The manufacturer's perspective on supply chain flexibility and customer satisfaction

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Abstract

Studies have shown how isolated flexibility dimensions are related to customer satisfaction. Little is known about what manufacturers perceive as important for customers. Yet, manufacturers' perceptions govern their actions and are likely to determine the relative investments in each flexibility dimension. The purpose of this study is to empirically investigate supply chain flexibility from the manufacturer's perceptive to see which flexibilities will increase the level of customer satisfaction when all flexibility dimensions are taken into account at the same time. We gathered survey data from managers in Dutch manufacturing companies. Results from structural equation modelling imply that in the eyes of the manufacturer, only logistics and spanning flexibility are perceived to have a significant positive impact on customer satisfaction. Using Bayesian model selection, we find that manufacturing managers prioritize spanning, then logistics, then manufacturing and then product development flexibility. Hence, the importance of product development flexibility and manufacturing flexibility, though highly valued by customers, are currently less acknowledged by manufacturers. With our study, we create awareness for the manufacturer's perspective on supply chain flexibility, which tend to focus on the service to the customer. Our study identifies the directions in which a further improvement of customer satisfaction can be achieved.

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Striving for flexibility in the supply chain can be seen as a reaction to various uncertainties in the environment of the firm (Giunipero et al., 2005; Wallace and Choi, 2011) and hence as an important requirement to stay in business (Yu, Tang and Niederhoff, 2011). Supply chains have become a crucial component of the competitiveness of many organizations, which are facing increasing competition due to globalization (Kwak, Seo, and Mason, 2018). Worldwide political developments (e.g., the situation in Ukrain/Russia), ecological developments (e.g., earthquakes and floods) and health developments (e.g., the COVID19 pandemic) may pose significant risks to supply chain activities and may cause unexpected disruptions (Manders et al., 2017; Namdar et al. 2018). Flexibility in the supply chain helps a firm to build competitive advantage and generate customer satisfaction (Phillips and Wright, 2009; Chang and Huang, 2012).

Whereas traditionally the flexibility literature focuses on improving manufacturing flexibility of the firm (e.g., Koste et al., 2004), it has become increasingly clear that firms must look beyond the manufacturing flexibility of their own firm, and instead take into account flexibility from a supply chain- or value chain perspective (Singh and Sharma, 2013; Piprani et al., 2022). Only in this way organizations obtain insight in the level of flexibility that adds value to customer needs. Supply chain flexibility goes beyond mere manufacturing aspects, such as being able to vary the production volume. It encompasses flexibility from the intrafirm, the so-called internal perspective, and from the interfirm level, the so-called external perspective (Stevenson and Spring, 2007; Jayant and Ghagra, 2013). More specific, supply chain flexibility includes product development-, manufacturing-, logistics- and spanning flexibility (Zhang et al., 2002b; Nair, 2005).

Product development flexibility refers to the ability of a company to adjust its product development processes to accommodate changing customer needs, market conditions, and technological advancements by adapting product designs (Du, Jiao and Tseng, 2006). It involves designing product development processes that are agile, responsive, and adaptable to changes in the environment (Nambisan, 2017). Manufacturing flexibility points to a company's ability to quickly adjust its manufacturing processes to meet changing customer demands regarding volume and delivery requirements (Goyal and Netessine, 2011). Logistics flexibility denotes the physical distribution of manufactured goods, including transportation, warehousing, inventory management, and order processing (Manders et al., 2017; Sandberg, 2021) and requires effective communication and collaboration channels with logistics partners, such as suppliers, carriers, and third-party logistics providers, to ensure seamless coordination and timely delivery of goods (Manders et al., 2017). Finally, spanning flexibility refers to a company's ability to adapt its business strategies, operations, and resources across different customer segments. It involves designing a flexible organizational structure that enables the company to leverage its core competencies, resources, and capabilities to pursue new growth opportunities and address changing market conditions (Zhang et al., 2006).

Prior studies have emphasized the importance of flexibility and customer satisfaction in relation to supply chain performance (e.g. Beamon, 1999; Gunasekaran et al., 2004). Studies that explicitly relate flexibility to customer satisfaction show that in isolation, product development-, manufacturing-, logistics- and spanning flexibility are positively related with customer satisfaction (e.g., Vokurka and O'Leary-Kelly, 2000, p.494). However, in daily business practice, multiple flexibilities are at play simultaneously (Koste and Malhotra, 1999; Sawhney, 2006). Furthermore, as these studies mainly reflect the customers' view, little is known about what manufacturers perceive as important for customers. Yet, manufacturers' perceptions govern their actions and are likely to determine the relative investments they undertake into each flexibility dimension. There is a need to investigate manufacturers' perception on the relative influence of flexibilities for achieving customer satisfaction. Hence, the objective of this study is to develop and empirically investigate a comprehensive model to analyse the relative importance of supply chain flexibilities on customer satisfaction in the eyes of the manufacturer.

The contribution of our paper lies in the advancement of existing knowledge about supply chain flexibility to come to a better understanding of the perceived relative contribution of isolated flexibilities to customer satisfaction. Specifically, we create awareness for the manufacturer's perspective on supply chain flexibility. Our study on the manufacturer's perspective identifies the directions in which a further improvement of customer satisfaction can be achieved.

The remainder of the paper is structured as follows. In the next section, we review the literature about supply chain flexibility in relation to customer satisfaction. We show that prior research finds positive significant relationships between each of the different types of supply chain flexibilities and customer satisfaction (Zhang et al. 2003; 2005; 2006). We raise the question whether manufacturing companies hold the same view when testing all flexibility dimensions simultaneously. The method section discusses the methodology of the study. The results of our analysis are presented in the subsequent section. The final section discusses our findings and shows limitations, managerial implications, and avenues for future research.

