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Supplier Flexibility and Postponement Implementation: An Empirical Analysis

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Abstract

Postponement has been recognized as a strategy to manage uncertainties in demand. Its performance however depends on various prerequisites. Numerous technical factors that influence postponement such as product modularity and process redesign have been widely studied. Notwithstanding, the effect of external factors on postponement have been paid much less attention. This paper addresses the external factors which affect postponement application, and in particular, concentrates on the relationship between supplier flexibility and postponement implementation. Four constructs of flexibility and three constructs of postponement – namely volume flexibility, mix flexibility, new product design flexibility, product modification flexibility, manufacturing postponement, ordering postponement and product design postponement – are identified, and measured variables for each construct are extracted from the literature. Supported by a theoretical ground, built based on the literature, the positive relationships among supplier flexibility and postponement constructs are then tested through structural equation modeling (SEM) using empirical data from a sample of 219 manufacturing SMEs in one country. The results indicate that the supplier impacts on postponement implementation for the buying firm are not identical for all types of postponements and supplier flexibilities. While manufacturing postponement and ordering postponement are supported by supplier volume and mix flexibilities, design postponement is only related with product modification flexibility. These findings enhance the postponement knowledge with respect to external influencing factors from a general level to a more precise, specific level. The implications of the research outcomes are discussed and directions for future research are provided.

Keywords: postponement, supplier flexibility, structural equation modeling (SEM).

1. Introduction

Postponement, in brief, is defined as a strategy that intentionally delays the point in time when an activity/task (e.g., as to the form and/or place of goods) is executed (Yang et al., 2004b: 469; Yeung et al., 2007: 332; Saghiri, 2008). Postponement is traditionally viewed as a delay in shipment or final configuration of the product (e.g. labeling, packaging, or assembly – see Pagh and Cooper, 1998; Fu et al., 2012). However, the delay can happen in a wider range of activities including upstream operations in the supply chain such as product design, ordering or purchasing items, and manufacturing. The main idea that this research is built upon is considering postponement in more upstream operations (including order management, and product design and development, in addition to manufacturing), and investigating the impact of suppliers on different types of postponement (including manufacturing, ordering, and design postponements); research areas which have been paid less attention to date.

In the product design literature, the idea of postponement is perhaps less well understood and appreciated than expected. Product design faces various uncertainties due to changes in the tastes of customers, alterations in national and international requirements for product specifications, or requests made by other internal departments such as production to change the product design. To manage uncertainties, the product design team can defer less stable stages of product design, and delay them until receiving more accurate information about the possible required changes in them. (Hegde et al., 2005).

In the ordering of the purchased items, unpredictable changes may apply to a number of factors such as order quantity, frequency of delivery and the specifications of purchased items. Early ordering under uncertainty conditions can lead to possession of items that may become of no use or obsolete – which is very crucial for high value items. In view of this, ordering may be delayed until more information about the purchased items that the firm needs becomes available.

In manufacturing processes, the focal point of postponement is configuration of the product. Various customer expectations lead to multiple derivatives for the product, and a higher level of uncertainty for the production system. When uncertainty is high, manufacturing of less stable parts of the product can be delayed (wholly or partially) until more information about each of them becomes available (MacCarthy et al., 2003).

Various enablers or barriers may affect postponement performance. Factors influencing postponement have been given considerable attention in the literature during the last ten years and include: sales fluctuation and product life cycles (Yang et al., 2004b), product customization (MacCarthy, 2013), the number of products (Su et al., 2005), product and process features such as decouplability, standardization and modularity of products and processes (Swaminathan and Lee, 2003; Skipworth and Harrison, 2004; Yang et al., 2004b), and product and process redesign (Brun and Zorzini, 2009). The majority of the studies on postponement enablers and barriers are limited to product and/or process configurations and their technical considerations. In a more extensive view, the structure of a supply chain can affect the success of a postponement strategy (Yang et al., 2007; Yeung et al., 2007). Yang et al. (2005a), Davila and Wouters (2007) and Trentin and Forza (2010) address suppliers as enablers for postponement. Yang et al. (2005a) realize that supplier delivery performance, involvement of suppliers in engineering and operations, and communication with suppliers has an impact on postponement implementation. Davila and Wouters (2007) find that cooperation with suppliers is crucial to making the implementation of postponement possible. They believe that through collaboration, the benefits of postponement will be more apparent for suppliers. Trentin and Forza (2010), in a set of propositions, show that lateral relations with suppliers in the production-planning process enable postponement by reducing information processing needs for the buying company.

