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Effects of customization and product modularization on financial performance

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ABSTRACT

The need amongst customers for customized products is constantly increasing, and companies can gain competitive advantage by being able to offer a broad product assortment. This study's purpose is to investigate the financial effects of using product modularization as a strategy to manage the need for product customization The paper is based on analysis of data collected through an online survey of Swedish manufacturing firms. The results show that product modularization is a mediator between the need for customization and financial performance, suggesting that product modularization is an efficient strategy to facilitate companies' needs for developing customized products.

1. Introduction

Customer needs for increasingly more customized products continue to grow (Jiao and Tseng, 1999; Magnusson and Pasche, 2014; Simpson, 2004), and companies can gain competitive advantage by being able to offer product variants that meet these specific needs. Increased globalization and different laws across countries also drive the need for customization and companies' abilities to develop product variants. Hence, it is important for companies to develop their ability to meet customers' needs, which can not be fulfilled by standard products, through maximizing individual customization, at a low cost (Mikkola, 2007). At the same time, increased global competition puts pressure on companies to continuously strive to decrease costs (Lau et al., 2011). Moreover, customers push companies to offer these unique and personalized products at prices similar to those of mass-produced products (Fuchs and Golenhofen, 2019), which means companies constantly need to reduce both product development costs and development lead-time. Many companies therefore strive towards mass customization, with the aim of become able to offer customers unique value in an efficient way (Gilmore and Pine, 1997). Mass customization that is about a company's ability to exactly fulfill customers' requirements and not providing them with cheap standard products (Blecker and Abdelkafi, 2006). But, the increasing demand for customization means that more product variants need to be developed and manufactured, which adds greater complexity to product development and manufacturing operations (Perera et al., 1999; Wang et al., 2016). To mitigate the negative effects of this variant complexity caused by need for product customization amongst customers, many companies have adopted product modularization strategies (Simpson, 2004). Modularizing products allows for greater product variety at lower cost compared to developing unique products for different customer segments (Salvador et al., 2002), it allows companies to produce customer configured products at mass production prices (Kumar, 2004) and also contributes to reducing development lead times and costs (Baldwin and Clark, 1997; Magnusson and Lakemond, 2017; Pasche, 2011).

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Product modularization involves dividing a product into physical modules, each of which may consist of a number of components. Jacobs et al. (2011) argue that the product decomposability given by product modularization can decrease for example manufacturing lead-time because different modules can be built in parallel. To achieve loose coupling, standardized interfaces are then defined between the modules, while minimizing the interconnections between the module interfaces (Gershenson et al., 2003; Jacobs et al., 2007). The goal is to define and develop interfaces that result in interchangeable modules that are thus able to be mixed and matched according to different customer demands (Schilling, 2000; Starr, 1965). This interchangeability means that modules can be developed and managed independently in different configurations (Baldwin and Clark, 1997; Sanchez and Mahoney, 1996). Hence, modularized products make it easier for companies to respond to new customer demands by, for example, allowing offerings of different product variations to suit individual needs (Simpson, 2004; Shibata, 2009); in other words, modularization is a strategy that can be used to fulfill the need amongst customers for customized products. Adopting product modularization can also benefit companies' R&D operations (Un and Rodríguez, 2018), such as reducing product development lead time and costs (Magnusson and Lakemond, 2017) by using common components across different products (Marion et al., 2015). Product modularization also increases the potential for decoupling tasks, which makes it possible to accomplish different development activities in parallel (Baldwin and Clark, 1997; Gargiulo and Sosa, 2016), thereby accelerating the product development process and shortening development lead times.

Over the years, much research has been conducted on product modularization. Initially, most studies were case-based works describing single success stories that represent the "best practices" of companies that have applied modular product design (Lau et al., 2007; Lau, 2011). Early examples include Sony's Walkman and Black & Decker's power tools (Sanchez and Mahoney, 1996). In the truck industry, Scania's high profit margin has been driven by its product modularization strategy, which has been in place since the 1940s (Johnson and Bröms, 2000). Johnson and Bröms (2000) show that product modularity reduces cost by providing economies of scale effects (Pine et al., 1993). In other words, product modularization facilitates standardizing components, which makes it possible to increase product variety without incurring additional costs (Mikkola and Gassmann, 2003). Recently, there has been more quantitative research on product modularization. One example is Danese and Filippini (2010), who investigate the relationship between product modularization and new product development time performance. Studying 186 manufacturing companies in several different countries, they find a direct positive effect of modularization on new product development performance. Lau et al. (2011) also investigate the effect of product modularization on product innovativeness. Other studies have focused on various positive performance effects of product modularization in manufacturing. For example, Piran et al. (2016) and Barbosa et al. (2017) find that product modularity eliminates the trade-off between variety and efficiency. A related result is that the degree of complexity and the number of components in the product architecture seems to depend on the organizational design (Querbes and Frenken, 2018).

In spite of the amount of quantitative research that focuses on the performance effects of product modularization, there are limited studies on how modularization affects actual company financial performance (Jacobs et al., 2011). To address this gap in the literature, this study's purpose is to investigate the financial effects of using product modularization as a strategy to manage the need for product customization amongst customers, considering product modularization as a common and suitable strategy for companies to develop customized products in an efficient way. The study uses external data about firms' actual financial performance, rather than relying on respondents' estimations. This study focuses on return on equity (ROE) and return on assets (ROA), two of the most commonly used financial performance measures (Xu and Liu, 2021). The main contribution of this study is that product modularization has been shown to be a mediator between the need for customization amongst customers and companies' financial performance. In addition, companies with a high degree of product modularization tend to have both higher profit margins and higher return on equity, hence modularization has positive effects on financial performance.

