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Brokerage and balance: Creating an effective organizational interface for product modularization in multinational R&D

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ABSTRACT

Despite numerous studies on modularity, the modularization processes have received less attention. In the global context, product modularity can be leveraged to satisfy heterogeneous market requirements across countries with low costs. Through a longitudinal case study of HomeTech, we examined how multinational R&D created an effective organizational interface to facilitate recombination of its organizational units, and thus product modularization. We found that three elements of an organizational interface were established through a process composed of three phases in HomeTech R&D: regional concentration, establishing a module pool, and creating architecture leader posts. We also found that the three elements exerted the balancing effect and the brokerage effect so that the organizational interface was effective in facilitating recombination of organizational units. We contribute to the literature through showing how organizational modularity can affect product modularity within a firm. We also reveal the critical role of architecture leaders in product modularization. Finally, we enrich the organizational interface concept by highlighting the combination of elements.

1. Introduction

Product modularity has received considerable attention over the years (Baldwin and Clark, 1997; Fixson, 2005; Lau et al., 2011). One important benefit of product modularity is that it can provide product variety for heterogeneous market requirements with component commonality (Robertson and Ulrich, 1998; Ulrich, 1995). While modularity-as-property and modularization-as-process have been clearly differentiated (MacDuffie, 2013), prior studies have mainly focused on modularity-as-property from a rather static perspective (Fixson, 2005; Sanchez and Mahoney, 1996; Zeschky et al., 2014). The product modularization process – how product designs evolve towards higher modularity and the related organizational dynamics – within a firm has received less attention. In many industries, there is no industrial standard for the designs of physical interfaces of components, the benefit being freedom to experiment with product designs without the constraint of the standards (Baldwin and Clark, 1997). In such industries, many firms conduct intra-firm product modularization for competitiveness (Gunzenhauser and Bongulielmi, 2008; Li et al., 2013), but it is quite challenging due to compatibility and coordination issues (MacDuffie, 2013).

Studies have acknowledged the relationship between product modularity and organizational modularity, which is referred to as the mirroring hypothesis (Hoetker, 2006). The predominant argument in this area is that products design organizations – modular products lead to modular organizations (Henderson and Clark, 1990; Sanchez and Mahoney, 1996). However, research also indicates that organizations may design products under certain conditions (Gunzenhauser and Bongulielmi, 2008), which sheds some light on intra-firm product modularization. Through achieving organizational modularity of R&D with recombination of (loosely coupled) organizational units, physical interfaces can be decoupled and modules made compatible with each other (MacCormack et al., 2012). Such recombination (loose-coupling) of organizational units needs to be facilitated by an effective organizational interface providing opportunities for collaboration (Campagnolo and Camuffo, 2010). However, prior studies could not fully explain this relationship – how an effective organizational interface could facilitate organizational modularization and thus product modularization. A (dynamic) process view is also missing, which hinders our understanding.

We define 'organizational interface' as the media or platform (with certain protocols) through which organizational units with boundaries can connect, interact, and coordinate with each other (Brown, 1983; Moenaert and Souder, 1996; Raes et al., 2011). An organizational

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interface, including tangible and intangible aspects, can be designed to promote interaction and coordination (Brown, 1983). Previous studies have suggested possible elements of an organizational interface, such as forums, electronic databases, and procedures for information exchange (Campagnolo and Camuffo, 2010). However, these studies have not analyzed the combination of elements – the minimum set of elements needed and the sequence of establishing these elements – for creating an effective organizational interface. The combination of elements of an organizational interface can possibly influence organizational modularization and thus product modularization, which needs investigation.

This study explores the *process* of creating an organizational interface for product modularization in the context of globally dispersed R&D centers in a multinational corporation (MNC). Multinational R&D is an ideal context for exploring the organizational interface for product modularization for three reasons. First, multinational R&D needs to meet heterogeneous market conditions across countries, calling for product modularization (Gunzenhauser and Bongulielmi, 2008; Zeschky et al., 2014). Secondly, dispersed R&D centers and their engineering teams/units (for product components) have clear geographic and functional boundaries, so they may have different objectives, tasks, and habits (Birkinshaw and Morrison, 1995; Mäkelä et al., 2012). Creating an effective organizational interface is challenging but has great potential benefits in this context. Thirdly, previous studies have indicated that one important issue in designing an organizational interface is centralization vs. decentralization (Lei et al., 1996; Wren, 1967). Likewise, centralization-decentralization is important to R&D centers of MNCs, affecting innovation capabilities (Chen et al., 2012; Gassmann and von Zedwitz, 1999).