LITERATURE REVIEW

FLEXIBILITY AND CUSTOMER SATISFACTION

The term flexibility has been brought under attention of the economics literature by Stigler (1939), in the context of a firm's ability to accommodate to greater variations in the demand output. This view has been extended to an organizational perspective within the 1950's, 1960's and 1970's, which modelled how organizations can operate responsively in a rapidly changing environment and add customer value (e.g., Georgopoulous and Tannenbaum, 1957; Child, 1972; Ackoff, 1977). In these and follow-up studies the trade-off between flexibility and efficiency became visible (Sethi and Sethi, 1990, Zhang et al., 2002b). Studies in the 1980s and 1990s mainly focused on flexibility from a narrow manufacturing perspective and led to the development of conceptual frameworks, models and measures for manufacturing flexibility (Manders et al., 2016; Das and Narashiman, 2000). Over time, focus shifted to the flexibility of entire (networks of) organizations and supply chains (Stevenson and Spring, 2007). Firms increasingly realized that it is of strategic importance to take into account circumstances and performance of supply chain partners when striving for flexibility (Barad, 2013).

Customer satisfaction involves the overall experience of the product or service concerning the purchase and the use and consumption over a period of time. It is an important outcome variable, next to financial performance indicators. There are several studies linking supply chain flexibility to (financial) performance (e.g. Fawcett, et al., 1996; Vickery et al., 1999; Fantazy et al., 2009; Arawati, 2011). Typically, these studies find support for a relationship between one or a few flexibilities with a constructed performance measure. Often this performance measure is a composition of different variables such as sales growth, assets, return of investment, return on sales, market share, financial performance, customer service, customer satisfaction, lead time, productivity, delivery competence, and responsiveness. Instead of using a composed performance measure, we limit the scope of our study to customer satisfaction. Using customer satisfaction allows us to link the firm to its wider supply chain context, specifically to its customers. Furthermore, several studies have linked various flexibilities to customer satisfaction (e.g. Lummus et al., 2003; Kumar et al., 2006), and to the customer relationship itself (Soon and Udin, 2010).

Incidentally, studies have even related supply chain flexibility to customer satisfaction (Zhang et al., 2002b). Supply chain flexibility ensures that a firm can deliver a variety of innovative, low cost, high quality products in the appropriate amount on the right moment at the right place to foresee in customer demand. This flexibility is not only generated by a firm's logistic flexibility. It also originates from the integration of flexibility along the entire supply chain (Zhang et al., 2002b). Studies have shown that to achieve the level of flexibility that adds value for customers, firms must look beyond organizational flexibility, towards flexibility from a supply chain- or value chain perspective (Krajewski et al., 2005; Schmenner and Tatikonda, 2005). Cross functional and cross company efforts are needed to cope with uncertainty that stems from a continuously changing business environment. Supply chains as a whole need to be flexible to adapt to economic and societal developments, such as globalization, technological change and innovation, disruptions and changing customer needs and expectations (Duclos et al., 2003; Pujawan, 2004, Blome et al., 2013). Our definition of supply chain flexibility closely follows Upton (1994) and Zhang et al. (2002b), defining supply chain flexibility as the ability "to meet an increasing variety of customer expectations while keeping costs, delays, organizational disruptions and performance losses at or near zero" (Zhang et al., 2002b, p. 561). This flexibility notion encompasses the following dimensions: product development flexibility, manufacturing flexibility, logistics flexibility and spanning flexibility (Day, 1994; Zhang et al., 2002a; 2002b; 2003; 2005; 2006).

Moreover, flexibilities are interdependent to some degree. With product development, firms can quickly respond to a rapidly changing environment by applying product modification and new product commercialization. Such flexible design and modification capabilities create room for manufacturing flexibility by simplifying the product structure, reducing the number of parts, and standardizing parts. This results in an easier and faster manufacturing process in which product quality can be easily monitored and controlled. Flexibility in logistics facilitates the manufacturing process by delivering the right product at the right moment to the customer. With spanning flexibility this whole process can be coordinated by different supply chain actors simultaneously in order to fulfil customer demand.

Prior research has provided evidence for positive significant relationships with customer satisfaction of each of the different types of supply chain flexibilities (Zhang et al., 2003; 2005; 2006). The question arises whether manufacturing companies hold the same view when testing for all flexibility dimensions at once. What image do manufacturers have about the flexibilities that increase customer satisfaction, specifically when overseeing several flexibilities simultaneously? Do manufacturers perceive some types of flexibility as more important for customer satisfaction than other types?

HYPOTHESES

The purpose of this study is to empirically investigate which flexibilities – that amount to a flexible supply chain – will increase the manufacturer's perception of customer satisfaction when all flexibilities are taken into account at the same time. Following Zhang et al. (2002b) and Nair (2005) we consider product development-, manufacturing-, logistics- and spanning flexibility as being important aspects of supply chain flexibility.

The relationship between product development flexibility and customer satisfaction was shown by Zhang et al. (2002a; 2009). The rationale being that flexibility in modifying existing products and/or in commercializing new products allows firms to better meet customer needs by improving current products and maintaining the depth and breadth of a firm's product portfolio (Zhang et al., 2002a; 2009). Flexible product development enables firms to anticipate customers' latent needs and adapt rapidly to evolving customer requirements and changing technologies by modifying and adapting designs (Du, Jiao and Tseng, 2006), develop prototypes, while guarding costs, delivery times and quality (Giunipero et al. 2005; Berghman et al. 2012; Nambisan, 2017). Product development flexibility on account of the manufacturer appeals to the quality appraisal by the customer and is therefore found to be important for customer satisfaction (Zhang et al., 2002a; 2009).

