# STRATEGIC MANAGEMENT OF A PORTFOLIO OF CONNECTED BUSINESS MODELS: AN APPLICATION TO THE DIGITAL SECTORS

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## Summary

The contemporary digital age provides opportunities to design strategies based on leveraging connected digital product and service offerings. These complex offerings, however, require the development of portfolios of business models that are themselves connected, enabling economies of scale and scope, increased revenue capture, and significant competitive advantage. However, the literature is limited in understanding how to strategically manage such portfolios, particularly because the perspective of connecting business models is not addressed. Therefore, our research provides two contributions. First, we propose a conceptual framework to analyze the architecture of a portfolio in order to reconstruct its functioning and to identify the possibilities of connection between business models. Second, by qualitatively analyzing the case of Apple, Google and Microsoft, we show that their business model portfolios can be strategically managed through the implementation of a common architecture, intimately linked to the modular architecture of their product and service offering, and in which business models can be connected to create positive effects for the company. Our study thus contributes to a better understanding of the strategic functioning of connected business model portfolios in the digital sectors and highlights some key elements of their design.

**Keywords:** business model, portfolio, digital, modularity.

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## INTRODUCTION

Digital sectors are characterized by modular product and service offerings that connect a multitude of devices to content platforms. At the strategic level, the economic success of this type of offer seems to depend on the creation of a portfolio of adapted business models (BM), in which the BMs must also be connected to strategically and commercially support the pre-existing connections between the products, services and platforms of the offer. An emblematic example is that of Apple, which is developing a complex BM portfolio with its iTunes Store and App Store platforms, accessible from iPhone, iPad, iPod and iMac. By distributing digital content on a massive scale, created and renewed by communities of developers, Apple maximizes its terminal sales and appropriates significant revenues. Following this success, other players such as Google and Microsoft are now marketing similar offers.

A BM portfolio exists when a company seeks to diversify by engaging in at least two different ways to create and/or monetize value (Aversa and Haefliger, 2017). In the digital sectors, the value of creating a connected product and service offering lies in the modularity of use that allows the consumer to self-assemble their offering, to choose, separate and recombine products and services according to their specific needs (Baldwin and Clark, 2000). This type of offer therefore has strategic implications (Jiao et al., 2003) because they involve the creation of connections between BMs, since a BM conceptualizes how a company creates value (product, service, other), offers it to a target customer segment, and captures revenue from it, particularly through a revenue model (Baden-Fuller and Morgan, 2010; Teece, 2010). However, the literature is still very limited in understanding how to strategically manage this type of complex portfolio. Moreover, the possibilities of connection between BMs and how to identify them are still poorly understood by existing research that focuses more on portfolio design and the overall and individual performance of BMs (e.g. Sabatier et al., 2010).

Our research therefore addresses the question: **how do we strategically manage a portfolio of connected BMs?** To answer this question, this paper is divided into four parts. The first part details the literature on the BM portfolio approach, its limitations, and proposes an analytical framework for portfolio architecture. The second presents the qualitative methodology and massive secondary data collection in the digital sectors. The third presents the results and strategic management of connected BM portfolios of the Apple, Google and Microsoft cases. The fourth discusses the theoretical and managerial implications.

## THEORETICAL FRAMEWORK

The objective is to propose a conceptual framework to analyze the architecture of a BM portfolio, useful to identify and design the possibilities of connections between BMs. The proposal of this framework is motivated by the limitations of current research on BM portfolio, thus requiring the development of a conceptual tool to better understand the issue of connections between BMs. To do so, we draw on Fixson's (2005) multi-level framework on product and product/service offering architectures.

### BM portfolio and conceptual limits

Research on the BM portfolio is still quite limited and refers mainly to the previous work of Sabatier et al. (2010) who show how SMEs in the biopharmaceutical industry can develop and manipulate several complementary BMs in order to generate and capture more revenues.

Therefore, the notion of portfolio applies to describe how a company organizes and manages the combination of different types of activities to satisfy different consumer needs in a market. However, the BM portfolio differs from the concept of a portfolio of activities in that the analysis goes beyond the simple level of the activity and the market, and takes into account all the components of the BM in order to assess the degree of interdependence between the BMs (Sabatier et al., 2010). The BM is generally defined as a model for designing and formalizing business strategy (Baden-Fuller and Morgan, 2010) that describes how a firm organizes itself to create, deliver, and capture value (Osterwalder and Pigneur, 2010). Despite the richness of the literature, the conceptualization of the BM still remains very heterogeneous (see e.g. Massa et al., 2017; Zott et al., 2011 for a comprehensive review) and several models overleap, incorporating more or less constituent components. In order to avoid entering this theoretical debate and to the extent that our level of analysis is the BM portfolio, we choose to conceptualize the BM in a consolidated manner, based on two widely accepted consensuses from the main reference works (e.g. Casadesus-Masanell and Ricard, 2010; Baden-Fuller and Mangematin, 2013; Baden-Fuller and Morgan, 2010; Gassmann et al., 2016; Massa et al., 2017; Teece, 2010; Zott et al., 2011): (1) the value logic is at the heart of the BM, its design, operation and evolution and (2) the constituent components of the BM, their organization and thus the architecture of the BM, are at the service of value creation, proposition and capture. Therefore, we choose to understand the BM through its three value functions (a conceptualization already proposed and used by Richardson, 2008).

The first function of the BM is to create value (product, service, technology, knowledge, etc.) by bringing together and organizing activities, resources, skills, partners, (etc.) within a value chain or value network. Value creation, as a multi-level concept, can be understood both as an outcome and as a process (Lepak et al., 2007), generating costs. In a portfolio of BMs, the optimization of value creation can reside in the development of synergies between the activities, resources, partners, (etc.) of several BMs in order to achieve economies of scale (Sabatier et al., 2010). The second function of the BM is to propose value (product, service, etc.) to a target consumer in a specific market segment by means of marketing and logistical elements (customer relations, distribution methods, consumer commitment to the value proposition, propensity to pay, etc.). In a BM portfolio, the interest lies in delivering multiple value propositions to satisfy a variety of consumer needs (Sabatier et al., 2010). The third function of a BM is to capture tangible value (revenues, technologies, patents, etc.) and/or intangible value (knowledge, reputation, etc.) by developing one or more revenue models and capture mechanisms (value capture can also be understood as an outcome or a process, Lepak et al., 2007). In a portfolio of BMs, the objective is to design enough synergies or connections[1] between the BMs (at the level of value creation and/or value proposition) to create positive impacts for revenue capture (Sabatier et al., 2010). These connections can also be a source of growth when new BMs connect to the original BM, strengthening it (Sachsenhofer et al., 2018). Thus, developing and managing a portfolio of BMs may require managing connections between different BMs, specifically at the level of value creation, proposition, and capture, which can be complex.

Although the literature now advocates connecting BMs in a portfolio, there is little research that specifically addresses the "how to". Only the work of Sabatier et al. (2010) and

[1] In this research, we prefer to use the term connection which corresponds to a relationship established between two elements.

