The Dual Nature of Information Systems in Enabling a New Wave of Hardware Ventures: Towards a Theory

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Abstract

Hardware ventures are emerging entrepreneurial firms that create new market offerings based on development of digital devices. These ventures are important elements in the global economy but have not yet received much attention in the literature. Our interest in examining hardware ventures is specifically in the role that information system (IS) resources play in enabling them. We ask how the role of IS resources for hardware ventures can be conceptualized and develop a framework for assessment. Our framework builds on the distinction of operand and operant resources and distinguishes between two key lifecycle stages of hardware ventures: start-up and growth. We show how this framework can be used to discuss the role, nature, and use of IS for hardware ventures and outline empirical research strategies that flow from it. Our work contributes to broadening and enriching the IS field by drawing attention to its role in significant and novel phenomena.

1. Introduction

Prior research on information systems (IS) in the context of entrepreneurship has largely focused on software ventures [e.g., 45] and internet-based business models [e.g., 41]. Little attention has been paid to hardware ventures, that is, emerging entrepreneurial firms that create new market offerings based on the development of digital devices [29]. However, hardware ventures are an important element in the global economy and have recently witnessed a surge in interest and investment. For instance, the Wall Street Journal reported that venture capital investment in consumer electronic ventures rose from around US$ 150 million in 2010 to US$ 848 million in 2013 [47], and investment in electronics and computer hardware ventures arrived at an all-time high of US$ 2.6 billion in 2014 [9]. Google’s recent acquisition of Nest Labs for US$ 3.2 billion is another case in point [47]. However, while hardware ventures are gaining importance in the global economy, to date there is no extant literature that offers explanations for these movements.

Hardware ventures and their business models differ substantially from software ventures and purely internet-based business models on at least two counts. First, new product development requires extensive knowledge networks involving expertise in operations, IS, marketing, strategy, engineering management, production, and others [29]. Second, business operation of hardware ventures, such as production and sales of hardware products, requires specific equipment, expertise, and distribution networks. Whereas software ventures can comparatively easily scale and are essentially only limited by availability of human capital and IT infrastructure, hardware ventures face increased and more diverse constraints due their high dependency on numerous external actors and resources. As a result, development of hardware products was traditionally a costly endeavor and thus, out of reach for new ventures which typically face considerable resource constraints [10].

The case of Lockitron [36] illustrates these challenges well. For instance, competencies that were required for this company “not only encompass the app and web development but also industrial design, mechanical design, operations, embedded development, and more.” Also, challenges were faced around “debugging tooling, coordinating dozens of suppliers and establishing QC procedures” plus many others.

The Lockitron case also suggests that the success of the venture was to no small part due to their use of IS in various forms and purposes for co-creation. For example, Lockitron used a “homebrew crowdfunding app” to involve consumers in fund raising and problem follow-up sheets to engage manufacturers in problem resolution. Yet, there is no explanation available from the literature to elucidate whether, why or how information systems can assist the development of hardware ventures.

Drawing on literature from Entrepreneurship, Information Systems, Management, and Marketing
we set out to provide an explanation. Specifically, we set out to answer the research question: How can managers use IS to successfully develop hardware ventures?

In this article we suggest that IS possess a dual nature in enabling the emergence of hardware ventures, namely as operand and as operant resources [43]. Operand resources are typically tangible, static resources that can be directly acted on to produce an effect. Operant resources are typically intangible, dynamic resources that act on other (operand or operant) resources to produce an effect [43]. We use this conceptualization to develop four quadrants of IS roles that delineate their nature across two lifecycle stages of hardware ventures: start-up and growth. In the start-up stage, hardware ventures have to assemble resources and develop their solutions, whereas in the growth stage, hardware ventures have to commercialize their solution and scale operations. On basis of this conceptualization we argue that managers have to structure, bundle, and leverage (i.e., orchestrate) a mix of both operand and operant resources across the lifecycle stages of a hardware venture in order to create value and to eventually succeed. We develop a set of strategies to guide IS researchers in exploring IS support for hardware ventures and develop knowledge about this important phenomenon. We briefly describe different empirical research strategies that could be used to explore our four quadrants.