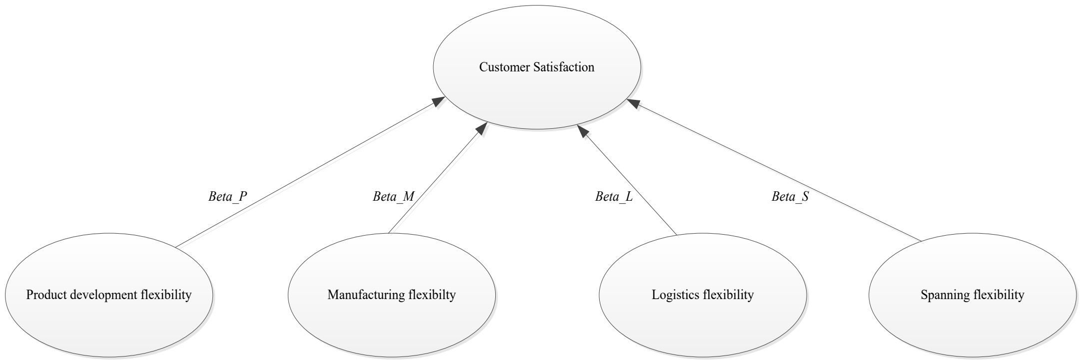
Various studies (e.g. Zhang et al., 2003; Chandra et al., 2005; Fantazy et al., 2009) have shown that manufacturing flexibility is positively related with customer satisfaction. Manufacturing flexibility comprises volume- and mix flexibility (Zhang et al., 2003; Goyal and Netessine, 2011). Volume- and mix flexibility mitigate demand uncertainty for the manufacturer, and improve service towards the customer in terms of a flexible delivery, low waiting times, no extra costs in case of demand fluctuations (Das and Narashiman, 2000). Both are expected to be important for planning and managing purposes to meet performance goals and customer demand (Jüttner et al., 2007), which in turn may lead to achieving customer satisfaction (Chandra et al., 2005).

Logistics flexibility has also been positively related with customer satisfaction (e.g. Zhang et al., 2005). Logistics flexibility refers to the physical distribution of manufactured goods. Physical distribution links the company's internal activities to the activities of its customers (Skjøtt-Larsen et al., 2007).

It involves transportation and warehousing processes such as order processing, inventory management, packaging and labelling (Lin and Chen, 2009; Manders et al., 2017; Sandberg, 2021). In sum, physical distribution flexibility enhances customer satisfaction by offering correct delivery at a competitive cost to the final customer, thereby increasing the price-value ratio for customers (Nair, 2005; Chang and Huang, 2012).

Spanning flexibility refers to strategy development flexibility which is a market sensing and customer linking capability. Spanning flexibility is especially useful for developing and managing customer relationships in which firms and customers share interdependences, values and strategies (Day, 1994; Santos and D'Antone, 2014). With accumulated information, the firm can adapt and integrate its organizational skills, functional competences and resources to match the requirements of the changing environment and yet remain competitive (Nair, 2005; Zhang et al., 2006; Berghman et al., 2012). Spanning flexibility includes learning from experience, acting on timely information and using advanced information technology (Jüttner et al., 2007; Madhavaram and Hunt, 2008). With spanning flexibility a firm can quickly coordinate its sources and react efficiently to satisfy changing customer needs (Zhang et al., 2006; Santos-Vijande et al., 2012).

Figure 1: Conceptual model



In this study we aim to investigate the relative influence of each of the above flexibilities for achieving customer satisfaction (see the conceptual model in Figure 1). Hence, the question remains whether all flexibilities contribute equally to customer satisfaction, or, as was noted by Stevenson and Spring (2007), whether certain dimensions of flexibility are more important than others in the view of the manufacturer. As current literature does not provide empirical findings about the relative influence of all these flexibility dimensions at the same time, we start from the thought that, from a manufacturer's perspective, all dimensions will contribute equally to customer satisfaction. Hence, we arrive at the following hypothesis:

Hypothesis 1. Product development-, manufacturing-, logistics- and spanning flexibility contribute equally to customer satisfaction.

Additionally, we compose four competing hypotheses on the relative contribution of each flexibility dimension to customer satisfaction. Each of these hypotheses contains a view that stems from the literature about what manufacturing managers regard as important for achieving satisfied customers.

First, we suggest a ranking that is firmly rooted within a manufacturing view. The most used and most often mentioned flexibility dimension within the manufacturing- and supply chain literature is volume flexibility (Vickery et al., 1999; Sánchez and Pérez, 2005; Stevenson and Spring, 2009), regularly combined with mix flexibility (Zhang et al., 2003). In our study we lump together these intertwined flexibility dimensions into manufacturing flexibility. It is likely that manufacturing managers are focused on the manufacturing system. The manufacturing system is within their own span of control (Kathuria 1998; Das, 2001; Boyle, 2006), and it is likely that they identify manufacturing (and spanning) flexibility as being essential to fulfil the customers' needs (Olhager and West, 2002). To determine whether manufacturers perceive volume and mix flexibility, i.e. manufacturing flexibility, as most important for achieving customer satisfaction, we hypothesize that:

Hypothesis 2. Manufacturing flexibility and spanning flexibility are more important for customer satisfaction than product development flexibility and logistics flexibility.

Second, several studies emphasize the importance of the flow of information within the supply chain to adapt to the changing customer needs (Lummus et al., 2005; Schmenner and Tatikonda, 2005; Stevenson and Spring, 2007). Timely access to relevant information can be seen as a requirement for fulfilling the flexibility targets of different processes, including product development, manufacturing and logistics (Golden and Powell, 2000; Gosain et al., 2004). Spanning flexibility is focused on collecting relevant information, learning from experience, and developing and improving current practices (Zhang et al., 2002b). Based on these studies we expect that spanning flexibility is necessary to enable product development-, manufacturing- and logistics flexibility, each of which are needed to satisfy customers' needs by fulfilling their demands. More specifically, we expect that from a manufacturer's perspective:

Hypothesis 3. Spanning flexibility is more important than product development flexibility, followed by manufacturing flexibility; and logistics flexibility is least important for customer satisfaction.

Within the manufacturing- and supply chain flexibility literature, several flexibility hierarchies are presented that distinguish between internal and external flexibility, or between different levels of flexibility, e.g. operational-, tactical and strategic flexibility (Koste and Malhotra, 1999; Das and Narashiman, 2000; Stevenson and Spring, 2007; Malhotra and Mackelprang, 2012). We address these different views within the literature by differentiating between a supply chain view and a value chain view.