Demil et al. (2013) is sufficiently developed to provide a means of analyzing the operation and management of a BM portfolio. However, these works do not address the problem in its entirety, i.e., the complete architecture of the portfolio and the details of the connections between BMs (nature and type of connection, role and consequences). This is probably due to the lack of a conceptual tool to analyze and model a portfolio of BMs. In the research by Sabatier et al (2010), the BM portfolio is represented by analogy (a dinner in which the recipe represents the combinations between BMs) and the analysis of the connections between BMs is reduced to the analysis of the combinations of activities and key resources and skills. However, nothing is said about how to assess the portfolio architecture or identify opportunities for connections, nor about the extent of their positive effects (other than revenue generation). In Demil et al. (2013), the portfolio can be analyzed using a BM matrix (derived from business portfolio analysis matrices[2] ) that qualifies the strategic positioning of strategic business areas and their possible sources of competitive advantage. However, the matrix does not analyze the portfolio architecture and possible connections between BMs (nor their consequences), but rather assesses the overall coherence of portfolio activities and predicts future strategic directions. In a more recent research, Aversa et al (2017) propose an eight-step method to design complementarities between BMs within a portfolio by addressing issues such as resource pooling, competencies and performance indicators. However, this research deals with a problem of design and not of strategic management of connected BM. In the end, the portfolio approach of the BM requires the development of a more adapted analysis framework. This is particularly relevant in the case of digital sectors where the specificities of modular product and service offering architectures imply the assembly and disassembly of BMs (Mangematin et al., 2014), but in which the logics of connections within a portfolio are unknown.

## Proposal of an analysis framework for the architecture of a connected BM portfolio

Understanding how to strategically manage a portfolio of connected BMs requires answering two prior questions: (1) how to analyze the architecture of a portfolio to identify the BMs that comprise it and the connections between these BMs? And (2) how to identify future connection opportunities in order to optimize the design of new BMs within the portfolio? To answer these two questions, we believe that Fixson's (2005) framework for analyzing product architectures can be an interesting source of inspiration, for three reasons. First, this framework allows us to describe the functioning of a system according to three dimensions: the function/component allocation, the characteristics of the interfaces and the qualification of the architecture[3] . This systemic view is well suited to the BM, which can be viewed as an interdependent system of activity (Zott and Amit, 2010). By extension, the BM portfolio can also be understood systemically with constituent components (BMs), possible synergies between BMs (Aversa et al., 2017) and thus a specific architecture. Second, Fixson's framework is multi-level as it shows that design decisions in product architecture influence operational, organizational and strategic levels. In digital industries, offering architectures that connect products and services often require BM innovation (e.g. Richter et al., 2017) as the company must adjust its organization and strategy to support these technical and functional connections (Yoo et al., 2012). Hence,

[2] The most classic are the BCG (Boston Consulting Group), McKinsey, ADL (Arthur D. Little) matrices.

[3] The function/component allocation identifies the system components and their main functions, the interface qualification identifies the nature of the link between the components and its intensity (degree of coupling) and the architecture qualification determines the level of modularity (open system with standard interfaces) or completeness (completely closed system with specific interface) (Fixson, 2005).

there may be a link to the BM portfolio. Third, even if Fixson's (2005) analytical framework originally focused on product architectures, its applicability nowadays goes beyond this single product view and extends to the fields of strategy and marketing, in the analysis of service architectures and product and service offerings (e.g. Voss and Hsuan, 2009; Rahikka et al., 2011; Brax et al., 2017). Thus, considering the natural existence of the link between the product, process, organization, and strategy dimensions demonstrated by Fixson and the replicability of his analytical framework, we propose three dimensions to analyze the architecture of a BM portfolio (see Figure 1): (1) the identification of BMs, (2) the characteristics of connections between BMs, and (3) the qualification of the BM portfolio architecture.

### *Identification of BMs*

The objective is to identify the different BMs within the portfolio based on the components of the product and service offering. Fixson's (2005) framework associates a component with a specific function, which distinguishes it from other components in the product architecture. In the BM literature, the core function of a BM is related to its value proposition (Teece 2010) as it connects the value created by the firm (product or service) with the need of targeted consumers in a specific market (Chesbrough, 2010). Therefore, the BM, as a boundary object, articulates the necessary elements (strategic logic, technical/economic/marketing data, organization of resources, etc.) to support the value proposition made to customers (Teece, 2010). From one BM to another, the value proposition is usually specific because the objective is to (1) disseminate specific information about the product or service (information known via the value creation process) and (2) engage targeted consumers in the act of purchase in order to capture revenue (Baden-Fuller and Mangematin, 2013). In the development of a product and service offering, segmentation of specific customer groups helps define the different value propositions to be designed for each group (Lecoq et al., 2006). Segmentation therefore implies a reflection on the boundaries of each BM that will exploit and deliver the components (products / services) of the offer. Depending on the breakdown of the value propositions carried out by the company, it becomes possible to identify the BMs and determine to which components of the offer they correspond. However, a BM does not necessarily correspond to a single product or service. There are offers in which certain products and services are bundled or unbundled (Lecoq et al., 2006), as well as multi-sided offers that involve the creation of complementary value propositions in a single BM (Parmentier and Gandia, 2016). From then on, the analysis of value propositions can lead to the identification of several types of BMs: classical BMs corresponding to a specific product or service, dual BMs[4] corresponding to a coupling between products, between services or product/service (Markides and Charitou, 2004) and multifaceted BMs corresponding to multifaceted offers (characteristic of digital sectors) in which digital products, services and content are coupled (Gandia and Parmentier, 2017).

### *Characteristics of the connections between BM*

The objective is to identify the type of connection between BMs and the intensity of these connections. The literature already shows that BMs can coexist or complement each other when resources, assets and activities are shared (Casadesus-Masanell and Tarziján, 2012; Benson-Rea *et al*., 2013). As a result, at a more global level, connections can occur in the three main functions of the BM: (1) in value creation, with the pooling of resources, skills, activities, and

[4] This is the example of Nespresso's dual BM with a strong coupling between the coffee machine BM and the capsule BM.

partners within the value chain and network, (2) in value proposition, with the creation of complementarities between different values delivered by several BMs, and (3) in value capture, with the pooling of capture mechanisms, revenue models, or elements of these models (e.g., a single user account, a common monetary transaction system). These connections can be stronger or weaker depending on the objective to be achieved. At a weak level, the objective of connections between BMs is to generate positive effects such as economies of scale and/or economies of scope in value creation in order to (1) optimize the use and valuation of key resources, (2) reduce the risk of investing in new resources, and (3) better manage time to market (Sabatier et al., 2010). At a medium level, connections between BMs can be based on the complementarity of several value propositions, allowing connected BMs to enrich each other and offer a level of connection that is visible in the market (Casadesus-Masanell and Tarziján, 2012). This is the example of *bundling* offers that propose for sale a combination of several complementary products and/or services in order to create additional value (the package) and increase revenues (Stremersch and Tellis, 2002). This complementarity can also be envisaged between several market segments, by means of multifaceted BMs[5] that deliver several complementary value propositions to different user groups (Baden-Fuller and Mangematin, 2013; Parmentier and Gandia, 2016). At a strong level, the connections between BMs reflect a true interdependence. This is the example of dual BMs (Markides and Charitou, 2004), which are based on a strong coupling between products (example: video game consoles and video games) or between product/service (example: Internet boxes and Internet operator services). In the end, it is possible to identify several types, natures and intensities of connections between BMs within a portfolio.