By postponing one or more value adding activities, typically, less time will be left for them to be fulfilled. This necessitates the availability of resources with an adequate capacity to be reserved for the delayed operations. Flexible manpower that can work overtime or handle multiple tasks, multi-purpose machines which can cover the extra capacity needed for the delayed operations, and advanced technologies such as computer-aided design and computer-aided manufacturing (CAD/CAM) that accelerate the product development process can facilitate postponement implementation. By and large, flexible resources provide the delayed activities with more capacity and support them to meet the customer deadline – while a shorter lead-time is available due to postponement (Yang et al., 2007). Given that, the role of key enablers such as the flexibility of the resources in postponement implementation is not, as yet, adequately addressed in the literature. Van Hoek (2001) and Forza et al. (2008) have underlined the opportunity for studies on postponement in the context of the supply chain. It has been also highlighted by Yang et al. (2007) and Yeung et al. (2007) that the most significant difficulties in postponement implementation are related to managing external networks. Saghiri and Hill (2014) have studied the impact of relationship with supplier on postponement. However, the literature specifically lacks studies on the role of supplier performance in different types of postponement strategies (i.e. manufacturing, ordering and design). Even the few studies that mention the role of suppliers in postponement (for example, Yang and Burns, 2003; Yang et al., 2005a, Davila and Wouters, 2007, Saghiri and Hill, 2014) do not investigate which aspects of supplier performance may affect what types of postponement, how, and to what extent.

Supplier flexibility has a more immediate link with the implementation of postponement in the buying firm - which needs possible changes in buying material. This makes supplier flexibility more important to study – compared to other factors such as supplier cost and quality. Krajewski et al. (2005) mention that supplier flexibility is related to the level of postponement. Their study, however, is limited to contract flexibility.

To fill the gaps mentioned above, this research examines the impact of the flexibility of external sources on postponement implementation. More specifically, this paper tries to find whether supplier flexibility is linked with the application of postponement to the supplier-related activities of the buying firm, and if such a relationship exists, how strong it is. Accordingly, the research question can be defined as follows: "What is the relationship between the supplier flexibility and the implementation of product design, ordering and manufacturing postponement?"

The theoretical context of the impact of supplier flexibility on postponement implementation is explained in more detail in the next section, where the research constructs and hypotheses are identified. Based on the proposed theoretical framework, section 3 explains the research methodology and phases of the research program, including sampling, data collection and methods of analysis. Subsequently, the findings of the main study are presented, and the outcomes are discussed in the penultimate section. Finally, the last section rounds off with conclusions and implications for future research and practice.

2. Postponement and supplier flexibility

To work on a theory, construct development is essential. The literature review in this section identifies and explains the research constructs in two domains of this research: postponement and supplier flexibility. The last sub-section links these constructs together and develops the research hypotheses.

2.1. Postponement

Postponement can occur in various stages of the supply chain: product design, purchasing/ordering, manufacturing and distribution (Yang et al., 2004a). This typology is helpful as it indicates the form or mode of a value-adding operation(s) that is postponed. Considering this classification, the postponement constructs selected in this study are *manufacturing postponement* (MP), *ordering postponement* (OP) – including purchasing, and *design postponement* (DP) – including all product development activities. This selection seems reasonable since the relationships among design, ordering, and manufacturing postponements and supplier flexibility have theoretical supports (see sub-section 2.3). It is notable that distribution postponement is not considered in this paper, since the impact of suppliers on distribution and logistics activities of the buying firm (as the main theme of this research) seems negligible, and this study could not find enough theoretical ground to test it.

Product design consists of a series of activities including conceptual design, screening, detailed design, value engineering, and modifications. Product design postponement can be defined as deferring product design and development tasks until receiving the order (Yeung et al., 2007) or better information about the product's specifications, combinations and functions (Gil et al., 2004; Boone et al., 2007). A delay can occur in any of product design activities. Minor corrections or modifications in product design or major changes in product concept or detailed design can be delayed according to uncertainties in the market and the extent to which the customer order penetrates to the supply chain (i.e., the customer order decoupling point). The level of design postponement might also depend on the marketing strategy or the arrangements made between the buyer and the supplier (Rudberg and Wikner, 2004; Wikner and Rudberg, 2005). Accordingly, product development and design modifications can be delayed until the first round of the buyer's feedback on the initial design arrives. Such a postponement may need the cooperation of suppliers and their involvement in product design, as explained later.

Ordering postponement can be defined as delaying the order placement until more information about the purchasing items arrives (Chaudhry and Hodge, 2012). This may move purchasing components as close to the point of manufacture as possible (Yang and Burns, 2003). Li et al. (2009) show that how postponement of an order "until one-period demand information is observed" leads to a lower cost and a higher threshold for making delivery requests. This is helpful when demand uncertainty is high and the purchasing material and components cannot be easily planned in advance. Ordering postponement is more fruitful for more expensive or valuable materials and components. The postponement may occur in different activities of the ordering process. The wider the range of ordering activities the delay applies to, the higher the level of postponement. In ordering postponement, collaboration between the buying firm and suppliers is crucial, since suppliers should be ready to fulfill the buyer's last-minute changes in the orders. The link between suppliers and ordering postponement is explained in sub-section 2.3.

Manufacturing postponement tries to retain the product in a neutral and non-committed status to the latest possible point (Pagh and Cooper, 1998). It may include delays in fabrication, assembly and packaging operations (Lin and Wang, 2011). Manufacturing postponement can be employed in single or multiple manufacturing processes. It can also be applied to one or more products. The delayed manufacturing can support customization of the products (Rungtusanatham and Salvador, 2008), manage risks, and reduce finish goods and work-in-process inventory costs (Wong et al., 2011; Sharda and Akiya, 2012). To meet the fast-approaching deadlines, manufacturing postponement needs the support of internal and external resources. The shorter lead-time available for the delayed manufacturing process(es) requires suppliers to coordinate with the last minute changes made by the manufacturing system – see detailed explanations in sub-section 2.3.

