

DIGITAL RESOURCES AND THEIR ROLE IN ADVANCED SERVICE PROVISION: A VRIN ANALYSIS

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ABSTRACT

Purpose: We examine the role of digital resources in the context of advanced service provision to determine their strategic potential.

Approach: We conduct a theoretical review of the literature to identify digital resources which we subsequently analyse with regards to their value, rarity, inimitability and non-substitutability (VRIN).

Findings: Our analysis shows that the strategic value of the digital resources is unlocked through their complementarity.

Value: The research has implications for the management of advanced services and contributes towards the grounding of servitization research in the wider economic and management theory.

Key words: Servitization, advanced services, resource-based view, resource value, complementarity, digital resource

1. INTRODUCTION

Information technology (IT) plays an essential part in *servitization* – a recent trend that implies the provision of advanced product-based services and solutions that replaces a traditional product offering. Prominent examples such as Rolls Royce’s ‘power by the hour’ (Neely 2008) or Alstom’s provision of train-life services (Baines et al. 2011) highlight IT resources as important enablers for delivering outcome-focused product-based services. Two important developments on the technical and business fronts require a focused analysis of the IT resource that goes beyond the individual examples.

First, new technological developments in the domain termed ‘Internet of Things’ and products digitalisation (Bharadwaj et al. 2013) have direct implications for understanding of the central role of IT resources in the advanced services context. As sensing and transmission technology becomes increasingly more available and affordable, substantial opportunities open up for manufacturers to further increase the digitalization of their products and reap the potential strategic advantages that digitization offers. Second, reflecting on the technological advancements there is an emerging understanding in the business and management literature that the IT resource can be more than an enabler of a strategic process but instead can itself be a source for sustainable competitive advantage (Wade & Hulland 2004). Hence, in the context of advanced services it is critical to understand to which extent the IT resource could be a source of long-term strategic differentiation – a realisation that would have substantial managerial implications.

The present study draws on the resource-based-view (RBV) of the firm and insights on digitalization to examine the role of digital (i.e., IT-based) resources in the provision of advanced services. The RBV theory argues that only resources that are Valuable, Rare, Inimitable and Non-substitutable (VRIN) have the potential to create sustainable competitive advantage (Barney 1996). Based on these criteria we examine the digital resources that form part of the advanced service provision and determine their strategic potential. We first conduct a theoretical review (Paré et al. 2014) of the extent literature to identify the range of core digital resources and subsequently apply a VRIN analysis to identify their strategic potential. Our analysis shows that a number of digital resources identified are rare, inimitable and non-substitutable, but are not necessarily valuable. In particular the value of product-service data and interpretive capability is only unlocked through the *complementarity* of these resources. The analysis further shows that the product-service data and the sensor & transmission device offer significant protection from competition.

2. THEORETICAL BACKGROUND: SERVICITIZATION, IT AND THE RESOURCE BASED VIEW

The notion of *servitization* describes a business model transformation where a manufacturer increasingly offers services integrated with their product (Baines & Lightfoot 2013). The provision of advanced services represent a special case of servitization where the manufacturer provides the customer with a capability instead of a product. In the frequently used example of the ‘power-by-the-hour’ service provision Rolls Royce provides a propulsion capability to airlines instead of selling its engines in a traditional way (Neely 2008). The airline is charged on the basis of the propulsion value that has been provided (‘value in use’) and Rolls Royce retains the ownership of the engines, remains responsible for their upkeep and ultimately the availability of the propulsion capability. Offering such advanced services provides the manufacturer with resilient revenue streams, opens up new revenue streams and long-term business relationships (Baines & Lightfoot 2013). Advanced services that manufacturers offer rely to a great extent on IT which is embedded in physical products. Such embedded IT constitute what we termed ‘digital resource’, and in order to unpack the role of such digital resource we turn to the Resource Based View (RBV).

The RBV as an economic theory argues that a firm’s competitive advantage lies within the use of its strategic resources (Barney 1991). RBV theory puts a focus on the individual resource and the systematic evaluation of its ‘strategic potential’ for creating a sustainable competitive advantage. The strategic potential of a resource is identified along four attributes: the resource value, rarity, imperfect imitability, and non-substitutability (Nevo & Wade 2011). The four VRIN attributes together describe a necessary but not sufficient condition for a candidate resource to constitute a source for sustainable competitive advantage (Barney 1991).