The remainder of this paper is organized as follows. Section 2 reviews the literature on customization and product modularization and their effects on performance, and explains the research model. Section 3 describes the study's methodology, while the results are presented in Section 4. These results are analyzed and discussed in Section 5. The paper closes by offering conclusions, managerial implications, and suggestions for future research in Section 6.

2. Conceptual framework

2.1. Effects of the increasing need for product customization

The need amongst different customers for customized products is constantly increasing (Jiao and Tseng, 1999; Magnusson and Pasche, 2014; Simpson, 2004). In addition, the ability to offer product customization has been argued to increase a company's potential for reaching new markets (Jiao and Tseng, 1999; Simpson, 2004). The trend toward increased globalization has also motivated companies to try to sell their products in more countries, and it is not uncommon for customers' needs to vary globally. Legislation may also differ among countries, implying the need for companies to develop product variants to sell in different parts of the world. Many consider the ability to offer a broad product assortment to fulfill different customer requirements one way for companies to gain competitive advantage. For example, Worren et al. (2002) has in a previous study, by interviewing 20 managers in three home appliance companies, found that model variety (the number of product models offered by the company) is positively related to companies' financial performance.

However, customization often forces companies to develop product variants that add cost to the entire product life cycle, as well as to both product development and manufacturing operations (Perera et al., 1999). Skinner (1974) argued that for a factory to be efficient it can only produce a narrow product mix, producing a larger product mix would decrease the possible economy of scale effects. But, the increased customization need amongst customers means that the number of product variants a company needs to develop and manage increases. In addition, today's customers push companies to offer customized products at prices similar to those of standardized, mass-produced products (Fuchs and Golenhofen, 2019). Customization can be considered the opposite of standardization; while standardization and mass production allow companies to lower costs through economies of scale (Wang et al., 2016), customization refers to using common components in different products and product variants (Perera et al., 1999). Because there is a trade-off between variety and efficiency (Piran et al., 2016), it is likely that this need amongst customers for product customization will negatively affect companies' financial performance. Thus, the challenge for companies is to develop mass customization capabilities that allow them to produce customized products at low cost (Pine et al., 1993). This leads to the following hypothesis:

H1. *Customization is negatively associated with financial performance.*

2.2. Product modularization and customization

Adopting a product modularization strategy and using modularity in product design is argued to enhance a company's ability to fulfill individual customer needs (Jacobs et al., 2011; Magnusson and Pasche, 2014), in other words it enhances customization possibilities (Jacobs et al., 2011). Salvador et al. (2002) describe product modularity as a design strategy that can be used to develop product variety at lower cost than designing unique products for every market and customer segment. This is related to the concept of mass customization that denotes a company's ability to offer customers unique value in an efficient way (Gilmore and Pine, 1997). As stated by Piller (2007, p. 631) "The term mass customization denotes an offering that meets the demands of each individual customer, but that can still be produced with mass production efficiency". By mass customization companies can gain competitive advantage by combining product differentiation and cost efficiency (Blecker and Abdelkafi, 2006). Wind and Rangaswamy (2001) takes this even one step further and describe what they call customerization, that is a business strategy in which mass customization is combined with customized marketing. In a customerization strategy it is important that the marketing function of the company interact with customers and establish close relationships with them (Wind and Rangaswamy, 2001). Pine et al. (1993), Kumar (2004) and Mikkola (2007) argue that the best strategy for achieving mass customization, or the ability to offer customized products at low cost, is to develop a modular product whose different modules can be configured in a large number of product variants. As said, modular products enable mass customization, but also increase companies' strategic flexibility (Worren et al., 2002). Central to mass customization is the term postponement, which means that some of the activities in the supply chain are not accomplished before the company obtains a customer order for a specific product (Hsuan Mikkola and Skjøtt-Larsen, 2004). For example, postponement can mean that product customization is done in the very late stages of the product assembly process (Comstock et al., 2004) or even in the distribution stage of the supply chain. Instead of a retailer storing all the different product variants, which is costly, the company may use intermediate distributors that are located close to the retailer (Salvador et al., 2004). These distributors can quickly deliver the specific product variant that was ordered to the retailer or directly to the end customer. This means that products can be customized at different stages in the company's supply chain (Pagh and Cooper, 1998). However, for postponement and customization to be possible, the products need to have a modular structure (Lee, 1998). This means it is necessary to involve the company's product development function in modular product structure design.

