

Beyond the Service Factory: Service Innovation in Manufacturing Supply Networks

Forthcoming in *Industrial Marketing Management*
special issue on
Business-to-Business Service Networks

Martin Spring¹

Luis Araujo²

¹Department of Management Science

²Department of Marketing

Lancaster University Management School

Lancaster LA1 4YX

United Kingdom

m.spring@lancaster.ac.uk

l.araujo@lancaster.ac.uk

Acknowledgement

Martin Spring gratefully acknowledges financial support in the form of an AIM Research Fellowship in Services, ESRC Grant number RES-331-27-0036 and a period of sabbatical leave provided by Lancaster University Management School. We also acknowledge the generous participation of managers and employees at Ariel, comments on various drafts from Katy Mason, and the always beneficial effect of conversations on related themes with Juliana Bonomi Santos and Linda Hendry, both of Lancaster University Management School.

We are grateful to the two anonymous reviewers for their perceptive and constructive comments and advice, and to the Guest Editors for their helpful contributions.

All remaining errors of omission and commission are ours.

Beyond the Service Factory: Service Innovation in Manufacturing Supply Networks

Abstract

This paper is concerned with the nature of the connection between services and manufacturing in manufacturing-oriented supply networks. The existing literature on manufacturing shifting into service is reviewed and, although such moves are seen as a way to increased revenue and profit, there are concerns that firms do not understand how the capabilities that underpin manufacturing may be extended to enable effective service delivery. Inspired by Chase's concept of the 'service factory', which sees the factory as a repository of knowledge and a platform for services, the paper applies Edith Penrose's conception of services as emanating from firms' resources to examine an advanced component manufacturing firm in the course of a number of service-oriented projects. This leads to a model of service development in manufacturing firms, consisting of a network trigger, an opportunity to change the 'productive opportunity', the 'revelation' of resources and Penrose-services, a reconfiguration of the network, leading to an expanded productive opportunity and hence a platform for marketing new service capabilities. In this sense a network is seen as an inter-connected set of productive opportunities. It also draws attention to the importance in theory and practice of understanding both the institutional and the ontological connection between service offerings and the products, factories, firms and networks with which they are associated.

Keywords

Service Innovation, Network, Penrose, Service Factory, Servitization

1. Introduction

In both industrial marketing and operations management, discussions on the ‘transition to service’ by manufacturing firms have proliferated (see e.g. Cova & Salle, 2007; Jacob & Ulaga, 2008; Wilkinson, Dainty, & Neely, 2009). The argument is that manufacturers, facing increasing commoditisation of their business, should consider service offerings as a way to capture new revenue streams and increase profitability. Similarly, Ostrom et al.’s (2010) wide-ranging review of the service management field identifies ‘Fostering service infusion and growth’ in goods-based organizations as the first of ten research priorities. The transition from manufacturing to services is conventionally known as ‘servitisation’, a term first coined by Vandermeire and Rada (1988), and the accounts of this literature are mainly concerned with a shift in the vertical scope of firms’ activities from those typically classified as manufacturing by standard industry classifications to those similarly classified as services, such as maintenance, spares provision and condition monitoring. Such shifts are portrayed as changes in the division of labour in a value chain that is otherwise largely assumed to be static^a, with manufacturers taking over activities previously carried out by their customers. Such additional services might be sold separately, or under arrangements based on the ‘rental/asset paradigm’ of service (Lovelock & Gummesson, 2004), which emphasises the retention of ownership of the asset (typically a capital asset) by the firm that has made or assembled it, and the provision of users with access to it, rather than outright ownership of it (e.g. ‘Performance Based Logistics’ (Doerr, Lewis, & Eaton, 2005)).

However, despite the evidence that manufacturing firms in many sectors are indeed adding service activities to their offerings, there are both empirical and theoretical problems on the horizon. It seems that manufacturers who invest heavily in growing their service business often don’t achieve the growth in revenues that they might expect. This has been termed the

‘service paradox’ (Gebauer, Fleisch, & Friedli, 2005). Furthermore, Neely (2008) identifies a so-called ‘servitisation paradox’, which suggests that, even if they increase revenues, servitising firms often make less profit than manufacturing firms who do not extend their activities into services. Recognising this type of problem, recent studies have examined the challenges for manufacturers in shifting into the less familiar territory of services, with the differences in customer relationships and associated operations strategy this entails (Baines et al., 2009). Others have drawn attention to the need for wholesale strategic re-alignment, considering resources, structure and incentives among other key issues (Neu & Brown, 2005). Resources and capabilities have been the focus of still more recent work in marketing: MatthysSENS et al. (2009), using a competence-based marketing perspective, identify a broad range of capabilities required for the transitioning to service; and Ulaga and Reinartz (2011) similarly identify categories of resources and capabilities that must underpin the transition to service.

In this paper, we complement these recent studies in two ways. First, while also taking a broadly capabilities-based view, we dwell less on categories and typologies of apparently novel or additional capabilities, and more on the very nature of the connection between manufacturing and service capabilities. In doing this, we are inspired by Chase’s concept of the ‘service factory’ (Chase & Garvin, 1989), and Pavitt’s reflection on high-value manufacturing and its relationship to services (Pavitt, 2003). The ‘service factory’ concept was proposed over twenty years ago, with Chase and Erikson (1988) and Chase and Garvin (1989) proposing that factories should be seen as repositories of specialist knowledge, providing a range of service benefits to both external customers and internal customers, especially marketing. Arguing that ‘The service tasks of the business can no longer be separated neatly and sequentially from the work of the factory’ (Chase & Garvin, 1989: 69),

they propose four possible services factory roles – laboratory, consultant, showroom and dispatcher. In short, factories should be seen as service platforms rather than as sites insulated from the rest of the company. Pavitt (2003) pursues a similar theme, arguing that manufacturing in advanced economies is surrounded by intimately linked, high-skill activities, the ‘...skilled activities that manufacturing firms undertake except manufacturing itself’ (Pavitt, 2003: 88), adding perceptively that ‘...the fact that most of these activities are defined as “services” often confuses rather than clarifies’ (*ibid*).

The second way in which we complement the existing research is by linking this close examination of the factory or firm’s manufacturing capabilities to the network in which the firm operates. In particular, we capture and characterise how services are provided in a process of frequent network reconfiguration, rather than as a process of simply ‘moving downstream’ in a largely fixed collection and sequence of activities in a static value-chain. To achieve this we draw on key concepts from the work of Penrose (1959), especially her notion of the firm’s ‘productive opportunity’, and apply them to an in-depth study of a high-tech component manufacturing firm as it explores the ‘shift to service’. Our rather fine-grained study shows some of the dynamic detail of what could be characterised ‘from afar’ (Van de Ven, 2007) as a more straightforward ‘transition’: in revealing some of this detail, we may be able to partly explain some of the difficulties experienced by manufacturing firms shifting into service. Our analysis results in a network-oriented process model of how network reconfiguration and resource use can allow the revelation of service opportunities inherent in manufacturing capabilities.

The paper is structured as follows. After a focussed account of the literature on the shift to services in the next section, we then discuss alternative theoretical perspectives related to

capabilities, arguing for an approach based on Penrose. Then, we summarise the method we used to study our single, focal firm, and present data on three exemplar projects. In the analysis and discussion sections that follow, we propose a model for the development of services that are rooted in manufacturing resources, and then explore how these services relate to products, the factory, the firm, and the network. The final section concludes and suggests further work.

2. The move into services and solutions: promise, directions and doubts

Early arguments for the transition to services drew attention to the revenue streams available from after-sales service activities, especially for capital equipment (Levitt, 1983; Potts, 1988). Similarly, a decade later, Wise and Baumgartner (1999) set out a manifesto for ‘going downstream’, helpfully subtitling their article ‘the new profit imperative for manufacturing’. Mattsson (1973) had already stressed the competitive advantage provided by differentiation through selling product-service combinations. Vandermerwe and Rada (1988) coined the expression ‘the servitisation of business’ to denote the move into the provision of services and integrated solutions. Anderson and Narus (1995) identified a range of ‘supplementary service’ opportunities for manufacturing firms, not least the idea of charging for services such as applications advice that were already provided free of charge.

These early studies, then, characterised the shift into services as predominantly a matter of changing – extending – the boundaries of the firm’s activities, colonising more of a largely pre-existing value-chain, taking over activities previously performed by the customer and/or third parties. ‘Moving downstream’ would generate extra revenues, and bundling products with services would create entry barriers and differentiation, improving profit margins. The next phase of this research was to delineate different forms and degrees of servitization, and

to ask serious questions about whether and how it should be brought about. For example, building explicitly on Wise and Baumgartner, Davies (2003; 2004) examines the emergence of a new type of firm in high-value capital goods sectors - the systems integrator. Not only do such firms 'move downstream', adding services to existing products and taking over some of their customers' activities, they also frequently outsource much or all of the (upstream) manufacturing activity: in some cases, systems integrators are firms entering the industry from bases such as consultancy, with no roots in product manufacturing. Products are regarded by systems integrators as ways to provide services on an ongoing basis, including those that minimise ownership and operational costs, often over contract periods of many years; systems integrators offer services before and during the manufacture of the product, as well as after. This also raises new issues for the client firms procuring such offerings from suppliers (Caldwell & Howard, 2011).

Mathieu (2001) provides a typology of shifts to service ('maneuvers') for a wide range of manufacturing firms, based on the extent of the move into service offerings ('service specificity'), and the 'intensity' of the organizational change undertaken. Importantly, she identifies both the potential benefits of alternative shifts to service, and the costs, risks and difficulties they entail, a prominent theme in a number of subsequent studies in marketing, service management and elsewhere (Baveja, Gilbert, & Ledingham, 2004; Davies, Brady, & Hobday, 2007; Galbraith, 2002; Gebauer, 2008; Neu & Brown, 2005; Oliva & Kallenberg, 2003; Reinartz & Ulaga, 2008). These have mainly been concerned with aligning strategy and structure, notably the question of whether manufacturing firms should deliver services through a separate division or unit; the development of a service relationship with customers; and, particularly in Davies et al. (2007), whether to deliver the product-service largely from within one firm, or from a network coordinated by a systems integrator. These studies draw

on contingency theory, organisational culture and notions of capabilities. Similar general requirements for structural change are usefully summarised by Cova and Salle (2007: 142): the need for a change in orientation, the development of new capabilities, a transformation of intra-organisational structures and processes as well as the successful implementation of those transformations.