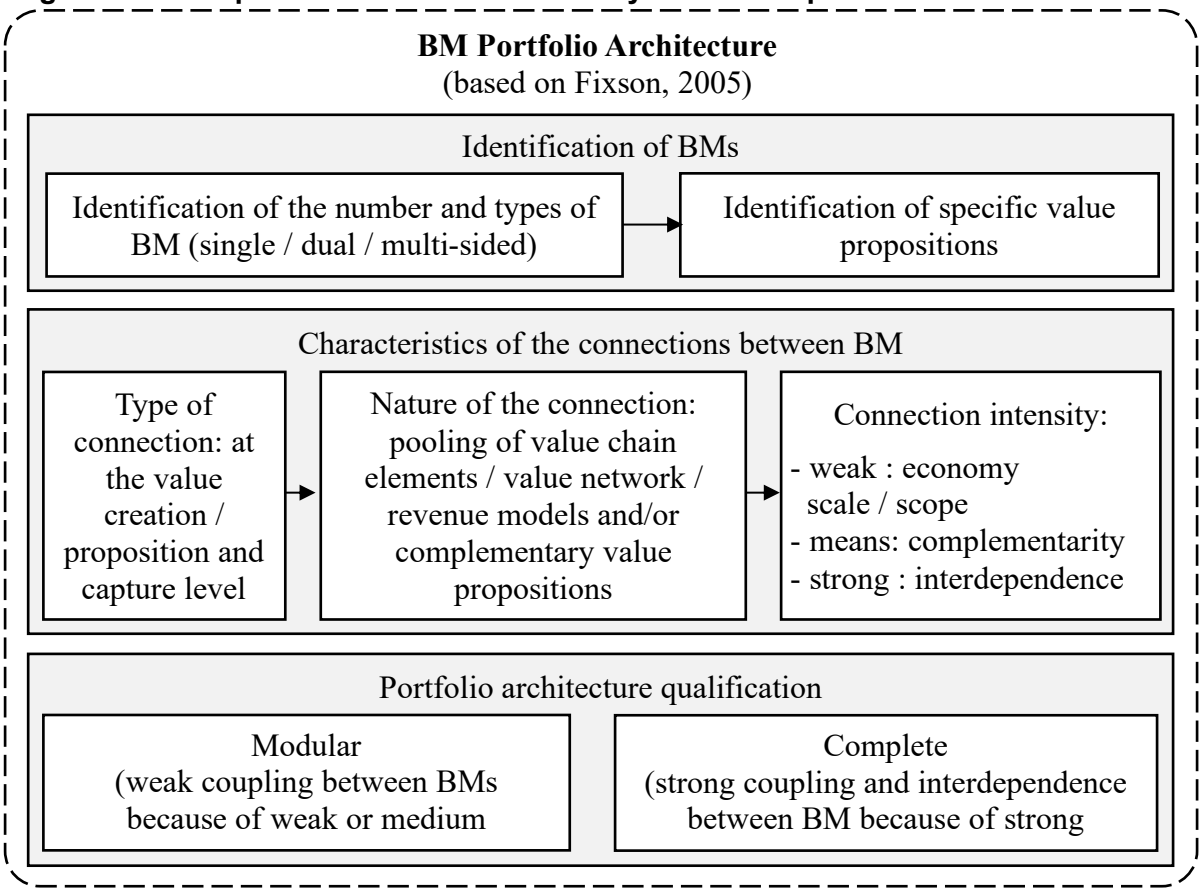
### *Qualification of the architecture of the BM portfolio*

The objective is to determine the level of modularity or completeness of the BM portfolio architecture. In the same way that a business portfolio defines the perimeter in which the strategic business areas of a company are managed (Demil et al., 2013), a BM portfolio defines the perimeter in which the BMs of a company are managed. Therefore, the qualification of the architecture of a BM portfolio results from the analysis of its constituent elements (the BMs) and their relationship, within the perimeter that it defines from the company's point of view. Based on Fixson's (2005) definition, we believe that a BM portfolio architecture can be qualified as modular when the BMs are weakly or moderately coupled, thus implying possibilities of connection and disconnection according to the needs of the company and/or market opportunities. The literature already shows that some BMs, especially in the digital sectors, can be qualified as modular (Aversa et al., 2015). Indeed, digital and infrastructure technologies (Internet, communication protocols, mobile networks) play a key role in the development of new BMs, as they allow the creation of new modular architectures in which products and services are coupled (Yoo et al., 2012). Thus, the design of a modular product and service offering architecture may involve the design of a modular BM portfolio architecture. Conversely, we believe that a BM portfolio architecture can be called integral once the BMs are strongly coupled, thus forcing the firm to create an interdependent relationship between the BMs that prevents disconnections. Insofar as the BM can be considered as an interdependent system of activities (Zott and Amit, 2010), interdependence can also be considered between

[5] This type of BM architecture is often based on multi-sided platforms or markets, which are economic environments in which products and services are sold to different user groups in different market segments (Rochet and Tirole, 2006).

BMs. This is the example of the Ebay auction platform, whose BM is interdependently connected with the BM of the online credit card payment service managed by PayPal[6] . The interdependence exists because the payment mechanism is integrated into the ergonomics of the Ebay platform (specific interface according to Fixson, 2005) and proves to be essential to guarantee the functioning of the platform while providing users with security in their financial transactions (Amit and Zott, 2012).

**Figure 1: Conceptual framework for the analysis of a BM portfolio architecture**




## METHOD

This study focuses on the sectors of the digital economy, which brings together the producing sectors and actors linked to the use and trade of information and communication technologies (ICT), including the sectors of computer and mobile technologies, telecommunications and networks, media and entertainment and communication services. These sectors are very interesting to study because they are characterized by modular product and service offerings, which couple hardware and software elements with service and digital content platforms, in which the user is the actor of the personalization because he is free to assemble the elements of the offering according to his needs. Moreover, these sectors are structured around a few large reference companies (e.g. Apple, Google, Amazon, Facebook, Microsoft, etc.), widely publicized, which develop and manage complex BM portfolios. This field therefore offers

[6] Even if Paypal is used for other platforms, from the point of view of Ebay's BM portfolio, the online auction service is dependent on Paypal's online payment and insurance system to secure buyers' transactions. Of course, buyers can choose other payment methods (check, wire transfer) but the financial transaction is then done outside the secure environment of the Ebay platform.

research opportunities to identify connected BM portfolios, describe their functioning and understand their management.

Our research approach is exploratory because we are exploring theoretically and empirically a very little studied phenomenon: the connected BM portfolio. Therefore, the interest of the exploratory study lies in the contribution of new elements (Thietart, 2014). In this research, we propose a conceptual framework to analyze the architecture of a connected BM portfolio and we use our exploratory approach to illustrate its empirical application. To firstly achieve this objective and secondly understand how to strategically manage a portfolio of connected BMs, we adopted a qualitative method based on a "holistic multiple" case study according to Yin's (2013, p. 50) typology. This method allows us to explore a phenomenon in depth in its contemporary context and identify its constituent elements through the observation of similarities and differences between cases (Thietart, 2014). We looked for cases of companies present in all digital sectors (computing, mobile, telecommunications, networks, services, media, and Entertainment) with sufficient maturity and history to deploy an extensive BM portfolio with modular product and service offerings (theoretical sampling criterion[7]). At the time of our study, only Apple, Google, Microsoft and Samsung were fully committed to this strategy. We finally selected Apple, Google and Microsoft for three reasons. (1) They have developed a BM portfolio with a complete modular offer in which hardware products, software, operating systems, services and digital content are coupled. (2) They have demonstrated exemplary economic success[8], which suggests a successful and relatively mature BM portfolio (which allows us to avoid the analysis of BM portfolios that are under development or creation and therefore potentially unstable). (3) They are widely publicized and studied, which guarantees a very high volume of available data. They are therefore suitable for analyzing the strategic management of a portfolio of connected BMs.

Our qualitative approach relies exclusively on the collection of secondary data[9] , widely available in the media, Internet sites, specialized press and professional and academic articles. We also consulted several books on the history of Apple, Microsoft and Google. Therefore, our research is descriptive in nature as we seek to describe the functioning of a portfolio of connected BMs through an in-depth analysis of its architecture, using the conceptual framework proposed in the theoretical part. The final objective is to understand how to strategically manage this type of complex BM portfolio. The data processing is based on a descriptive thematic coding and then an emergent coding by crossing the theoretical data with the empirical data in order to distinguish the data related to the architecture of the product/service offer and the data related to the architecture of the portfolio of connected BMs (via the analysis framework proposed in the theoretical part). In each of the secondary data sources, pieces of text related to the studied phenomenon were selected and then isolated in three Excel files corresponding to the Apple, Google and Microsoft case. The coding was carried out on the basis of this selected secondary data. The objective was to examine retrospectively the evolution of the architecture

[7] We chose to attach importance to the modularity of offerings because this feature is characteristic of offerings in digital sectors (Yoo et al., 2012).

