its status and strong reputation. Thereby, *referent power* is a key factor for decision-making. In particular, raising capabilities that allow companies to exercise *referent power* is rather strategic in ecosystems formed by SMEs, because these companies generally do not hold this asset.

Strategies related to H_5

Referent power is associated with a company that hold strong respect and trust from other vendors due to its reputation in a given market segment or in the software industry as a whole. Consequently, this power type helps companies to attract others that seek visibility through a partnership with a player holding a relevant position. The project manager from Company D illustrated a typical occurrence of *referent power* during a famous healthcare exhibition in Brazil: *"the number of companies that visited Company D booth (was great)… A big lab came to us considering we are a reputable company, so that we could establish a partnership and launch (our products together), (so that the lab could say) 'we are integrated with one of the biggest health players of Brazil'"*. Similarly, Company F highlighted its status as important healthcare player through recent awards, such as the award for best clinical systems vendor in Latin America. Company F already recognised the attractiveness of such status given an increased number of partnership proposals from other vendors. In light of that, the company could improve negotiations: *"the relevance (of the awards) made us look at partnerships in a slightly different way",* explained its commercial director. Currently, Company F starts negotiations by certifying the quality of partners' products to protect its image. Then, it analyses the financial benefits it will obtain once systems are integrated. In the same direction, the CEO of Company I assured such implicit prerogatives created by *referent power*: *"the market leader picks you as partner when it wants"*. Company I has to deal with the *referent power* from other players, such as Microsoft, which controls its value-added reseller certification.

In spite of the key role played by *referent power* in partnerships, it is seldom used in isolation. Large software players frequently rely on this power type to attract partners to the ecosystem. However, neither these companies nor SMEs have *referent power* as a sufficient power force. It means that *referent power* cannot supersede other power types. Even with the distinguished status of big players such as Oracle or Apple, there must be an advantage beyond stating 'we are partners of this important company'. In the short term, partners expect a financial benefit, in particular – directly or indirectly provided by the other party. The following arguments of the commercial director of Company F illustrate this fact: *"(when we*

proposed the partnership,) we started emphasising our brand and recognition in the market as an important factor, (but) the biggest asset we can offer to companies is an open market of 1.200 hospitals". The operations director of Company B also remarked that potential partners approach the company considering its *"brand and number of customers"*. Based on these arguments, we propose $S_{5.1}$ and $S_{5.2}$.

- ***$S_{5.1}$ – Exercise referent power in combination with other power types.***

Referent power stems from a company's reputation due to its recognition as a key supplier in the market or owner of a well-known product, for instance (Blois and Lacoste, 2009; Finne, Turunen and Eloranta, 2015). It is also possible that a company has the ability to orchestrate players and then emerge as a leader, obtaining *referent power*, consequently. This power type underlines a marketing sponsorship, as it allows a company to share its strong image with others. *Referent power* enables a company to attract partners, who can raise network diversity and generate productive innovation that fosters niche creation.

Besides reputation, ecosystem members are interested to ensure their long-term financial well-being (Hyrynsalmi et al., 2015). Therefore, *referent power* is not enough to sustain the position of a company in an ecosystem. To 'hit the bull's eye', companies that hold this power must combine it with *reward power* and *expert power*. *Referent power* will actually boost other power types due to its automatic feedback nature, e.g. the prestige of an actor strengthens its image as expert and reinforces its potential to grant partners some sort of benefit. Since *referent power* is scarce, in general, partners face difficulties to employ the *withdrawal* and *extension of power network* operations to reduce their dependence on the powerholder company. In fact, the company can even leverage this power type via *attachment* operation.

- ***$S_{5.2}$ – Use referent power to influence other companies and orchestrate the software ecosystem.***

The admiration from other players is a first step for a player to become a keystone. This is a key position desired by most companies, who recurrently and aggressively seek to change their role in a software ecosystem (Bosch, 2016). To achieve this goal, it is imperative that a company understands its level of *referent power* to develop strategies that use the respect from partners to promote network coordination and effectiveness (Maloni and Benton, 2000). The company can facilitate this process by implementing the *attachment* operation, increasing the number of advantages offered to partners (e.g. creating a partnership program). Once partners establish stronger ties due to the identification with the way the company manages its business and governs the ecosystem, the company gains more prestige and reinforces its *referent power*. Such enhanced relationships can maintain partners in the network, contributing for ecosystem robustness. However, if the company exercises *referent power* in an unhealthy manner (e.g. dominating relevant resources and over-controlling companies), partners can adopt a *coalition formation* operation. By forming external alliances, they restrict or hamper the access of the company to other relevant resources. For instance, a coalition of SMEs may acquire smaller companies that provide strategic features. Consequently, such coalition is able to neutralise excessive use of power in the ecosystem.