As for the *process* of transition to services, several frameworks have been proposed. For example, Baines et al. (2009) suggest a framework for helping product-centric firms servitise their offerings, whilst Gebauer et al. (2010) identify four strategy-structure configurations for successful transitions. Others, however, cast doubts as to how far transitions can be planned or implemented, notably Kowalkowski et al. (2012), who characterise transitions as emergent, reactive and gathering momentum only when services grow in volume. This more specific concern with volume of activity, scale of investment in service and the balance between product and service has been identified in a number of other recent studies (Brax & Jonsson, 2009; Skarp & Gadde, 2008; Windahl & Lakemond, 2010).

The role of capabilities has been increasingly evident in the more recent literature. It is touched upon by Mathieu when she suggests that, for some types of service, ‘manufacturing companies get the opportunity to capitalize on their experience, their expertise, and their lasting image built through their goods offering’ (Mathieu, 2001: 461). Similarly, Oliva and Kallenberg draw the conclusion that it is necessary for firms to adopt ‘a developmental approach – based on capabilities – to the challenge of becoming a service provider’ (Oliva & Kallenberg, 2003: 171). Not surprisingly, given their other concerns, neither of these studies dwelt upon the theorisation of expertise or capabilities. Subsequently, however, capabilities have been more explicitly and fully considered. Skarp and Gadde (2008) emphasise the need

for manufacturing firms wishing to become solutions providers to develop their problem-solving capabilities. Matthyssens et al. (2009), building on the ‘competence-based marketing’ stream of research (Golfetto & Gibbert, 2006; Zerbini, Golfetto, & Gibbert, 2007), argue that value-added marketing must be underpinned by bundles of capabilities, processes and cultures which may be difficult to align and sustain. And this alignment between capabilities and the elements of service offerings is more fully delineated by Ulaga and Reinartz (2011), who draw on established notions from the resource-based view (Barney, 1991; Peteraf, 1993). Given our concern, based on Chase and on Pavitt, with understanding the link between manufacturing and service in terms of specialist knowledge, capabilities and skilled activities, we too are motivated to understand better how resources and capabilities can be theorized in this context. As such, we now consider some of the alternative ways in which this concern might be theorized, and use that theorization to define our research focus.

3. Theoretical perspective and research focus

Our underlying concern is with the nature of the connection between manufacturing and service, in terms of what have typically been called ‘capabilities’ in the literature we have reviewed here. Our related concern is with the network. In this section we review some alternative perspectives on capabilities and resources, developing the argument that key concepts from Penrose (1959) provide a particularly useful insight into the manufacturing-service connection.

3.1 Capabilities and dynamic capabilities

As discussed, recent studies of the transition to service have used the idea of capabilities. Interpretations vary, but most of them resemble Jacobides and Winter’s recent formulation:

‘the firm-specific and time- and space-contingent ability to perform a particular productive activity’ (Jacobides & Winter, 2012: page numbers TBA). Richardson’s was the first usage in the current sense. He examined economic activity in terms of *activities* and *capabilities* and, in his interpretation, capabilities are the ‘appropriate knowledge, experience and skills’ (Richardson, 1972: 888) for the activities to be carried out. Loasby (1998) emphasises that capabilities are about ‘knowing how’ rather than ‘knowing that’, and that ‘what matters at any point of time is the range of future activities which [capabilities] make possible’ (*ibid*: 144). In contrast to this, many interpretations in management, marketing and elsewhere link particular capabilities with particular ‘productive activities’ much more tightly e.g. ‘Execution risk assessment and mitigation capability’ (Ulaga & Reinartz, 2011). In this way, capabilities have come to be widely treated as well-specified destinations - to be achieved, perhaps, in creating the servitised firm - rather than as potentialities.

Dynamic capabilities (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997) are usefully understood as ‘those that operate to extend, modify, or create ordinary capabilities’ (Winter, 2003: 991), where ‘ordinary’, or ‘zero-level’ capabilities are the ‘how we earn a living now’ capabilities (Winter, 2003: 992). For a manufacturing firm, specific production methods might be ordinary capabilities, and systems for new product introduction might be dynamic capabilities^b. But our concern in relation to products and services is not to identify some higher-order ‘transitioning’ capability (which we suppose might be construed as a dynamic capability in Winter’s terms), but to understand at a more fundamental level what the nature of the connection between products/production (or ‘manufacturing itself’) and service/service delivery might be. Dynamic capabilities, then, if they are an answer to anything, are an answer to a different question.

3.2 The resource-based view of the firm and the extended resource-based view (ERBV)

The resource-based-view of the firm (RBV) might also be considered to offer potential insight into our question. Wernerfelt suggested that a ‘resource perspective’ could address questions such as ‘On which of the firm’s current resources should diversification be based?’ (Wernerfelt, 1984: 172): resources of interest included ‘machine capacity’, ‘production experience’ and ‘technological leads’ (*ibid*: 174). Of course, the RBV subsequently became the pre-eminent theoretical frame in the strategy literature (Barney, 1991; Peteraf, 1993), although not universally accepted (Priem & Butler, 2001). The RBV is most frequently articulated in terms of Barney’s (1991) ‘VRIN’^c acronym which, as Kogut points out, is a typology, not a theory, and runs the risk that ‘resources are treated as Lego pieces...the job of the mythical strategist in RBV is to recognise that the dish needs more carrots, and carrots are purchased and added’ (Kogut, 2008: 31). The claim here is that RBV in this form neglects causality and is static. Like proponents of the RBV, we are concerned to look inside the firm – and the factory. But merely identifying a new set of ‘VRIN’ resources that is applicable to a firm that has transitioned to service is not our aim: we wish to understand how resources can be used and augmented to generate service offerings from a base of manufacturing resources and capabilities.

An additional issue arises from our concern with *inter-organizational* aspects of the product-service phenomenon: RBV’s sustained neglect of resources outside the firm (for example, see reviews in Barney, 2001; Barney, Ketchen, & Wright, 2011). The recently-emerging extended resource-based view (ERBV) seeks to address that shortcoming. It has its roots in Teece’s notion of ‘complementary assets’ (Teece, 1986) and the ‘relational view’ in strategic management (Dyer & Singh, 1998), and argues that competitive advantage can be derived in part from resources existing outside the firm (e.g. Lavie, 2006). The ERBV literature is

limited, but for the most part is based on the predominant view of the RBV, and the generation of rents from static resources that dominates that view. One author associated with a form of ERBV and who adopts a more dynamic view of resource development and transfer between firms, is Mathews (2003, 2010). He emphasises the role of entrepreneur, ‘the economic agent who in principle lacks resources (but knows where to find them)’ (Mathews, 2010: 224) and, in developing this approach, uses an understanding of resources explicitly and more faithfully rooted in the work of Penrose (1959). What Mathews draws from Penrose provides insight into the genuinely dynamic, disequilibrium settings that are present as firms work out how to shift to service. This, rather than any specific frameworks, is what we take from the ERBV. As such, we now review the key concepts from Penrose that we take forward into our analysis.

3.3 Penrose

In various ways, most of the alternative theoretical approaches we briefly review in the previous section can be traced back to the work of Edith Penrose. These approaches have selectively used aspects of her insight, but we suggest that, especially as they are widely deployed and interpreted, these have all diluted and neglected those aspects of Penrose that are the most powerful in helping us with our central concern of understanding new manufacturing-based service offerings ‘in the making’. Whereas the RBV (and most versions of the ERBV) stresses the accumulation of ‘VRIN’ resources, Penrose stresses the relationship between firm resources and the firm’s ‘productive operations’:

‘Resources... include the physical things a firm buys, leases, or produces for its own use, and the people hired on terms that make them effectively part of the firm. Services, on the other hand, are the contributions these resources can make to the

productive operations of the firm. A resource, then, can be viewed as a bundle of possible services.' (Penrose, 1959: 67)

For our purposes here, there are two especially important aspects of Penrose's original conception. First, in focussing on how resources are used, rather than what they are, she foregrounds the entrepreneurial function of managers in seeing what she terms the firm's 'productive opportunity', which '... comprises all of the productive possibilities that its "entrepreneurs" see and can take advantage of' (Penrose 1959: 31). Foss contends that the productive opportunity (not the resources as such) is 'arguably the key concept of *The Theory of the Growth of the Firm*' (Foss, 1999: 95), and we use it to develop our argument in later sections^d.

Second, especially for our purposes here, Penrose's use of the term 'service' is intriguing, and powerfully suggestive. Resources, on this view, are fungible and fecund, and can be used in many different ways to 'contribute' to the productive operations of the firm: furthermore, exactly what these productive activities are, and what the 'end-product' is, is a transient matter. As Penrose puts it:

'In a sense, the final products being produced by a firm at any given time merely represent one of several ways in which the firm could be using its resources, an incident in the development of its basic potentialities.' (Penrose, 1960: 3)

If resources are bundles of possible *services*, then it is a matter of managerial choice, and of the design of the institutions of production between organizations (Araujo & Spring, 2006; Coase, 1992), whether these services are used to make products within the firm, or traded as

services (in the sense of service offerings) in their own right. In this sense, Penrose's work reflects the time of its creation: her emphasis was on manufacturing, and the main empirical example we have access to (Penrose, 1960) is of a large, vertically integrated manufacturing firm, largely because that was such a predominant form of private sector activity. Indeed, Penrose subsequently commented that 'The analysis was confined to industrial firms (although it may apply to other types of firm as well)' (Penrose, 1985: 7). Moreover, this means that services in Penrose's sense may reach not only *within* the firm, but beyond it, into the 'productive operations' of other firms. It is also noticeable that Penrose does not insist that important resources be particularly exotic (*contra* the RBV's VRIN schema), nor that the 'services' be especially routinised or tightly linked to particular 'productive operations', in contrast to some of the interpretations of capabilities discussed above. As such, Penrose's conception offers us the most powerful and flexible framework with which to understand new service offerings 'in the making'.