[8] Their return on equity is higher than the industry average. In 2013, Apple's profitability was 29.98%, Microsoft's was 27.69%, Samsung's was 11.16% (vs. 26.03% for the hardware sector) and Google's was 14.80% (vs. 13.63% for the Internet sector). Source: www.stock-analysis-on.net, January 2015).

[9] In an exploratory approach, it is possible to use a relatively small sample of firms to generalize the results if the richness of the data collected is high (Thietart, 2014).

of each company's offer, as well as the evolution of their BM portfolio. We sequenced our treatment process in three steps.

Step 1: We identified the components of each company's offer. The objective was to compile a list of products and services and their relationships according to the historical evolution of the company. This list was easy to identify given the enormous amount of information available on each of the products and services offered by Apple, Google, and Microsoft, including date of release, evolution over the years, key features and functions, and functional and performance tests. This data was used to determine the architecture of the offering and the connections between products and services, and to establish the codes related to the offering, useful for step 2.

Step 2: We then analyzed each product and service from the perspective of the BM's functions: the value proposition (what is the value delivered? How is it delivered? For which user group?), value creation (how is the value created? Which value chain? What technologies are used?), and value capture via the revenue model[10] (how do consumers pay?). We first collected academic articles about these companies, to illustrate themes close to strategy, BM and digital technology development. Then we searched for books on the history and strategy of these companies in order to determine the functions of their BM. A search on blogs, economic information sites and information on digital technologies allowed us to complete and triangulate the data. The selected pieces of text were manually coded with 12 codes: 3 codes for the functions of the BM and 9 codes for the supply components (see Table 1). First, we performed descriptive coding, which consisted of linking pieces of text to the three BM functions. The coding was carried out by one of the researchers with regular collective exchanges on the description of the functions of the BM and a return to the data in case of doubt. In a second step, based on this data, a second emergent coding was performed to identify the generic types of BM and thus the composition of the three BM portfolios. The coded elements associated with the functions of the BMs (creation, proposition and capture of value) of the three cases studied were grouped together in order to identify a common meaning and then associated with a code corresponding to the type of BM identified (e.g. BM_Distribution, BM_Services). This grouping was carried out by each of the researchers and then the interpretations were compared collectively in order to converge towards a common interpretation. The interpretation identified seven generic types of BM: (1) digital distribution, (2) services, (3) online advertising, (4) OS and software, (5) computer, (6) mobile devices and (7) connected objects.

[10] We have restricted ourselves to the revenue model for the sake of operationalizing the research, as the secondary data do not allow us to identify intangible value capture mechanisms.

**Table 1: Data Coding**

| Type | Code | Description |
|---|---|---|
| Business model functions | PV | Value proposition: type of value delivered, how it is delivered and user groups. |
| | CRV | Value creation: elements of the value chain and the technologies used |
| | CAV | Value capture: billing and payment methods |
| Components of the offers | DN | Digital distribution: everything related to digital products distributed online. |
| | SER | Digital service: everything related to digital services: cartography, translation, voice control... |
| | PUB | Online advertising: everything related to online advertising services deployed on search engines, websites and applications |
| | OS | Operating system |
| | LOG | Software: everything related to the software offers designed and developed by the company |
| | ORD | Computer |
| | CON | Game console |
| | MOB | Mobile device: everything related to cell phones and tablets |
| | OBC | Connected object: everything about watches, glasses and connected cars |

In most cases, a specific value proposition and revenue model has distinguished the BMs. However, some BMs share common elements in terms of value creation and capture. We grouped the software offering with the OS under a single BM because the vast majority of software and OS are delivered in the same way and with the same revenue model. For the content distribution platform, we interpreted it as a multi-sided BM because the value proposition is itself multi-sided, with three sides (end consumers, developers and enterprises) and a single revenue model. This step allowed us to identify the different BMs in the Apple, Google, and Microsoft portfolio and the correspondence with the components of the offering.

Step 3: We identified the connections between the BMs in the studied portfolios in order to then qualify the type of architecture. Each researcher first qualified the type and intensity of the connections between the previously coded BM functions. In a second step, we compared our interpretations to converge on a common qualification. For each BM portfolio, the previous analysis of the connections between the products and services of the offer and the shared elements in the value creation chain allowed us to identify the connections between BMs. Here, the analysis framework proposed in the theoretical part was very useful to locate these connections in the functions of the BMs and their intensity according to the type and purpose of the connections (see Table 2 for the description of the criteria). The information on connections between products and services within the offer and between BMs within the portfolio gave us useful insights to think about (1) how to achieve economies of scale and scope, (2) how to offer more user experiences via personalization, and (3) how to generate network effects and adoption effects to capture positive returns. Based on the qualification of connections between BMs (type and intensity), we inferred the level of modularity and/or completeness in the architecture of Apple's, Google's and Microsoft's portfolios.

**Table 2: Dimensions of the BM portfolio analysis framework**

| Dimensions | Principle of analysis | | |
|---|---|---|---|
| Identification of BMs | Number of BMs | Identification of BMs through analysis of specific value propositions | |
| | Type of BM | Definition of the type of BM according to the relationship with one or several components (product, service, other) of the offer | |
| Characteristics of the connections between BM | Type and nature of connection | Value creation | Pooling of partners, activities, resources and skills within the value chain and/or value network |
| | | Value proposition | Complementarity of the value delivered by several BMs (connected BMs mutually reinforce their value proposition without disrupting the customer experience) |
| | | Value capture | Sharing of elements related to the revenue model (e.g. same user account, single monetary transaction system, etc.) |
| | Connection intensity | low | Achieving economies of scale and scope |
| | | medium | Creation of additional value for the consumer resulting from the connection of BM (complementary value propositions) |
| | | strong | Interdependence of BMs on some or all functions |
| Qualification of the architecture of the BM portfolio | Level of modularity | Modular portfolio architecture: BMs are loosely coupled because the intensity of the connections is low or medium | |
| | Level of completeness | Integral portfolio architecture: BMs are strongly coupled because the intensity of the connections is high | |

## CASE STUDIES

Following the application of our analysis framework, it is possible to describe the architecture of each company's BM portfolios with a description of the BMs and their connections.

### APPLE: architecture of the product/service offering and portfolio of connected BMs

Apple's product and service offering is a true ecosystem for consumers. To ensure its economic performance, the company has developed over the years an innovative portfolio with classic and multi-sided BM. In the early 1980s, Apple developed its first BM with the design and sale of computers with operating systems (OS). Subsequently, all other PCs were designed to enhance the performance of the initial PC. In 2002, the company expanded its product line with the iPod and, the following year, created an online music sales service (iTunes Store). The offer is then extended to mobile devices with the iPhone (2007) and the iPad (2010). Online sales were extended to all digital content available on Apple devices: music (2003), video (2005), applications (2008), books (2010) and additional services were developed: email and online storage (2008), video conferencing and advertising (2010), mapping (2012).

At the portfolio level, it is possible to distinguish: (1) “distribution” BMs for content, services and advertising, (2) “hardware” BMs dedicated to the sale of mobile devices, mobile objects and computers, and (3) a “software” BM acting as an interface with the provision of OSX and iOS and own software (see Table 3). The portfolio is thus composed of seven BMs: digital distribution, services, online advertising, software and OS, computers, devices and connected objects. These BMs complement each other insofar as the products and services in the offer are complementary (see table 3 on page 14).