5.6. H_6 – Power is fluid in a software ecosystem of SMEs

The contingent and relative nature of power requires that we examine this construct in practice (Isaac, 1987). By investigating the partnerships among software companies, we perceived that power is indeed a dynamic construct that shifts in a relationship over time. The power changes happen either naturally (e.g. a company increases its knowledge of a given segment, builds a stronger reputation and becomes a market leader) or intentionally (e.g. a company builds and shares a software platform with partners to improve its negotiations based on the dependence that the platform generated on partners).

Strategies related to H_6

Our case studies revealed power redistribution over the course of partnerships. An initial explanation for this fact lies in the observed process of power transformation or evolution itself. For instance, in a typical rotating leadership scheme, a partner can manage an integration project because of its knowledge of a technology (*expert power*) or reputation (*referent power*). Such leadership position fosters other types of power, such as the right to define integration standards (legitimate power) or the possibility to substitute a noncompliant partner (*coercive power*). In other situations, once inviting a partner to address a new market demand (*reward power*), the company can obtain other power capabilities in the relationship. For instance, it can define the requirements that it will implement (*legitimate power*) or appear as the sole supplier of the project (*legitimate power*).

We can also relate such power volatility to the fact that the studied software ecosystems are formed by SMEs. The collaboration among partners with similar sizes and limited resources differs from the interaction between by big players and small complementors. In the latter case, few players with superior resources and several others depending on them to operate and thrive cause substantial dependence asymmetries (Hurni and Huber, 2014). Such networks also have a stable hierarchy of roles, rights and responsibilities. In general, the keystone manages a central platform and controls the community of

participants, who fuel the network with innovative features and comply with rules defined by a partnership model. With a tendency for pre-defined power capabilities per participant, it is hard to alter the power advantage between partners or balance the relationships in a fair manner.

In addition, we can interpret the fluidity of power considering the phase of the ecosystem. We classify the studied cases in a birth stage (Moore, 1993), when the roles and duties of companies are under definition. In this case, the companies had not yet established a leader, who would occupy a fixed position in all joint initiatives. Moreover, companies are still shaping the structural elements of the ecosystem, such as technical (e.g. software platform and joint software product processes) and business assets (e.g. ecosystem planning and business model). During ecosystem evolution, a keystone may emerge depending on the contribution of SMEs to raise the network.

Such context of volatile power revealed that power relationships are not constantly balanced. We noticed that, in a given point of time, one player had a power advantage in a joint initiative among partners. However, this situation could change in other projects or phase of the partnership. We observed that the ultimate goal of companies is to guarantee benefits from their partnerships, which may happen in a scenario of balanced or unbalanced power. For instance, the operations director from Company B argued in favour of a positive hierarchy, considering tensions among companies in power-balanced collaborations. *"The problem was that we wanted to share power; even in contracts, it was 50%-50%, but this division of power led conflicts to unacceptable levels; when you have authority, the relationship is much calmer, as long as the dominated party does not feel overwhelmed (and that) both (partners) 'win'"*, explained him. In this case, the idea was to define a leader company to coordinate the decision-making process. The CEO from Company I also reported a similar situation when discussing the participation as a certified partner of big players such as Microsoft and Adobe. The unbalanced power relationships did not foster the emergence of a dominator. Instead, the keystone used its power capabilities to support partners: *"we obtained this partner through Adobe (ecosystem) and we are very happy about it; Adobe doesn't realise how much value it means to us; find a partner that helps you, but doesn't absorb you"*. We also perceived strong partnerships between companies holding a similar degree of dependence (and, thereby, a similar potential for power exercise), as reported by the commercial director of Company F: *"there are more egalitarian partnerships (in terms of dependence); we just want to do business together"*. Considering these facts, we present the strategies $S_{6.1}$ and $S_{6.2}$.