Applying the RBV to the IT context requires a careful consideration of the range of IT-related resources. Wade and Hulland (2004) differentiate between *IT assets* (i.e., hardware, software applications, data repositories) and *IT capabilities* (i.e., repeatable patterns of actions in the use of assets incl. technical IT skills, IT management skills, Business-IT relationships) (Piccoli & Ives 2005). Research has often rejected the strategic potential of software or hardware infrastructure as they are generally widely available or imitable (e.g., Bharadwaj, 2000; Carr, 2003). The data resource is less frequently examined in RBV studies although its strategic potential is recognised (Piccoli & Ives 2005). IT capabilities such as IT planning, development, operations (Ravichandran & Lertwongsatien 2005) or information exchange capability (Barua et al. 2004) are more frequently identified as ‘strategic resources’. Seddon (2014) also identifies Business Analytics as a strategic IT capability that provides the focal firm with a competitive advantage. In addition to a focus on individual resources recent developments in RBV theory have emphasised the value of resource combinations suggesting that resources that by themselves would not meet the VRIN-criteria in combination can create a ‘defensible strategic position’ (Bingham & Eisenhardt 2008). This focus on resource complementarity has been further advanced in studies exploring ‘IT enabled resource’ (Nevo & Wade 2010) or ‘IT embeddedness’ (Kohli & Grover 2008) where the synergistic combination of IT resources and organisational capabilities are identified as source of competitive advantage.

3. DIGITAL RESOURCES IN THE PROVISION OF ADVANCED SERVICES

The present study uses the term ‘digital resource’ to extend the way the ‘IT resource’ is defined in the Information Systems (IS) literature. Digitalization describes the process of incorporating digital capabilities (i.e. sensors or connectivity) into objects that are primarily physical (Fichman et al. 2014). Hence, an embedded digital component significantly amplifies the capabilities and value of the physical product and enables value creation outside the physical product itself (Porter & Heppelmann 2014), leading the product to be considered as a digital resource. Applying this notion of digital resource to the servitization context we define *digital resource* as a combination of digital assets and capabilities that play a role in the provision of product-based services.

To understand the diverse digital assets and capabilities that play a role in the provision of advanced services in the manufacturing sector we have carried out a theoretical review of the extent literature (Paré et al. 2014). A *theoretical review* seeks to “tackle an emerging issue that would benefit from the development of new theoretical foundations” (Paré et al. 2014 p.6). Such a review goes beyond assembling and describing past work but seeks to develop new conceptualisations. For the present study we have purposefully selected descriptions of advanced service provision in manufacturing and have examined the digital resources used and their particular roles and contributions. Our objective was to analyse the digital assets and capabilities that form part of the advanced service provision in order to subsequently analyse their strategic potential.

3.1 Digital Assets

Based on the review of the advanced services literature we have identified three distinct digital assets: Sensor & transmission device, analytic software and product-service data. **Sensor devices** detect, measure and digitally record data on the status and use of the product. **Transmission devices** transfer the sensor data from the product to the central data repository. The range of sensors and nature of transmission device are dependent on the nature of the product and its use. As an example, Baines et al (2011) describes how a rail systems manufacturer (Alstom) provides train systems to a transport provider (Virgin Trains) in form of advanced services. A large array of sensors and transmission devices on board of the trains continuously capture and transmit details such as propulsion, tilt, high tension, braking, air and aggregated error-codes via cellular networks to the manufacturer’s control centre. The incoming ‘**product-service data**’ accumulates over time creating a rich digital representation of the installed product base (Reim et al. 2014). Jagtap and Johnson (2011) describe how an engine manufacturer who provides advanced services in the aero engine industry has accumulated vast amounts of product-service data detailing the life of individual machine component, its deterioration and life cycle cost. Software and **analytic software** in particular is highlighted in several servitization descriptions. Manufacturers with more advanced service portfolios rely on more sophisticated software packages to process their data (Alghisi et al. 2013). As an example Vanzulli et al (2014) outline the decision surrounding the adoption of cloud-computing software at Hitachi highlighting the benefits of reduced initial investment and the shortening of implementation time.