Of course, Penrose's main focus was on matters inside the firm, whereas we are concerned to link that internal view with a network perspective. But to some extent, the external perspective was always present in Penrose, in her concept of the 'productive opportunity', which Pitelis interprets as follows: 'the dynamic interaction between the perceived by management internal and external environments' (Pitelis, 2007: 478). In order to 'see' the productive possibilities, the firm's managers must understand their customers' technologies, processes and challenges (Zander & Zander, 2005) so, in a sense, looking beyond the firm is a necessary if implicit part of Penrose's conception. A complementary perspective is provided by the 'resource interaction approach' (Baraldi, Gressetvold, & Harrison, 2012), which also builds on Penrose and stresses inter-firm resource combinations imagined and activated by managers. While sympathetic to the principle of that approach, we take our point

of departure in particular from the notion of ‘services’ in Penrose’s sense, and its relationship with the service *offerings* that manufacturing firms are attempting to develop in conjunction with network counterparts.

3.4 Research focus and question

The need to understand firm capabilities, then, has emerged gradually as a concern in the literature on the ‘shift to service’, becoming more explicit in the recent work of MatthysSENS et al. (2009) and Ulaga and Reinartz (2011). And, whereas early studies were focussed on the firm as acting, seemingly independently, to ‘shift into’ activities further down the value chain, a more nuanced conception of the firm acting *with* rather than acting *on* the firms in its network has emerged (Cova & Salle, 2008; Davies et al., 2007; Windahl & Lakemond, 2006). Building on these insightful studies, we suggest that a significant gap exists with regard to a deeper theorization of this link (or its absence) between the manufacturing resources and capabilities and the delivery of related services. Ulaga and Reinartz (2011) argue that manufacturers, by virtue of their manufacturing capabilities, have significant advantages over non-manufacturing-based entrants into markets for services. Inspired by the ‘service factory’ concept of Chase and colleagues, and by Pavitt’s reflections on ‘manufacturing itself’, we develop and deepen this line of argument by examining the nature of these capability-based advantages, and we do so with a network perspective. More specifically, we seek to determine how manufacturing firms generate new, product-related services, using their own and other firm’s resources, and how these services might be incorporated into an effective industrial marketing strategy. In doing so, we also seek to develop a finer-grained understanding of how manufacturing resources relate to the provision of services: in other words, we try to understand how ‘product-related’ services are related to the products with which they are associated.

4 Method

We adopted a qualitative method informed by a case study approach. Our work was part of a practical, engaged research study (Van de Ven, 2007) intended to explore opportunities for the development of service offerings in a manufacturing firm. Theoretically, we are informed by Penrose's conception of services, as well as a concern with inter-organisational or network-level analyses. As such, this could be seen as what Andersen and Kragh (2010) term an '*in vivo*' study, one that is predominantly informed by a certain theoretical perspective, and directed toward further elaboration and refinement of the application of that perspective to the research issue in hand. It is not what Yin (2003), for example, would call a 'theory-testing' case design.

Because our research aim was to examine closely the nature of the connections between manufacturing and service capabilities, we chose to study a manufacturing firm, Ariel (a pseudonym), that was in the process of making service 'maneuvers' that, on first impression, were closely rooted in some of the same resources as their manufacturing activities. Our aim was to gradually and iteratively elaborate on and refine theory within our Penrosian theoretical frame, inspired by the 'service factory' concept: as such, we felt it most effective to begin our exploration of services close to the manufacturing resources, rather than, say, the provision of financing services. In this way, theory and method were intertwined and mutually constitutive (Dubois & Araujo, 2007; Van Maanen, Sörensen, & Mitchell, 2007). We had sufficient prior knowledge of Ariel to know that it was appropriate as a setting in which to study these issues. And, since we did not aim to develop something like a contingency framework for the phenomena of interest, but rather to understand their nature in

more fundamental terms, an in-depth study conducted in one firm was deemed most suitable, rather than a multi-setting, comparative study.

More specifically, we studied Ariel over a period exceeding a year. The fieldwork consisted of many interviews and less-structured conversations with the General Manager, often combined with examination, on the shop floor, of various production issues, new products and new process technology. These were augmented by participation in four meetings of the manufacturing management team, of between 90 and 150 minutes' duration, which were specifically directed toward the development of service-oriented offerings. Then, to 'drill down' into particular examples of recent projects – and thereby to relate these to the more general issues – we conducted interviews with individual managers on particular service-intensive past and current projects for particular customers. Most of the interviews and meetings were recorded and, as appropriate, transcribed. Data analysis proceeded iteratively, by reviewing notes of meetings, interview texts, secondary sources and reflections on shopfloor observations, formulating potential managerial and theoretical perspectives, and bringing them back to successive meetings and interventions. In keeping with the engaged research approach, we as researchers did not have a monopoly on theory: our manager participants also brought theoretical frames to the discussions e.g. in relating business models to life-cycle stages. The specific project accounts were written up by us, then reviewed and critiqued by the entire management team. In this way, we proceeded by a process of 'disciplined imagination' (Weick, 1989), trying successive theoretical explanations against our emerging data-set, and using successive data-collection stages to challenge and work through possible interpretations e.g. by 'drilling down' via the specific project histories. We did not have the opportunity to visit and interview customers and suppliers: given the scope of the projects we examined, this would have increased the data-collection effort

exponentially; furthermore, Ariel's perspective on their own network linkages was our main interest, and so studying 'the whole network' was not necessary for our immediate purpose.

As will be clear from our analysis and discussion, we do not treat the firm, Ariel, simplistically as 'a case'. It is a setting in which we study phenomena, reserving judgment as to the most useful unit of analysis. As will become clear, an important concern was with the individual project or product, which reinforced our understanding of more general issues within the firm, but also provided detail on technological, organisational and – importantly – network processes in action. As Van de Ven puts it, we study the phenomena 'up close and from afar' (Van de Ven, 2007: 10). In some respects the model is rather like the 'embedded case' design of Yin (2003). However, the projects and products don't nest neatly within the higher-order 'case' of the firm, but have a tendency to reach out beyond this level and make sense, in some regards at least, only at the level of the network: indeed, the phenomena we are interested in are precisely about linking and moving between these levels. Our contention that these services can be understood as network reconfigurations (section 5) results from a process of 'casing' (Ragin, 1992), whereby the case is not the starting-point of the research process, but one of its outcomes. In other words, we did not enter the field looking for cases of network reconfigurations: they came looking for us.

5. Three new services at Ariel

5.1 The focal firm and context of the study

Ariel (a pseudonym) is a UK-based firm, supplying components to major OEMs (Original Equipment Manufacturers) who in turn produce gas turbines for aerospace, power generation and related uses. The components are critical functional parts of the turbines, mostly made from exotic alloys so that they can operate at the very high temperatures present in the

applications. Ariel's facility consists of a production workshop housing machine tools ranging from very high-specification machining centres to other, simpler machine tools for less precise pre-operations and other tasks such as testing and measurement. The central challenge of the production of the components is cutting extremely hard and unyielding materials to very complicated geometries while holding very exacting dimensional tolerances. The processes are mainly organised in product-specific cells, and the cellular approach extends beyond the shop floor in that each main product line is managed by one of three business unit managers. Because of the very concentrated nature of the OEM market, which is dominated globally by three or four main firms, the business unit managers often have very close relationships with one or two of these customers to whom they supply parts. Ariel has won many prestigious awards and achieved various accreditations for the excellence of their quality and delivery performance.

The focus of the study has been the exploration of alternative service-oriented approaches. In broad terms, Ariel's management are concerned that volume production of established components may be under threat from lower-cost overseas competitors, who increasingly are capable of achieving the demanding manufacturing tolerances of these difficult components. Therefore, it seems important to understand and exploit the most enduring areas and sources of competitive advantage, which reside in activities other than the steady-state production of mature components for supply to OEMs during the main build phase of their own products' life cycles. As part of this study, a number of examples of particularly challenging projects were selected. These reflected the more general feeling that the firm provided its most service-intensive offerings to its customers during the early stages of the OEM product life cycle, when designs were being developed, iterated and finalised, and during the latter stages, when the OEM's equipment had ceased to be in production and parts were required on a more

intermittent basis for replacements and repairs. Hence, the three projects examined here were seen as exemplars of what might become a more deliberate and proactive engineering service offering, one that would reduce Ariel's dependence on relatively high-volume production of components as its predominant source of revenue and profit.

5.2 Three projects for OEMs

Our account here centres on these particular exemplar projects. These are largely independent of one another, and are for different OEMs. The names of the OEMs have been disguised so as to preserve confidentiality.

5.2.1 OEM W - New Product Development

OEM W had a new gas turbine in development. During one of the trials of a prototype turbine, difficulties arose which would necessitate new components to be made. These would entail small but highly significant changes to the exact component dimensions but, until further tests and calculations were made, the exact dimensions for the new design could not be specified. However, OEM W had committed to a very tightly-planned new product development and introduction schedule, and needed to have a turbine to the revised specification ready within six weeks.

The manufacture of the components, even in the relatively small quantities required for prototypes, was normally achieved by first forging a piece close to the finished size, then machining it to final dimensions. However, because of the time limitations, it would be necessary to machine the revised component from a specially-cut solid bar, eliminating the forging stage. Ariel had never made these components - not even to their previous design (OEM W had their own manufacturing capacity as well as using other subcontractors), so it

needed to learn how to do this – and how to work with suppliers of the pre-cut blanks – in the time available. To make matters worse, the precise dimensions for the new version of the component would not be available until a mere *three weeks* before the delivery was due^e. Rather than wait until then, Ariel decided to manufacture a set of components to the old – i.e. obsolete – specification. Although they knew these would be scrapped, by making them Ariel were able to identify, evaluate and work with a new sub-contract supplier of plasma-cut blanks, develop and prove programs for their own numerically-controlled (NC) cutting and measurement machines, and learn about the particular process idiosyncrasies that inevitably arise. As such, by the time the final dimensions had been released by OEM W, Ariel were able quickly to adjust their process, and that of their blank supplier, and make the correct parts almost as though they were a repeat order, not a first-off. They were thus able to produce a set of complex components within just less than three weeks.