Simon (1962) pioneered modularity when he introduced the topic of nearly decomposable systems. Product modularization involves dividing a product or system into a number of decoupled modules, each consisting of a number of components (Gershenson et al., 2003; Ulrich and Tung, 1991). Dividing a product into a number of decoupled modules allows a company to efficiently increase the product variety it can offer to customers (Baldwin and Clark, 1997; Sanchez and Mahoney, 1996). An important aspect of product modularization is defining and specifying the interfaces between modules, which describes how the different modules work together (Baldwin and Clark, 1997). Baldwin and Clark (2000, p. 63) define a module as "a unit whose structural elements are powerfully connected among themselves and relatively weakly connected to elements on other units." Clearly, there are degrees of connection; thus, there are gradations in modularity. Baldwin and Clark (1997) describe modularity as a design strategy that aims to avoid creating strong interdependencies among different modules within a product. Dividing a complex product or system into smaller pieces, also makes it easier to overview and manage the product. The ultimate goal is to achieve a product whose modules are decoupled so that changes can be made in one module without affecting the others (Brusoni and Prencipe, 2001; Mikkola, 2003; Sanchez and Mahoney, 1996). Modularization thus increases product flexibility (Sanchez, 1995) and can be used to efficiently create a large variety of customized products (e.g., Sanchez and Mahoney, 1996; Starr, 1965).

Most previous research on product modularization has focused on the technical aspects, such as how to divide a product into modules; the purpose is to define the module interfaces such that the modules become decoupled (cf. McClelland and Rumelhart, 1995). Similarly, the literature has presented a number of structured methods, most of which are matrix based (e.g., Erixon, 1998; Huang and Kusiak, 1998); these methods are intended to aid in dividing a product into a number of modules.

However, modularization ideas have also been extended to the design of product development organizations (Brusoni and Prencipe, 2001). Most product development projects need to be divided (partitioned) into a number of smaller, and more manageable, subtasks that then can be distributed and executed by a number of different individuals (Von Hippel, 1990). Dividing a product into modules enables design tasks to be decoupled, which means that different development processes can be accomplished autonomously by loosely coupled organizational structures (Von Hippel, 1990; Sanchez and Mahoney, 1996). The standardization of interfaces between the different modules allows the processes for developing component designs to become loosely coupled (Gargiulo and Sosa, 2016; Magnusson and Lakemond, 2017; Sanchez and Mahoney, 1996). The development processes can then be effectively coordinated simply by requiring that all developed components conform to the standardized component interface specifications (Danese and Romano, 2004). This means that product modularization also increases the potential for reducing task complexity, in addition to reducing complexity caused by customization and product variety (Simpson, 2004; Wang et al., 2016). Product modularity also facilitates task decoupling because it makes it possible to accomplish multiple development and manufacturing activities in parallel (Baldwin and Clark, 1997; Ulrich and Tung, 1991). This accelerates product development and thus shortens development lead times. Sanchez and Mahoney (1996) argue that standardized module interfaces result in "embedded coordination", meaning that coordination can be achieved with minimal managerial effort. The modules and their interfaces can also help coordinate and integrate different pieces of knowledge that exist in R&D organizations (Un and Rodríguez, 2018).

Increased product modularity is associated with an increase in organizational modularity (Leo, 2020), often called the "mirroring hypothesis" (Henderson and Clark, 1990). This means that the product development organization and the product architecture would "mirror" each other (Leo, 2020).

Worren et al. (2002) found in their study of three home appliance companies partially support for their research proposition that companies in more dynamic market contexts employ higher degrees of product modularity. These various benefits suggest that companies that are in a market where there is a need for customized products amongst customers should more commonly adopt a product modularization strategy. Thus, the following hypothesis is proposed:

H2. *Customization is positively associated with product modularization.*

2.3. Product modularization and performance effects

As mentioned, product modularization strategies have the potential to reduce development lead times and costs (Baldwin and Clark, 1997) by using common components across products and product variants (Ulrich and Tung, 1991), which leads to economies of scale and scope (Jacobs et al., 2007; Muffatto and Roveda, 2002). In a case study, Piran et al. (2020a) find that product modularity increased engineering efficiency by 18.4%. Standardized module interfaces also make it possible to recombine different modules into alternative products (Pasche, 2011; Sanchez, 1996). Hence, firms can use product modularization to more efficiently develop customized products. Product modularization can also contribute to improved sustainability in terms of recycling possibilities (Gu et al., 1997), since the module interfaces facilitate product maintenance and remanufacturing (Seliger and Zettl, 2008). Moreover, product modularity contributes to increased organizational flexibility (Leo, 2020) which enhances strategic flexibility and allows companies to react quickly to changes in demand (Sanchez, 1995) and more easily make upgrades throughout the product lifecycle (Sanchez, 1996). Modularization also reduces investment costs since tooling, engineering, and testing are reduced when standardized components and modules are used (Fisher et al., 1999). Module commonality reduces stock, lowering total inventory costs, and safety-stock levels (Lau et al., 2007). Moreover, modular product design also improves product quality because each component can be tested independently at the modular level (Lau et al., 2007). Recent research has found that using product modularization can eliminate the traditional trade-off between variety and efficiency. For example, Piran et al. (2016) and Barbosa et al. (2017) investigate performance effects at a bus manufacturer and find that product modularization improved manufacturing performance. In another study, Piran et al. (2020b) identify a positive relationship between modularity and reduced manufacturing completion time, indicating that product modularization shortens the time to deliver products to customers.