3.2 Digital capabilities

We distinguish two distinct digital capabilities: interpretive capability and relational capability. The first, ‘interpretive capability’ draws on Daft and Weick’s (1984) notion of interpretation as “the process through which information is given meaning” (p.286). In the present context ‘interpretive capability’ captures the confluence of the *technical ability* for analyzing the product-service data, and the *domain knowledge* to convert the analytical insights into actionable insights. Several accounts focus on the service provider’s ability to utilize the ‘product-service data’ and its insights to effectively support business operations (**interpretive capability for operational purposes**). Operational benefits include the facilitation of *remote diagnostics* by providing insights into possible root-causes for systems failures, or required parts and expertise required for repair (Grubic 2014). MAN Trucks is able to analyze the product-service data to identify fuel-consumption and inefficient driver behaviours (Lightfoot et al. 2011). Product-Service data is also utilized to efficiently carry out *predictive maintenance* operations (Grubic 2014) and to create efficiency in the administrative aspect of the service provision by efficiently determining service charges (Brashear Alejandro et al. 2013) and controlling the conditions of product use.

Further accounts describe a service provider’s ability to utilize the product-service data to develop its service provision (**Interpretive capability for business development**). The ability to correctly interpret product-service data provides opportunities to identify service usage patterns, inefficiencies in product use or unmet service needs (Reim et al. 2014). An in-depth understanding of

the customer-base, the product and the market are critical to appropriately judge the patterns and insights that can be derived from the product-service data. The interpretive capability is also used to offer added value to existing service relationships by providing advice on asset efficiency (Ulag & Reinartz 2011) or additional process analysis (Brashear Alejandro et al. 2013). These offers are conditional on the service providers ability to utilize the accumulated product-service data in combination with its further customers insights and product understanding.

Other accounts in the servitization literature focus on a service provider's ability to use product-service data in combination with a detailed product understanding to draw conclusions about the product behaviour and production development (**interpretive capability for product understanding**). Baines (2013) describes how the visibility of asset operating characteristics together with the design and technical capabilities is key to improved equipment design, enhanced asset performance and availability. Product-service data is said to radically increase the speed of product innovation (Reim et al. 2014) and might even be interpreted as a R&D investment (Grubic 2014). Ulag & Reinartz (2011) describe how an aircraft engine manufacturer saw the interpretive capability as so important that they would, at times, take unprofitable contracts in order to enrich their product-service data, advance their predictive model and increase their failure rate predictions.

The second, '**relational capability**' draws on Lorenzoni & Lipparini's (1999) definition: "the capability to interact with other companies" (p.317). A digitally enhanced product-centered service constitutes a change in the provider-user relationship where the product remains in regular communication with the service provider requiring a high level of trust and careful explanation of the underlying data protection and use agreements (i.e., **product-service communication**). Westergren (2011) describes a case of a remote monitoring service provider who failed to properly articulate the value proposition and hereby threatened the product adoption. An organisation's ability to anticipate concerns regarding the digital capabilities of products and its ability to address these concerns are critical for integrating the digitized products into service offerings. The literature also points towards a service provider's ability to craft mutually beneficial forms of data use as an important relational capability (i.e., **data sharing strategy**). Organisations skilfully share product-service data with service users to directly communicate the created service value or payback simulation tools (Ulag & Reinartz 2011). Real-time utilization data of Toyota Trucks is shared with the service user to allow customers to increase safety and productivity improvement.

Our review of the digital resource that form part of the advanced service provision has revealed a number of critical assets and capabilities. Although we present these here as independent resources we recognise that they are highly interdependent in practice. For example, an enhanced understanding of failure rates and patterns (product understanding) enhances a service provider's predictive maintenance function (operations) or its ability to develop competitive contracts due to an enhanced product risk understanding (business development) (Ulag & Reinartz 2011).