To fill the research gaps identified above, we set the following research question: *How could multinational R&D create an effective organizational interface to facilitate product modularization (to satisfy heterogeneous requirements across countries)?* To be specific, we aim to examine the process of creating an organizational interface; the key elements; the sequence of creating them; their contributions to the effectiveness of the organizational interface for product modularization. Through a longitudinal case study of HomeTech, we identified a three-phase process creating three key elements of an organizational interface, and we analyzed the effect(s) of each element.

Our findings make three important contributions. First, we advance our understanding of the mirroring hypothesis through a dynamic view showing how organizations could design products. Second, we show the critical role of architecture leaders (ALs) in product modularization. Finally, we enrich the concept of organizational interface by highlighting the combination of elements which have not been analyzed in prior studies.

2. Theoretical background

2.1. Product modularity and modularization

Product modularity is defined by Ulrich (1995) as a one-to-one mapping from functions to components and decoupled interfaces. Modular products are decomposable into modules (Campagnolo and Camuffo, 2010; Ulrich, 1995) and these modules are interchangeable, which enables mixing-and-matching to build different product variants (Baldwin and Clark, 1997; Schilling, 2000). Modularity can be the open type (industry-level) or the closed type (firm-level) (Fujimoto, 2007; Pil and Cohen, 2006).

Studies on product modularity are abundant. However, most of these studies are static in nature, exploring the antecedents and consequences of product modularity at the firm or industry level (Pil and Cohen, 2006; Schilling, 2000; Worren et al., 2002). As a consequence of the static perspective, many studies have used 'modularity' and 'modularization' almost interchangeably (Brun and Zorzini, 2009; Doran, 2003; Kotabe et al., 2007; McDermott et al., 2013). MacDuffie (2013) clearly differentiated the two as modularity-as-property and modularization-as-process. The former refers to the design property and the latter reflects a process-based view – how product designs evolve towards higher modularity.

Scholars have identified the importance of understanding the product modularization process. Its complexity lies in the contingencies that can influence the level of product modularity during the process (MacDuffie, 2013; Schilling, 2000). It is quite challenging as it involves not only technical factors, but also organizational factors, such as interactions between different organizational units (Cabigiosu and Camuffo, 2012; Persson and Åhlström, 2006). When decoupling physical interfaces, engineers (working as organizational units) in R&D centers need to understand cross-module interdependencies (Fixson, 2005; MacDuffie, 2013). Coordination and communication are likely to affect the interchangeability or compatibility of product modules (MacDuffie, 2013). However, despite their importance, very few studies have revealed the organizational dynamics and efforts that facilitate product modularization.

While focusing on the effect of the modularity property (i.e. what will happen after a certain level of product modularity is achieved), some studies have shown how clearly defined physical interfaces between modules can serve as an embedded coordination mechanism that reduces the coordination cost for organizational units of R&D (Tiwana, 2008; Zeschky et al., 2014). However, this stream of studies has also indicated that physical interfaces – if not defined by industrial standards – can change over time within firms (Kar et al., 2009; Sanchez and Mahoney, 1996), which requires coordination between organizational units of R&D to realize high product variety and module interchangeability when designing physical interfaces (MacDuffie, 2013). Such flexibility of physical interfaces is desirable as it offers freedom to experiment with product designs for innovation (Baldwin and Clark, 1997; Pil and Cohen, 2006). Therefore, a process view of product modularization is needed to advance our understanding of how the interchangeability of modules can be progressively enhanced as a result of certain organizational changes within firms.

2.2. Product and organizational modularity

Studies of the mirroring hypothesis suggest that modular products lead to modular (loosely-coupled) organizations (Hoetker, 2006; Karim, 2006). With clearly defined product modules and decoupled physical interfaces, organizational units of R&D are loosely coupled allowing concurrent and autonomous activities of designing modules (Cabigiosu and Camuffo, 2012; Furlan et al., 2014; Sanchez and Mahoney, 1996).

However, some studies also indicate that the opposite direction of the effect – modular organizations lead to modular products – may happen when physical interfaces are not defined by industrial standards. Modular (loosely coupled) organizations are characterized by recombination or reconfigurability of organizational units (Galunic and Eisenhardt, 2001; Helfat and Eisenhardt, 2004; Schilling and Steensma, 2001). This provides favorable conditions for decoupling physical interfaces when designing modular products (MacCormack et al., 2012; MacDuffie, 2013). Recombination of organizational units of R&D allows engineers to better address cross-module interdependencies and increase module interchangeability or compatibility through communication (MacDuffie, 2013). However, we still have limited knowledge regarding how recombination of organizational units of R&D – with geographic and functional boundaries (Birkinshaw and Morrison, 1995; MacCormack et al., 2012) – can be promoted over time. A (dynamic) process view could advance our understanding of how to facilitate product modularization through organizational modularization over time.

2.3. Organizational interface

Organizational interface can be conceptualized broadly as a place