The literature on postponement introduces a number of variables which measure the degree of postponement implementation. They are discussed and listed in Appendix 1.

2.2. Supplier flexibility

Flexibility in the operations strategy and management context means the ability to respond effectively to changing circumstances, or meeting changes demanded by the customer or business environment (Vokurka and O'Leary-Kelly, 2000). Flexibility has a multidimensional nature. It can be employed or implicated in various areas such as material handling, machine operations, automation, labor, process, routing, product, new design, delivery, volume, expansion, program, design, production, and market (D'Souza and Williams, 2000; Vokurka and O'Leary-Kelly, 2000; Garavelli, 2003, *inter alia*).

Considering the theoretical framework of this research, four domains are used to define supplier flexibility constructs: *volume flexibility*, *mix flexibility*, *product modification flexibility* and *new product development flexibility*. These domains have been introduced by Koste and Malhotra (1999) as major dimensions of flexibility at the plant level[1], which absolutely match the level at which flexibility is studied in the current research. Numerous studies have used and cited those flexibility dimensions, and approved their validity and reliability (e.g. Zhang et al., 2003; Sawhney, 2006).

Volume flexibility refers to the ability to change the aggregate production rate quickly and efficiently (Duclos et al., 2003). Koste and Malhotra (1999) emphasize that the flexibility in volume should not incur a major alteration in performance outcomes and high transition penalties.

Mix flexibility means the ability of the manufacturing system to cope with changes in the share of products in the firm's product mix (Bengtsson and Olhager, 2002; Hallgren and Olhager, 2009). In mix flexibility, the total production volume may be kept unchanged, but the disaggregate production plans may vary according to the market's needs.

New product flexibility refers to the ability to launch a variety of new products fairly quickly (Lummus et al., 2003). It needs a manufacturing system capable of introducing and making new parts and products using existing facilities (Koste and Malhotra, 1999; Narasimhan et al., 2004).

Product modification flexibility is defined as the ease of making minor changes in product

[1]. There is a fifth dimension addressed by Koste and Malhotra (1999), named "expansion flexibility", which unlike the other dimensions, is not about the capacities and capabilities of the production system. Thus, it is not included in this study.

design to meet differentiation or customization requests (Narasimhan et al., 2004). The changes may apply to the structure, function or assembly of the product (Palani Rajan et al., 2005).

These flexibility dimensions indicate supplier performance, while studying their impacts on manufacturing, ordering and design postponements are in line with the research question, and their relationships with postponement strategies are testable – see further detail in sub-section 2.3.

To form the above mentioned flexibility types into operationalizable research constructs, measured items for the flexibility constructs need to be identified. This study follows the comprehensive classification of different aspects of flexibility provided by Koste et al. (2004). This classification has been adopted and thoroughly tested by many other recent studies (see for example Ketokivi, 2006). It identifies four elements for each type of flexibility, namely "range-number" (R-N), "range-heterogeneity" (R-H), "mobility" (M), and "uniformity" (U). Accordingly, 32 initial measured items were created for the flexibility constructs used in this study (see Appendix 2).

2.3. Linking supplier flexibility and postponement strategies: research hypotheses

By applying postponement strategy, the available time to complete the delayed operation is shorter. Thus, when accomplishing one or more delayed operations, the pre-assumption is that to not waste any time, all prerequisite activities required to start the postponed operation – including material or services provided by suppliers – should have already been completed. Consequently, this requires the supplier's quick response to last minute changes (as a result of postponement). Supplier flexibility supports the buying firm (Sanchez and Perez, 2005; Avittathur and Swamidass, 2007; Krause et al., 2007), and helps it manage the shorter available time to accomplish the delayed operation(s). Hence, a successful implementation of postponement can be related to the supplier's flexibility. In other words, the more the buying firm can rely on supplier flexibility, the higher level of postponement that is expected to be implemented.

Chaudhry and Hodge (2012) show that companies adopting ordering postponement work towards enhancing their supply chain capabilities. Based on the postponement and suppliers' flexibility constructs identified earlier, the research hypotheses which link postponement and supplier flexibility are formalized as follows.

To succeed, manufacturing postponement needs have the support of quick response systems (Nair, 2005). The shorter available lead-time in manufacturing postponement requires suppliers to deliver the required purchased items as quickly as possible (Prasad et al., 2005). By establishing a flexible manufacturing system, the supplier will be more effective to react to the regular changes in the requirements of the delayed manufacturing operations. Kesen et al. (2010) argue that in many cases to counter demand uncertainty, instead of an inventory holding strategy, the buyer may prefer to use supply flexibility. By more flexibility in production plans, buyer and supplier can adjust their capacities (Mukherji and Francis, 2008). Supplier flexibility and its ability to absorb demand fluctuations helps the buying firm to cope with a high level of uncertainty (Jack and Raturi 2002; Gosling et al., 2010). Milner and Kouvelis (2002) analytically illustrate that the value of supplier flexibility increases with the variation in demand. Salvador et al. (2007) state that to respond to market turbulences, build-to-order systems need supplier volume and mix flexibilities. Specifically, Squire et al. (2009) show how supplier flexibility in terms of volume and mix flexibility is linked with the buyer responsiveness. Devaraj et al. (2012) show that flexibility in the volume and mix of purchasing items gives the buying firm the ability of modifying its production rates dynamically. They particularly verify the positive impact of purchase volume and mix flexibilities on the buying firm's delivery performance. This will give the buyer enough confidence to delay manufacturing and make the last minute changes the customer demands. Therefore, the first group of hypotheses can be presented as follows.