- ***$S_{6.1}$ – Reinforce capabilities that allow the exercise of diverse power types.***

Companies should perform a SWOT analysis to understand what are their internal strengths and weaknesses. These aspects are the key sources of power and dependence in the ecosystem. Therefore, companies must foster their strengths (e.g. strategic and differentiating capabilities), which will allow them to exercise some form of power over others. Companies should not only rely on traditional measures of strength, such as market share or cash. Players should also use intangible resources to build legitimacy and trust (Yoffie and Kwak, 2006). The ability to exercise different types of power increases the resilience of SMEs, which also raises ecosystem robustness. In a similar way, companies should perform a critical analysis of their weaknesses (e.g. lack of clients) because, eventually, these vulnerabilities will give rise to some dependence on other players. Companies should develop capabilities to improve their own performance and foster the relationships built with partners around the ecosystem. A key motivation of creating and raising a software ecosystem is that a network of SMEs can join forces to battle larger competitors. By operating together with an appropriate use of power, companies increase their chances of survival and growth.

- ***$S_{6.2}$ – Take advantage from both balanced and unbalanced power relationships.***

We observed that companies tend not to use excessive coercive actions or exert ruthless dominance over players when interacting in unbalanced power relationships. Generally, they attempt to "play nicely" with others, which is indeed the best approach. We perceived that companies do not aim to achieve an ideal power-balance. In fact, it is important to understand if a balanced or unbalanced status is more fruitful. Exercising balanced power is especially common in the early phase of partnerships among SMEs, when companies are still shaping their collaboration by understanding what drives such interactions. However, in situations where it is more convenient to have a partner taking control of the integration project, companies let the partner manage it. Following the leader may be a successful strategy for both sides in the birth of the ecosystem. In several occasions where there is scarcity of resources, the company may simply depend on other players. In addition, assuming a dependent role in the ecosystem may reduce the risks the company is willing to take.

As partnerships grow and the ecosystem matures, it is quite natural that some power and dependence asymmetries emerge. Frequently, it is necessary that an orchestrator company assume the leadership to ensure the growth of the ecosystem. Finally, companies should carefully observe the conditions and implications of exercising power or accepting its dependence on others. They must exercise their power in a sustainable manner by employing power-changing operations when they need to alter the existing

power in the relationship. In this way, they can sustain the partnership evolution (e.g. gain legitimate power to improve negotiations) and their own health (e.g. eliminate the dependence on a partner with excessive control or coercive attitudes).

6. Discussion

In this section, we analyse the results of the expert review as well as limitations of our research. In addition, we describe related studies in software ecosystems and management fields.

6.1. Expert Review

The evaluation of the eleven strategies for power management in software ecosystems was conducted with twelve experts from academia and industry. All respondents confirmed the relevance of the strategies, whose acceptance rate varied from 50% ($S_{4.2}$) to 92% ($S_{1.1}$) – the average rate was 79%. Hence, none of the strategies was removed. Only five strategies ($S_{1.1}$, $S_{1.2}$, $S_{2.2}$, $S_{4.2}$ and $S_{5.2}$) had to be altered to become more complete or precise, based on examples or specific arguments from six experts. The strategies $S_{1.2}$, $S_{2.2}$ and $S_{4.2}$ were the most commented, probably due to their intuitiveness. They involve the common interpretation of power as authority, legitimacy or intimidation, for instance. Some opinions from experts also contributed to the discussion of future work in Section 7.2, since they required a deeper investigation of mature or platform-based ecosystems, such as Facebook and Apple. For more details, we included the Appendix B, with the complete set of evidence from the expert review.

6.2. Limitations

During the analysis of the case studies, we had to deal with the relative notion of partnership. It is not straightforward to qualify another actor as 'partner' (e.g. some professionals considered a supplier or even a client as partner). This required us to continuously assess the situations being reported to avoid unfruitful discussions. We also tried to restrict the scope of analysis to 'integration partnerships', which involve the complementation of software products or services by another actor (e.g. SME, developer). Our emphasis on semi-structured interviews allowed us to understand interfirm relationships from the rich perspective of professionals, whose practical involvement with partners complemented the analysis found on websites, for instance.