### GOOGLE: architecture of the product/service offer and portfolio of connected BMs

Initially, Google's offer is based on a multi-sided platform with: (1) free services for Internet users (search engine, web messaging, video streaming…) and (2) paid advertising campaign services (AdWords and AdSense) for professionals. These services are available on multiple devices under Windows or MacOSX through Internet browsers. From 2007, Google develops a new BM based on the distribution of free OS: Android (2007), Chrome OS (2011) and Android Wear (2014), first distributed on non-proprietary devices (Samsung phone). From 2010, Google develops its own devices equipped with its OS: Nexus (2010), GoogleTV (2010), ChromeBook (2011), Google Glass (2014) and Pixels (2016). The company is thus strengthening its first BM with an expanded offering of services, open OS and products, supported by multiple platforms. The BM of online sales of applications and content appears with the Android Market service (2008), then Google Play (2012).

Google has succeeded in developing a portfolio with distribution BMs, hardware BMs and software BMs (see Table 4), linked to each other by complementary value propositions valuing the modularity of the services and software offering and hardware innovation. Finally, the emphasis on digital distribution allows Google to offer its services and software on other non-proprietary devices and OS (Mac, PC, Windows, Linux), thus reinforcing the adoption of part of its offer. Google's BM portfolio is thus composed of seven BMs: digital distribution, services, online advertising, software and OS, computer, smartphone, and connected objects (see Table 4 on page 15).

## MICROSOFT: architecture of the product/service offering and portfolio of connected BMs

Microsoft started its software development and sales activity in the late 1970s. Its first OS (MS-DOS in 1981 then Windows in 1985) gave it a central position in the computer industry. The company created at the time a new BM based on the sale of the exploitation rights of its BASIC language (1976) and MS-DOS (1981), giving it the possibility to sell its software to other manufacturers. This wide distribution guaranteed him long term revenues. At the end of the 1980s, Microsoft's software offering became an industry standard. The company then strengthened its first BM with the launch of several software products: the Flight Simulator video game (1982), the Office software suite (1983-1987), database management (1994), the Internet Explorer browser (1996) and the Expression Studio multimedia suite (2005). In 2001, Microsoft develops a BM based on a multimedia device offer with its Xbox game console (2001) and the Zune music player (2006). In 2003, Microsoft develops a mobile version of its OS with Windows CE and Windows Mobile Monitoring, then Windows Mobile (2010) and Windows RT (2012). In 2012, Microsoft completes its offer of devices with the Surface tablet and then with the acquisition of the terminal division of Nokia for cell phones (2013), then sold in part to Foxconn (2016). On the services side, Microsoft created an advertising agency (2007) and launched its search engine Bing (2009), completed with the mapping service Bing Maps (2010). The digital distribution activity appears with Windows Marketplace (2004), now Windows Store (2012). Since the end of 2014, the company designs connected objects (Microsoft Band) and an augmented reality headset (2015).

All the BMs are connected to each other and aim to strengthen the sale of the OS. Microsoft has therefore developed a modular portfolio (see Table 5), made up of seven BMs in which we distinguish: (1) BMs for digital distribution, services and online advertising, (2) “hardware” BMs dedicated to the sale of game consoles, mobile devices and connected objects and (3) a “software” BM acting as an interface with the sale of software and OS (see Table 5 on page 16).

**Table 3 - Apple's BM Portfolio**

| | Digital distribution | Services | Online advertising | OS and software | Computer | Mobile devices | Connected objects |
|---|---|---|---|---|---|---|---|
| Type | Distribution | Distribution | Distribution | Interfaces | Material | Material | Material |
| Value proposition | Direct online access to a large catalog of video, music, books, press, applications | Service package available on all Apple devices | Advertising on IOS applications and iTunes Radio | User-friendly software and OS, linked and integrated with the hardware ecosystem | Attractive design and high-end computer | Attractive design and high-end multifunctional phones/tablets | Attractive design with a wide range of services connected to IOS |
| Value creation | Partnerships with film and music publishers<br>Development of a large data storage infrastructure and database management solution<br>Internal development of iTunes, iTunes Store and Mac Store | Internal development of a service infrastructure<br>Partnerships with banks and commercial networks (Apple Pay) and map data providers (Maps) | Internal development of online tools for creating and managing advertising campaigns (iAd Workbench)<br>Partnerships with other presenters to cross-reference user data to expand distribution | Internal design and development<br>Beta testing with a large community of developers | Internal design<br>Manufacturing with suppliers<br>Control of key technologies<br>Animation and collaboration with a large community of developers | Internal design<br>Manufacturing with suppliers<br>Control of key technologies<br>Animation and collaboration with a large community of developers | Internal design<br>Manufacturing with suppliers<br>Control of key technologies<br>Collaboration with a large community of developers<br>Communication campaign focused on luxury |
| Value capture | 30% on the sale price of digital products and content | Free service with premium version for the Cloud offer | Auction of advertising space<br>Shared revenue with application developers | OSX and freeware<br>Some Apple software is not free<br>IOS free | Distribution online and on Apple store-<br>High price with high margin | Phone operator, online distribution and Apple store-<br>High price with high margin | Online distribution, on Apple Store and jewelry store<br>High price with high margin |
| Connection between other BMs | **Medium**<br>PV: contents can only be played with Apple devices (except for music)<br>CrV: sharing of data management skills<br>CaV: sharing of credit card number and Apple account | **Strong**<br>PV: Services can only be used with Apple devices<br>CrV: shared data management skills<br>CaV: sharing of credit card number and Apple account | **Strong**<br>PV: Advertising is only valuable with a large number of Apple users<br>CrV: shared data management skills | **Strong**<br>PV: Apple OS and software only work on Apple devices | **Low**<br>PV: Needs OS and software but can do without other products and services.<br>CaV: sharing of credit card number and Apple account | **Medium**<br>PV: complementary with Apple computer<br>CrV: sharing processor design skills and technologies with connected objects<br>CaV: sharing of credit card number and Apple account | **Medium**<br>PV: complementary with an iPhone<br>CrV: sharing processor design and technology skills with devices<br>CaV: sharing of credit card number and Apple account |

*PV: Value Proposition; CrV: Value Creation; CaV: Value Capture*

**Table 4 - Google's BM portfolio**

| | Digital distribution | Services | Online advertising | OS and software | Computer | Devices | Connected objects |
|---|---|---|---|---|---|---|---|
| Type | Distribution | Distribution | Distribution | Software | Material | Material | Material |
| Value proposition | Direct online access to a large catalog of music, video, press, books and applications | Service package available on all devices equipped with Android OS, and in line with Windows OS and OSX | Android OS ads, websites and search engines | Free OS and software available on multiple devices | Low cost computer with minimal OS | Attractive design and multifunctional phones/tablets | Attractive design, high-end objects and a wide range of connected services with the iPhone |
| Value creation | Partnerships with developers, publishers and large film and music companies<br>Development of a large storage infrastructure and database solution<br>Internal development of Google play<br>No validation of content before distribution | Development of a service infrastructure<br>Purchase of technology companies<br>Partnerships with map data providers (Google maps), airlines (Flight search), hotels (Hotel finder), broadcasters (youtube) | Internal development of online tools for creating and managing advertising campaigns (Adwords)<br>Partnerships with other presenters to cross-reference user data to expand distribution | In-house design and development<br>Beta testing with a large user community | Internal design<br>External design with partnerships (Asus, Samsung, Acer, Dell...)<br>Manufacturing and distribution with external suppliers and partners | Internal design<br>Manufacturing with external partners<br>Control of key technologies<br>Animation and collaboration with a large community of developers | Internal design<br>Manufacturing with external partners<br>Purchase of technology companies<br>Control of key technologies<br>Animation and collaboration with a large community of developers |
| Value capture | 30% on the sale price of digital products and content | Free service with premium versions<br>Percentage of revenues related to intermediation | Bidding on keywords<br>Shared revenues with the website and partners | Free Android OS and Chrome OS<br>Free software | Online and retail distribution with low-margin price partnerships | Phone operator, Google Store (online distribution) and retailers<br>Average price with low margin | Online distribution on Google Store and other websites<br>High price with medium margin |
| Connection with other BMs | **Low**<br>PV: content can only be played on Android but on multiple devices<br>CrV: shared data management skills<br>CaV: sharing of credit card number and Google account | **Low**<br>PV: services are accessible online and on multiple devices and OS<br>CrV: shared data management skills<br>CaV: sharing of credit card number and Google account | **Medium**<br>PV: The advertisement is also broadcasted in other networks.<br>CrV: shared data management skills<br>CaV: sharing of credit card number and Google account | **Low**<br>PV: OS works on multiple devices of different brands | **Strong**<br>PV: cannot work without Google online services and Android OS<br>CaV: sharing of credit card number and Google account | **Medium**<br>PV: complementary with Google services<br>CrV: technology sharing with connected objects<br>CaV: sharing of credit card number and Google account | **Medium**<br>PV: complementary with Google services<br>CrV: technology sharing with mobile devices<br>CaV: sharing of credit card number and Google account |