Although most previous research on product modularization has been case-based and describes single success stories, there has been more quantitative research in recent years. For example, Jacobs et al. (2007) study 150 first-tier suppliers in the automotive industry to identify positive effects on cost, flexibility, and quality. Jacobs et al. (2011) quantitative study includes 57 first-tier suppliers to auto manufacturers in North America. Their focus was on examining the relationship between product and process modularity, particularly modularity's effects on firm growth, measured by return on investment, return on sales, and market share growth. However, no support was found for the hypothesis that product modularization has a positive effect on firm growth (Jacobs et al., 2011). Both of these studies focus on a single industry and do not investigate effects on actual company financial performance. Lau et al. (2007) is another example of a quantitative study on product modularization's performance effects and investigates the performance effects of product modularity in the Hong Kong manufacturing industry. They focus on performance effects such as quality, delivery, and customer service, but do not investigate financial performance effects. Zhang et al. (2019) focus on performance effects in supply chains and find positive effects of product modularity in improved supplier quality integration.

Previous research also focuses on product modularization's effects on company product development performance. For example, Danese and Filippini (2010) investigate the relationship between product modularization and new product development time performance by studying 186 manufacturing plants in several countries. They find a direct positive effect on new product development performance. In another study, Danese and Filippini (2013) study 201 manufacturing plants to investigate how product modularity affects development time and product performance, especially how it is mediated by supplier involvement in new product development. They show that product modularity positively affects development lead time. Vickery et al. (2015) also find positive effects of product modularity on product development performance, in terms of the speed of new product introduction. Lau et al. (2011) study product performance in 115 companies in the electronics industry and find an inverted U-shaped relationship between product modularity and product innovativeness. However, none of these studies (Danese and Filippini, 2010, 2013; Lau et al., 2011; Vickery et al., 2015) investigate product modularity's effects on actual company financial performance.

To summarize, previous studies have focused on various performance effects for companies of using product modularization as a strategy to manage the need for customization amongst customers and efficiently develop products to fulfill customers' specific needs. This previous research has identified several positive performance effects. Although financial effects have not been studied, one could expect that product modularization may also positively affect actual company financial performance. Hence, the following hypothesis is proposed:

H3. *Product modularization mediates the relationship between customization and financial performance.*

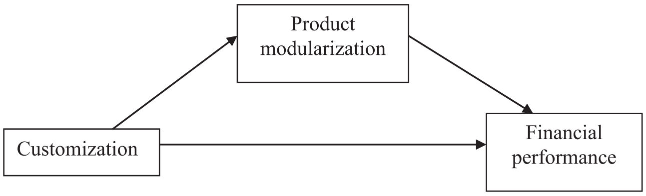

Fig. 1. Research model.

Table 1
Number of units in each industry.

Industry type	Number of units in the final sample
Rubber and plastics	15
Steel and metal	16
Metal products	33
Computer, electronics, and optics	16
Electrical appliance	10
Other machine hardware	51
Engine and trailer	16
Other vehicles	3

2.4. Research model and hypotheses

The three hypotheses proposed, which consider the financial effects of using product modularization as a strategy to manage the need for product customization amongst customers, can be summarized in the research model shown in Fig. 1.

ROE and ROA are two of the measures of financial performance most commonly used in the literature (Xu and Liu, 2021). ROE is generally defined as annual net income divided by shareholder's equity; thus, it is a metric describing how well the company utilized its equity to generate profits during the year (Helfert, 2001). ROA relates net income to the value of a company's total assets (Helfert, 2001). Thus, ROA is a metric describing how well the company utilized its assets to generate profits during the year, regardless of how the assets were financed (Helfert, 2001). Alternatively, ROA can be defined as the product of two other financial performance measures, asset turnover (AT) and profit margin (PM). This deconstruction is sometimes referred to as DuPont analysis or the DuPont model (Fairfield and Yohn, 2001). AT is defined as total revenue divided by total assets and measures how efficiently a company uses its assets to generate revenue, while PM is defined as net profit divided by total revenue and is a measure of operating efficiency. Total revenue is canceled out when the two measures are multiplied, leaving only net profit divided by total assets.

3. Methodology

The data used for this study were collected through an online questionnaire with the purpose of investigating product development practices in the Swedish manufacturing industry, where a subset of items was used in this paper. The development of the questionnaire and its various items relied on the guidelines in Dillman et al. (2014). The survey targeted individual business units and addressed the management and organization of their product development processes, as well as their use of practices such as product portfolio planning, lean product development, agile development, cross-functional project teams and modularization. The questionnaire respondents were R&D managers or individuals with similar roles within the business units. The sampling frame consisted of all Swedish manufacturing firms with more than 100 employees that could be expected to have product development within their business units. Firms from the following industries were included:

- Rubber and plastics
- Steel and metal
- Metal products
- Computer, electronics, and optics
- Electrical appliance
- Other machine hardware
- Engine and trailer
- Other vehicles

In Europe, an enterprise is typically denoted as "small" if it has fewer than 50 employees. Enterprises with between 50 and 250 employees are usually called "medium-sized" and are considered "large" otherwise (EU recommendation, 2003/361, 2003). However, these standards could not be applied in the present study because a sampling frame with only "large" Swedish companies would have been too small for scientific purposes. However, including smaller medium-sized companies might have biased the results because smaller companies generally have more limited product development activities and do not typically use formal product development processes to the same extent as larger companies. Hence, limiting the sampling frame to firms with over 100 employees was considered a reasonable compromise.