H1a: The higher the supplier's product volume flexibility, the higher the performance of manufacturing postponement in the buying firm.

H1b: The higher the supplier's product mix flexibility, the higher the performance of manufacturing postponement in the buying firm.

It should be noted that manufacturing flexibility is not hypothesized to relate to supplier flexibility in product modification and new product development, as those links do not have theoretical support. As explained earlier, manufacturing postponement needs more operational support in terms of product delivery to the production line with last minute changes. Those changes do not usually involve product design – or at least we could not find any evidence for it. Any alteration in the purchasing items' design, including modification and new product development, is expected to be applied in ordering or product design stages.

In ordering postponement, the buying firm tries to delay its order to the supplier. It then waits to learn more about the order to minimise the risk of overstocking inventories (Tong, 2010). Then, the buying firm may make changes to the order quantity's size or timing (Yang et al., 2007). Following the delayed ordering, the buying firm will have less time available to acquire its purchasing items, and it should be able to procure them quickly. This needs a quick response supply chain, with high delivery performance (Boulaksil and Fransoo, 2009). Therefore, the supplier should be flexible in terms of the volume and mix of its production to meet the buyer's delayed order requirements.

The delayed orders do not just ask for changes in delivery timing or quantity, but also changes in the purchasing item's design. The changes may be about minor modifications or major re-design of the item. Bidault et al. (1998) characterize the supplier support in product innovation and customization by its participation in the design of parts or components. A flexible supplier that copes with the last minute changes in purchasing items' design, demanded by the buying firm's delayed orders, can be a great support for ordering postponement.

Thus, the second group of hypotheses are formalized as follows:

H2a: The higher the supplier's product volume flexibility, the higher the performance of ordering postponement in the buying firm.

H2b: The higher the supplier's product mix flexibility, the higher the performance of ordering postponement in the buying firm.

H2c: The higher the supplier's flexibility in product modification, the higher the performance of ordering postponement in the buying firm.

H2d: The higher the supplier's flexibility in new product development, the higher the performance of ordering postponement in the buying firm.

Product design postponement tries to deal with uncertainties and changes in product specifications (Yang and Burns, 2003). However, to still be competitive in introducing new products to the market, design postponement needs to accelerate the product design process. A compressed time to market needs quicker product design process, where supplier involvement is crucial. This involvement may be as little as feedback on the design ideas, developed by the buying firm, to full design of components or modules by the supplier. Suppliers may be involved at different stages of the product design and development process as well (Petersen et. al., 2005; Lettice et al., 2010). To that end, buying firms try to take advantage of the immediate supplier's capability and technology during the product design stage through early supplier involvement.

Accelerating the design process does not always or only depend on the supplier's design capacity. As Handfield et al. (1999) illustrates, suppliers may contribute to the product design process in various ways. Flexible production capabilities of the supplier can assure the buying firm that the components of the newly designed product will be made by the supplier quickly and properly. Consistent with that, Tan (2001) confirms volume flexibility as a key measure for supplier assessment where he shows it positively affects the firm's product design and development. Accordingly, the supplier's high flexibility in design and production processes is expected to support the implementation of product design postponement in the buying firm. This is reflected in the third group of hypotheses in this paper:

H3a: The higher the supplier's product volume flexibility, the higher the performance of product design postponement in the buying firm.

H3b: The higher the supplier's product mix flexibility, the higher the performance of product design postponement in the buying firm.

H3c: The higher the supplier's flexibility in product modification, the higher the performance of product design postponement in the buying firm.

H3d: The higher the supplier's flexibility in new product development, the higher the performance of product design postponement in the buying firm.

The full research model is shown in Figure 1, which depicts all hypotheses tested in the study.

*** INSERT FIGURE 1 ABOUT HERE ***

3. Methodology

In this section we briefly outline the main phases of the investigation: the pre-pilot study, the pilot study and the final large-scale study. The details covered below include the development of the specific constructs for testing the structural research model, sampling, tests of validity and reliability, and the final analysis of the structural equation model. A detailed overview of the different steps and related activities involved in the study is provided in Figure 2. The first two phases were discussed above, where the domain and constructs were specified and defined and an initial list of survey questions was developed based on the salient literature. The survey instrument is further purified in the pre-pilot and pilot phases before a final application to test the research model in the main study, including rigorous tests for validity and reliability.

*** INSERT FIGURE 2 ABOUT HERE ***

3.1. Pre-pilot: early development of the research instrument

Expert feedback on the constructs and items developed from the literature was first sought from five practitioners and five faculty members in fields of operations and supply chain management. Some items were merged and reworded and a total of 21 items were removed from the initial list of items based on this stage of scale purification.