Third, as defined by the supply chain council (2002), "a supply chain encompasses every effort involved in producing and delivering a final product from the supplier's supplier to the customer's customer" (Supply Chain Council 2002, cited in Lummus, 2003, p. 1 and Chen and Paulraj, 2004, p. 122). Supply chains focus on the chain of supply, elaborated later to include all efforts involved in producing and delivering a final product or service in an efficient way. Removing unnecessary steps, speeding up the information and material flows, consolidating supplier and customer bases can improve performance and customer service (Stevens 1989; Heikkilä, 2002; Vickery et al. 2003), which is vital to attain customer satisfaction (Innis and La Londe, 1994; Mentzer et al. 2001). The supply chain view covers the goods flow from supplier to the customer. We expect the manufacturing managers to follow this view and hypothesize:

Hypothesis 4. Product development flexibility is more important than manufacturing flexibility followed by logistics flexibility and spanning flexibility is least important for customer satisfaction.

Finally, in contrast, the value chain view follows Gunasekaran et al. (2004), who poses that a happy and satisfied customer is crucial. All activities within the supply chain that add value (Porter, 1985; Christopher 2005; Ketchen and Hult 2007) and contribute to satisfying customers' needs (Vickery et al., 1999) have to receive priority (Kumar et al., 2006). Value creating processes are geared towards fulfilling the end customers' demand. Gathering and exchanging information is necessary to accommodate to unique customer requests, react to unexpected operational circumstances and to integrate (Bowersox et al., 2000). Integration activities occur in terms of material flows and information sharing (Frohlich and Westbrook, 2001) and are necessary to increase value added and enhance customer satisfaction (Prajago and Olhager, 2012). Spanning and logistics flexibility are immediately visible to the customer and therefore they may be seen as most important for them.

However, to be flexible within these areas, manufacturers have to be flexible within their own internal product development and manufacturing processes as well. Covering a value chain perspective, we expect that in the eyes of manufacturing managers:

Hypothesis 5. Spanning flexibility is more important than logistics flexibility, followed by manufacturing flexibility; and product development flexibility is least important for customer satisfaction.

METHOD

SAMPLE AND DATA COLLECTION

Data was gathered by administering a questionnaire to managers of operations, manufacturing and supply chain management in Dutch manufacturing companies (SIC codes from 20 till 39 from the Nace2Rev database from Eurostat) with one hundred or more employees. A set of 1000 companies was at random selected from the Nace2Rev database and each company website was checked to see whether the company fulfilled selection criteria. We excluded holding companies without production activities in the Netherlands, as well as terminated firms due to bankruptcy or company take-overs. The survey was administered among the remaining 859 companies. To encourage submission of the questionnaire, each respondent was given a chance to win a bottle of wine. Following Dillman's tailored design method (Dillman, 2007; Dillman et al., 2009) a system of multiple compatible contacts was used to approach the companies in the sample, including: a pre-notice informing mail sent to the respondents a few days before the questionnaire; a hardcopy questionnaire including an invitation letter and return envelope with response number sent by post; an e-mail with the URL-link to the questionnaire on the internet; a thank you/reminder e-mail sent after one week; and a second reminder e-mail with the URL-link to the questionnaire sent after two weeks after the first mailing. Out of 97 responses received, 8 forms were returned blank, and 6 were incomplete, resulting in 83 useable responses. These 83 responses were complete, without missing entries. The response rate of 9.7% is similar to response rates in previous studies about supply chain flexibility (for example Zhang et al., 2003; 2005). Non-response bias was tested by identifying the differences between early and late respondents, as late respondents are more similar to non-respondents than early respondents (Armstrong and Overton, 1977). No significant differences were found between waves.

The majority of responses came from manufacturing of fabricated metal products (18%), food products (13%), and industrial and commercial machinery

(11%). For comparison, data from the Dutch central bureau of statistics shows that the three major subsectors of Dutch manufacturing industry are fabricated metal products (18%), food products (14%), and industrial and commercial machinery (11%). Hence, our sample reflects the distribution of firms over sectors in the Netherlands. Within our sample, 39% of the responses came from firms with 100-249 employees, and 76% of the firms have less than 1000 employees (Table 1).

Table 1: Descriptives of the sample

Firm size (number of employees)	Respondents	Percent of total
100-249	32	39
250-499	21	25
500-999	10	12
1000-2499	7	8
2500-4999	3	4
5000-7499	3	4
7500-9999	3	4
10000-	4	3

Position	Respondents	Percent of total
CEO/President	5	6
Vice President	3	4
General Manager	8	10
Director	10	12
Production Manager	1	1
Logistics Manager	21	25
Other	35	42

Prior to sending the survey to the sample companies the questionnaire was pilot tested by ten subject matter experts with a university or management background (Flynn et al., 1990). This led to a few adaptations in the layout of the questionnaire.

Conway and Lance (2010) demonstrate that the threat of common method bias is generally overrated. In contrast, Guide and Ketokivi (2015) emphasize that researcher should be cautious with strong claims about common method bias in single-informant studies. Hence, we undertook the following procedural remedies to minimize common method bias as well as social desirability bias. First, the respondents' anonymity was assured. Respondents were instructed that there are no right or wrong answers, and they were urged to answer questions as honestly as possible (Podsakoff et al., 2003). Also, the questionnaire was accompanied by a cover letter stating the purpose of the study (Podsakoff et al., 2003). Second, the questionnaire contained less than 50 items. Therefore, it was short enough to avoid boredom and fatigue, which might shift the cognitive effort of respondents away from response accuracy to response speed (Yu and Cooper, 1983). This would make the last items of the questionnaire vulnerable to biases in the direction of consistency with previous responses, and stereotypical responding, such as all midrange responses or all extreme responses (Lindell and Whitney, 2001). Taken together, although we cannot rule out common method bias and social desirability bias in our sample, but we undertook various procedural measures to hedge against it.

MEASURES

Multiple-item scales, closely following previous studies, were used to measure each construct. Items for dimensions of flexibility and customer satisfaction were based on Zhang et al. (2002a; 2002b; 2003; 2005; 2006). Appendix A reports the items that were used to assess the construct variables as well as their internal consistency. Cronbach's alpha is around 0.8 for all constructs, hence they are considered to be internally consistent (Nunally and Bernstein, 1994). All items were measured using five point Likert scale, anchored by 1 = strongly disagree, to 5 = strongly agree. We provided verbal labels for the midpoint of scales and avoided using bipolar numerical scale values (e.g., -1 to +1) in order to reduce acquiescence bias (Tourangeau et al., 2000). Inspection of the individual item loadings indicates that all items with a loading higher than 0.5 provide support for individual item reliability (White et al., 2003).