5.2.2 OEM X – New product testing

This customer needed to test out a new turbine. They had identified a market opportunity and needed to quickly prove out a variant of an existing turbine product. New turbines have to be tested by building what is known as a ‘rig’ - a version of the turbine with extensive instrumentation built in, which enables all the operating parameters to be monitored and recorded under various conditions. OEM X had rig equipment available from the ‘sister’ turbine model and wanted to test the new model by making a 70% full-size version of the new turbine, as re-using the existing rig equipment would shorten the time required to build and run a rig test. Ariel were asked to produce the components.

Reducing the dimensions of the components by 30% is something which, in principle at least, can be achieved easily enough by altering parameters on the NC machine programs. But the

tolerances were also reduced, making the process even more demanding and, critically, the radii of various detail features such as the transitions between different diameters were also reduced. Such features would be designed with the industry standard cutting-tool dimensions in mind (e.g. 0,8mm radius), but in the scaled-down version, would have to be reduced accordingly to entirely non-standard dimensions (e.g. 0,56mm radius). This in turn entailed the special manufacture and supply of customised cutting tools by Ariel's tooling suppliers. Furthermore, because of the need for such detailed data capture and analysis during the rig test, Ariel were required to provide, for every component (normally a sample would suffice), detailed co-ordinate measuring machine data. Unusually, Ariel were asked to produce the whole set of turbine components, not just certain sub-sets, because of the benefits derived from keeping all the activities under one roof.

5.2.3. OEM Y – Low-volume spare parts

OEM Y have a particular turbine in service in the field that is no longer in volume production, but still requires maintenance services and spare parts provision. Ariel supply a cover plate for this turbine. There is only one of these per turbine, so volumes required are very low, just a few hundred pieces per year. Ariel machine the plate from a titanium-alloy sand-casting, which they buy in from a North American supplier. The volumes are low, but the supplier makes the castings in occasional large batches to reduce their own down-time, and, because of the low volumes and relatively low revenue, do not prioritise this part or OEM Y as a customer. As such, delivery is increasingly slow and unreliable. Furthermore, the parts are subject to the idiosyncrasies typical of the casting process and this leads to relatively high scrap rates in Ariel's process, which involves the machining of a complicated set of profiles, holes and other features.

Ariel have developed an alternative approach to producing this component. This is to machine the part from an easily (and locally) sourced simple blank of solid material, rather than from a specialised casting close to the final dimensions. This process route is more appropriate to the lower-volume, more mature stage of the product's life-cycle, since the greater loss of raw material in the cutting process is more than outweighed by the simplification of the process by removal of the casting stage altogether, and the attendant labour costs. This change has entailed the creation of a computer model of the component as a basis for designing the process. (As the product was designed before such modelling technologies were available, no model existed, only traditional engineering drawings.) Machining the part from solid means that it can be made from readily available material, and eliminates all the sources of uncertainty inherent in casting. Small changes have been made to the geometry of the part, to achieve critical weight savings and to take out details that were only present because of the requirements of casting. The process is proved out using the combination of CAD modelling, computer-based cutter-route simulation, and stereolithographic modelling. The latter is used in part for internal purposes, to double-check that the finished part will have acceptable surface finishes and the like, but, more importantly, proves useful in demonstrating to the customer – who is, reasonably enough, cautious about changing proven processes in a highly safety-conscious and regulated industry – that the new method is capable of producing satisfactory results. The routine conversion of the product data into a CAD model is to be done remotely by outsourced engineering service providers, providing extra engineering capacity at low cost.

6. Towards a model of product-related service innovation

What do these exemplary cases tell us about what is happening at Ariel? In all three examples, the outcome is a component or a set of components - i.e. a product. But what is it that is valuable to the OEM customer? And what does that tell us about the nature of services in this manufacturing-oriented network? We structure our discussion around a network-oriented process model of the development of new capabilities (sections 5.2-5.6). Before that, however, we suggest an approach to thinking about the relationship between resources, products and services.

6.1 Resources, Penrose-services and products

We find it helpful to conceive of the basic relationships as shown in Figure 1. A resource (R) gives rise to multiple productive services, which, in order to distinguish them from service offerings that are traded (which we discuss below), we will call ‘Penrose-services’ (S). These in turn give rise to products (P). Those shown in solid lines are the Penrose-services and products actually being produced at a particular time; those shown in broken lines are those that could be. (They are, of course, potentially limitless.) Managers will be able to conceive of some of these potential uses of resources, but not others. This is partly defining of the firm’s ‘productive opportunity’, which ‘... comprises all of the productive possibilities that its “entrepreneurs” see and can take advantage of’ (Penrose 1959: 31) and arises from under-used resources, or resources that are being used, but that might be used and combined differently. (Another aspect of this is that managers may be able to see that certain resources could be used in different ways, but lack the time and money to effect the change. This might be interpreted as having insufficient organizational slack (Pitelis, 2007).)

FIGURE 1 ABOUT HERE

This conceptualisation informs our process model, which is shown in Figure 2, and which we discuss next. In the discussion, links are made to the relevant part of the diagram by means of numbers in parentheses.

FIGURE 2 ABOUT HERE

6.2 The trigger

In all three examples, the development effort is triggered by a disruption to established patterns of network activity (Figure 2, stage 1): from the OEMs due to a difficulty in new product testing (OEM W), a requirement for rapid response to a market opportunity (OEM X) and, in the case of OEM Y, from within Ariel - the sensing and seizing of an opportunity to provide more reliable and economic availability of products, given a shifting economic context, unsatisfactory network connections (the increasingly unreliable casting supplier) and new possibilities of design and production technology. For OEM W, using Ariel *at all* as a supplier for these products is a reconfiguration of their wider network, as they had hitherto used internal capacity and external sources other than Ariel. Ariel regularly supplied OEM W with other products, and their success in doing this led to their being approached by OEM W for the special new product task.

6.3 Changing the productive opportunity

The responses to these triggers were never simple activations of tried and tested routines, but ‘occasions’ (Barley, 1986) for rethinking the productive opportunity (Figure 2, stage 2). This involved considerable exploration and uncertainty, as we have shown. Ariel’s overall value proposition was to be able credibly to claim that it could take on the challenge while still figuring out ways to deliver on its promise. And, in turn, its ability to deliver on its promise

inherited in ‘the basic potentialities’ (Penrose, 1960) of Ariel, its managers’ ability to understand those potentialities (cf. the idea of sense-making as deployed in Henneberg, Naudé, & Mouzas, 2010) and to confidently commit them to opportunities, despite considerable uncertainty as to exactly how to fulfil promises made to customers.

6.4 Revealing resources and Penrose-services

Enacting the productive opportunity (Baraldi et al., 2012) might entail using Penrose-services to produce different products and/or using resources to generate new Penrose-services (Figure 2, stage 3), which in turn can be used to make different products or, indeed, to make existing products in different ways. These alternative resource-service-product chains might be dormant practices or might be ‘revealed’ to the firm’s management through experimental adaptation of existing resources and Penrose-services. In other words, the trigger engenders the disequilibrium that presents an opportunity for revelation of new uses for resources and/or Penrose-services: this is so in all the exemplar projects. In general terms, we show this schematically in Figure 3 (a) and Figure 3 (b). The chain-line ellipses show the productive opportunity at each time T_0 and T_1 . At T_0 , managers are aware of other products they could make from the Penrose-services currently available. As a result of the trigger and the reconfiguration of their resources and network, at time T_1 they establish in practice a new, expanded productive opportunity (Figure 3 b). This could be seen, at least in part, as a process of effectuation (Wiltbank, Dew, Read, & Sarasvathy, 2006) rather than deliberately planned, purposeful capability development (cf. Kowalkowski et al., 2012). It is also likely to be iterative, in that an initial judgment about the new productive opportunity will lead to some trial-and-error learning, which in turn will reveal more specifically what the potentialities of the firm’s resources are and, often, where there are shortfalls that must be acquired or made up by accessing external resources (Figure 2, stage 4).

FIGURE 3a AND 3b ABOUT HERE

6.5 Network and resource reconfiguration

The search for Penrose-services and resources, then, also extends beyond the firm: part of the realisation of the productive opportunity then becomes the entrepreneurial move of (paraphrasing Mathews) ‘lacking resources, but knowing where to find them’. Consequently, in all the examples, the network is reconfigured (Figure 2, stage 4), and we have outlined these in each of our accounts. For OEM W, Ariel’s solution hinged on changing the process route and the network used to carry it out, including finding, evaluating and working with the specialist plasma-cutting contractor. In the work for OEM X, it was necessary to engage with the tooling suppliers to source specially-adapted cutters to accommodate the non-standard geometry of the scaled-down parts. The solution for OEM Y again involved re-thinking the production process sequence and approach: effectively bringing in-house a large part of the metal-shaping activities, hitherto achieved using a sand-casting process by the increasingly unreliable supplier, but also outsourcing some of the *engineering design* work that was now becoming the more central - and scarce – resource. As suggested by Figure 2, stages 3 and 4 are iterative, as initial explorations of resources and Penrose-services identify what can and can’t be done, and hence what resources (probably) need to be acquired or accessed. The Penrose-services available from newly configured resources then have to be confirmed by trial-and-error, until it is possible to make the required product, in a newly-reconfigured and stabilised network.

6.6 Expanded productive opportunity

The newly-revealed resource-service-product connections also result in a subsequently enlarged understanding of the firm’s (and its network’s) productive opportunity. What once

were speculative, one-off experiments become established as practices and routines both within and beyond the firm (Figure 2, stage 5); new R-S-P connections are current and exercised (see Figure 3b) and become cognitively and practically accessible to managers facing related demands from their customers^f.