Convergent and discriminant validity in this pre-pilot stage were examined using the Q-sort method (Nahm et al., 2002). Judges were selected from the executive levels of the firms within the sample frame or partners of the sample frame firms. In each iteration all measured items, in no particular order, were provided to two judges (*n*=12 in total). The judges were asked to allocate variables to the research constructs independently. The judges' agreement level was measured using Cohen's Kappa (Cohen, 1960) and Moore and Benbasat's hits ratio (Moore and Benbasat, 1991). Each iteration was followed by discussions on judgments changes in the items. This process was continued until the good levels of both Cohen's Kappa (>80%) and Moore and Benbasat's hits ratio (>90%) were achieved. The Q-sort was run for two groups of postponement constructs and flexibility constructs separately. A further 14 items were removed based on the results from this phase.

3.2. Sample frames for the pilot and main studies

The structural analysis (i.e. SEM) in this research is fulfilled based on the empirical data collected from small- to medium-sized manufacturers of a wide range of automotive parts and components, which represent a wide range of manufacturing industries (including textiles, rubber and plastic parts; metal components, electrical products, and others). The sample frames for the pilot study and large-scale study consist of 70 and 593 firms respectively. As explained in the following sub-sections, 45 and 219 responses were received in pilot and large-scale studies respectively. The sample profile, including the industries that the responding companies were belong to, is provided in Table 1. Each manufacturer in the sample frame had a number of suppliers. This supported the current research to examine the role of suppliers in postponement implementation properly. The target respondents in the firms (one person in each firm) were senior or middle managers in the areas of purchasing, supply chain, logistics, quality, operations, production or strategic management.

*** INSERT TABLES 1 ABOUT HERE ***

3.3. Pilot study

In the second phase of the investigation, the pilot study examined construct unidimensionality, as well as convergent and discriminant validity, in a series of measurement models via confirmatory factor analysis (CFA).

Confirmatory factor analysis was then conducted on the data collected from 45 usable responses (a comparable number with similar studies such as Tan and Vonderembse, 2006), received out of 70 questionnaires which had been randomly distributed to the sample frame. The factor loadings for the items on each construct were calculated and examined. Any items with a factor loading below 0.7 were removed. This rigorous test ensured that only very strongest items remained in the scales. As a result, eight further items were removed from the scales. The levels of AVE of the final constructs varied from 0.679 to 0.841, well above the recommended 0.50 level (Fornell and Larcker, 1981). Furthermore, the levels of Cronbach's α varied from 0.804 to 0.953, exceeding both the standard threshold of 0.70 recommended by Nunnally (1978) and the more rigorous 0.80 threshold recommended by Straub and Carlsson (1989). Discriminant validity was examined using the method of Fornell and Larcker (1981), by comparison of the AVE and squared correlations for pairs of constructs. All constructs passed the tests with very large margins of difference between AVE and squared correlations in all cases. Further, the unidimensionality for sets of items for all pairs of constructs was examined; all items for each pair of constructs loaded strongly and clearly on their relevant construct, with a good margin of difference among item loadings. Overall, the result is a set of highly reliable, valid constructs that will subsequently be used to test to the research hypotheses in the large-scale study, as follows.

3.4. Large-scale study

Empirical data to test the research hypotheses (as reflected in the structural model) was targeted via a sample frame of 593 manufacturers of automotive parts and components. In total, some 219 questionnaires were found usable. The achieved 37% response rate is well-comparable to similar studies. In order to ensure that the collected sample was adequate for testing the research model using PLS (please see further details about PLS in section 4), a power analysis was employed. Power analysis is superior to unwieldy 'rules of thumb' and it is the most accurate way to identify the requirements of sample size for a specific statistical analysis and its power to explain population effects (McQuitty, 2004; Faul et al., 2008). A power analysis in G*Power 3.0 approves the capacity of the sample to explain relatively small to medium population effects ($n=219$; $\alpha=0.05$; $1-\beta=0.80$; $f^2=0.056$) within our proposed research model and that the sample has a very high power ($1-\beta=0.998$) for explaining medium effect sizes ($n=219$; $\alpha=0.05$; $f^2=0.15$) (Faul et al., 2008).

Any questionnaires that were returned with three or more missing values were considered unusable and were not included in the analysis (this related to seven cases in total). However, those with one or two questions without a response were retained. As a result, only eight missing values existed in the research data set and PLS employed the case-wise replacement technique for missing values before calculating the PLS algorithm.

To test for non-response bias, we followed the extrapolation method recommended by Armstrong and Overton (1977). The first wave of responses was compared with those responses received after follow-ups (which may be considered as non-responses to the first round). A random sample of 30 responses was taken from each group, and then these samples were tested for possible differences; a t-test was used to test for differences between the two samples for each measured item. The results indicated no differences at the 5% level of significance or greater. Furthermore, possible differences among the various groups of respondents were also assessed. For this purpose, usable responses were segmented based on two criteria: (*i*) response mode or channel (i.e. manual/hard copy vs. electronic/e-mail); and (*ii*) the industry group (or ISIC group) that a firm belongs to. A random sample of 30 responses was taken from each group for both of these segments and the possible differences between them were tested. The ANOVA revealed no significant differences among any of the different groups at the 5% level of significance or greater.