4. ANALYZING THE STRATEGIC ROLE OF THE IT RESOURCES

We now examine the digital resources identified above with regards to their value creation, rarity, inimitability and non-substitutability. The analysis also examines the complementarity among those digital resource (Bingham & Eisenhardt 2008) to shed light on their synergistic relationships.

4.1 Value creation from digital resources

The *value creation* describes a resource's "ability to support strategies intended to capitalize on market opportunities or fend off threats" (Nevo & Wade 2010, p.164). In detail, this includes (i) the extent to which it reduces a firm's cost base, or (ii) the extent to which it provides a source of differentiation (Bingham & Eisenhardt 2008). First, the combination of product-service data together with the interpretive capability create diverse opportunities for **cost-reduction** in advanced services

provision. Remote diagnostics and predictive maintenance reduce the number of expensive unscheduled field visits and help to ensure service availability in a more cost-efficient format. The ability to observe product behaviour provides a cost-efficient way to ensure that the contractually agreed terms are met. Utilizing product-service data to improve product design can further reduce expensive repair-visits. Utilizing the data to increase the accuracy of failure rate predictions provides opportunities for being more competitive in service pricing. Second, the combination of product-service data and interpretive capability provides opportunities for **differentiation** as it allows the service provider to identify unmet user needs, target service offers or provide additional services as point of differentiation. The service providers ability to identify early market shifts or develop separate business propositions help to create new opportunities. The opportunities for cost-reduction and differentiation are based on the *complementarity* of product-service data and interpretive capability. An organisation's interpretive capability (analytical ability and domain knowledge) or product-service data alone does not create a comparable value proposition. The other resources are supplementary in their ability to create value: they are essential in the creation of the data resource (i.e. sensor & transmission device, relational capability) or are critical enablers of interpretation (i.e. analytic software, software integration).

4.1 Rarity of digital resources

The *rarity* of a resource is determined by its relative unavailability to current and potential rivals (Nevo & Wade 2010). Assessing the rarity of **sensor & transmission devices** requires a differentiation between their consideration as technical artefact or as distributed data source. As technical artefacts sensor & transmission devices are widely available (thus offer little strategic potential). As distributed data source 'rarity' refers to their distribution range, which is tied to the installed base. In the context of advanced services a high market share creates the rarity of the distributed sensor & transmission devices. Assessing the rarity of **product-use data** requires a differentiation between the data on individual service-provider–user dyads and the data that captures the wide range of service-provisions. The data of individual dyads may be shared with the individual user, however, the wider range of product-service data that captures different service contracts will not be available outside the service provider (unless a third-party technology provider is involved) and would be considered as rare. Assessing the rarity of **interpretive capability** also requires a differentiated consideration as it captures both the analytical ability and domain knowledge. The analytical capability, although highly sought after, is available in the market. However, the domain knowledge and contextual insights about the product, the customer, and the market is generally more specific, scattered within the service provider and would likely be considered as rare. The available case descriptions are not sufficiently detailed to assess to which extent the **relational capabilities** could be considered as rare. **Analytic software** is widely available.

4.3 Inimitability of digital resources

The *inimitability* of a resource is determined by the costs and difficulties that are associated with its duplication (Nevo & Wade 2010). Barriers to resource duplication include ownership rights, path dependencies, time compression diseconomies or causal ambiguity (Bingham 2008). The inimitability of the **product-service data** is defined by the effort involved in its duplication. In most cases the product-service data will capture product health and utilization records covering an extensive range of sensors over a larger period of time therefore path dependencies and time-compression diseconomies create significant barriers to imitation. A wide distribution of sensors and long time utilization periods are required to create a rich data resource, which is a barrier to its inimitability as a competitor would face significant cost and time delays before obtaining a comparable data resource. To the same extent, a focal company's well developed **interpretive capability** is difficult to imitate as it has been honed over years by trialling and refining predictive algorithms which is preconditioned by the availability of meaningful product-service data. The **sensor & transmission devices** as distributed data source are protected by path dependencies due to its link to the installed product

base which is difficult to imitate. Further, long replacement cycles in some of the products negatively impact on the time-frame for sensor-distribution even in case of a large installed base. The other resources (software, relational capability) do not provide significant barriers to imitations as they are not protected from ownership rights, path dependencies and time-diseconomies.