Focusing on power and dependence was challenging, given their subjective nature. For an improved understanding of these constructs, we explored specific aspects of partnerships. For instance, we considered varied situations involving negotiations among companies, e.g. definition of requirements that each partner can implement, or selection of the leader in a joint project. Besides, we relied on different rounds and sources of data to verify our conclusions with participants. In particular, we tried to involve the same professionals in the different phases of the research to enable a gradual evaluation of findings by participants previously interviewed. This approach reduced the chances of introducing interpretation bias, and performing a superficial investigation by neglecting relevant information about the phenomenon.

We highlight that the availability of participants was a limiting factor. Therefore, we did not manage to involve all companies in the second and third phases of the research. However, we guaranteed that the subset of companies that participated in these phases were representative and/or figure as critical players in the ecosystems (e.g. are engaged in most of the studied partnerships, are in charge of critical decisions or fuel the networks with resources and business opportunities). We plan to have feedback from the other companies in future studies, which may adopt different data collection techniques, such as a focus group.

6.3. Related Studies

Our research presents one of the few empirical studies that explore the constructs of power and dependence in software engineering. We identified three studies related to ours.

- Yoffie and Kwak (2006) explored the relationships between companies and complementors. The study focused on firms that sell complementary products and services to mutual customers. The authors presented a general analysis of the interactions among big players such as Microsoft, Apple and Intel with their respective complementors. The authors did not adopt any specific power taxonomy. Instead, they proposed the classification of 'hard power' and 'soft power', which were analysed together with the notion of dependence. A particular similarity with our research is a discussion about strategies to leverage power relationships. The strategies were introduced as lessons based on real examples. However, the work did not relate the lessons with software ecosystems issues, such as development and control of the software platform and definition of roles in the network.

- The work from Milne and Maiden (2012) examined the software business with an emphasis on the role of power and politics in requirements engineering. They also adopted French and Raven's power types to assess relationships in an intraorganisational setting (e.g. interactions between product and sales teams). The authors adopted a social network view to analyse power relationships. The study highlighted that power relationships are volatile – which is a conclusion that we also noticed. We extended their investigation by exploring the sources of power in partnerships. In this paper, we address the different contexts of interfirm relationships. Our contribution lies in the careful analysis of the effects of power exercise, which we used to shape strategies for power management in software ecosystems.
- Hurni and Huber (2014) examined how the exercise of power influences the trust of complementors on platform owners. Differently from our research scope, this empirical study focused on the investigation of ecosystems managed by large platform owners. After identifying patterns of interaction between trust and power, the work did not move forward to the proposition of strategies that ecosystem participants can adopt in their power relationships. Therefore, by proposing a set of power-related strategies that can be adopted by software ecosystems players, we believe that our research provides a novel contribution to the field.

7. Conclusion

7.1. Contributions for Research and Practice

From a research perspective, our study contributes to the literature on software ecosystems management by examining how companies deal with power and dependence in partnerships. Both constructs play an important role to understand interfirm relationships (Hopkinson and Blois, 2014; Meehan and Wright, 2012). In addition, the issue of SMEs creating a new ecosystem has not been explored, despite extensive investigation of software ecosystems over the last decade. We addressed this gap through an analysis of the influence of power and dependence in partnerships established by SMEs during the formation of software ecosystems. Seppanen et al. (2017) claims that software ecosystem is a maturing field that still lacks the conceptualisation of phenomena, in which a set of hypotheses can be empirically evaluated. To address this research gap, we proposed six hypotheses to explain how SMEs exercise power based on empirical evidence gathered by means of three case studies. Moreover, we explained each hypothesis with empirical data and further analysed them through the lens of related literature. An additional theoretical contribution of this paper is a meta-model that makes explicit the relationships between constructs from software ecosystems literature and classical power theories. By building theoretical models such as the one proposed here, it is possible to advance the field towards the construction of a theory of software ecosystems (Manikas, 2016). The meta-model contributes towards the goal to standardise the modelling of software ecosystems (Jansen, Handoyo and Alves, 2015).

From a practical perspective, our contribution lies in a set of strategies that SMEs can apply to manage their own operation and relationships with partners in the ecosystem. During the process of establishing a new software ecosystem, SMEs are seeking for new resources to increase business opportunities and access different consumer markets. Generally, the degrees of power and dependence on other players define the position and role of a company in the ecosystem. For instance, a company that has low number of power capabilities but holds high level of dependence on resources from partners faces a risky situation. In such power imbalanced structure, powerful players may take advantage of the company's weaknesses. One strategy to alleviate high dependence involves forming coalitions with other partners or relying on resources from other players. In an opposite situation, a company that owns strong power capabilities and keeps low dependence on resources provided by partners has the ability to exercise different types of power over partners. Such situation may enable the company to act as a keystone by sharing its assets and orchestrating participants.