As discussed above, the questionnaire developed for this study was aimed at addressing supplier flexibility and postponement as measured constructs and items. The measured items of the research constructs were evaluated by respondents via a five-point Likert style rating scale (Tharenou et al., 2007; Saunders et al., 2011). As shown in Figure 2, the initial pool of 74 candidate items was subject to a rigorous process of scale purification for validity and reliability via several rounds of expert review, a Q-sort and piloting. The final questionnaire contained 31 items for the seven constructs (see Appendix 1 and 2). Based on the outcomes of scale development activities, including the empirical data collected in the survey described above, the main study examined the proposed structural model illustrated in Figure 1. Details of the path estimations and further analysis of the model are discussed in next section.

4. Research findings

The first step in the analysis of our structural model was to further test for validity and reliability. Table 2 provides the AVE, reliability and intercorrelations for each of the constructs in the model. Convergent validity is approved by the high levels of AVE, ranging from 0.790 to 0.879, well in excess of 0.50, suggested by Fornell and Larcker (1981). Comparison of the intercorrelations between constructs with the square-root of AVE confirms discriminant validity (Fornell and Larcker, 1981); in every case the square-root of AVE is higher than intercorrelations with other variables by a sizeable margin. According to Table 2, all postponement constructs have significant positive correlations with flexibility constructs (except one, MF-DP which is negligible) which support the prediction that those constructs are positively related. This approves the nomological validity (Hair et al., 2014: 633). Cronbach and Meehl (1955) argue that nomological validity is a form of construct validity evidenced by the development of a nomological network. Such a network must have at least two constructs and theoretical propositions specifying linkages between them. Theoretical constructs must be operationalizable through empirical measurement. Linkages are established empirically by hypotheses which are then supported after data collection and can be generalized. Nomological validity is demonstrated by the degree to which a construct behaves as expected within the nomological network. Since the main objective of PLS path modelling is prediction, the goodness of a theoretical model is assessed via an assessment of the strength of each structural path and the combined predictiveness (R^2) of exogenous constructs (Chin 1998; Duarte and Raposo 2010). According to Falk and Miller (1992), the level of acceptable predictiveness for R^2 is 0.1. Thus, based on this criterion, all endogenous constructs in our model display an acceptable level of predictiveness (see Figure 3), leading to a positive overall evaluation of the nomological validity of our model.

Composite reliability and Cronbach's α values for the research constructs in Table 2 indicate high reliability in the model; Cronbach's α varies from 0.916 to 0.954, while composite reliability varies from 0.939 to 0.968, well in excess of the 0.70 and 0.80, recommended in the literature (Nunnally, 1978; Straub and Carlsson, 1989). Finally, Table 3 indicates the factor loadings, t-values, standard errors and cross-loadings of all items and constructs. All loadings exceed 0.70 level, and are significant at the 0.1% level, which approves convergent validities (Anderson and Gerbing, 1988). Moreover, the cross-loadings shown in Table 3 verify the unidimensionality and discriminant validity of the constructs. Overall, the results demonstrate a strong, valid and reliable set of constructs in the research model.

*** INSERT TABLES 2 AND 3 ABOUT HERE ***

Estimations of all paths (representing the research hypotheses) and the calculation of corresponding t-values were done via the calculation of the PLS algorithm and the application of bootstrapping respectively in the Smart-PLS 2.0 software package (Ringle et al., 2005). The structural model with estimation of the paths and R^2 values are shown in Figure 3. One path was found to be significant at the 0.1% level of significance (*H2b*: MF→OP), one path was significant at the 1% level (*H1b*: MF→MP), and three paths were significant at the 5% level (*H1a*: VF→MP; *H2a*: VF→OP; and *H3c*: PF→DP – *note:* t-value of PF→DP is 1.959 which seems acceptable to be rounded up to 1.96 to be significant at the 5% level). Overall, the level of explained variance of the postponement constructs is healthy, ranging from R^2=0.538 for product design postponement, to R^2=0.394 for ordering postponement and R^2=0.202 for manufacturing postponement. The R^2 values of DP and OP are medium to high, while that for MP is more moderate (Ringle et al., 2010).

*** INSERT FIGURE 3 ABOUT HERE ***

5. Discussion

We now consider the outcomes of the main study from both the perspectives of supplier flexibility constructs and postponement constructs. Manufacturing postponement (MP) has been found to be affected by both VF and MF (i.e. the supplier's product volume and mix flexibility). The supplier's volume and mix flexibilities help the supplier, as well as the buying firm (which employs manufacturing postponement), to adjust production capacity and increase it as and when required. This supports the higher performance of postponement – when it is considered that a tighter capacity limits postponement (Gupta and Benjaafar, 2004). The positive impact of volume and mix flexibility on manufacturing postponement supports the idea of Yang et al. (2005a) who believe that supplier performance affects postponement implementation. Moreover, manufacturing postponement can be seen in wider contexts of lean production, agile supply chain and mass customization strategies (Qrunfleh and Tarafdar, 2013). The recent literature indicates that customization decisions need the support of supplier flexibility in production and inventories (Brown and Bessant, 2003), customer responsiveness depends on product mix flexibility of supply (Chiang et al., 2012), and an agile manufacturing is linked with supplier flexibility (Gosling et al., 2010). The outcomes of this research emphasize the key role of supplier flexibility in terms of production volume and mix. This can have a broader implication for supplier evaluation and selection criteria, sourcing decisions, and off-shoring versus re-shoring analyses. Therefore, when purchasing materials have a higher share in the buying firm’s products, delay in manufacturing or ordering decisions and operations can be supported by supplier production volume and mix flexibilities. This can boost more extensive strategies such as lean, agile, customization and responsiveness.