ANALYTICAL STRATEGY

Structural Equation Modelling, specifically Partial Least Squares (PLS), is used to simultaneously test all flexibility dimensions within our model in relation to customer satisfaction. This approach allows us to investigate whether each flexibility is related to customer satisfaction when other flexibilities are taken into account at the same time. We also tested for interaction effects between flexibilities with Hayes module in SPSS. We tested for all possible two-way interactions, and we found no significant interaction effects between flexibilities. We also tested for all possible mediation effects. Also these were not significant. However, these findings may result from the power issue at play. If our sample would have been larger (we now have n = 83) we may have found significant results. Future research may want to further investigate moderation and mediation effects between flexibilities. In order to test our hypotheses and rank the flexibility dimensions with respect to perceived importance for customer satisfaction, we used Bayesian analyses.

RESULTS

PLS ANALYSIS

The measurement model and structural model were estimated by means of Structural Equations Modelling (SEM), specifically Partial Least Squares (PLS) using SmartPLS (Ringle et al., 2005). SEM allows an analysis of systems of variables all at once, whereas multiple regression analysis does not. PLS is the most appropriate analyse technique for this study for the following reasons (O'Loughlin and Coenders, 2004). First, Appendix A shows that the distribution of the data in our sample deviates from normality. We find a kurtosis value of 4.27 and 2.16 for the fourth and sixth item of spanning flexibility, and kurtosis values higher than 1.99 for all the items of customer satisfaction. This means that Ordinary Least Squares analysis is not appropriate. As PLS uses no distributional assumptions, this is a fit analysis tool for this situation (Chin et al., 2003, Hair et al., 2013). Second, PLS is a very powerful tool that can be used in situations where the sample size is relatively small in proportion to the parameters (Chin et al., 2003). This is also the case for our study.

A PLS model assesses the measurement model and structural model at the same time, but uses two stages for analysing and interpreting (White et al., 2003). In the first stage reliability and validity are determined to assess the measurement model. Subsequently, the final estimates of the outer weights and loadings are calculated, as well as the structural model's path coefficients (Hair et al., 2013).

Reliability was assessed at the level of the structural model, by evaluating the unidimensionality of items through their factor loadings and composite reliability (Fornell and Larcker, 1981). All composite reliability values in our sample are higher than 0.7, therefore the items measuring the constructs can be considered as internally consistent (Nunally and Bernstein, 1994). By inspection of each construct's AVE, we find that for each construct it is above the threshold of 0.50 (Chin et al., 2003). Discriminant validity can be determined by means of Fornell and Lacker's (1981) test of the square root of the AVE. The square root of the AVE should exceed the correlation between two respective constructs. This is indeed the case for all square rooted AVE values in our study (Table 2). These results lead to the conclusion that our constructs have sufficient discriminant and convergent validity (Chin, 1998).

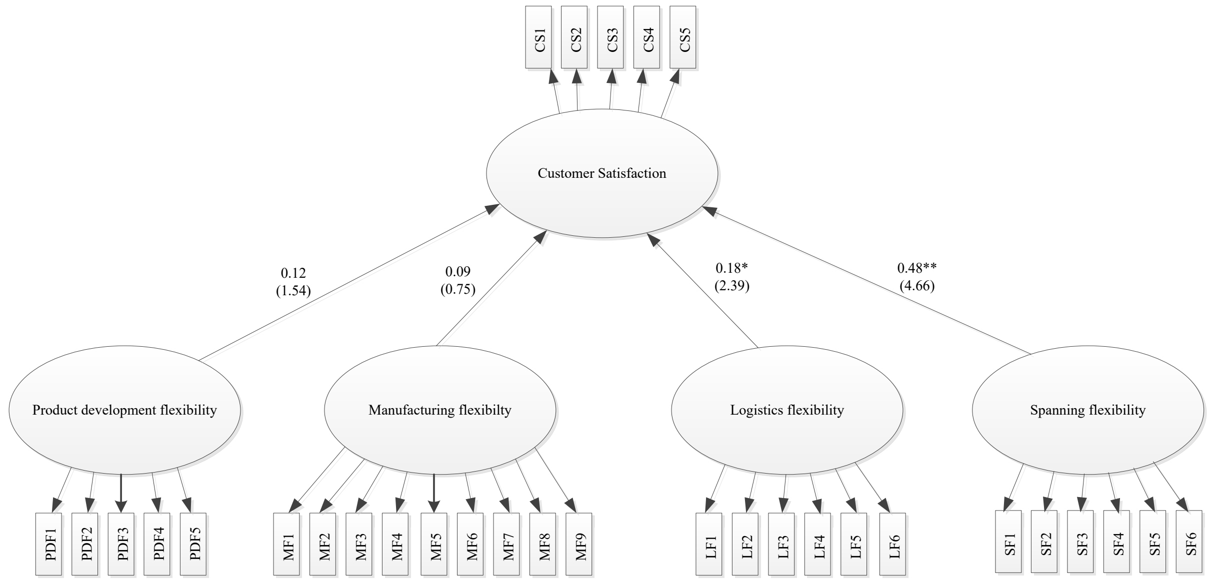
The structural model represents the relationships between different flexibilities and customer satisfaction. The goodness-of-fit R^2 of the latent endogenous variable customer satisfaction has a value of 0.43. Another criterion for assessing the structural model is the predictive relevance Q^2 (cv-redundancy index: i.e. Stone-Geisser's Q^2). Values of Q^2 larger than zero indicate that exogenous latent variables have predictive relevance for a specific endogenous latent variable (Chin, 1998). A Q^2 value of 0.07 for customer satisfaction supports the predictive relevance of the associated PLS path model relationships. Application of the finite mixture procedure, FIMIX-PLS, results in an Akaike Information Criterion of 273.83, a Bayesian Information Criterion/Schwarz criterion of 314.95, and a normed entropy statistic (EN) of 0.51. Hence, the fit indices for the structural model indicate a good fit to the data. Figure 2 shows the empirical results for the structural model. The t-values for the individual coefficients are obtained via a bootstrap resampling procedure (White et al., 2003).