Our results also suggest that a powerful player may not use unbalanced power relationships to have coercive attitudes towards partners. Players that explore their power advantage to govern the ecosystem should foster the wellbeing of the network. For instance, it is important to use coercive power and legitimate power with parsimony, avoiding predatory attitudes of a dominant keystone and an excessively centralised decision-making, respectively. In addition, to safeguard a sustainable position in the ecosystem, companies should cultivate resources (e.g. expertise, reputation, money, and so on) that are desired by other players, so that they can exercise some form of power as a survival action. Understanding the subtle mechanisms underlying power and dependence structures enables companies to deploy strategies that increase their chances of survival and growth. Healthy ecosystems should cultivate mutual power relationships that enable reciprocity, trustworthiness, and shared vision among the partners.

7.2. Future Work

Future research would benefit from the analysis of constructs related to power and dependence, such as trust, resistance and conflict (Dapiran and Scott, 2003; Hopkinson and Blois, 2014). In addition, we plan to analyse the correlation between power types and health elements to verify whether there are cause-effect relationships. For instance, to what extent increasing the exercise of expert power raises the productivity of the ecosystem. We also stress that the hypotheses and strategies proposed in this paper should be further evaluated in new studies. Ideally, different research groups could conduct these studies. This would minimise the threat of researcher bias. Another interesting area for future research is conducting empirical studies to understand how power and dependence occur in different configurations of software ecosystems (e.g. global platform ecosystems dominated by a powerful keystone, local ecosystems formed by SMEs with different levels of maturity, open source, and hybrid ecosystems). The comparison of how power and dependence influence relationships in different types of ecosystems can bring a rich analysis. For instance, we can investigate whether partners in platform-based and mature ecosystems such as Facebook are more up to accept severe penalties given their dependence on the opportunities within such attractive network (i.e. the shared benefits overtake the potential punishments). In addition, we can explore which characteristics of a player increase its *referent power* in open ecosystems, for instance. This power type may derive from the reputation for trustworthiness and goodwill of a company, for instance. Future research may also examine the temporal aspect of power and dependence via longitudinal case studies, i.e. how these constructs change during ecosystems lifecycle.

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Appendix A – Interview Protocol

In this appendix, we describe the semi-structured interview guide adopted in Phase 3 of the research. The goal of the interview was to evaluate the hypotheses and discuss with participants of the case studies strategies to manage power relationships with participants of the studied companies.

	Question	Goal
1	What is your opinion about the hypotheses?	**Hypotheses assessment**
2	Do you think your company needs to maintain a power-balanced relationship with a partner?	**Power-balancing**
3	Are there situations when unbalanced relationships are beneficial for the parties involved?	
4	What is your opinion about dominance in a partnership?	
5	What strategies do you suggest for your company to deal with a partner with more power to balance your relationship?	**Strategies to manage power relationships**
6	What strategies do you suggest for your company to collaborate with a partner with less power and avoid dominance?	
7	Has your company used any of the following power-changing operations in partnerships: withdrawal, extension of power network, attachment or coalition formation? How was your experience?	**Power-changing operations**

Appendix B – Evidence from Expert Review

In the following table, we describe the results of the expert review, which involved 12 participants. We list the strategies with their respective rate of acceptance and comments provided by experts (e.g. suggestions for improvement, doubts, etc.). In a final column, we indicate our decision, i.e. actions taken in light of the comments from experts.