We proceed as follows. Next, we review the literature on high-technology (high-tech) ventures, introduce Service-Dominant Logic as the basis for our distinction of IS as operand and operant resources, and discuss resource orchestration as a perspective on resource management. Next, we develop a framework to assess the role of IS in supporting start-up and growth stages of hardware ventures. We then discuss potential research strategies that are relevant to enacting and extending our framework. We end by discussing contributions and limitations of our research.

2. Background

2.1. Hardware ventures

Hardware ventures are one form of high-tech ventures. High-tech ventures differ from low-tech ventures (such as gastronomy or wood manufacturing) because creation of technology involves the use of sophisticated machinery [42], requires specific technical expertise and capabilities [17], and is usually based on distributed processes involving multiple actors from different domains [16].

Research has shown that not only low-tech and high-tech, but also different types of high-tech ventures differ significantly from each other [26]. Yet, this distinction has been largely ignored in the IS literature. The research that exists on information technology (IT) ventures largely analyses either IT ventures' abilities to obtain venture capital funding [e.g., 1] or focuses on software ventures as one type of high-tech venture [e.g., 45].

We posit that hardware ventures as a specific type of IT ventures are a) conceptually different to software ventures, and b) an important research phenomenon for the IS field, with the potential to position the field as a reference discipline for entrepreneurship, new product development, and management at large. Our argument rests on the observation of hardware venture trends such as the emergence of compatible standard platforms, open architectures, and a drop in hardware and software costs, which are not dissimilar to those trends several decades ago that primarily contributed to the formation and establishment of the IS discipline in the first place [20]. Thus, the current resurgence of digitally enabled hardware ventures provides an opportunity for IS researchers to draw on the discipline's knowledge base to contribute to the understanding of this emerging phenomenon, and thereby address questions of the nature of the relationship between IS and entrepreneurship [18].

Development of new ventures can generally be distinguished into two major stages [e.g., 38]: start-up and growth. In the start-up stage, hardware ventures have to assemble resources and develop their solutions, which is a challenging, knowledge intensive process [28] typically involving various activities from strategic planning, idea development and screening, business and market opportunity analysis, technical development, product testing, to coordination of market launch [40]. Important success factors during start-up are acquisition and accumulation of necessary resources and minimization of development costs and time-to-market [32].

After a solution has been developed, hardware ventures have to start commercialization of this solution (i.e., enter the growth stage), which involves management of the physical supply of goods and coordination of various activities across a number of actors such as suppliers, manufacturers, distributors, retailers, and end-customers [23]. Important success

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1 A third type of studies in the IS context focuses on the role of the internet as business enabler of new ventures [41]; yet, these ventures do not necessarily qualify as high-tech ventures.
factors during growth are minimization of production and distribution costs and maximization of value delivery to customers [23].

2.2. Service-dominant logic

IS are a key resource for any firm. In fact, they have been argued to be the most significant resource for productivity improvement in the last half century [49]. To examine the nature of IS as key resources in supporting hardware ventures, we will draw on the distinction between IS as operand versus operant resources [e.g., 30]. This distinction originates from Service-Dominant Logic (S-D Logic), which is a theory of value creation that broadens the traditional focus on value creation from production of tangible goods to creation of more comprehensive service systems [44]. Service systems are essentially solutions that are based on configurations of different resources such as social and economic actors, goods, knowledge, and skills. Importantly, S-D Logic characterizes resources as anything that an actor can draw upon for support [43], be they tangible or intangible, dynamic or static, internal or external.

The S-D Logic distinguishes these resources as operand versus operant resources [13] as described above. For example, an instant messaging tool can smoothen and simplify communication flows by directly enabling actors to overcome spatial collaboration barriers, thereby acting as an operand resource. In contrast, a crowd-sourcing platform can boost and amplify value creation by activating external actors for knowledge creation, thereby acting as an operant resource.