6.6 Marketing

One-off interventions can provide a platform for more deliberate marketing of capabilities (Figure 2 stage 6). For example, in making its proposal to OEM Y, Ariel wasn't just addressing unreliability of supply, but anticipating that, as the cover plate went into the mature/decline phase of its life cycle, Ariel's new solution would be attractive and valuable to OEM Y and, by implication, to others in similar positions with similar components, laying the foundations for a more generally applicable 'decline stage supply solution'. This would relieve OEMs of concerns about spares availability – which were increasingly directly *their* concerns, as they themselves moved toward offering servitised, performance-based solutions including maintenance (Caldwell & Howard, 2011; Doerr et al., 2005).

Hence, we can construe the relationship between Ariel and its OEM customers as the connection of successive 'productive opportunities'. In the exemplar cases above, OEM customers turned to Ariel when they were exploring their own productive opportunities under severe time pressures (cf. Lewis, Brandon-Jones, Slack, & Howard, 2010). Managers at Ariel were able to recognise their customers' productive opportunities and translate them into - or connect them with - their own productive opportunity (cf. Grönroos, 2008). Through the iterative revelation of Penrose-services and reconfiguration of the network, satisfactory solutions were provided. But for this to be a commercial as well as a technological

achievement, it is necessary to stabilise an offering for the purposes of making a transaction (Callon, 2002; Callon, Meadel, & Rabeharisoa, 2002); in this instance, although the transaction was made notionally for the end-products (they were the ‘price-carrier’ (Normann, 2001: 124-128)), it was well understood that what was being bought was in large part a sustained exercise in engineering process design, and that the price of the parts had little to do with the raw material and direct manufacturing costs^g.

Our analysis here builds on the discussion of Blois and Ramirez (2006) on the marketing of capabilities. Whereas their analysis is primarily concerned with the very helpful categorisation of the capabilities (following Normann and Ramirez (1994)) as either ‘relieving’ or ‘enabling’, our data also show some of the ways in which capabilities – or Penrose-services – are implicated in marketing activities, very much in the way envisaged in Chase’s ‘service factory’ concept. Most importantly, and in the sense discussed by Blois and Ramirez, if we take Ariel’s strategy to its logical conclusion, the Penrose-service can be detached as an offering from the product, becoming a price-carrier in its own right. Secondly, however, capabilities can play a part in relationship development and marketing communications. For example, although making obsolete products for OEM W served mainly to provide a platform for Ariel’s capability development (see discussion below), it also served to convey to OEM W that ‘something was happening’, and that they (OEM W) could be confident enough to continue planning for the next stage of their own product development project. For OEM Y, Ariel had to go to considerable lengths to qualify the new process that they themselves had instigated, and the creation of stereo-lithographic models served primarily to give the customer interim tangible evidence of progress (cf. Levitt, 1981) rather than contributing much insight for Ariel’s own purposes^h. Other ‘by-products’ of the production process played a more functional role: for example, OEM X were supplied with

huge sets of co-ordinate measuring machine data as well as the components these data described. Despite the close tolerances, each component has slightly different mechanical properties and resonant frequency signatures, so that the General Manager wittily described them as ‘identical one-offs’. In Blois and Ramirez’s terms, this ‘relieved’ the customer from the need to measure each of the components themselves prior to balancing them in the final installation.

This brings us back to a number of emerging themes in service research identified by Ostrom et al (2010), including business model development, service design and ‘branding and selling service’. Part of the marketing task, of course, is to align such marketing efforts with the superabundant and valuable Penrose-services freed up by the revelation and acquisition of new resources. In this way, the ‘restless’ firm (Bloch & Metcalfe, 2011) keeps exploring possible relationships between its ever-changing set of resources and Penrose-services, and its ever-changing productive opportunity, temporarily stabilising those relationships from time to time to make transactions possible (Araujo & Spring, 2006) and earn a living.

7. Discussion

The starting-point for this exploration of Ariel’s development of services was the recent research drawing attention to the importance of capabilities in determining which service ‘maneuvers’ might be possible and successful for manufacturers. The resource-service-product analysis set out in section 5 and in Figures 1 and 3, although applied here to a manufacturing firm beginning a shift to services, could be applied more generally to the analysis of any firm’s resources and their uses. So, what is special about services? For Ariel, part of the motivation was to deliberately develop an explicit service offering that was

separated commercially from the sales of parts. The exercise here in identifying the Penrose-services is suggestive of the next step: making the end ‘product’ a service offering, or a ‘service-product’ (SP), which is transacted for in its own right – possibly alongside product transactions, possibly not. We represent this schematically in Figure 4.

FIGURE 4 ABOUT HERE

In mode (a), although extra services may be developed to augment the product manufacturing and delivery offering (e.g. stereo-lithographic models or very detailed component measurement data), the price carrier is the physical product, and the ‘service-products’ are bundled with it. This requires that the costs of developing and delivering the SP are somehow amortised over a certain number of physical products. In mode (b), the two are separated, each acting as an independent price carrier. This requires new efforts to quantify and specify what the ‘service product’ is, and how it will be traded (a vast topic in its own right, of course). Mode (c) takes this to the logical conclusion: Penrose-services are converted into a service product and sold without any products being made for sale. An example of this might be developing a package of tool specifications and process definitions that would allow a customer or third party (e.g. contract manufacturer) to manufacture the products. Again, valuation and pricing are new challenges.

So, if services can be sold alone, does this mean that Ariel’s engineers are engineering consultants who happen to work in a factory? No it does not. It is evident from the practices they engaged in that the close interrelationships between the Penrose-services and the ‘final’ cutting of metal were crucial to success and, in two of the three instances, to the speed of the work. While they also drew on suppliers, the triangle between detailed product designⁱ,

process design and actual metal-cutting and measurement was at the heart of the firm's capabilities-as-potentialities or Penrose-services. There is always a machining process involved somewhere in Ariel's work on these exemplar projects. Such material conversion processes are, perhaps, what is understood by 'manufacturing itself' (cf. Pavitt, 2003). We suggest that an analysis of the relationship between manufacturing and the development of 'related' service offerings can usefully be considered in three ways: the relationship between services and the product; between services and the (service) factory; and between services and the firm. This then leads to a reflection on services in the manufacturing network.

7.1 Services and the product

Our empirical material leads us to consider the role of products in the ways capabilities are developed, used, procured and marketed. For Corey (1975: 121) '...the product is what the product *does*: it is the total package of benefits the customer receives when he buys'. And the total package can comprise anything from the functional characteristics of the products, to technical assistance and after-sales service, implying that material artefacts are just one independent component and, in some cases, the least important one. Following this line of thought, products have been variously described as 'the packaging of a problem-solving service' (Kotler, 1980), 'frozen knowledge' (Normann & Ramirez, 1993), 'distribution mechanisms for services' (Vargo & Lusch, 2004) or 'carriers of competence' (Michel, Vargo, & Lusch, 2008). Our study shows that, although it may be useful to think of products as (in various ways) embodiments of productive knowledge, it is important to remain aware that products do not exhaustively embody such knowledge. In other words, valuable production-related knowledge – Penrose-services – can leave the supplier's premises by many means other than by being shipped, on a pallet, from the loading-bay.

Our empirical examples also highlight a different role for products in relation to the means by which they are produced. The fact that all three cases involved elements of modelling, simulation, making versions of parts, redesigning processes and connecting to others in the network, emphasises that products have an important role in the development of capabilities. The most telling illustration of this is in the work for OEM W: even when Ariel managers knew that the first product to be made was going to be scrapped, they went ahead and made it in order to reveal and refine the Penrose-services its production entailed - such is the inseparability of the artefact from the processes that bring it into being. This goes beyond *ex post* discovery that the production of certain products leads to the development of capabilities that are useful for successive products in a sequence (cf. Helfat & Raubitschek, 2000); rather, it sees the product enlisted almost as an active participant in the capability development process. In other words, products are constitutive of capabilities rather than being mere projection screens for them. This reverses the teleology of Penrose's analysis – the product-as-artefact (rather than as object of exchange) becomes the means, not the end, i.e. the means to develop the Penrose-services that, in turn, become the object of exchange in a service-based business. In this sense, service can be seen not as infused (literally ‘poured in’) into manufacturing (Ostrom et al., 2010) but as inhering in (literally, ‘sticking firmly to^j) manufacturing, and the firm’s task can sometimes be to reveal services and detach them from manufacturing rather than adding services *to* manufacturing.

7.2 Services and the service factory

Reaching beyond the factory and reaching beyond the firm is, for Ariel, essentially the same thing, since it is a single-site operation. But two distinct factors – space and direct managerial control - are at work here, and bear on different aspects of the situation in different ways. Chase’s service factory concept foregrounds the spatial, insofar as it emphasises connection

between activities that occur under the same roof: in our examples, the fact that the design of tooling paths was being done in the office next door to the machines doing the metal cutting made iterations between the two quicker, richer and more effective, as explained compellingly by von Hippel's (1994) concept of 'sticky information'. In this sense, the factory space is not merely a 'backdrop' (cf Giddens, 1984: 136) to work, but constitutive of it.

7.3 Services and the firm

The fact of some of the work being undertaken within the *firm*, and some outside it, is important in different ways. According to Langlois:

‘The essence of the firm, and its source of advantage over spontaneous product markets, lies in its flexibility in circumstances of change and uncertainty.’ (Langlois, 2007: 1110)

That is, with specific reference to our examples, Ariel's managers could commit to providing their OEM customers with particular outcomes, while remaining as yet uncertain about the details of how these outcomes would be achieved, because they knew that it was in their gift to deploy resources as emerging circumstances dictated. In practice at Ariel, this meant that certain individuals ‘worked silly hours’ at weekends and on night-shifts, for which allowances such as ‘time off in lieu’ could be made on an inflexible and informal basis.