Strategy	Rate of acceptance	Comment	Action
$S_{1.1}$ – Continuously invest in expert power to foster partnership continuity.	*Neutral* – 8% *Agree* – 42% *Strongly agree* – 50%	*"I would break this in 4 items' "Expert power is a critical asset for companies to hold in an ecosystem, as it may promote several positive aspects of interfirm relationships, such as trust'; 'higher levels of expert power are associated with higher levels of cooperation, satisfaction and coordination'. I am not sure that I agree, because companies like Apple has expert power but does not negotiate easily. So, the association with more cooperation might not be appropriate"* (E2)	**Result**: we altered the description of strategy $S_{1.1}$ to remove the possibly weak association between expert power and cooperation. We argue that this power type may promote trust, satisfaction and coordination in the software ecosystem.
		"Continuous investment leads to platform innovation, which incentives developers and attracts users" (E7)	Full agreement with the strategy $S_{1.1}$. **Result**: no changes to perform.
$S_{1.2}$ – Rely on the expertise of multiple competing actors	*Disagree* – 8% *Neutral* – 8% *Agree* – 50% *Strongly agree* – 34%	*"Of course the dependency between actors in an ecosystem is inevitable. However, in order to avoid risks, could be important to increase the co-dependency between X and Y"* (E8).	**Result**: we improved the strategy $S_{1.2}$ by suggesting that partners also invest in the *attachment* operation, which increases the dependence of the other party. It is a way of implementing such co-dependency approach.
		"I have to interpret the question as to judge whether the approach itself is safer and more productive than its alternative. I do not think this holds in general. Depending on the relationship, building trust and communication channels outweighs the ability to replace suppliers. At some point, showing real commitment from both sides can be very beneficial. Of course, it is good to have a "plan b", but maintaining two or more intense partnerships can in my opinion not seen as a good general strategy. Should this not depend on whether the goal is about innovation or commodity aspects?" (E12).	This opinion considers the traditional reasoning of working with a single or fixed partner, which involves a rather stable and less risky scenario. In the current volatile and competitive market, a company can face unprofitable situations (e.g. a stronger partner using its power capabilities to threat the company by raising its dependence or imposing restrictions); if the company does not invest in more outside options. Companies must analyse their dependence on external resources and shape their business models to consider substitutes for current partners, with an appropriate partner selection criteria. **Result**: we improved the strategy $S_{1.2}$ to reinforce that it is fundamental in cases of less tenable relationships.
		"That I agree! It is basically my interpretation of question 1, the reason why I answered neutral" (E2)	Full agreement with the strategy $S_{1.2}$. **Result**: no changes to perform.
		"Coopetition is the norm in high technology industry and SECOs are coopetitive platforms that encourage coopetition among participants" (E7)	Full agreement with the strategy $S_{1.2}$. **Result**: no changes to perform.
$S_{2.1}$ – Avoid exercising coercive power in a hard manner	*Neutral* – 36% *Agree* – 28% *Strongly agree* – 36%	*"I agree that might happen but only if that is an ecosystem in its infancy. A mature ecosystem will not be affected by that"* (E2)	Even in mature stages of ecosystem evolution, we believe that companies may harm ecosystem success by exercising coercive power in a hard manner, with critical punishments. **Result**: no changes to perform.
		"Some punishments are necessary to maintain order in the ecosystem. This power must exist, but less expressively in relation to others" (E3)	Full agreement with the strategy $S_{2.1}$ (which argues companies shall be careful with the application of *coercive power* over partners) and others, such as $S_{1.1}$ and S_3 (which propose that companies strengthen their *expert power* and *reward power*). **Result**: no changes to perform.