The initial sampling frame of 478 firms was derived from the Swedish Postal Address Register. Altogether, 148 of these companies (31 %) were excluded, as they lacked internal R&D departments. Of the remaining 330 business units, 294 were contacted by phone to verify the respondent's name and secure their willingness to participate. The survey was also sent to the remaining 27 business units without any initial telephone contact. Of the 330 business units, 160 responded after a round of reminders, resulting in a response rate of 48.5 %. The detailed distribution of these units over industry types appears in Table 1.

A series of two-sample *t*-tests on turnover, net profit, and number of employees found no significant differences in the demographics of the companies that responded and those that did not. Thus, we proceeded under the assumption that nonresponse bias did not impact our results (Wagner and Kemmerling, 2010).

Regression analyses based on Baron and Kenny's (1986) approach were used to test for mediation effects. This approach relies on the fact that there are two paths from the independent variable (in this study, customization) to the dependent variable (in this study, financial performance): a direct path and an indirect path through the mediator (in this study, product modularization). A regression model is used to analyze the independent variable's direct effect (together with the control variables but without the mediator) on the dependent variable. Two regression models are used to analyze the indirect effect: one model includes only the independent variable to predict the mediator, and one model includes both the mediator and the independent variable (as well as the control variables) to predict the dependent variable. The indirect effect is supported if the coefficient of the independent variable is significant in the first model and the coefficient of the mediating variable is significant in the second model. If both conditions are met, the indirect effect is defined as the product of these two coefficients. Kappa-squared (denoted κ^2) is used as a measure of the size of the indirect effect (see Preacher and Kelley (2011) for a discussion of κ^2).

As an alternative to Baron and Kenny's (1986) regression approach, Structural Equation Modeling (SEM) could have been used to study the mediation effects, however, research show that regression generally works equally well for relatively simple mediation models such as the ones here unless some special feature of SEM is required (e.g., Rijnhart et al., 2017; Xiao, 2013). Nevertheless, the corresponding SEM models have been run with the same overall results as the regression approach, hence, the results should be regarded as valid.

Financial performance data for individual firms were retrieved from the Business Retriever database. The Business Retriever database includes information about all Swedish companies and annual reports from all stock companies. Four different measures of financial performance were used as dependent variables (DV) in this study: ROE, PM, AT, and ROA. As mentioned above, ROA can be defined as the product of PM and AT.

Two financial measures retrieved from the Business Retriever database were used as control variables, namely firm size (SIZ) and the debt-to-equity ratio (D2E). Both can impact financial performance measures (Bodie et al., 2011) and may thus be controlled for when such measures are used as dependent variables. More specifically, the SIZ variable measures firm size as the natural logarithm of the book value of a firm's total assets, and the D2E variable is a measure of firm risk, defined as the firm's total debt divided by its total equity.

The degree of customization (CUS) and degree of product modularization (MOD) were used as independent variables. MOD was measured using three seven-point Likert items from the questionnaire to investigate the extent to which the company's products were modularized. The three Likert items correspond to three different constructs and were derived from the literature:

- Decomposability–the degree to which the company's main products can be decomposed into separate modules. This measurement item was adopted from Starr (1965), Worren et al. (2002), Lau et al. (2007,2009).
- Interchangeability–the degree to which modules be combined in different ways to create product variants. This measurement item was adopted from Sanchez and Mahoney (1996), Baldwin and Clark (1997), Schilling (2000), Worren et al. (2002), and Lau et al. (2009).
- Independence–the degree to which a module be changed without the need to redesign other modules. This item was adopted from Brusoni and Prencipe (2001), Gershenson et al. (2003), Mikkola (2003), Duray (2004), Jacobs et al. (2007,2011).

Similarly, customization (CUS) was measured using the average of three seven-point Likert items from the questionnaire to investigate the extent to which there is a need in the market, amongst different customers, for customization and hence the extent to which it is important for the company to offer its customers customized products:

- The extent to which demand for customization characterizes the company's market situation.
- How important customization is for the company to gain competitive advantage.
- How important it is to increase customization ability in product development work.

These items were developed based on the fact that many markets are characterized by an increasing need for customized products (Magnusson and Pasche, 2014; Ramdas, 2003; Simpson, 2004) and that the ability to offer product customization increases the potential for companies to reach new markets (Jiao and Tseng, 1999; Simpson, 2004), thus giving them a competitive advantage. At the same time, today's competition is forcing companies to offer customized products at prices similar to those of mass-produced products (Fuchs and Golenhofen, 2019). Because there is generally a trade-off between variety and efficiency (Piran et al., 2016), it is important for companies to increase their ability to develop products that enable more efficient customization.

Table 2
Construct descriptive statistics.

Construct	Item	n	Mean	S.D.
The degree of customization (Cronbach's α = 0.811)	The extent to which demand for customization characterizes the company's market situation	147	5.25	1.36
	The importance of customization for the company to gain competitive advantage	149	5.42	1.39
	The importance of increased customization ability in product development work	148	5.31	1.34
The degree of product modularization (Cronbach's α = 0.904)	The degree to which the company's main products can be decomposed in separate modules	137	4.28	1.93
	The degree to which modules be combined in different ways to create product variants	137	4.51	2.04
	The degree to which a module be changed without the need to redesign other modules	136	4.32	1.97
Financial performance	ROE (%)	155	38.19	109.61
	ROA (%)	155	8.67	14.41
	Profit margin (%)	155	6.30	11.43
	Asset turnover (ratio)	155	1.60	0.97

Table 3
Means, standard deviations, and correlations.