7.4 Services and the network

Despite this internal absorption of some of the uncertainty (cf. Easton & Araujo, 1997), Ariel did not do *everything* that was out of the ordinary within the firm: by virtue of their understanding of what was *likely* to be required and what their suppliers – some current, some not – would *probably* be able to do, they could make judgments about how to use the

network, including their own facility, to solve the problem^k. Indeed, all the exemplars we discuss here hinged significantly on Ariel's redesigning the sequence, nature and disposition of the activities in the business network as much as on redesigning the components or the in-house 'manufacturing' (metal-cutting) process. That is to say that the roots of Ariel's offering are in its service factory, but extend to its ability – which, it must be stressed, is strongly determined by its production capabilities – to orchestrate and access others' capabilities and provide its customers with access to a 'service network'. In other words, Ariel have to 'know more than they make' (Brusoni, Prencipe, & Pavitt, 2001). A potentially important insight from this study, then, is that of a strong link between understanding the resources and Penrose-services of other firms, and an ability to provide a valuable service offering. Ariel knows something about its customer's processes, technologies and practices, and can therefore understand what might be of value to them; it understands something about *its own* suppliers' processes, technologies and practices, and so can judge what *they* can do that it, Ariel, would value. The boundaries of the firm, in some sense, reaches into the resources of its network counterparts (Araujo, Dubois, & Gadde, 2003).

8 Conclusions, limitations and suggestions for further work

8.1 Conclusions

Our close examination of the relationship between products, production processes and the services surrounding them and connected to them allows us to build on the work of Mathieu, allowing a finer-grained analysis of the 'service specificity' dimension of her framework for service maneuvers (Mathieu, 2001). Our approach also adds a complementary perspective to that of MatthysSENS and Vandenbempt (2008): whereas their manufacturers looked to technical and business process integration (always including and based on products) as the added service element, Ariel were digging deeper into their Penrose-services with a view to

selling these in their own right, possibly without the products as such. In other words, there are multiple dimensions along which manufacturing firms might ‘shift to service’, and multiple logics as to which service offerings build most readily on existing and readily accessible resources. In this sense we also agree with Matthyssens and Vandenbempt’s emphasis on the need for entrepreneurship (2008: 326), which we have examined specifically in terms of the productive opportunity.

Above all, rather than framing the ‘transition’ to service as an unfortunate but necessary phase before manufacturing firms achieve ‘service infusion’, we have stressed the continuously emergent and exploratory nature of the shift to service. The restless firm – in conjunction with its restless network counterparts – is engaged in network reconfiguration rather than simply ‘moving downstream’. We have delineated at least some of the main features of that process. Furthermore, our analysis has allowed a preliminary understanding of the relationship between the service offering on one hand, and the products, factories, firms and networks with which it is associated on the other. Hence we begin to build a notion of the manufacturing-service firm and the manufacturing-service network, as well as revealing more of the characteristics of the service (manu)factory. And in doing so, we identify some of the ways in which the service factory, and the resources underpinning it, can be used to develop a more proactive marketing approach.

8.2 Limitations and suggestion for further work

We hope that this close consideration of the roots of some product-related services has shed new light on some of the challenges faced in the ‘shift to service’. However, we are also aware that there are a number of limitations in our work, and several opportunities for it to be developed further. Empirically, the instances of service development we studied had all been

brought to fruition. It would be revealing also to examine instances of attempts to develop service-intensive offerings that had been rejected or that had not been successful, in order to identify some of the fault-lines and limitations to the ‘productive opportunity’. Also, as discussed, we chose to begin with services that seemed most closely related to the resources implicated in production processes. A development of this study would be to examine closely, in another more appropriate setting, the connections between resources, ‘Penrose-services’ and service products seemingly further removed from production, such as commissioning, equipment operation and maintenance. Finally, our data collection was limited to the focal firm, Ariel. A fuller picture of the projects, especially the notion of ‘chains of productive opportunities’, could perhaps have been achieved if we had been able to negotiate access to some of the OEMs and the various suppliers involved.

Theoretically, our use of Penrose foregrounds the dynamic phase of service ‘in the making’. A complementary view, based more in capabilities-as-routines (Winter, 2003), would illuminate the subsequent stabilisation of services as more regular offerings. Another extension beyond our analysis might be to develop interlinked diagrams of the form of Figures 1, 3 and 4 for network counterparts: this would allow exploration of how one firm’s products and service-products become resources for another firm, and how the productive opportunities of firms connect to one another. This is graphically and conceptually complicated. There is also much more to be done in understanding the ontology of ‘manufacturing itself’. We have pursued an approach which still, to some extent, black-boxes resources and focuses on what they can do: complementary perspectives can be derived from studying more fundamentally what technological resources are, for example using Heideggerian notions of tools (Harman, 2010), and how they are socially constructed (Bijker, 2010) and implicated in organizational practices (Nicolini, 2010). Strangely, then, it seems

that one route to a fuller understanding of services of this type is a still closer look at the products and production processes to which they are supposedly related.

References

- Andersen, P. H., & Kragh, H. 2010. Sense and sensibility: Two approaches for using existing theory in theory-building qualitative research. *Industrial Marketing Management*, 39(1): 49-55.
- Anderson, J. C., & Narus, J. A. 1995. Capturing the value of supplementary services. *Harvard Business Review*, 73(1): 75-83.
- Araujo, L., Dubois, A., & Gadde, L.-E. 2003. The multiple boundaries of the firm. *Journal of Management Studies*, 40(5): 1255-1277.
- Araujo, L., & Spring, M. 2006. Services, products, and the institutional structure of production. *Industrial Marketing Management*, 35(7): 797-805.
- Baines, T., Lightfoot, H., Peppard, J., Johnson, M., Tiwari, A., Shehab, E., & Swink, M. 2009. Towards an operations strategy for product-centric servitization. *International Journal of Operations & Production Management*, 29(5): 494-519.
- Baraldi, E., Gressetvold, E., & Harrison, D. 2012. Resource interaction in inter-organizational networks: foundations, comparison, and a research agenda. *Journal of Business Research*, 65(2): 266-276.
- Barley, S. R. 1986. Technology as an occasion for structuring: evidence from observations of CT Scanners and the social order of radiology departments. *Administrative Science Quarterly*, 31(1): 78-108.
- Barney, J. B. 1991. Firm resources and sustained competitive advantage. *Journal of Management*, 17: 99-120.
- Barney, J. B. 2001. Resource-based theories of competitive advantage: A ten-year retrospective on the resource-based view. *Journal of Management*, 27(6): 643-650.
- Barney, J. B., Ketchen, D. J., & Wright, M. 2011. The future of resource-based theory. *Journal of Management*, 37(5): 1299-1315.
- Baveja, S. S., Gilbert, J., & Ledingham, D. 2004. From Products to Services: Why It's Not So Simple. *Harvard Management Update*, 9(4): 3-5.
- Bijker, W. E. 2010. How is technology made?—That is the question! *Cambridge Journal of Economics*, 34(1): 63-76.
- Bloch, H., & Metcalfe, S. 2011. Complexity in the theory of the developing firm. In C. Antonelli (Ed.), *Handbook on the economic complexity of technological change*: 81-104. Cheltenham: Edward Elgar.
- Blois, K., & Ramirez, R. 2006. Capabilities as marketable assets: A proposal for a functional categorization. *Industrial Marketing Management*, 35(8): 1027-1031.
- Brax, S. A., & Jonsson, K. 2009. Developing integrated solution offerings for remote diagnostics: A comparative case study of two manufacturers. *International Journal of Operations & Production Management*, 29(5): 539-560.
- Brusoni, S., Prencipe, A., & Pavitt, K. 2001. Knowledge specialization, organizational coupling, and the boundaries of the firm: why do firms know more than they make? *Administrative Science Quarterly*, 46(4): 597-621.
- Caldwell, N., & Howard, M. (Eds.). 2011. *Procuring complex performance: studies of innovation in product-service management*. New York: Routledge.
- Callon, M. 2002. Writing and (re)writing devices as tools for managing complexity. In J. Law, & A. Mol (Eds.), *Complexities: Social Studies of Knowledge Practices*: 191-217. Durham and London: Duke University Press.
- Callon, M., Meadel, C., & Rabeharisoa, V. 2002. The economy of qualities. *Economy and Society*, 31(2): 194-217.

- Chase, R., & Erikson, W. J. 1988. The service factory. *The Academy of Management Executive*, 11(3): 191-196.
- Chase, R., & Garvin, D. 1989. The service factory. *Harvard Business Review*, 67(4): 61-70.
- Coase, R. 1992. The institutional structure of production. *American Economic Review*, 82(4): 713-719.
- Colbert, B. A. 2004. The Complex Resource-Based View: Implications for Theory and Practice in Strategic Human Resource Management. *The Academy of Management Review*, 29(3): 341-358.
- Corey, E. R. 1975. Key options in market selection and product planning. *Harvard Business Review*, Sep-Oct: 119-128.
- Cova, B., & Salle, R. 2007. Introduction to the IMM special issue on 'Project marketing and the marketing of solutions': A comprehensive approach to project marketing and the marketing of solutions. *Industrial Marketing Management*, 36(2): 138-146.
- Cova, B., & Salle, R. 2008. Marketing solutions in accordance with the S-D logic: Co-creating value with customer network actors. *Industrial Marketing Management*, 37(3): 270-277.
- Davies, A. 2003. Integrated solutions: the changing business of systems integration. In A. Davies, M. Hobday, & A. Prencipe (Eds.), *The business of systems integration*: 333-368. Oxford: Oxford University Press.
- Davies, A. 2004. Moving base into high-value integrated solutions: a value stream approach. *Industrial and Corporate Change*, 13(5): 727-756.
- Davies, A., Brady, T., & Hobday, M. 2007. Organizing for solutions: Systems seller vs. systems integrator. *Industrial Marketing Management*, 36(2): 183-193.
- Doerr, K., Lewis, I., & Eaton, D. R. 2005. Measurement issues in performance-based logistics. *Journal of Public Procurement*, 5(2): 164.
- Dubois, A., & Araujo, L. 2007. Case research in purchasing and supply management: Opportunities and challenges. *Journal of Purchasing and Supply Management*, 13(3): 170-181.
- Dyer, J. H., & Singh, H. 1998. The relational view: co-operative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, 23(4): 660-679.
- Easton, G., & Araujo, L. 1997. Interfirm responses to heterogeneity of demand over time. In M. Ebers (Ed.), *The formation of interorganisational networks*: 66-94. Oxford: Oxford University Press.
- Eisenhardt, K. M., & Martin, J. A. 2000. Dynamic capabilities: what are they? *Strategic Management Journal*, 12: 1105-1121.
- Foss, N. 1999. Edith Penrose, economics and strategic management. *Contributions to Political Economy*, 18(1): 87-104.
- Galbraith, J. R. 2002. Organizing to deliver solutions. *Organizational Dynamics*, 31(2): 194-207.
- Gebauer, H. 2008. Identifying service strategies in product manufacturing companies by exploring environment-strategy configurations. *Industrial Marketing Management*, 37(3): 278-291.
- Gebauer, H., Edvardsson, B., Gustafsson, A., & Witell, L. 2010. Match or mismatch: strategy-structure configurations in the service business of manufacturing companies. *Journal of Service Research*, 13(2): 198-215.
- Gebauer, H., Fleisch, E., & Friedli, T. 2005. Overcoming the service paradox in manufacturing companies. *European Management Journal*, 23(1): 14-26.
- Golfetto, F., & Gibbert, M. 2006. Marketing competencies and the sources of customer value in business markets. *Industrial Marketing Management*, 35(8): 904-912.
- Grönroos, C. 2008. Service logic revisited: who creates value? And who co-creates? *European Business Review*, 20(4): 298-314.
- Harman, G. 2010. Technology, objects and things in Heidegger. *Cambridge Journal Of Economics*, 34(1): 17-25.
- Helfat, C. E., & Raubitschek, R. S. 2000. Product sequencing: co-evolution of knowledge, capabilities and products. *Strategic Management Journal*, 21(10/11): 961-979.
- Henneberg, S. C., Naudé, P., & Mouzas, S. 2010. Sense-making and management in business networks -- some observations, considerations, and a research agenda. *Industrial Marketing Management*, 39(3): 355-360.