4.4. Non-substitutability of digital resources

The *non-substitutability* of a resource refers to the nonexistence of strategically equivalent resource (Nevo & Wade 2010). Hence, a focal resource that would offer the same functionality as other resources would be ‘substitutable’ (Barney 1991). An assessment of the substitutability of the digital resources can only consider the technology and business practices currently in place. Future developments and innovations may create resource substitutes (as outlined in the discussion). Based on the current market insights the **distributed sensor & transmission resource** is essential for capturing raw data at the point of product-performance and use. While in some instances the service user’s system could create some of the **product-use data** (e.g. manufacturing information systems) the same level of detail on the individual product health and usage will be provided. The analytical process can certainly be supported by dedicated applications, however, the domain knowledge, which is an essential part of the **interpretive capability** will unlikely be substitutable. The other digital resources are subjected to substitution threats: cloud-based software services (e.g. Salesforce.com) are already substituting individual **software** installations and the increasing acceptance of digitized products is a likely substitute some of the **relational capabilities**.

5. DISCUSSION & CONCLUSION

The present study has set out to examine the role of digital resources in the context of advanced service provision and identify their strategic potential. Our analysis shows that none of the digital resources on their own meet all VRIN criteria (see table 1). Hence, as individual resources they have a very limited potential to create a sustainable competitive advantage for the focal firm. However, the combination of product-service data and interpretive capability meets the VRIN criteria and hereby has the potential to be a source of sustainable competitive advantage for the service provider. Indeed, a resource combination creates a sustainable competitive advantage if it reinforces the competitive advantage over time (Piccoli & Ives 2005): By creating cost-efficiencies and opportunities for differentiation the combination of rich product-service data and superior interpretive capability can stimulate growth in market share which would further enrich the product-service data, provide for additional insights and further strengthens the strategic value of these digital resource.

	Value creation	Rarity	Inimitability	Non-substitutability
Distributed sensor & transmission devices	low	High	high	high
Analytic software	low	Low	low	low
Product-Service Data	High (in combination)	High	high	high
Interpretive capability	Low (as individual)	Medium	high	high
Relational capability	low	Low	low	low

Table 1. A VRIN analysis of digital resources in advanced services

Our analysis and findings lead to a range of theoretical and managerial implications. The identification of digital resources as source for competitive advantage emphasises the need to explicitly consider the digital domain in future research on servitization and advanced service provision. The *information systems* discipline offers a range of insights that help understand the intrinsic properties of digital assets and capabilities and its management. The study also offers implications for RBV theory which traditionally considers ‘ownership’ of resources as a critical

precondition for creation of competitive advantage (Barney 1991). Our research points to data as potentially shared resource with significant strategic potential. Hence, current RBV theory-development that explores the strategic role of shared resources (Lavie 2006) should take note of the servitization context as a domain with significant potential for shared resource use.

Our research creates a series of direct managerial implications but also points to future managerial challenges. Our VRIN analysis identifies the *potential* for competitive advantage but the *realization* of this competitive advantage is dependent on the effective development and strategic exploitation of the digital resources. In particular the complementarity between product-service data and interpretative capability requires a systematic and coordinated approach to resource development. Our research also points to the information and analytical advantage that can develop as part of the digital resource exploitation although at this point the information advantage is rarely included in the economic rationale for servitization (Baines & Lightfoot 2013). Managers should consider the increasing value that can be derived from developing these digital resources and the spill-over effect for traditional product sales channels in the assessment of their servitization decision. The identification of strategic resource should also encourage managers to focus on protecting the resource base from losing its competitive potential. The sharing of data might on the one hand allow to increase the value that can be derived from it, but on the other hand may reduce the rarity of the data resource which could undermine its strategic potential.

The resource-based view and the VRIN analysis in particular has offered a viable framework for a systematic analysis of the digital resource. While the framework itself has limitations our use of secondary data and the intrinsic challenge of categorizing and assessing the attributes should be acknowledged as additional limitations. Nevertheless, our work and the insights that we have created point to the digital resource as a critical factor in the further trajectory of servitization practice and research.

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