Variables	Mean	S.D.	1	2	3	4	5	6	7
1. SIZ	13.0	1.71							
2. D2E	0.55	0.22	0.25						
3. CUS	5.32	1.17	-0.16	0.11					
4. MOD	4.36	1.82	-0.18	0.01	0.21				
5. ROE	38.2	109	0.04	0.27	-0.03	0.19			
6. ROA	8.67	14.4	-0.07	-0.01	-0.05	0.15	0.74		
7. PM	6.30	11.4	0.06	-0.08	-0.08	0.18	0.50	0.65	
8. AT	1.60	0.96	-0.19	0.34	0.07	0.07	0.20	0.28	-0.04

Note: Correlations with absolute values greater than 0.17 are significant at $p < 0.05$.

Table 4
Customization as a predictor of ROE, mediated by product modularization.

	Model A1 DV: ROE		Model A2 DV: MOD		Model A3 DV: ROE	
IV	beta	t	beta	t	beta	t
1. SIZ	–1.79	–0.31			1.04	0.17
2. D2E	145.36	3.36***			162.53	3.53***
3. CUS	–6.04	–0.75	0.31	2.40*	–12.43	–1.46
4. MOD					14.26	2.58*
R^2	0.08		0.04		0.14	
F	3.94**		5.76*		5.09***	

Note.
† $p < .1$
*** $p < .001$
** $p < .01$
* $p < .05$

The scales CUS and MOD were validated with a Confirmatory Factor Analysis (CFA) in Jamovi (version 2.2.5). The full information maximum likelihood method was used to handle missing data (Enders & Bandalos, 2001). The test for exact fit ($\chi 2 = 11.0$, df = 8, p = 0.201) and the fit measures (CFI = 0.993, TLI = 0.987, SRMR = 0.0414, RMSEA = 0.0502) indicate that there is a relatively good fit between the hypothesized two-factor model and the observed data (Hu & Bentler, 1999). The factor loadings are displayed in the Appendix. Furthermore, the average variance extracted (AVE) for the factors CUS and MOD were 0.613 and 0.758, and the factor covariance was 0.176 (Z = 1.87, p = 0.062). Hence, the convergent validity and discriminant validity of the factors were adequate.

4. Results

4.1. Descriptive statistics

Table 2 displays the data's descriptive statistics. The items related to the degree of customization and degree of product modularization range from 1 (not at all / totally unimportant) to 7 (to a very large extent / very important). Both constructs have high reliability (Cronbach's α > 0.80). The reported sample sizes are less than 160 due to partial nonresponse.

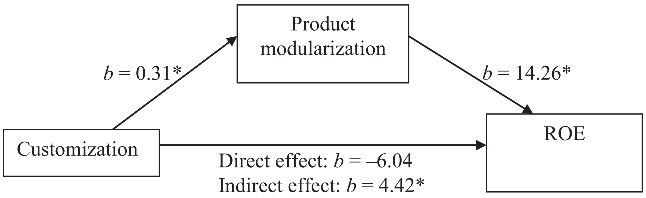

Fig. 2. Customization as a predictor of ROE, mediated by product modularization.

Table 5
Customization as a predictor of PM, mediated by product modularization.

	Model B1 DV: PM		Model B2 DV: MOD		Model B3 DV: PM	
IV	beta	t	beta	t	beta	t
1. SIZ	0.67	–0.9			0.89	1.36
2. D/E	–4.99	–0.69			–4.4	–0.88
3. CUS	–0.48	0.05	0.31	2,40*	–1.04	–1.14
4. MOD					1.52	2.55*
R^2	0.02		0.04		0.06	
F	0.88		5.76*		1.06†	

Note.
*** $p < .001$
** $p < .01$
† $p < .1$
* $p < .05$

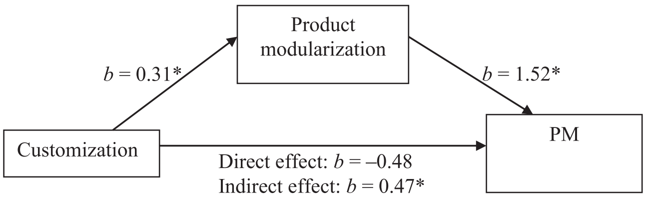

Fig. 3. Customization as a predictor of PM, mediated by product modularization.

4.2. Findings

Table 3 displays the mean values, standard deviations, and Pearson's correlation coefficients for all variables.

Table 4 shows the results of the analysis using ROE as the dependent variable. As model A1 shows, our data reveal that customization has a negative, albeit statistically insignificant, direct effect on ROE when controlling for firm size and the debt-to-equity ratio. Hence, among the sample companies, a greater need for customization tends to correspond with lower ROE, but the effect is not statistically significant. Model A2 shows a statistically significant and positive relationship between the need for customization and modularization; hence, a greater need for customization tends to correspond with greater use of product modularization. Finally, model A3 identifies a significantly positive relationship between use of modularization and ROE when controlling for firm size, the debt-to-equity ratio, and customization.

Thus, customization has a significantly positive indirect effect on ROE through product modularization; hence, product modularization is a mediator of the relationship between customization and ROE (see Fig. 2). However, the effect was relatively small.