- Jacob, F., & Ulaga, W. 2008. The transition from product to service in business markets: An agenda for academic inquiry. *Industrial Marketing Management*, 37(3): 247-253.
- Jacobides, M. G., & Winter, S. G. 2012. Capabilities: Structure, Agency, and Evolution. *Organization Science*.
- Kogut, B. 2008. Introduction: knowledge, options and institutions. In B. Kogut (Ed.), *Knowledge, options and institutions*: 1-44. Oxford: Oxford University Press.
- Kotler, P. 1980. *Marketing Management: Analysis, Planning and Control* (7th ed.). Englewood Cliffs, NJ: Prentice-Hall.
- Kowalkowski, C., Kindström, D., Alejandro, T. B., Brege, S., & Biggemann, S. 2012. Service infusion as agile incrementalism in action. *Journal of Business Research*, 65(6): 765-772.
- Langlois, R. N. 2007. The entrepreneurial theory of the firm and the theory of the entrepreneurial firm. *Journal of Management Studies*, 44(7): 1107-1124.
- Lavie, D. 2006. The competitive advantage of interconnected firms: an extension of the resource-based view. *Academy of Management Review*, 31(3): 638-658.
- Levitt, T. 1981. Marketing intangible products and product intangibles. *Harvard Business Review*, 22(2): 37-44.
- Levitt, T. 1983. After the sale is over... *Harvard Business Review*, 61(1): 87-93.
- Lewis, M., Brandon-Jones, A., Slack, N., & Howard, M. 2010. Competing through operations and supply: the role of classic and extended resource-based advantage. *International Journal of Operations & Production Management*, 30(9-10): 1032-1058.
- Loasby, B. J. 1998. The organisation of capabilities. *Journal of Economic Behavior & Organization*, 35(2): 139-160.
- Lovelock, C., & Gummesson, E. 2004. Whither services marketing: in search of a new paradigm and fresh perspectives. *Journal of Service Research*, 7(1): 20-41.
- Mason, K. J., & Leek, S. 2008. Learning to build a supply network: An exploration of dynamic business models. *Journal of Management Studies*, 45(4): 774-799.
- Mathews, J. A. 2003. Competitive dynamics and economic learning: an extended resource-based view. *Industrial and Corporate Change*, 12(1): 115-145.
- Mathews, J. A. 2010. Lachmannian insights into strategic entrepreneurship: resources, activities and routines in a disequilibrium world. *Organization Studies*, 31(2): 219-244.
- Mathieu, V. 2001. Service strategies within the manufacturing sector: benefits, costs and partnership. *International Journal of Service Industry Management*, 12(5): 451-475.
- Matthyssens, P., & Vandenbempt, K. 2008. Moving from basic offerings to value-added solutions: Strategies, barriers and alignment. *Industrial Marketing Management*, 37(3): 316-328.
- Matthyssens, P., Vandenbempt, K., & Weijns, S. 2009. Transitioning and co-evolving to upgrade value offerings: A competence-based marketing view. *Industrial Marketing Management*, 38(5): 504-512.
- Mattsson, L.-G. 1973. Systems selling as a strategy on industrial markets. *Industrial Marketing Management*, 3(2): 107-120.
- Michel, S., Vargo, S. L., & Lusch, R. F. 2008. Reconfiguration of the conceptual landscape: a tribute to the service logic of Richard Normann. *Journal of the Academy of Marketing Science*, 36(1): 152-155.
- Neely, A. 2008. Exploring the financial consequences of the servitization of manufacturing. *Operations Management Research*, 1(2): 103-118.
- Neu, W. A., & Brown, S. W. 2005. Forming successful business-to-business services in goods-dominant firms. *Journal of Service Research*, 8(1): 3-17.
- Nicolini, D. 2010. Practice as the site of knowing: insights from the field of telemedicine. *Organization Science*, 22(3): 602-620.
- Normann, R. 2001. *Reframing business: when the map changes the landscape*. Chichester: John Wiley.
- Normann, R., & Ramirez, R. 1993. From Value Chain to Value Constellation - Designing Interactive Strategy. *Harvard Business Review*, 71(4): 65-77.
- Normann, R., & Ramirez, R. 1994. *Designing interactive strategy*. Chichester: John Wiley and Sons.
- Oliva, R., & Kallenberg, R. 2003. Managing the transition from products to services. *International Journal of Service Industry Management*, 14(2): 160-172.

- Ostrom, A. L., Bitner, M. J., Brown, S. W., Burkhard, K. A., Goul, M., Smith-Daniels, V., Demirkan, H., & Rabinovich, E. 2010. Moving forward and making a difference: research priorities for the science of service. *Journal of Service Research*, 13(1): 4-36.
- Pavitt, K. 2003. Specialization and systems integration: where manufacture and services still meet. In A. Davies, M. Hobday, & A. Prencipe (Eds.), *The business of systems integration*: 78-91. Oxford: Oxford University Press.
- Penrose, E. T. 1959. *The Theory of the Growth of the Firm*. Oxford: Basil Blackwell.
- Penrose, E. T. 1960. The growth of the firm - A case study: the Hercules Powder Company. *Business History Review*, 34(1): 1-23.
- Penrose, E. T. 1985. The theory of the growth of the firm twenty-five years after. Uppsala: University of Uppsala.
- Peteraf, M. A. 1993. The cornerstones of competitive advantage: a resource-based view. *Strategic Management Journal*, 14(3): 179-191.
- Pitelis, C. N. 2007. A Behavioral resource-based view of the firm: The synergy of Cyert and March (1963) and Penrose (1959). *Organization Science*, 18(3): 478-490.
- Potts, G. W. 1988. Exploit your product's service life-cycle. *Harvard Business Review*, 66(5): 32-36.
- Priem, R. L., & Butler, J. E. 2001. Is the Resource-Based "View" a Useful Perspective for Strategic Management Research? *The Academy of Management Review*, 26(1): 22-40.
- Ragin, C. C. 1992. "Casing" and the process of social enquiry. In C. C. Ragin, & H. S. Becker (Eds.), *What is a case? : exploring the foundations of social inquiry*: 217-226. Cambridge England ; New York, NY: Cambridge University Press.
- Reinartz, W., & Ulaga, W. 2008. How to sell services more profitably. *Harvard Business Review*, 86(5): 90-96.
- Richardson, G. B. 1972. The organisation of industry. *The Economic Journal*, 82: 883-896.
- Skarp, F., & Gadde, L.-E. 2008. Problem solving in the upgrading of product offerings -- A case study from the steel industry. *Industrial Marketing Management*, 37(6): 725-737.
- Teece, D. J. 1986. Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy*, 15(6): 285-305.
- Teece, D. J., Pisano, G., & Shuen, A. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7): 509-533.
- Ulaga, W., & Reinartz, W. J. 2011. Hybrid offerings: how manufacturing firms combine goods and services successfully. *Journal of Marketing*, 75(6): 5-23.
- Van de Ven, A. H. 2007. *Engaged Scholarship: A Guide for Organizational and Social Research*. Oxford: Oxford University Press.
- Van Maanen, J., Sörensen, J. B., & Mitchell, T. R. 2007. The interplay between theory and method. *Academy of Management Review*, 32(4): 1145-1154.
- Vandermerwe, S., & Rada, J. 1988. Servitization of business: Adding value by adding services. *European Management Journal*, 6(4): 314-324.
- Vargo, S. L., & Lusch, R. F. 2004. Evolving to a new dominant logic for marketing. *Journal of Marketing*, 68(1): 1-17.
- von Hippel, E. 1994. "Sticky information" and the locus of problem solving: implications for innovation. *Management Science*, 40(4): 429-439.
- Weick, K. E. 1989. Theory construction as disciplined imagination. *The Academy of Management Review*, 14(4): 516-531.
- Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management Journal*, 5: 171-180.
- Wilkinson, A., Dainty, A., & Neely, A. 2009. Changing times and changing timescales: the servitization of manufacturing. *International Journal of Operations & Production Management*, 29(5).
- Wiltbank, R., Dew, N., Read, S., & Sarasvathy, S. D. 2006. What to do next? The case for non-predictive strategy. *Strategic Management Journal*, 27(10): 981-998.
- Windahl, C., & Lakemond, N. 2006. Developing integrated solutions: The importance of relationships within the network. *Industrial Marketing Management*, 35(7): 806-818.