This research has demonstrated that ordering postponement is also affected by the supplier’s volume and mix flexibilities. This supports the idea of Yang et al. (2005a) on relating the supplier's performance with postponement implementation. Ordering postponement and its links with suppliers also back other operations strategies of a firm such as mass customization, which needs a special attention to inbound supply chain management and procurement (Schentler, 2009). Supplier flexibilities in production volume and mix give peace of mind to the procurement team of the buying company in coping with the last-minute changing requirements of the other departments properly. This effect of suppliers becomes even more important as the scale and scope of the procurement function expands across industries. Today, more activities are outsourced, a wider range of products and services are purchased and procurement becomes a core process to manage sourcing and supply (PricewaterhouseCoopers, 2013). Organizations are increasingly engaging procurement in strategic decisions and supply chain management. This is not a particularly unexpected role for procurement, when some firms spend up to 70% of their revenue with suppliers (CAPS Research, 2013). Accordingly, purchasing decisions (including ordering postponement) and their influencing factors (including supplier production volume and mix flexibilities) have an extended impact on organization performance.

This result indicates that the impact of suppliers on product design postponement depends decidedly on their flexibility in product modification. The role of suppliers that can participate in product design is very crucial; they can reduce the lead-time and cost and improve the quality of design (Petersen et al., 2005) and ultimately support the product design postponement. This implication expands Yeung et al.'s (2007) research, which recommends product design postponement for supply chains with unbalanced structures. They believe that if the buying company postpones its design activities, it can demand the suppliers to tailor their products and processes and share information. Our results indicate that the supplier's flexibility in product design modification is typically necessary to apply the design postponement by the buying company. Involving suppliers in product design also supports both lean and agile strategies (Inman et al., 2011) and gives a wider implication to design postponement.

The structural model outcomes can also be discussed from the perspective of the supplier's flexibility factors. The significant impact of the supplier's product volume and mix flexibilities on manufacturing and ordering postponement partially supports the idea of Yang et al. (2005a) in terms of the link between the supplier's performance and postponement. The support is incomplete since volume and mix flexibilities have not been found to have an influence on product design postponement. This may indicate that design postponement requires a greater degree of supplier infrastructural competence (e.g. design and development competence). Hence, having suppliers which can quickly change the product volume or mix does not support all types of postponement decisions made by the buying company. If postponement is going to be employed at more strategic levels such as product design, then the operational capabilities of suppliers such as volume or mix flexibility are not very helpful. Furthermore, it might be suggested that operational aspects of the supplier's production performance are less related to higher levels of customization strategies such as design-to-order.

The path estimates indicate that the impacts of mix flexibility are more significant than the impacts of volume flexibility. This may imply that the supplier's capability in changing the mix of products is more important than the capability of changing the overall production volume. When implementation of postponement leaves less delivery lead-time for the supplier, mix-flexibility gives the supplier a quick-response ability with less need for major investment in new capacities. This can be one of the key reasons which makes supplier mix-flexibility more favorable to support postponement. The supplier's flexibility in its product mix can be positively associated with product modularity (see Yang et al., 2004a; Su et al., 2005), a higher proportion of generic components (see Swaminathan and Lee, 2003) and component standardization (see Forza et al., 2008; Yang et al., 2005a) in postponement. Thus, product modularity, standardized components and/or generic components provide a higher level of flexibility (i.e. mix flexibility), which in turn supports postponement directly. This outlines the importance of focusing on the direct influencing factors (i.e. mix flexibility in this case) on postponement first, and then exploring the indirect factors (e.g. modularity) that support the direct factors.

The impacts of the supplier's product design and modification flexibilities on postponement have not been found to be as wide-reaching in their significance. The supplier's flexibility in product modification has a significant impact on product design postponement, while the supplier's flexibility in new product development is not significant at 5% or 10% levels - NF→DP is significant at the 13% level (close to 10% level), hence, it can be claimed that NF has a less significant impact on DP.

The impacts of the supplier's product design and modification flexibilities on ordering postponement were not found to be significant. This shows that the idea of Yang et al. (2005a) in linking the postponement implementation with supplier performance is not applicable to all types of postponement and supplier performance. It can also be implied that when purchasing orders are delayed, the delayed requirements are mostly about the shipment size, product mix, and delivery time and location. Hence, there is less which can be done by the supplier's design team.

Figure 4 summarizes the overall outcome of the SEM analysis. Suppliers' volume flexibility and mix flexibility, which are mainly production/product-related factors, affect manufacturing and ordering postponements. On the other hand, suppliers' flexibilities in product modification and new product development are only linked with design postponement.