Table 5 presents the results using profit margin as the dependent variable. Model B1 reveals that customization has a negative, albeit statistically insignificant, direct effect on profit margin when controlling for firm size and the debt-to-equity ratio. Hence, among the sample companies, a greater need for customization tends to correspond with a lower profit margin, but one should note that the effect is not statistically significant. Model B2 is identical to model A2 in Table 4, illustrating the statistically significant and positive relationship between the need for customization and modularization. Finally, model B3 shows a significantly positive relationship between use of modularization and profit margin when controlling for firm size, the debt-to-equity ratio, and customization.

Thus, customization has a significantly positive indirect effect on a firm's profit margin through product modularization, indicating product modularization is a mediator of the relationship between customization and profit margin (see Fig. 3). However, the effect was relatively small.

Table 6 shows the results of the analysis using asset turnover as the dependent variable. Because there was no significant

Table 6
Customization as a predictor of AT, mediated by product modularization.

	Model C1 DV: AT		Model C2 DV: MOD		Model C3 DV: AT	
IV	beta	t	beta	t	beta	t
1. SIZ	–0.17	–3.78***			–0.19	–3.97***
2. D/E	1.91	5.63***			2.09	5.77***
3. CUS	–0.01	–0.12	0.31	2.40*	–0.04	–0.59
4. MOD					0.02	0.44
R^2	0.22		0.04		0.24	
F	12.8***		5.76*		10.0***	

Note.
**$p < .01$
† $p < .1$
*** $p < .001$
* $p < .05$

Table 7
Customization as a predictor of ROA, mediated by product modularization.

	Model D1 DV: ROA		Model D2 DV: MOD		Model D3 DV: ROA	
IV	beta	t	beta	t	beta	t
1. SIZ	–0.49	–0.9			–0.49	–0.85
2. D/E	–2.87	–0.69			–1.09	–0.25
3. CUS	0.04	0.05	0.31	2.40*	–0.6	–0.73
4. MOD					0.85	1.60
R^2	0.01		0.04		0.03	
F	0.59		5.76*		1.06	

Note.
***$p < .001$
**$p < .01$
† $p < .1$
* $p < .05$

relationship between product modularization and asset turnover in model C3, no indirect effect of customization on asset turnover through product modularization could be established. In addition, as model C1 indicates, customization has no significant direct effect on asset turnover.

Finally, Table 7 shows the results of the analysis using ROA as the dependent variable. Since the relationship between product modularization and ROA in model D3 was statistically insignificant, no indirect effect of customization on ROA through product modularization could be established. Furthermore, as model D1 indicates, customization has no significant direct effect on ROA.

5. Discussion

5.1. Effects of product customization

In our data analysis, we first focused on the need in the market, amongst different customers, for customization and its effects on actual company financial performance. A larger product variety adds complexity to a company's operations (Perera et al., 1999; Wang et al., 2016); hence, if standardization is generally an advantage for company performance, customization need amongst customers should generally be a disadvantage. However, due to our relatively small sample size, the negative relationship between customization and financial performance observed in the data failed to reach statistical significance. Therefore, our first research hypothesis that need for customization is negatively associated with financial performance was not supported.

5.2. Product modularization and customization

Further, we focused on analyzing the relationship between the need for customization and companies' use of product modularization as a strategy for developing customized products in an efficient way. In the data analysis, we found a direct effect of need for customization on product modularization. This finding suggests that companies in markets where there is a large need for product customization tend to have a higher degree of product modularization. These companies have products that are more modularized, which means the modules in their products are more or less decoupled from each other. This decoupling makes it possible to mix and match the modules to efficiently create the required product variety (Magnusson and Pasche, 2014; Simpson, 2004). A modular product structure also makes it possible for product customization to occur at later stages in the supply chain (Pagh and Cooper, 1998). These results support the hypothesis that need for customization is positively associated with product modularization (H2).

5.3. Product modularization and financial effects

In the data analysis, we also found that product modularization is a mediator between customization and financial performance. In other words, the degree of product modularization, which is a result of the degree of need for customization, explains companies' financial performance. The positive indirect effect of need for customization on financial performance through product modularization becomes even more interesting because the observed, albeit statistically insignificant, direct effect of customization on financial performance is negative. Hence, all else being equal, a greater need for customization amongst customers seems to negatively affect companies' financial performance but using product modularization as a strategy to facilitate such a need has a positively impact on financial performance. Hence, these results support the hypothesis that product modularization mediates the relationship between need for customization and financial performance (H3).