		"Soft Power, as conceptualized by Prof. Jonathan Nye, is more sustainable over the long-term especially in fragmented SECOs with diffusion of control" (E7)	Full agreement with the strategy $S_{2.1}$ (which argues companies shall be careful with the application of *coercive power* over partners). **Result**: no changes to perform.
		"The definition of coercive power is about perception. Exercising this power is then to increase the perception? I would argue that Facebook does this. However, since it is still very attractive, people at least know what they are up to. So, the potential to damage value-co-creation will depend on the point of view. If the exercise of power is in line with the ecosystem goals of X, there should be a positive outcome in the majority of cases (i.e. future partners will better align their value-creation with X, thus increasing the value from their point of view)" (E12)	**Result**: we included such argument in future work discussion (Section 7.2). We argued about our interest in investigating whether partners in platform-based and mature ecosystems such as Facebook may accept severe penalties given their dependence on the opportunities within this attractive network. In addition, we altered the title of the strategy to make it clearer ("Avoid using coercive power to apply severe punishments").
$S_{2.2}$ – Anticipate negative actions in contracts and general rules that guide partnerships.	*Disagree* – 16% *Neutral* – 17% *Agree* – 50% *Strongly agree* – 17%	*"True, but it's like an API: people will misuse it, and that's okay. That's part of an evolving ecosystem, and you can take corrective measures as you go along"* (E10)	**Result**: we improved the description of the strategy $S_{2.2}$ to highlight that some rules can be added or adapted in the course of the relationship, with the evolution of the partnership and the ecosystem.
		"I am not sure about that. Maybe an orchestrator role will be better in this kind of ecosystems than a controller role" (E8)	Full agreement with the strategy $S_{2.2}$ (which proposes the use of orchestration mechanisms to support the exercise of *legitimate power*). **Result**: no changes to perform.
		"That would imply that legal punishments are not considered arbitrary. As an academic, I may not have sufficient experience to judge this aspect. I guess a strategy to avoid available punishments lightly might have more success. Having strong contracts plus the reputation to sue everybody will not generate an environment of trustful co-creation of value" (E12)	The previous strategy already suggests that companies avoid exercising coercive power with severe punishment ($S_{2.1}$). The goal of the strategy $S_{2.2}$ is to define disciplinary sanctions and punishments that are established in contracts after agreements among partners. However, the observation is relevant and should be included in the text. **Result**: we improved the description of the strategy $S_{2.2}$ by discussing the fact that companies must recognise the importance of a trustful scenario and avoid too strict rules.
		"There is a wide variety of business arrangements on different types of SECOs among various kinds of stakeholders. So, an overall rule that describes all of that variance may be challenging to codify" (E7)	It is clear in the description of the strategy $S_{2.2}$ that we are not proposing general rules for software ecosystems, but rather anticipating specific rules in contracts or similar documents defined with partners. **Result**: no changes to perform.
S_3 – Guarantee that business benefits are shared to maintain the value of partnerships.	*Neutral* – 8% *Agree* – 42% *Strongly agree* – 50%	*"Only focus on your own main business model, and allow others to take the crumbs that are left on the table"* (E10)	The suggestion does not recognise the relevance of cooperation in an ecosystem. With no guarantee of a win-win approach, which involves a greater alignment of partners goals, partnerships may not thrive. **Result**: no changes to perform.
		"I do not agree that it reduces conflicts. In addition, certain rewards may generate false collaborative/relationship interests. Finally, I also believe that promoting this kind of force causes a dependence on Y, that is, Y will only cooperate if X gives a reward" (E3)	In fact, partnerships that involve a great flow of rewards may lead a company to hold high dependence on a partner. However, this is the essence of the ecosystem, which lies over interdependent parties and win-win relationships. It is up to a company to regulate such level of dependence via the power-changing operations discussed here. **Result**: no changes to perform.
		"Coopetition is the norm in SECOs and it is clear that participants 'cooperate to grow the pie and compete to split the pie'. Therefore, it is important that all stakeholders are better off as a result of a win-win strategy by the SECO operator and controller wherein everyone is better off by joining a SECO" (E7)	Full agreement with the strategy S_3. **Result**: no changes to perform.