*PV: Value Proposition; CrV: Value Creation; CaV: Value Capture*

**Table 5 - Microsoft BM Portfolio**

| | Digital distribution | Services | Online advertising | OS and software | Game consoles | Mobile devices |
|---|---|---|---|---|---|---|
| Type | Distribution | Distribution | Distribution | Software | Material | Material |
| Value proposition | Direct online access to a limited catalog of applications | Service package available on all devices equipped with the Windows OS | Advertising on Bing, Windows 8 apps, Skype and Xbox | Ergonomic software and operating system available on computers, tablets and smartphones | Living room game console | Multifunctional phones and tablets with Windows OS |
| Value creation | Partnership with developers<br>Internal development of a Windows Store | Design and internal development of a service infrastructure<br>Purchase of technology companies<br>Partnerships with map data providers | In-house development of online tools to create and manage advertising campaigns (Ad Exchange)<br>Partnerships with other presenters to cross-reference user data to expand distribution | Internal design and development<br>Beta testing with a large community of developers | In-house design<br>Manufacturing with suppliers<br>Collaboration with game publishers | Internal design (Nokia phone)<br>Manufacturing with suppliers<br>Animation and collaboration with a large community of developers |
| Value capture | 30% commission on the sale price of applications (20% after $25,000 in sales) | Free service with premium versions | Billing of the broadcasting space<br>Bidding on keywords<br>Revenue sharing with application developers | Sold on computers via online distribution and retailers | Distribution to retailers<br>Royalties on games sold by publishers | Phone operator, online distribution (Microsoft Store) and retailers<br>Average price with average margin |
| Connection with other BMs | **Medium**<br>PV: content can only be played on Android but on multiple device brands<br>CrV: shared data management skills<br>CaV: sharing of credit card number and Microsoft account | **Medium**<br>PV: services are accessible on multiple devices under Windows<br>CrV: shared data management skills<br>CaV: sharing of credit card number and Microsoft account<br>: | **Strong**<br>PV: advertising is only valuable with a large number of Windows services users and Windows OS users<br>CrV: shared data management skills | **Low**<br>PV: the OS does not work on multiple devices of different brands<br>CaV: sharing of credit card number and Microsoft account | **Low**<br>PV: the console is independent of other offers but the games run on Windows<br>CrV : sharing of skills on the software part<br>CaV: sharing of credit card number and Microsoft account | **Medium**<br>PV: needs the OS but can do without the other BM<br>CaV: sharing of credit card number and Microsoft account |

*PV: Value Proposition; CrV: Value Creation; CaV: Value Capture*

## RESULTS

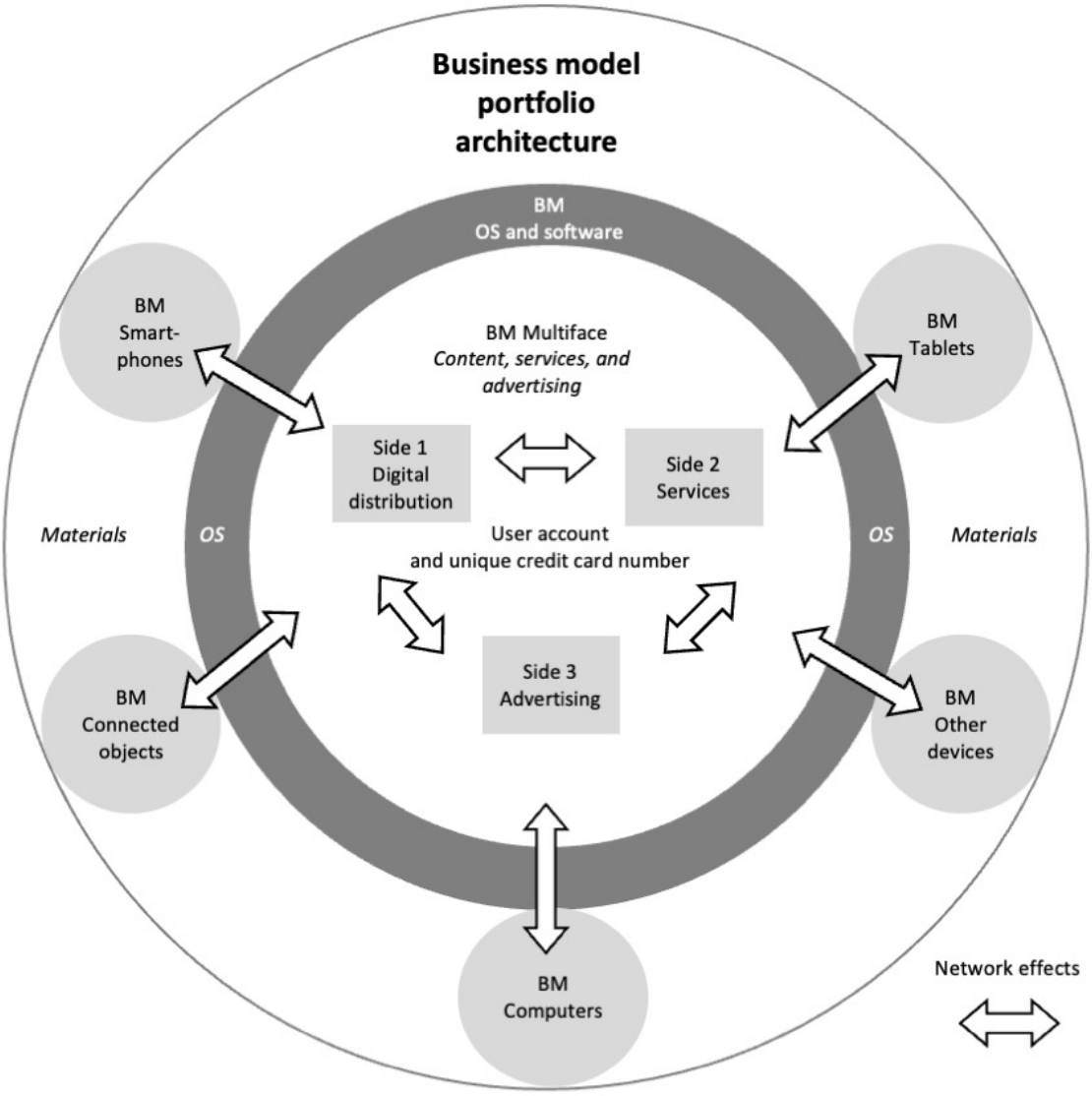
The analysis of the data collected on Apple, Google and Microsoft allows us to identify three results: (1) the strategic management of a portfolio of connected BMs seems possible through the implementation of a similar architecture with three layers of BMs (hardware/software/digital distribution), (2) there are more or less strong connections between the functions of the different BMs within the portfolio, and (3) the presence of a multi-sided BM at the center of the portfolio seems to play a determining role for the modularity of the architecture.