Table 2: Descriptive statistics on factor level

	Mean	**St. Dev.**	**Composite reliability**	**Average variance extracted (AVE)**	**Product development flexibility**	**Manufact uring flexibility**	**Logistics flexibility**	**Spanning flexibility**	**Customer satisfaction**
Product development flexility	3.11	1.00	0.84	0.52	***0.72***				
Manufacturing flexibility	3.81	0.93	0.90	0.50	.33** (.001)	***0.71***			
Logistics flexibility	3.81	0.95	0.87	0.52	.14 (.104)	.41** (.000)	***0.72***		
Spanning flexibility	3.53	0.74	0.86	0.51	.14 (.106)	.38** (.000)	.34** (.001)	***0.71***	
Customer satisfaction	4.07	0.70	0.87	0.58	.20* (.034)	.37** (.000)	.40** (.000)	.57** (.000)	***0.76***

Notes: Square root values of AVE (Average Variance Extracted) are given on the diagonal; *p < 0.05 and **p < 0.01. N=83.

Figure 2: Results structural model



Notes: Bold lines are for paths; t-value is in parenthesis; ** path is significant at 0.01; * significant at 0.05; $R^2 = 0.43$

We find that product development flexibility has a positive but non-significant relationship with customer satisfaction (ß = 0.12; p = 0.124). Manufacturing flexibility has a positive but non-significant relationship with customer satisfaction (ß = 0.09; p = 0.456). Finally, there is a significant relationship between logistics flexibility and customer satisfaction (ß = 0.18; $p < 0.05$), and spanning flexibility and customer satisfaction (ß = 0.48; $p < 0.01$).

BAYESIAN ANALYSIS

Hypothesis H1 to H5 were analyzed by using Bayesian model selection with the software package BIEMS (Mulder et al., 2012). This software package was used to compute so-called posterior model probabilities, which quantify the likelihood of each model after observing the data, when assuming that each model is equally likely before observing the data. This methodology differs fundamentally from null hypothesis significance testing using p-values. A fundamental property of the p-value is that it can only be used to falsify a null hypothesis, i.e., there is either enough evidence in the data to reject the null hypothesis or not; a p-value cannot be used to find evidence in favor of a hypothesis. Posterior model probabilities on the other hand can be used to quantify how much evidence there is for each hypothesis, model, or theory in light of the observed data. Therefore, posterior model probabilities provide direct answers on the level of support for each of our expectations. Furthermore, evaluating hypotheses with multiple order constraints (as in the current paper) can be quite problematic with classical p-values (e.g., van de

Schoot et al., 2011). Posterior model probabilities can be used to evaluate such order hypotheses relatively easily using BIEMS. In BIEMS, default priors with minimal information are automatically generated using the observed data. For more information about the technical details of Bayesian model evaluation we refer the interested reader to Mulder et al. (2009; 2010; 2012). For less technical references on this topic we refer to van de Schoot and Hoijtink (2011), Kluytmans et al. (2012), Andraszewicz et al. (2015), and Braeken et al. (2015).

First we test a start hypothesis that assumes that all flexibility constructs contribute positively to customer satisfaction, against its complement, which assumes that not all constructs contribute positively to customer satisfaction. We assume that both hypotheses are equally likely a priori. After observing the data this start hypothesis received a posterior model probability (PMP) of 0.96 and the complement hypothesis received a PMP of 0.04 (see Table 3). This means that there is strong support in favor of this start hypothesis.

Table 3: Bayesian Model Selection test 1

Hypotheses	Constraints	PMP
Hstart(all positive):	(beta_S, beta_L, beta_M, beta_P) > 0	0.96
Hcompl(not all positive):	not Hstart	0.04

Table 4: Bayesian Model Selection test 2

Hypotheses	Constraints	PMP
H1(equal positive effects):	beta_S = beta_P = beta_M = beta_L > 0	0.186
H2(manufacturing):	(beta_S, beta_M) > (beta_P, beta_L) > 0	0.076
H3(spanning):	beta_S > beta_P > beta_M > beta_L > 0	0.041
H4(supply chain):	beta_P > beta_M > beta_L > beta_S > 0	0
H5(value chain):	beta_S > beta_L > beta_M > beta_P > 0	0.690
Hcompl(complement):	not H1-H5	0.006

Second, we test the competing hypotheses with different expectations about the relative importance of the four different flexibility dimensions, i.e. H1 (equal positive effects) vs H2 (manufacturing) vs H3 (spanning) vs H4 (supply chain) vs H5 (value chain) vs the complement hypothesis. Again all hypotheses are assumed to be equally likely a priori. The posterior model probabilities can be found in Table 4. Hypothesis H5 (value chain) received most support with a PMP of 0.690, followed by H1 (equal positive effects) with a PMP of 0.186. Hence, we find a 69% chance that the value chain hypothesis is true. In other words, there is positive evidence that spanning flexibility is expected to have a stronger effect on customer satisfaction than logistics flexibility, followed by manufacturing flexibility, and followed by product development flexibility, which is expected to be least important for customer satisfaction in the eyes of manufacturers. Although we have a 69% chance that this hypothesis is true after observing the data, we cannot yet rule out the other hypotheses. In particular, there is still 19% chance that H1 is true, i.e. that all effects are equal and positive.

DISCUSSION, LIMITATIONS AND FURTHER RESEARCH

Companies are dealing with complex, continuously changing and uncertain environments due to globalization, technological progress and associated changes in their customers' needs and expectations. To cope with this dynamic and quickly fluctuating environment, firms strive for flexibility and resilience on many accounts (Piprani et al., 2021). To achieve the level of flexibility that adds value for customers, firms should increasingly approach flexibility from a broad supply chain- or value chain perspective (Stevenson and Spring, 2007). However, whether managers of manufacturing firms indeed adopt such a broad view has been scarcely researched until now (Piprani et al., 2021).