We deem S-D Logic a suitable framework to being our conceptualization. This argument rests largely on its prior use in product and service innovation research [30]. We are conscious that other frameworks exist that conceptualize IS resources, e.g., the original resource-based view [8], or resource dependence theory [12]. We opted for S-D Logic over these alternatives because it provides a concise framework for resource classification and draws attention to the role of individual resources in creation of holistic service systems.

2.3. Resource orchestration

Possession of and access to key resources such as for example, IS as key enablers of complex service systems [34], does not automatically guarantee firm success. A firm also has to take actions to effectively orchestrate resources, that is, structure, bundle, and leverage them [38]. Structuring refers to the acquisition, accumulation, and divestment of resources in order to shape a firm’s resource portfolio. Bundling refers to the combination of resources from a firm’s portfolio to establish capabilities and involves stabilization and enrichment of existing and pioneering of new capabilities. Leveraging refers to the application of a firm’s capabilities in order to create value and involves mobilization, coordination, and deployment of capabilities. Importantly, all of these processes and sub-processes have to be synchronized and coordinated in order to optimize value creation.

Effective resource orchestration, it can be argued, is particularly relevant to hardware ventures due to their amplified resource needs, resulting from the blended nature (i.e., mix of hardware and software) of their solutions. In the start-up stage, managers of hardware ventures have to structure and bundle resource portfolios that support development of solutions and capabilities as the foundation of future business operation [38]. This structuring and bundling accompanies a highly iterative trial-and-error learning process in which new venture ideas are verified, rejected, and adapted [14], requiring managers to create flexible resource portfolios that can be adapted to a venture’s emerging value proposition.

In the growth stage, managers of hardware ventures have to structure and bundle resource portfolios that support business operation and allow the venture to scale its operations. Thus, managers have to build on the capabilities developed during the start-up stage [3], acquire and accumulate new resources, and divest resources that are not needed anymore [38]. Importantly, during the growth stage ventures have to gradually align their resources and capabilities in order to position themselves in the market [3].

3. An assessment of the role of IS in hardware ventures

To understand how managers of hardware ventures can identify and orchestrate IS resources to create value, we propose a new framework for assessment. The framework we propose is based on the distinction of operand and operant resources and the identification of the two key stages of start-up and growth. Together, these components provide a suitable perspective for examination of resource orchestration and value creation in hardware ventures.

We are not the first to use such a distinction. For instance, IS have been assessed in terms of their potential as operand resources (enabler) or operant resources (integral component) for product and
service innovation [30]. It is based on this assessment that we use a similar distinction. New hardware ventures typically create innovative products and services [22], which suggests that IS can also be operand or operant resources during both formation and growth of hardware ventures. However, we differ from Nambisan [30] in that his model is used to examine product development in mature firms and distinguishes between the impact of IS on the innovation process and the innovation outcome, whereas our framework focuses on new ventures (i.e., non-mature firms) and the two different lifecycle stages of such firms. Figure 1 shows our framework, which is analogous to that of Nambisan [30]. It shows that IS can occupy four roles in enabling hardware ventures: during start-up as progress smoothers (operand resource) or boosters (operand resource); during growth as value simplifiers (operand resource) or amplifiers (operand resource).

### Figure 1. IS as operand and operant Resources for hardware ventures

#### 3.1. IS as an operand resource

Operand resources are resources that are acted on to create an effect. Managers can use IS as operand resources to facilitate basic tasks that lead to predetermined outcomes and involve a limited number of known actors. Thus, as an operand resource IS involve a relative low level of outcome uncertainty.

#### 3.1.1. IS as operand resource during the start-up stage

Various studies have examined the role of IS as operand resource of new product development in mature firms. These studies demonstrate that the use of appropriate IS such as virtual design tools enhances new product development efficiency and effectiveness [e.g., 21].

Little research has been conducted with a focus on new product development in hardware ventures, which is not surprising considering the hitherto significant financial investments required for hardware development. For example, hardware development typically requires specialized software such as EE (electronic engineering) CAD and CAM (computer aided design and manufacturing) tools.