### A common BM portfolio architecture for all three cases

The three companies studied have developed a similar BM portfolio architecture, intimately related to the modular architecture of their product and service offerings, in which BMs are organized into three layers: (1) hardware BMs dedicated to consumption and content creation devices, (2) software BMs dedicated to OS and software, and (3) multi-sided digital distribution BMs dedicated to the distribution of services, advertising and content (see Figure 1). The analysis of these layers allows us to identify the connections between BMs. The hardware BMs are connected to the software BM because the purchase of a device allows the customization of the software environment. Indeed, even if it is possible to use, for example, Apple's computers or Microsoft's tablets with native applications, the additional software offer of these companies allows to extend the functionalities according to the users' needs. The software BM also acts as an interface between the hardware BMs and the multi-sided distribution BM because users must have a device equipped with the OS and the software allowing access to the digital distribution platform. Indeed, for example, for Apple and Microsoft, access to the digital distribution platforms requires dedicated software and the applications purchased only run on the operating systems of these companies. As a result, the value propositions of all the BMs are complementary in order to promote all the connections between products and services in the offer. The focus on distribution positions the multi-sided BM at the center of the portfolio, where content, services and advertising are connected through digital technologies. Indeed, for Google and Apple, the complementary offering of apps and services adds value to the phones, tablets and computers that will be able to deliver this offering. Users buy a device, expandable and customizable, open to thousands of additional features.

However, there are differences between Apple, Google and Microsoft, particularly in the evolution of their product and service offering architectures and their BM portfolio. Apple started with a hardware BM while Google started with a service BM and Microsoft with a software BM. The origin and nature of the BMs in their portfolios are therefore different, but their evolution has similarities as each company has supplemented its portfolio with new device, software, and service-oriented BMs to develop a similar BM portfolio architecture. The strength of the BM portfolios studied lies in the development of a modular offering of software and services, operated by connected devices. This is particularly true for Apple and Google, which have created a true digital ecosystem for consumers, while Microsoft's ecosystem was a later development. Although these companies started with a different BM, they structured their portfolios with a similar architecture (see Figure 2).

**Figure 2: Apple, Google and Microsoft's BM portfolio architecture**




## Nature and intensity of connections between BMs within a portfolio

The close connection between the product and service offerings of Apple, Google, and Microsoft and the architecture of their BM portfolios allows us to identify more or less strong connections between the core functions of the BMs.

At the value creation level, the BMs use common resources that depend on the BM's core mission. The multi-sided digital distribution BM uses software and hardware resources common to other BMs, and also shares common hosting and big data management skills between these three sides (content / services / advertising). For example, at Apple, the same server infrastructure manages the distribution of *iTunes* content and *iCloud* services. The technologies implemented in Apple's data centers are derived from its experience in developing *Xserve* servers and *Webobject* technologies. This connection between the BMs in value creation allows for economies of scale as the goal is to use single resources and skills for multiple

services. Hardware BMs and software BMs share common technologies, resources and skills in the design and development of products (OS, software and consumer electronic devices). For example, for Apple and Microsoft tablets, there is a great deal of integration between the hardware and the OS, and the same microprocessor and touchscreen technologies are used on all mobile devices. The connections between hardware BMs and between software BMs allow for economies of scale as the companies studied use common technologies and common production lines to produce software, mobile devices and connected objects.

At the level of the value proposition, the connections between BMs result from the complementarities of use between products and services in the offer. The digital distribution BM and the software BM enrich computers and mobile devices by diversifying usage possibilities and providing various applications, services and content. Connected objects extend the use of mobile devices. Therefore, we can deduce that these connections seem to favor the development of positive network effects. Indeed, the complementarity of the value proposition between the hardware BM and the multi-sided digital distribution BM is likely to encourage users to buy several devices to access the same content and services. For example, Apple and Google's synchronization of content, contacts and calendars between distribution devices multiplies usage possibilities and mutually reinforces the value of each hardware product. This incentive is likely to reinforce the adoption of the hardware offer because users can satisfy a need for mobility and diversity of uses. Thus, users can become customers on multiple BMs. In turn, this can have positive effects on the revenue model of the multi-sided digital distribution BM. This is because the more device users there are, the more purchases are likely to be made on the digital distribution platform. In turn, the mass and variety of content and services distributed on the digital platform are attractive to users, who are likely to purchase one or more devices to access them.

At the value capture level, Apple, Google and Microsoft have implemented easy purchase management via a common user account (and associated credit card) directly linked to the multi-sided digital distribution BM. Therefore, there are connections between the BM revenue models as they take advantage of this simplicity of payment and billing. Of course, physical BMs also have traditional monetization mechanisms with the sale of products in traditional physical distribution channels. However, the ability of computers, game consoles and mobile devices to connect to the Internet allows users to make other purchases. Thus, based on the complementarities between value propositions that encourage users to be customers on multiple BMs, the sources of revenue capture are likely to increase as ease of payment and personalization possibilities encourage consumption of the products and services on offer.

In the end, the nature and intensity of the connections between the functions of the BMs allow us to qualify the architecture of the portfolios of Apple, Google and Microsoft as rather modular. Indeed, we find that the connections between the BMs are weak and moderate, with the exception of Apple where some BMs (notably hardware and OS) are strongly connected. In the other cases, each BM can work independently of the others but it is the combination of BMs that brings positive effects. Within the portfolio, it is therefore possible to add or remove some BMs without preventing the functioning of the others.

## DISCUSSION

Our results, even if descriptive, enrich BM portfolio research (notably Sabatier et al., 2010; Demil et al., 2013; Aversa et al., 2017) by providing two contributions: (1) the proposal and empirical application of a conceptual framework to analyze the architecture of a connected BM portfolio and (2) the description of a common architecture of three BM portfolios in the digital sectors, in which BMs are organized in three interconnected layers (hardware, software, and digital distribution). Our results allow us to discuss four points: (1) the analysis of the architecture of a connected BM portfolio, (2) the positive consequences of connections between BMs in a portfolio, (3) the role of the multi-sided BM in the development of a modular BM portfolio architecture, (4) the strategic principles supporting the development of a connected BM portfolio, and (5) the role of the BM portfolio in the pursuit of a sustainable strategic advantage.

First, our results illustrate the empirical application of the analytical framework developed in the theoretical part, offering scientists and managers a new exploration tool to analyze the architecture of a portfolio of connected BMs. While existing research proceeds by analogy (Sabatier et al., 2010), uses positioning matrices of BMs within the portfolio (e.g. Demil et al., 2013) or develops design methods (Aversa et al., 2017), our analysis framework provides a more in-depth diagnosis on three dimensions: the identification of BMs, the characteristics of connections between BMs and the qualification of the BM portfolio architecture. In the digital sectors, there appears to be a strong link between the architecture of a modular product and service offering and the architecture of the connected BM portfolio. This reinforces Fixson's (2005) findings that the design of a modular product and service architecture also implies the design of connections at the organizational and strategic level (connections between activities in the value chain, see e.g. Chesbrough and Prencipe, 2008), but also at the market level (to foster personalization, see e.g. Jiao et al., 2003). Therefore, the three dimensions of our framework seem relevant in the specific case of modular offerings in digital sectors where networks, products, services and content are coupled (Yoo et al., 2012).

