

# Chapter 9

## The Effect of Product Modularity on Supplier Integration: A Multi-Objective Approach

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### **ABSTRACT**

*This chapter seeks to identify the set of conditions under which the mirroring hypothesis holds, proposing that modular product architecture leads to organizational modularity (i.e., supplier disintegration). The contradictory results on the mirroring hypothesis in the extant literature call for a more holistic analysis of the issue. To this end, this chapter develops a multi-objective mathematical model, allowing for the simultaneous examination of potentially influential factors, including those claimed to be neglected by the mirroring hypothesis. The findings reveal that modular product architecture does not necessarily lead to supplier disintegration, but that its effect is contingent on a firm's priorities.*

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## **INTRODUCTION**

Operational factors indicating an ideal supplier integration level has been under investigation for a while. Modularity theory (Baldwin, 2008) explains this issue at task level; accordingly, firms should integrate with their suppliers to the extent that their tasks are interdependent with the tasks of their suppliers. Since technical interdependencies across components largely determine the degree of task interdependencies with suppliers, product design architecture is an important determinant of the ideal supplier integration level.

Product modularity (PM) is the design property of products showing the decoupling degree between the product components (Schilling, 2000). Modular product (high PM level) contains few spatial, structural, and material interdependencies across components (Sosa et al., 2003) because each component is responsible for one separate product function (Ulrich, 1995). The standardized interfaces embed the remaining interdependencies across components in the codified form (Sanchez & Mahoney, 1996). In contrast, integral product (low PM level) is composed of tightly coupled components. Components are jointly responsible for implementing each product function. Thus, the design change in one component entails the significant changes in other components (Ulrich, 1995).

Organizational modularity (OM) indicates the decoupling degree between organizational units to perform organizational functions. Colfer and Baldwin (2016) define three analysis levels for OM, which are within-firm, across-firm, and open and community-based projects. The second one, across-firm, refers to the organizational decoupling degree (OM level) when product is developed by at least two firms. Therefore, the decoupling degree between a firm and its suppliers is analyzed at across-firm level. Likewise, many previous studies (Furlan et al., 2014; Sorkun, 2016; Zirpoli & Becker, 2011) used the supplier integration level to measure the OM level at across-firm level. Accordingly, while supplier integration indicates low OM, supplier disintegration indicates high OM.

“The mirroring hypothesis” establishes a positive link between PM and OM (Colfer & Baldwin, 2016). The reduced technical interdependencies in modular products decrease the coordinative needs across firms, enabling them to form modular organizations (high OM) (Cabigiosu & Camuffo, 2012; Sanchez & Mahoney 1996). Fine et al. (2005) show the positive effect of PM on OM in supply chains, stating that modular products tend to be produced by modular supply chains.

However, the mirroring hypothesis has received criticisms because of its overlooking other relevant operational factors. According to the papers assuming critical position, the relationship between PM and OM is not straightforward as hypothesized. Modular product may encourage supplier disintegration for reducing coordination costs but other operational factors such as logistics (Jacobs et al., 2007;

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