Recent IS innovations such as Software-as-a-Service, 3D printing, and electronics prototyping platforms have lowered the costs of hardware development and thus, brought hardware development within financial reach of new ventures. For example, cloud based EE CAD tools such as Upverter provide comparatively cheap alternatives to their traditional counterparts, at the same time extending collaboration functionalities. 3D printing enables rapid prototyping and testing, thereby reducing both time and costs required for hardware development. The emergence of relatively low priced electronics prototyping platforms enables prototyping and development of hardware products for a fraction of the initial costs, at the same time making development of hardware products accessible to developers without hardware experience. Thus, managers of hardware ventures can use IS that act as operand resources during start-up to facilitate development tasks and to smoothen progress.

A much more simple example in the Lockitron case [1] is that of digital problem follow-up sheets that assisted the monitoring and resolution of hardware issues during development.

#### 3.1.2. IS as operand resource during the growth stage

Whereas software ventures can relatively easy scale production, distribution, and maintenance of their products via the Internet, managers of hardware ventures have to deal with complexities arising from the physical nature of their solutions. For example, managers of hardware ventures have to accurately estimate market demands to be able to coordinate supply chain networks, production capacities, as well as shipment and distribution. Mature manufacturing firms usually tackle this complexity by using IS enabled planning and control systems such as enterprise resource planning, supply chain management, or process management systems [e.g., 48] that facilitate management of interdependent processes and coordination of independent actors. Implementation of such enterprise systems typically requires extensive financial investments and has thus been out of reach for most hardware ventures; however, IS advancements such as the availability of Software-as-a-Service (SaaS), cloud computing, and online platforms have significantly lowered financial barriers for adoption of enterprise systems [e.g., 7] and thus, enable managers of hardware ventures to leverage enterprise systems for resource
orchestration. In addition, internet-enabled markets provide hardware ventures with direct market access [35] and thus, reduce complexity of orchestrating supply chains and distribution networks. In sum, managers of hardware venture can use IS that act as operant resources during growth to simplify value creation.

3.2. IS as operant resource

Operant resources act on other resources to create an effect. Managers can use IS as operant resources to activate other (external) resources, thereby increasing flexibility of their resource portfolios. Further, managers can use IS as operant resources to facilitate potentially unprompted and uncontrolled adaptation of solutions. Thus, used as operant resources IS induce a comparably high level of outcome uncertainty; yet, enhance market responsiveness by enabling flexible adjustment of resource portfolios and making solutions receptive to externally triggered and/or implemented change.

3.2.1. IS as operant resource during the start-up stage

IS act as operant resources when they enable hardware ventures to leverage and bundle external with internal resources in dynamic ways for networked value creation and capture. The emergence of web 2.0 technologies and open (source) hardware have created opportunities for managers of hardware ventures to leverage IS as operant resource during start-up. Related IS fall to a large extent in the categories digital crow-sourcing and funding platforms and online communities, marketplaces, and repositories. A good example is that in the Lockitron case [1], where a homebrew crowdfunding app was used successfully after participation in a third-party platform (Kickstarter) was rejected.

In the context of new product development crowd-sourcing is often considered as a means to outsource idea generation [5]. Most studies examine large corporations’ innovation initiatives [e.g., 37]. However, in the particular context of new hardware ventures crowdsourced idea generation becomes less important, as new ventures are often founded based on innovative ideas. Instead, most new ventures face resource constraints that impact team composition [22] and thus, influence availability of expertise and manpower. In hardware ventures the impact of resource constraints is amplified as hardware development requires a broad range of specialized expertise from electrical engineering to mechanical engineering to product design. Therefore, crowd-sourcing provides managers of hardware ventures a means to flexibly and purposefully complement their resource base externally to perform tasks that cannot be performed by the venture itself.