Second, the use of our analytical framework allows us to identify the connections between BMs and more precisely the location of these connections within the value creation, proposition and capture functions. Even if our exploratory research design does not allow us to measure the associated benefits, it is possible to discuss these connections and to deduce the positive effects for the company. Indeed, the three portfolios studied show a similar architecture in which hardware BMs and software BMs are connected to each other in terms of value creation. From then on, firms are likely to achieve not only economies of scale, but also economies of scope to multiply product development from common resources, skills, and technologies (Aversa et al., 2017). The majority of connections between BMs are then observed at the level of the value proposition as the objective is to promote the complementarity of products and services as well as the customization of the offer (Jiao et al., 2003). From then on, the multiplication of complementary value propositions makes it possible to satisfy a wide variety of consumer needs (Sabatier et al., 2010) and supports diversification (Aversa and Halfinger, 2017). These complementarities in turn provide a unified user experience and are a source of value creation because they produce useful effects for the user (Rahikka et al., 2011). Furthermore, creating an entire “proprietary” hardware ecosystem is likely to enhance loyalty to the extent that the consumer is technologically locked in (according to the lock-in dimension of Zott and Amit, 2010). By seeking to engage and retain users in the overall consumption of their offering, companies thus ensure value capture over several BMs. Indeed, the cases studied show connections between the revenue models of several BMs, especially because personalization

opportunities are a source of profitability as they generate multiple purchases (Jiao et al., 2003). Moreover, with a single user account, users can purchase software, services, and digital content from their devices. This simplification and speed of purchase is an additional lever for engagement in the purchase act and for revenue multiplication.

Third, our results suggest the central role of the multi-sided digital distribution BM in the development of a modular BM portfolio architecture. A multi-sided BM indeed enables the delivery of several complementary value propositions to several complementary user groups in order to generate positive network effects (Parmentier and Gandia, 2016). From then on, the principle of complementarity and connections between different user groups (the faces) within the BM supports the modularity and personalization of the offer. This principle is at work in modular BMs (Aversa et al., 2015) and more generally in digital sectors (Mangematin et al., 2014). Positive network effects help create and capture more value (Parmentier and Gandia, 2016) and in turn lead to adoption externalities (Church et al., 2008), which are beneficial for supply retention. In multi-sided architectures, the value of a product or service depends on direct network effects on the same side and indirect network effects between sides (Eisenmann et al., 2006). For example, the higher the number of consumers who buy iPhone, the stronger the BM of iPhone becomes due to direct network effects and adoption effects that attract new customers. In addition, this high number of users creates value for other BMs (software BM and digital distribution BM) because iPhone users are likely to consume software, digital services and content. Thus, the development of a portfolio of connected BMs around a multi-sided BM seems to be a major strategic element to build a sustainable competitive advantage in the digital sectors.

Fourth, although our results are descriptive, it is possible to derive three strategic principles that can help develop a portfolio of connected BMs in the digital sectors: (1) design a modular offering of products and services, (2) adopt a multi-sided platform, and (3) implement a hierarchical structure among BMs. First, the Apple, Google, and Microsoft cases show a link between the modular architecture of their product and service offerings and the modular architecture of their connected BM portfolio. This overlay principle can lead managers to think about the coherent design of their BM portfolio based on the design of a modular product and service offering. In the case of a pre-existing BM portfolio, the thinking can focus on how to intelligently connect new BMs to existing BMs (Aversa et al. 2017). Just as the BM positioning matrix is used to define future trajectories of BMs in a portfolio (Demil et al. 2013), our analytical framework could be used to identify future connections between new BMs and existing BMs within the portfolio. Second, the adoption of a multi-sided platform as the technological support for the digital distribution offering allows for the design of a BM that is itself multi-sided (Parmentier and Gandia, 2016), which promotes portfolio modularity in that it becomes possible to assemble and disassemble multiple BMs (Mangematin et al., 2014). From then on, managers can think about developing and integrating such a multi-sided BM into their portfolio to support modularity. Finally, setting up a hierarchical structure between BMs seems to be a good way to organize the connections between BMs and to consider the possibilities of mutual enrichment of BMs. In the same way that the portfolio approach makes it possible to distinguish key activities from secondary activities (Sabatier et al., 2010), the cases studied seem to reveal a form of hierarchy in three levels, modelled on the three layers of hardware, software and digital distribution BMs. This structuring logic can encourage managers to reflect on the strategic (or economic) importance of their BM, and in particular their possibilities of mutual enrichment via the degree of hybridization between core BM and

peripheral BM (Aversa and Haefliger, 2017). The interest would be to facilitate the definition and organization of connections between BMs (according to their level of importance and/or added value for other BMs) in order to understand portfolio management in a more organic way and not as simply diversified.

Fifth, the similarity in the architecture of the BM portfolios of Apple, Google and Microsoft raises questions about the foundations of competitive advantage in the digital sectors. Indeed, we note that competitive advantage is no longer only a consequence of generic strategies of cost control or differentiation (Porter, 2003) and internal ownership of strategic resources (Barney, 2001), but is also established through the implementation of a portfolio of connected BMs, capable of producing network and adoption effects. The multi-sided approach (platform and/or BM) is therefore not the only explanatory factor for network effects in digital sectors (as is the case in general, e.g. Eisenmann et al., 2006) and other elements such as the modular approach of the portfolio and the hierarchical orchestration of connections between BMs can explain these effects. These findings are fully in line with the research agenda of McIntyre and Srinivasan (2017) who show that platforms, network effects and complementor dynamics are the new levers of competitive advantage.

## CONCLUSION

Our study contributes to a better understanding of the strategic management of a portfolio of connected BMs in the digital sectors, in particular the specific case of modular MB portfolios based on the exploitation of a modular offering of devices, software, services and digital content. We provide two contributions: (1) the empirical application of an analytical framework for the architecture of a portfolio of connected BMs and (2) the description of the operation of the BM portfolios of Apple, Google and Microsoft, which show the value of the strategic management of a modular architecture in which BMs are structured in layers and connected on the functions of value creation, proposition and capture. We deduce that this type of architecture allows to diversify and multiply revenue sources, to favor the production of positive network effects and to technologically lock the consumer to a global offer. Our results allow us to consider the BM portfolio as a multidimensional model, whose analysis can be useful to optimize strategic decisions related to the product, process, value chain/network and market dimensions. We thus contribute to the work on the BM portfolio and more broadly to the literature on BM.

The generalizability of our results remains limited, however, because our exploratory research design is based on three case studies with exclusively secondary data and a retrospective, historical analysis of BM's portfolio evolution. Although Apple, Google, and Microsoft can be considered emblematic cases of their category, they do not constitute a reference sample and our results deserve to be compared to other cases and types of companies, especially in contexts other than digital sectors. Further studies and especially comparative analyses would thus be beneficial to (1) empirically test and validate our analytical framework to go beyond simple application, (2) identify other types of modular BM portfolio architectures and compare them, and (3) further analyze the cross-fertilization dynamics of BMs to better understand the benefits of connections. In addition, work with a more micro level of analysis, incorporating the study of BM components, would be welcome to refine the analysis of a BM portfolio. Indeed, the adoption of a consolidated conceptualization of the BM on the sole functions of value creation, proposition and capture remains limited to apprehend the

complexity of a portfolio of connected BMs, and this is only one way to describe the studied phenomenon. Beyond the contributions of this study, however, several questions remain. For example, we suggest the existence of a possible hierarchy between the BMs of the portfolios studied, but how should this hierarchy be conceived? On the basis of what criteria, logic or strategic thinking? What precisely are the value transactions between the different hierarchical levels? How can we design the evolutionary trajectory(s) of a BM portfolio? How does the architecture of the BM portfolio influence the competitive dynamics in an industry? This question seems key to us because Apple's model is a form of strategic revolution which, by being imitated by Google and Microsoft (and recently by Samsung), shows that the digital sectors are moving towards a dominant model.

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