The theoretical contribution of this study is twofold. First, we explicitly studied the view of the manufacturer on the importance of each flexibility in relation to the manufacturer's view on customer satisfaction, and not the actual customer satisfaction with respect to each of the flexibilities. This is an important contribution of our study to the existing literature and ties in with recent studies addressing supply chain resilience (e.g., Dubey et al., 2019a; 2019b; Piprani et al., 2021). Studies in this field focus on flexibility dimensions as antecedents of supply chain resilience (Dubey et al., 2019a; Piprani et al., 2021) or competitiveness (Dubey et al., 2019b). Yet, supply chain resilience studies still lack addressing the fact that managers are confronted with managing several flexibilities at once. The uniqueness of our study is that we show the flexibilities that managers actually address first – based on assumptions about the impact of each flexibility on customer satisfaction – when time and money are limited. It is crucial to become aware of the manufacturers' perspective, as this perspective influences the self-perception of managers and their sense of urgency regarding necessary measures to fulfil certain specific customer needs. The view of a manager on the manufacturer's own flexibilities and his view regarding customer satisfaction is what strongly influences a manager's behavior and his business decisions.

Second, previous studies on flexibility emphasize the need for research that takes a comprehensive view of the concept of flexibility, and considers various flexibility dimensions (Das and Narashiman, 2000; Barad, 2013; Manders et al., 2016). We investigated the simultaneous relationship between customer satisfaction and four supply chain flexibilities, namely product development flexibility, manufacturing flexibility, logistics flexibility and spanning flexibility. Previous research (Zhang et al., 2002a; 2003; 2005; 2006) found that each of these flexibilities is positively related to customer satisfaction when tested in isolation. For instance, Zhang et al. (2003) shows direct positive relationships of manufacturing flexibility with customer satisfaction. However, by testing a research model in which we employ all flexibilities simultaneously, we reveal the relative emphasis that manufacturers adhere to each of the different flexibilities.

For our sample, the PLS analysis reveals that, in the manufacturers' view logistics flexibility and spanning flexibility are positively and significantly related to customer satisfaction. The relationships with product development flexibility and manufacturing flexibility are also found positive but are not significant. In other words, the manufacturing managers from our sample expect customer satisfaction to be related to flexibility with respect to logistics and spanning activities, and not to flexibility in product development and manufacturing activities. Hence, it is likely that in daily practice managers will prioritize activities that induce logistics and spanning flexibility over activities related to product development and manufacturing flexibility. These findings differ from those of Vickery et al. (1999) and Sánchez and Pérez (2005), who suggest that firms are focused on basic flexibility capabilities, such as manufacturing flexibility and product development flexibility. However, our findings are in line with findings by Kathuria (1998), Das (2001) and Boyle (2006), who find that managers are focused on activities that are within their own span of control. Our findings are also in keeping with studies such as Nair (2005) and Chang and Huang (2012), which show that logistics and spanning flexibility are crucial to fulfil customer needs.

The Bayesian analysis shows that when all flexibilities are taken into account simultaneously, we find support for a value chain point of view, i.e. spanning flexibility is considered to be most important for customer satisfaction, followed by logistics-, manufacturing- and product development flexibility respectively. The low consideration for manufacturing flexibility and product development flexibility in our sample could be explained by the fact that manufacturers feel that logistics and spanning activities are of direct importance to the customer, and therefore may have a higher impact on customer satisfaction than manufacturing flexibility and product development flexibility (Vickery et al., 2003; Oke, 2005). Apparently, in our sample, the manufacturer's view of their customers is that these do not dedicate much importance to exactly how an order is met, i.e. whether a product needed high innovation efforts, or whether much manufacturing flexibility was required on part of the manufacturer, as long as the customers' wishes are met in time, with a product that is adjusted to fulfil their needs (Innis and La Londe, 1994; Oke, 2005). The customer needs a product, and hence the product should be distributed to the customer according to specified agreements (logistics flexibility) and the manufacturer's responsiveness to fluctuating customer demands should be high (logistics flexibility) (Nair, 2005). In the view of the manufacturer this is valued highly by customers, possibly because customer complaints for a large part concern delivery problems. Furthermore, manufacturers seem to interpret recent trends in service dominant logic to signify that customers want manufacturers to improve their practices and adjust their strategies in order to better serve the customer (spanning flexibility) (Santos and D'Antone, 2014). Apparently, manufacturers expect the customer to have a mass customization perspective: They seem to believe that the customer wants a customized product delivered in the right amount at the right time (logistics flexibility) (Kumar et al., 2006), based on information that spans various connections across the value chain (spanning flexibility) (Da Silveira et al., 2001).

Our findings have important managerial implications. Our results contribute to preparing more robust supply chains by creating awareness among managers that their gut reactions may be flawed, or at least sub-optimal. Our Bayesian model selection approach indicates that managers apparently do not prioritize product development flexibility and manufacturing flexibility in real life situations, though these are known to have a positive effect on customer satisfaction (Zhang et al., 2002a; 2003). Following the literature about co-creation in value adding activities (Vargo and Lusch, 2004; Grönroos and Voima, 2013), we would expect that manufacturers would have been much more aware of the importance of product development- and manufacturing flexibility for customer satisfaction. Managers should realize that in practice they tend to take product development- and manufacturing flexibility for granted, as in their eyes, logistics- and spanning flexibility make the difference regarding customer satisfaction. Our study can alert managers about their unsubstantiated predisposition to logistics and spanning flexibility, which may to a large extent influence their behavior towards the customer. An adaptation of their behavior in this regard is likely to improve actual customer satisfaction.

A related managerial implication concerns the realization that flexibilities must be managed in a comprehensive way to gain benefits (Boyle, 2006). This is only possible when a broad perspective on flexibility is adopted and when all flexibility types are taken into consideration at once. To be successful in current technological intensive markets, supply chain partners have to realize that they need to display a wide array of flexibilities to provide value for customers (Lummus et al., 2003). In other words, they have to view “the large picture”.

Our findings have to be seen in the light of several limitations to our current study, each of them harboring avenues for future study. A first limitation is related to our methodology. Although we adopted structural equations modelling that estimates all relationships simultaneously, as well as Bayesian modelling that evaluates hypotheses with multiple order constraints, we focused at direct relationships between four types of flexibility with customer satisfaction. Our sample was relatively small, and when we tested for interaction effects between flexibility types we did not find significant effects. Yet, this could be caused by the lack of power of our analysis which is due to the limited number of responses in our dataset. From a theoretical and practical viewpoint, flexibilities can be expected to influence each other. For instance logistics flexibility can hardly be achieved without any manufacturing flexibility activities (Oke, 2005). Further research should aim at taking into account such interaction effects between several flexibility types, and the consequences for customer satisfaction.