Crowdfunding provides managers of hardware ventures a means to overcome financial constraints by tapping into the potential of digital networks. Crowd-funding thereby reduces the traditional importance of spatial proximity to investors [2] and allows managers to obtain funding from a potentially large number of geographically dispersed and potentially unknown individuals [27], at the same time providing early market feedback through participant benefit mechanisms such as pre-ordering or profit-sharing [6]. As a result, crow-funding can be considered as an important mechanism fostering the emergence of hardware ventures, as it provides their managers a means to both reduce the barriers imposed by the asset intensity of hardware development and manufacturing, and at the same time facilitates demand planning which is essential to plan scaling of business operation. In addition, crowdfunding provides managers the opportunity to obtain funding without the necessity to give away equity shares [6]. An example for a venture that successfully used crowdfunding is Oculus VR, a venture specialized on head-mounted virtual reality displays. Oculus VR used crowdfunding to raise more than US$ 2.4 million from more than 9,500 individuals during the prototype stage. Less than two years later the company was acquired for US$2 billion, thereby illustrating the potential of crowdfunding to provide early market feedback.

Networks in turn are an important means for new ventures to obtain access to resources [39], and online communities and repositories provide new ventures opportunities to leverage digital networks of potentially unknown external actors for knowledge collaboration on a large scale [15]. While there exists little research on online communities in the new venture context, studies have shown that new ventures can use online communities to obtain advice and support from peers, even in situations of direct competition [24], and that software ventures leveraging open source communities perform better in terms of product innovation than their non-open source counterparts do [33]. Considering the knowledge diversity that is required for hardware development, digital networks and in particular open (source) hardware can be seen as important ways for structuring and bundling internal and external resources, as they lower barriers for obtaining essential knowledge and involving other actors into co-development. In sum, managers of hardware venture can use IS that act as operant resources
during start-up to activate other (external) resources and thereby to boost progress.

3.2.2. IS as operant resource during the growth stage

Managers of hardware ventures can use IS as operant resource during growth in order to enable or enhance solutions through activation of external resources. From this perspective, the growth and penetration of ubiquitous and often inter-connectable IS such as smartphones and portable computers [46] has enabled managers to leverage external digital components for provision of core functionalities of hardware ventures’ solutions. For example, most advanced activity trackers or home automation devices are essentially sensors with network connectivity that require external IS comprised of hardware and software components such as mobile phones to unfold their value. By leveraging external digital components to provide functionalities of their solutions managers of hardware ventures can transfer maintenance and support efforts to the providers or operators of these components and at the same time cut manufacturing costs.

In a similar way, managers of hardware ventures can use IS as an operant resource to allow for digital generativity of ventures’ solutions, which refers to an “overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences” [50:1980]. For example, in the video game industry producers are often developing games as platforms and thus, enable generative innovation by empowering users to create modified derivations [4]. In a similar way managers can establish solutions of hardware ventures as platforms that enable external actors to enhance or alter functionality. For example, Ultimaker [51], a manufacturer of 3D printers, has developed its product based on open source hardware and has revealed all construction plans as well as software codes. By taking these steps, Ultimaker has enabled users to enhance functionality of the product on behalf of the company and thus, established the foundation for digital generativity. The increasing availability of digital prototyping tools like 3D printers makes it even easier for hardware ventures to leverage users for value co-creation. In sum, managers of hardware venture can use IS that act as operant resources during start-up to activate other (external) resources and thereby to amplify value creation.

Summarizing this section, Table 1 provides an overview of our framework and the conceptualization of IS as operand and operant resource.

3.3 Orchestration of operand and operant resources

As discussed in the previous sections, IS perform a dual role in enabling hardware ventures. As a result, managers have to orchestrate balanced portfolios of both operand and operant IS resources to facilitate start-up and growth of hardware ventures. It is thereby important to bear in mind that IS resources themselves have inherent resource orchestration capabilities. In turn, operand and operant IS resources enable managers to perform different orchestration activities. We now discuss which orchestration activities in a hardware venture could be enacted through IS resources following our distinction.