When assessing specific measures of actual company financial performance, rather than relying on respondents' own estimations, we found that product modularization indirectly affects ROA. A common method of calculating ROA uses the DuPont model, in which ROA is measured as asset turnover times profit margin. Hence, product modularization's positive effect on ROA comes either from higher asset turnover or a higher profit margin. In our further analysis, we found no significant indirect effect on asset turnover, but there was an effect on profit margin. Therefore, we can conclude that for companies in markets where it is important to be able to offer customized products to gain competitive advantage, a product modularization strategy contributes to a higher profit margin. A company's profit margin is calculated by dividing net profit by total revenue and is an indicator of a company's pricing strategies and how well it controls costs (Fairfield and Yohn, 2001). A product's profit is determined by the price the customer pays for the product minus the product's cost, which is the sum of all costs related to the product. These costs include product development cost, manufacturing cost, and sales cost. This suggests there are two possible explanations for how product modularization increases profit margin: it either lowers costs or raises selling prices (or both). In terms of decreasing costs, previous case-based research has shown that product modularization can decrease product development costs (Baldwin and Clark, 1997; Marion et al., 2015), investment costs in manufacturing tools (Fisher et al., 1999), total inventory cost, and safety stock levels in manufacturing since the commonality among modules increases (Lau et al., 2007). In terms of raising selling prices, product modularization might make it possible for a company to set higher prices for its products due to the constantly increasing demand for customized products that satisfy individual customer needs (Simpson, 2004). Companies that are able to meet customers' diverse needs can gain competitive advantage (Ramdas, 2003). Since product modularization creates a decoupled product whose modules can be efficiently mixed and matched (Magnusson and Pasche, 2014; Schilling, 2000), companies may have adopted product modularization strategies to obtain higher prices for their products, since customers might be willing to pay higher prices for products that satisfy their specific needs.

In the analysis, we also found a significant indirect effect of need for customization on ROE through product modularization. ROE measures the amount of profit a company can generate with the money invested by shareholders; thus, ROE can be increased by either increasing profit or decreasing the capital invested in a company. As discussed above, adopting a product modularization strategy can contribute to increasing firm profits. However, it can also enable lowering the capital invested in a company. For example, using common components and modules reduces the need for tooling, inventory, and safety stock levels in manufacturing, which lowers investment costs (Fisher et al., 1999; Lau et al., 2007). It might also be possible to decrease the amount of capital invested in a company because product modularization can lower the risks in new product development. Modular product design makes it possible to test new components at the modular level because the different modules are decoupled (Lau et al., 2007). Therefore, the risk of quality problems in new products is lower.

6. Implications

This study's purpose is to investigate the financial effects of using product modularization as a strategy to manage the need for product customization amongst customers, using data derived from a sample of manufacturing firms in Sweden. The results of the study's analysis indicate that using product modularization as a strategy to facilitate companies' needs for developing customized products in an efficient way, to fulfill specific customer needs, positively affects financial performance. Hence, companies that are developing and selling products to customers in markets in which the need for product customization is important should adopt a product modularization strategy, since it will most likely improve their financial performance as measured by profit margin and ROE. These conclusions contribute to the existing body of knowledge on product modularization because they are based on survey data combined with quantitative data analysis. Previous research indicates that companies can gain positive performance effects from modularization. However, a major part of this research is case based, describing the financial benefits that single companies have gained from adopting and implementing product modularization strategies. In contrast, the research done in this study includes companies from many different sectors, such as the plastics, metal, computer, and electronics industries.

In recent years, more research studies have been based on quantitative analysis with a focus on product modularization's performance effects, such as performance in terms of cost, quality, and flexibility (Jacobs et al., 2007; Jacobs et al., 2011); manufacturing performance (Lau et al., 2007); and product development performance (Danese and Filippini, 2010, 2013; Vickery et al., 2015). Hence, the research done in this study contributes by focusing on its effects on actual company financial performance.

The managerial implications of these conclusions are that adopting a product modularization strategy can be expected to have positive effects on financial performance for companies that are in a market where there is a need for customized products amongst

Table 8
Factor loadings for the CFA.

Factor	Indicator	Estimate	SE	Z	p	Stand. Estimate
CUS	Custo1	1.049	0.107	9.80	< .001	0.774
	Custo2	1.281	0.107	12.02	< .001	0.927
	Custo3	0.822	0.105	7.80	< .001	0.616
MOD	Modu1	1.697	0.134	12.66	< .001	0.882
	Modu2	1.848	0.139	13.30	< .001	0.912
	Modu3	1.597	0.141	11.31	< .001	0.816

customers. This demand for customization means that companies need to develop and manufacture more product variants to fulfill different customers' specific needs and requirements, resulting in an increased product variety adding complexity to companies' product development and manufacturing operations. But, adopting a product modularization strategy will help to mitigate the negative effects of this variant complexity. Decomposing the product into physical modules and defining interfaces in between these modules makes them loosely coupled, and interchangeable. This results in modules that can be mixed and matched according to different customer demands, hence, that facilitates product customization. Companies having a high degree of product modularity tend to have both higher profit margins and higher return on equity. Hence, adopting a product modularization will likely improve companies' financial performance.

The study's potential limitations relate to validity, reliability, and generalizability. Because our study relies on previously validated scale items and theoretical concepts, the validity of the results should be satisfactory. The statistical methods utilized for the data analyses are themselves well proven, so the main potential reliability issue is related to non-response bias. However, an analysis of differences in demographics between responding and non-responding firms showed no significant results; hence, the reliability of the results should be acceptable. However, regarding generalizability, we must acknowledge that our sample frame was, for practical purposes, limited to Swedish firms with more than 100 employees. Thus, the results may not be representative of small firms and/or non-Swedish firms. Because smaller firms rarely have product development within their business units, it may be more fruitful to study companies in other countries, since there might be differences in business culture. A comparison between companies with large home markets and those that sell products internationally might also be interesting. Because countries often have different laws, companies selling in global markets might have to offer more product variants than companies selling only in their home markets, which could impact the effects of customization and product modularization on financial performance. Another interesting area for further research would be to investigate possible cumulative effects based on longer experience of using a product modularization strategy.

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Appendix

See Table 8.

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