Second, our sample consisted of manufacturing firms in the Netherlands with one hundred or more employees. Other studies could use other samples and larger samples to test whether our findings are robust. For example, the study could be complemented by including small and medium sized firms, a setting which may reveal different dynamics, as smaller firms may have more intense and intimate relationships with customers. A larger sample may also enhance generalizability of findings.

Third, our study focused on the manufacturer’s perspective on customer satisfaction. This served our purpose, as we wanted to reveal the behavior of managers when confronted with the necessity to manage several flexibilities at once, as is common practice. It was hitherto unknown what flexibilities managers actually perceive to be of major influence on customer satisfaction. Hence, further research should sample customers and investigate the relative importance that they adhere to the identified flexibilities when considered simultaneously. In that way we can arrive at a more complete understanding of the role of flexibilities in customer satisfaction.

Fourth, although we only claim to investigate the manufacturer’s perception of which flexibility is important for customers, it would be interesting to find out why certain flexibilities are prioritized over others. Several factors are at play for understanding the level of importance of the flexibilities for customer satisfaction, for example product category and type of industry. Future research may consider including these factors as control variables.

Finally, for further research it may be of interest to take the entire supply chain as a unit of analysis, instead of solely the manufacturer or the customer perspective. A feasible research design may include semi-structured interviews with at least a supplier, a manufacturer, a distributor and a customer. This type of study would provide in-depth insights on the role of flexibility in dyads and over the entire chain. Ideally, a longitudinal study could be applied to determine how flexibility affects customer satisfaction over time. With regard to the increasing importance of service activities in customer oriented supply chains, a new challenge would consist of testing the model while incorporating service flexibility dimensions, or testing the model in service related firms.

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DATA STATEMENT

Respondents have not consented to sharing of the data.

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APPENDIX A: Constructs and measures

Construct	Items	Mean	St. Dev.	Loading	t-value	Z-value skewness	Z-value kurtosis
Product development flexibility (5items, α=0.79)	We can quickly modify product design in response to customer requests	3.35	1.02	0.89	3.20	-0.33	-0.79
	We can easily modify products to a specific customer need	3.47	1.04	0.83	3.23	-0.32	-0.92
	We can modify existing products quickly	3.11	1.00	0.67	3.58	0.08	-0.88
	We can launch new products easily	2.93	0.91	0.62	2.84	-0.06	-0.93
	We can launch new products inexpensively	2.67	1.01	0.53	2.38	0.55	-0.10
Manufacturing flexibility (9items, α=0.87)	We can quickly change the quantities for our products produced	3.76	1.07	0.55	2.65	-0.80	-0.16
	We can vary aggregate output from one period to the next	3.73	0.83	0.55	2.40	-0.79	0.91
	We can easily change the production volume of a manufacturing process	3.60	0.97	0.57	2.60	-0.66	0.34
	We can produce a wide variety of products in our plants	3.90	1.00	0.70	3.31	-0.79	0.01
	We can produce different product types without major changeover	3.66	0.95	0.74	3.31	-0.65	-0.15
	We can build different products in the same plants at the same time	3.99	0.86	0.80	3.31	-0.91	1.13
	We can produce, simultaneously or periodically, multiple products in a steady-state operating mode	3.76	0.85	0.77	3.44	-0.61	0.57
	We can vary product combinations from one period to the next	4.01	0.88	0.79	3.13	-1.03	1.28
	We can changeover quickly from one product to another	3.88	0.97	0.84	3.69	-0.75	0.08
Logistics flexibility (6 items, α=0.81)	We pick and assemble multiple customer orders accurately and quickly at the finished goods warehouse	3,75	1,00	0,82	22,88	-0,52	-0,40
	We can provide multiple kinds of product packaging effectively at the finished goods warehouse	3,49	1,03	0,63	5,77	-0,29	-0,56

	We can use multiple transportation modes to meet schedule for deliveries	3.81	0.96	0.66	5.92	-0.63	-0.04
	We can quickly and accurately label finished products	3.71	0.94	0.72	9.40	-0.54	-0.13
	We have accurate records of quantities and locations of finished goods	4.11	0.88	0.83	15.29	-1.09	1.33
	We can take different customer orders with accurate available-to-promise	3.96	0.86	0.64	5.10	-0.75	0.19
Spanning flexibility (6 items, α=0.81)	We continuously renew our competence to meet changing customer needs	3.69	0.73	0.78	11.79	-0.97	1.82
	We quickly take action based on all the information continuously collected along the value chain	3.33	0.84	0.76	14.87	-0.43	-0.41
	We continuously develop strategy based on maintaining a good relationship with our major suppliers	3.52	0.79	0.59	4.97	-0.60	0.51
	We continuously experiment, learn, and improve our practices to improve productivity	3.78	0.64	0.67	5.65	-1.44	4.27
	We quickly develop strategy based on the coordination and integration of information along the value chain	3.19	0.76	0.73	10.92	-0.34	-0.21
	We continuously experiment, learn, and improve our practices to improve customer satisfaction	3.70	0.69	7.57	7.57	-0.86	2.16
Customer satisfaction (5 items, α=0.81)	We have high customer retention rate (customers keep doing business with us)	4.20	0.82	0.69	7.62	-1.48	3.15
	Customers are satisfied with ratio of price and function of our products	3.80	0.64	0.78	9.11	-1.23	4.06
	Customers perceive their money's worth when the purchase our products	4.01	0.59	0.83	12.61	-1.43	7.61
	Our customers are satisfied with the quality of our products	4.04	0.72	0.69	4.55	-1.05	3.18
	Our firm has a good reputation for our products	4.31	0.70	0.80	9.23	-1.40	4.85

Notes: Z-values are presented. Significant skewness and kurtosis if -1.99 < Z-value < 1.99