$S_{4.1}$ – Define agreements that promote the definition of roles in the ecosystem.	*Neutral* – 8% *Agree* – 50% *Strongly agree* – 42%	*"Partnership models should be available, but other models should also be available to avoid that the ecosystem is restrict"* (E4)	Full agreement with the strategy $S_{4.1}$. **Result**: no changes to perform.
		"Agreements may not be the sole option of sharing a culture and its expectations towards roles" (E12)	Full agreement with the strategy $S_{4.1}$. **Result**: no changes to perform.
$S_{4.2}$ – Use authority to reconcile partners' interests and increase their satisfaction.	*Disagree* – 42% *Neutral* – 8% *Agree* – 25% *Strongly agree* – 25%	*"I don't think there will sure be negative outcomes for ecosystem health. It might have positive outcomes as companies realize that such authority might keep the ecosystem 'under control'"* (E2)	Full agreement with the strategy $S_{4.2}$. **Result**: no changes to perform.
		"In a fragmented SECO that has diffused authority, it is not straightforward for any stakeholder to exert direct control over all other stakeholders. Thus, authority by itself may be more or less tenable as a tool for reconciliation among divergent stakeholders depending on the level of centralization and consolidation of a SECO" (E7)	Full agreement with the strategy $S_{4.2}$. **Result**: no changes to perform.
		"The authority in an ecosystem is very difficult to define. It is an implicit characteristic of the main actors in the ecosystem, according to the importance of the actor in the network" (E8)	The respondent confused *legitimate power* with *referent power*, arguing the former is hard to define. However, the description of the strategy S4.2 is clear about that: legitimate power denotes the rights of an actor and may originate in a given leadership position occupied. It is not related to the importance (status or reputation) of a firm. **Result**: no changes to perform.
		"I do not understand the text under this strategy. Also, I do not understand how this strategy can help to 'Legitimate power establishes rules and roles in partnerships'" (E12)	The respondent did not understand the strategy. **Result**: we improved the introductory text of the strategy $S_{4.2}$ to reinforce its link with the hypothesis H_4.
$S_{5.1}$ – Exercise referent power in combination with other power types.	*Neutral* – 25% *Agree* – 58% *Strongly agree* – 17%	*"Referent power is great, but legitimate power will also be more powerful"* (E10)	Full agreement with the strategy $S_{5.1}$, which highlights that *legitimate power* may grant a company with a position in the ecosystem. **Result**: no changes to perform.
		"Many examples of this exist including Apple iOS app store and Google Play store where referent power is combined with other types of power to maintain SECO health and sustain its relevance for all stakeholders" (E7)	Full agreement with the strategy $S_{5.1}$. **Result**: no changes to perform.
		"I cannot understand the relationship of this strategy and the hypothesis. It also occurs to me that these are rather stratagems. Does one not need to judge an overall strategy and its ability to generate the desired outcome?" (E12)	In fact, the strategies can be seen as stratagems (i.e. artifices used to attain a goal or to gain an advantage over a competitor). Since we built them from interviews, we already observed their outcomes in practice (we cite them in strategy description). **Result**: no changes to perform.
$S_{5.2}$ – Use referent power to influence other companies and orchestrate the software ecosystem.	*Neutral* – 17% *Agree* – 75% *Strongly agree* – 8%	*"In proprietary and walled-garden SECOs, referent power may depend on the market position of a particular vendor (e.g., Apple or Google). In open SECOs, referent power may depend on other characteristics of a vendor, such as its reputation for trustworthiness and goodwill"* (E7)	This research focused on proprietary or closed ecosystems. However, this is an interesting observation, which may illustrate how this phenomenon may happen in an open-source scenario. **Result**: we included such examples in the future work discussion (Section 7.2).
		"Perhaps just referent power itself remains elusive to me. Why do you suggest this causality? I would think it is the other way around: If I am a keystone, my power is partly referent power (by construction). It may help to attract new partners, but not because I use it on existing partners" (E12)	**Result**: we improved the strategy $S_{5.1}$, which also discusses the origins of referent power. We included the possible situation where a given company has to ability to orchestrate players and then emerges as a leader, obtaining *referent power* consequently.
		"I'm not sure how 'hard' this power is" (E10)	**Result**: in the paragraphs right before the strategies S5.1 and S5.2, we present examples from studied companies that denote the strength of *referent power*.

$S_{6.1}$ – Reinforce capabilities that allow the exercise of diverse power types.	*Neutral* – 25% *Agree* – 42% *Strongly agree* – 33%	*"This is an ongoing imperative for SECO members because joining a SECO can benefit a vendor (e.g., give access to clients), but can also lead to vulnerabilities for that vendor (e.g., disclosure of intellectual property). Thus, reinforcing capabilities to exercise diverse power types is important to increase opportunities for advantage and decrease chances of disadvantage"* (E7)	Full agreement with the strategy $S_{6.1}$. **Result**: no changes to perform.
$S_{6.2}$ – Take advantage from both balanced and unbalanced power relationships.	*Neutral* – 8% *Agree* – 67% *Strongly agree* – 25%	*"The frontier between balanced and unbalanced power creates opportunities for technical and managerial innovation such that new value propositions and administrative systems can be developed at the point of confluence of balanced and unbalanced power relationships in SECOs"* (E7)	Full agreement with the strategy $S_{6.2}$, which discusses the combination of both balanced and unbalanced power in partnerships. **Result**: no changes to perform.
		"Yes, but without abuse" (E10)	Full agreement with the strategy $S_{6.2}$, which remarks that studied companies often "play nicely" with others. **Result**: no changes to perform.

Προφ. Δρ. Γεοργε ςαλεν| α

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Προφ. Δρ. Χαρινα Αλϖεσ

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Προφ. Δρ. Σλινγερ θανσεν

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