IS that act as operand resources typically improve processes in general and hence lend themselves particularly to structuring and bundling internal components of resource portfolios. For example, the use of 3D printing during start-up smoothenes accumulation of prototyping knowledge and skills (i.e., resource structuring), and the use of supply chain management systems during growth simplifies development of production and distribution capabilities (i.e., resource bundling). Thus, IS that act as operand resources are particularly important for effective and efficient orchestration of stable resource portfolio components.

IS that act as operant resources lend themselves particularly to complement resource portfolios externally. For example, crowdsourcing enables managers to boost acquisition and accumulation of external resources and capabilities that are required during start-up for solution development, at the same time enabling managers to rapidly divest these resources and capabilities if they are not needed anymore (i.e., resource structuring and bundling). Similarly, platforms that integrate external actors into co-creation activities amplify value creation during growth (i.e., resource leveraging), at the same time reducing internal resource requirements. Thus, IS that act as operant resources are particularly important to enhance flexibility of resource portfolios.

Importantly, managers have to orchestrate resource portfolios that comprise a balanced mix of both operand and operant IS resources in order to foster development of key resources and capabilities internally on the one hand, and to enable flexible adjustment of resource portfolios on the other hand.

4. Discussion

The framework we present can be conceived as a theory for analysis [19]. It allows for describing and classifying IS in-use or potentially-in-use by
Table 1. Conceptualization of IS as operand and operant resource

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<tr>
<th>The role of IS</th>
<th>Conceptualization</th>
<th>Key properties</th>
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<tr>
<td><strong>Operand resource</strong></td>
<td></td>
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<tr>
<td>Start-up</td>
<td>Enable efficient and/or effective solution development</td>
<td>Enable or facilitate specific development tasks</td>
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<td></td>
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<td>Reduce development time and/or costs</td>
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<td>Ease collaboration between different actors</td>
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<td>Growth</td>
<td>Enable efficient and/or effective value delivery</td>
<td>Enable or facilitate specific operational tasks</td>
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<td>Reduce complexity and coordination efforts</td>
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<td>Facilitate management of interdependent processes</td>
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<td><strong>Operant resource</strong></td>
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<tr>
<td>Start-up</td>
<td>Activate external resources for solution development</td>
<td>Enable or foster dynamic exploitation of external resources</td>
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<td>Provide access to resource networks comprised of potentially unknown actors</td>
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<td>Facilitate adaptation of solutions to market needs</td>
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<td>Growth</td>
<td>Activate external resources for value delivery</td>
<td>Enable or enhance functionality of solutions</td>
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<td>Make solutions receptive to externally triggered and/or implemented change</td>
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<td></td>
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<td>Foster value co-creation between internal and external actors</td>
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hardware ventures and their managers. However, we believe the framework can also provide a theory for explanation and prediction [19:628]. It can provide an explanation of why certain properties of an IS correspond to the system being appropriated as an operand or operant resource in hardware ventures. Furthermore, based on these properties, it can provide predictions about whether hardware ventures and their solutions will evolve and adapt more or less dynamically. A dynamic evolution and adaptation in turn might be an antecedent of competitive advantage and business success.

Depending on the causa finalis for using our framework for a particular problem or question, therefore, different strategies should be contemplated about how to enact and examine the framework. We now elaborate on such strategies to guide future research involving our framework.

4.2. Enacting and extending the framework as a theory for analysis

To enact our framework as a theory for analysis, one research strategy could be to examine cases of hardware ventures and their IS resource portfolios in use, to ascertain whether properties of the systems in use match the properties ascribed to the proposed roles in our framework. Such research would focus on examining IS infrastructures and software portfolios in hardware ventures. Because the distinction of operand and operant resources draws not on the resources themselves but on the services they render to the venture [43], the research strategy must include an examination of IS appropriation within the venture [31]. Such research might be particularly fruitful, as their challenge to overcome inherent resource constraints makes managers of new ventures susceptible to resource appropriation. For example, a whole stream of research on entrepreneurship is dedicated to bricolage, that is, new ventures’ recombination of elements at hand for new purposes. Such research is well-suited to qualitative, inductive case methods. To extend this theory, research could be carried out to examine IS portfolios of hardware ventures to identify properties that align, misalign, exceed, or contradict the ascribed properties in our framework. Another extension could be to distinguish further sub-classes of the two stages, start-up and growth. In either case, new roles of IS as operand or operant resources might be identified that lead to a revision of our framework. A second strategy would be to identify cases of hardware ventures through replication logic, that is, cases of hardware ventures where the role of IS in use is not as predicted in our framework. The study of such cases will clarify degrees of generalizability and identify relevant boundary conditions.