- Windahl, C., & Lakemond, N. 2010. Integrated solutions from a service-centered perspective: Applicability and limitations in the capital goods industry. *Industrial Marketing Management*, 39(8): 1278-1290.
- Winter, S. G. 2003. Understanding dynamic capabilities. *Strategic Management Journal*, 24(10): 991-995.
- Wise, R., & Baumgartner, P. 1999. Go downstream - The new profit imperative in manufacturing. *Harvard Business Review*, 77(5): 133-141.
- Yin, R. K. 2003. *Case study research : design and methods* (3rd ed.). Thousand Oaks, Calif. ; London: SAGE.
- Zander, I., & Zander, U. 2005. The inside track: on the important (but neglected) role of customers in the resource-based view of strategy and firm growth. *Journal of Management Studies*, 42(8): 1519-1548.
- Zerbini, F., Golfetto, F., & Gibbert, M. 2007. Marketing of competence: Exploring the resource-based content of value-for-customers through a case study analysis. *Industrial Marketing Management*, 36(6): 784-798.

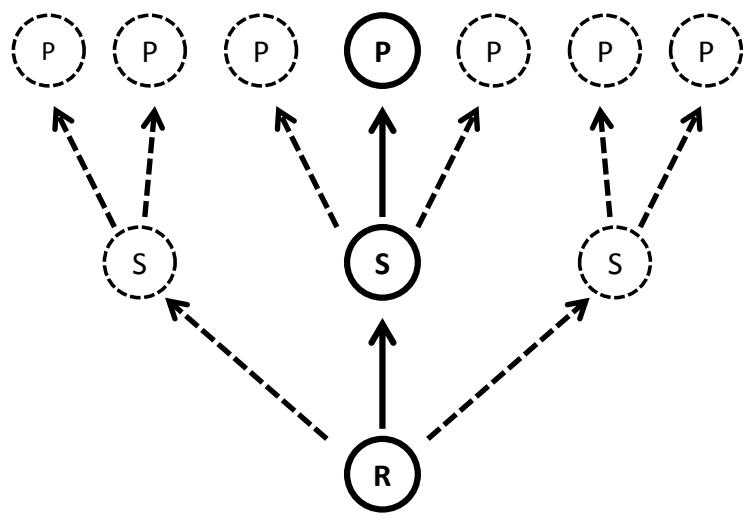


Figure 1 – Resources, Penrose-services and products

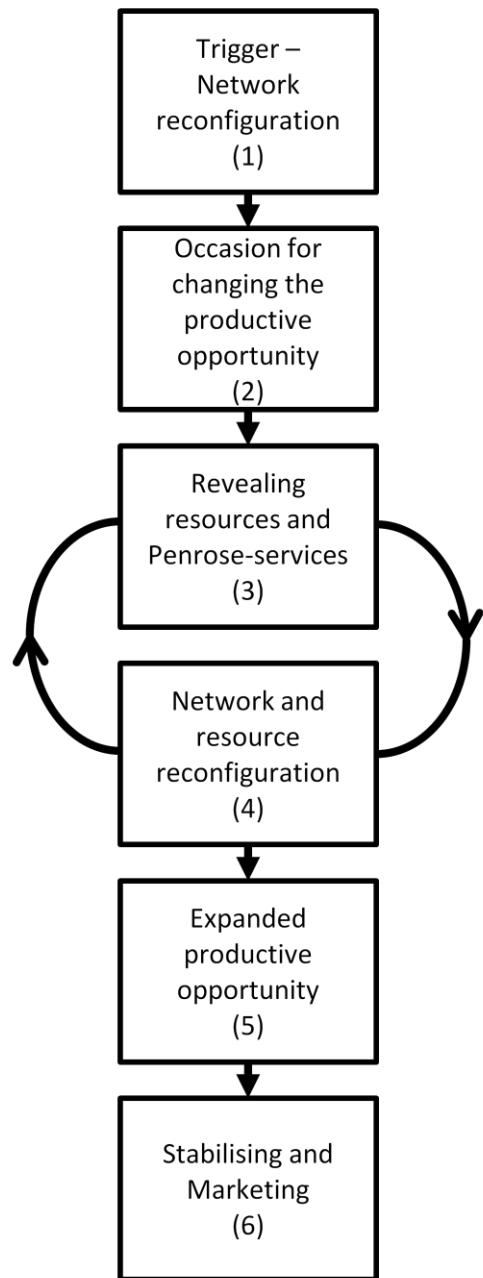


Figure 2 – Network and resource reconfiguration process

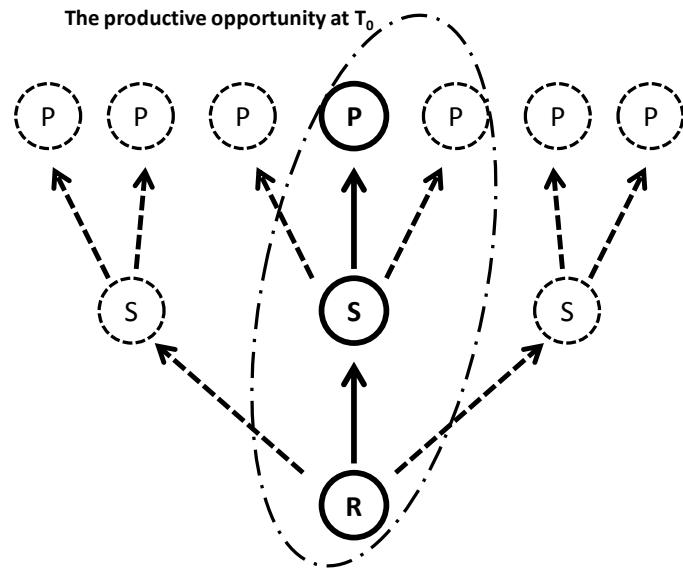


Figure 3 a – The productive opportunity at T_0

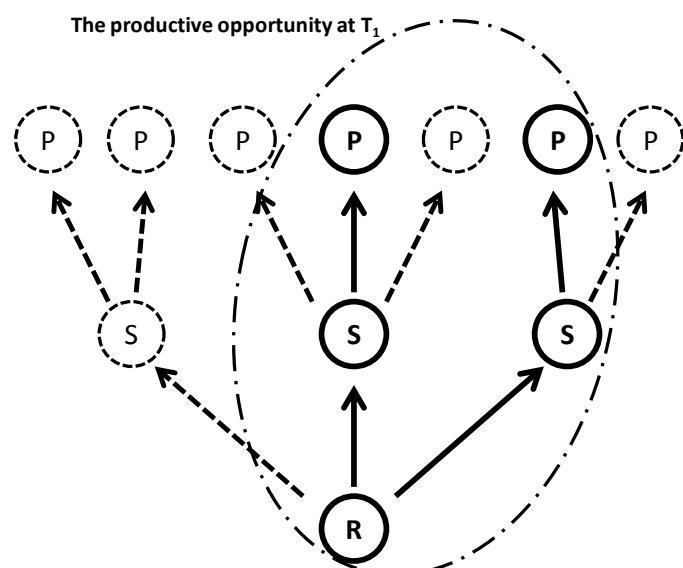


Figure 3 b – The productive opportunity at T_1

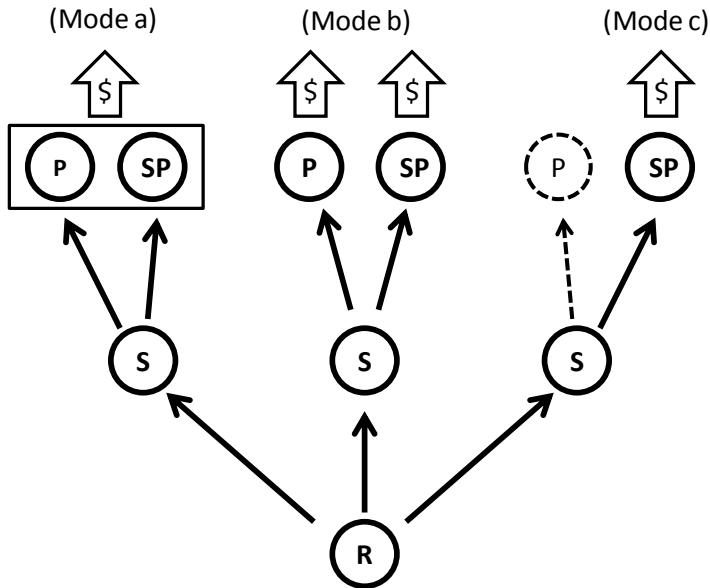


Figure 4 – Three ways to sell product-related services

^a Although see Mason and Leek Mason, K. J., & Leek, S. 2008. Learning to build a supply network: An exploration of dynamic business models. *Journal of Management Studies*, 45(4): 774-799. for one example of a more dynamic interpretation.

^b Note that in an interpretation such as Loasby's, capabilities themselves are construed as inherently dynamic anyway, so one might question the need to delineate a separate category of 'dynamic' capabilities.

^c Valuable, rare, inimitable, nonsubstitutable.

^d See also Colbert Colbert, B. A. 2004. The Complex Resource-Based View: Implications for Theory and Practice in Strategic Human Resource Management. *The Academy of Management Review*, 29(3): 341-358., who argues that the latent creative potential in Penrose's conception of the productive opportunity has also been neglected in the use of the RBV in the human resource management literature.

^e In a masterpiece of provincial English understatement, the Business Unit Manager concerned described the production of the set of components for OEM W in three weeks as 'a bit sporty'.

^f A non-trivial aspect of this is the establishment of more realistic estimates of costs.

^g Confidentiality does not permit us to be more specific about the pricing of the offering.

^h In a fourth project, which space did not allow us to report in full, Ariel made video diaries of the stages in development of a new process, which were then posted on an intranet site for the benefit of the US-based customer.

ⁱ Most of the design was established by the OEM, but Ariel had some marginal but important discretion or influence over details.

^j And here the link to von Hippel's 'sticky information' doesn't go unnoticed.

^k Of course, the OEMs were making similar judgments about Ariel.