4.2. Enacting and extending the framework as a theory for explanation and prediction

To enact our framework as a theory for explanation and prediction, one research strategy could be to examine the influence of managers’ IS use on hardware ventures’ evolution and adaptation. For example, as operant resources are considered to increase market responsiveness [25], such research could focus on the product-market fit of hardware

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ventures’ solutions [11] and evaluate whether the product-market fit differs between hardware ventures that use IS as operant resources in both start-up and growth stages, only in one stage, or do not rely heavily on IS as operant resources at all. Such research is likely best carried out by means of quantitative research methods and the use of large cross-sectional samples of ventures and IS solutions in use.

To extend our theory, one research strategy could be adoption of a longitudinal research design, to examine how managers of hardware ventures orchestrate IS resources over time. This could provide a fine-grained picture of IS use as operant and operand resources and yields the potential to identify varying influences during particular tasks, processes, or stages. Thus, a longitudinal design could help to refine the framework and to improve its predictive power. It would also allow identification of important configuration patterns between operand and operant resources. Such research is likely to benefit from a combination of qualitative and quantitative methods to first obtain an in-depth understanding of hardware ventures evolutionary trajectories and afterwards empirically validate this understanding.

5. Implications

Our framework provides implications for both research and practice. First, our framework lays the foundation for future research in the context of hardware ventures. By drawing on Service-Dominant Logic we identify two fundamental types of IS (i.e., operand and operant resources) that enable different value creation processes in hardware ventures. Further, we explain how these two types of IS facilitate orchestration of other resources. Thus, our framework is particularly relevant for future research on hardware ventures that takes a resource orchestration perspective. Second, we believe our framework offers insights for entrepreneurs and managers of hardware ventures. Managers of hardware ventures must be aware of the importance to create flexible resource portfolios that can be adapted to the changing resource needs during start-up and growth stages. Our framework highlights how two fundamental types of IS influence the flexibility of resource portfolios, thereby providing managers of hardware ventures a useful guidance for strategically structuring and bundling resources. Further, by outlining the influence of IS on value creation and capture flexibility, our framework can help venture capitalists to assess the future resilience of hardware ventures.

6. Conclusion

What is the role of IS in hardware ventures? We suggested that one way of answering this question is by describing IS as operand and operant resources during start-up and growth stages of hardware ventures. Through this conceptualization, we provide a framework both for analysis and explanation, which allows for a) examination of an important empirical domain (hardware ventures), b) an understanding of IS as operant and operand resources, and c) a description of their capacities for resource orchestration. To illustrate fertility of our theory, we discussed research strategies that could be carried out to enact or extend our framework.

The contributions of our framework are bounded by at least two limitations. First, conceptually, we have based our view primarily on Service-Dominant Logic and resource orchestration theory. However, we did not perform a theoretical comparison to other frameworks that would yield different lead assumptions and might lead to different implications for testing. For example, the resource based view would imply that ventures have to develop unique IT resources that are valuable, rare, difficult to imitate, and non-substitutable to be successful [8]. Second, our construction of the new theoretical framework does not guarantee its validity. The propositions we offer require further experimentation as well as empirical observation. To mitigate this limitation, we discuss different research designs (e.g., longitudinal or quantitative studies) in this paper, and we invite our colleagues to join this research. In our own research, our next step involves carrying out a more systematic literature reviews to a) relate our framework to other relevant theories and b) validating our framework by applying it to cases of ventures already discussed in the literature.

7. References