*** INSERT FIGURE 4 ABOUT HERE ***

6. Conclusions

The literature on enablers and barriers of postponement implementation is mostly limited to two areas: (i) product and/or process configurations and their technical considerations (e.g. modularity), and (ii) supply chain mostly downstream activities such as manufacturing, assembly, packaging, labelling, and delivery. Although postponement has been viewed in a wider context of the supply chain by a few studies, such as Yang et al. (2005b), Davila and Wouters (2007), Yang et al. (2007) and Yeung et al. (2007), it has been studied at a very broad and general level. The external influencing factors on postponement have not been explored and discussed in detail, and the role of supplier performance in postponement implementation has been addressed only cursorily. Yang et al. (2005a) recognized the supplier's delivery performance as the most important barrier to postponement. Details of the supplier's performance, however, are not clear. The results of this research expand and enhance the existing perception of the impacts of suppliers on postponement. By concentrating on the supplier's flexibility as a key supplier performance factor, the idea of Yang et al. (2005a) has been studied and tested in this paper in detail. It has been remarked that flexible resources provide the postponed activities with more capacity and support it to manage the shorter available lead-times. Thus, the impact of different types of supplier flexibility on different types of postponement has been tested. The outcomes provide a much more detailed understanding of and partially challenge the work of Van Hoek (1998), Yang et al. (2005a) and Davila and Wouters (2007), whose results are limited to very few cases. Van Hoek (1998) underlines the role of qualified suppliers in postponed manufacturing. Davila and Wouters (2007) focus on the delivery of more generic products by suppliers, as the main contribution of suppliers in postponement. They also mention the supplier's flexibility as a key factor to make postponement responsive while keeping inventory level down. This paper, expands Van Hoek (1998) and Davila and Wouters (2007) initial notes on the role of suppliers in postponement, and shows that different types flexibility may support different types of postponement. It also reveals that, despite the general comments of Van Hoek (1998) and Davila and Wouters (2007), not necessarily all supplier capabilities (e.g. new product development flexibility and product modification flexibility) are positively related to all types of postponement (e.g. manufacturing postponement and ordering postponement). Hence, the application of different types of postponement may need the support of suppliers in various ways at various levels. They have been examined by the current research for the supplier's production volume and mix flexibilities and new product and product modification flexibilities. This has moved the body of knowledge on postponement from a general level (i.e. studying the role of suppliers) to a more precise, specific level. Moreover, as its secondary contribution, this research has shown that defining postponement constructs based on the value-adding activities which are postponed (i.e. product design, ordering, and manufacturing) is a useful approach to conceptualize and measure postponement – as the postponement constructs could be linked with external factors reasonably. Using structural equation modeling, the impact of the supplier's volume and mix flexibilities on ordering and manufacturing postponements has been found to be significant, while the supplier's product modification flexibility could only be significantly linked to design postponement, and the supplier's product development flexibility has been much less significantly linked (significant at 13% level) with product design postponement.

In addition to the analysis of the links among the supplier's flexibility and postponement constructs – as the main contribution of this paper – its outcomes can be considered within a wider knowledge area. Postponement is compatible with various strategies, including agile, *leagile* (i.e. lean + agile) and responsive strategies (Sharifi and Zhang, 1999; Lee, 2002), each of which have been introduced to confront demand uncertainties. The role and impact of suppliers in postponement strategies is compatible with leagile and agile strategies. By exploring the factors influencing postponement, this research contributes to the body of knowledge of a wider range of supply chain strategies. Different types of postponement are influenced by different supplier performance factors. The supplier's impact may consequently be expanded to agile and leagile strategies. Postponement research also overlaps with other related research areas such as flexible manufacturing systems and the just-in-time approach (Waller et al., 2000). Although the scope, objectives and functions of postponement are not exactly the same as those of flexible manufacturing systems and just-in-time approaches, they are largely relevant and have positive interaction (Yang et al., 2005b), and the external enablers of postponement (as studied in this research) can also provide a contribution to those areas.

Beside the theoretical discussions, the outcomes of this research have significant practical implications. Like any other strategy, postponement needs to measure the impact of other factors on its implementation, and ultimately on its success or failure. The validation of a structural model of postponement types and their influencing factors (i.e. supplier flexibility in this paper) provides a practical platform to operations managers and strategists to measure and monitor the postponement critical success factors. A second practical implication of this research is the involvement of suppliers in postponement implementation. By pursuing postponement, managers should consider the role of suppliers. This should be compatible with the firm's other operations strategies or production management systems such as just-in-time and total quality management approaches. For example, just-in-time strategy urges a close relationship with the supplier and their involvement in product design. This, however, may not be the highest priority for a firm which employs ordering postponement. The conflicts between postponement and other strategies is more highlighted when supplier management requirements and practices are taken into consideration.

Finally, by involving suppliers in postponement strategies, the practical knowledge of postponement will be spread across the supply chain. This may support the application of postponement in multiple stages of the supply chain – wherever postponement can help managers to deal with uncertainties.

The current study has some limitations. It does not study the potential links among different types of postponement. In practice, application of one type of postponement (e.g. manufacturing postponement) might lead to other type of postponement (e.g. ordering postponement) too. Hence, future research can study how supplier performance may have an indirect impact on some postponement applications via other types of postponement (e.g. PF→OP→MP).

This study does not discuss the complexity of applying postponement to different products, sourced form same or different suppliers, and their links with marketing and sourcing policies. This paper covers only one aspect of the supplier's performance (i.e. flexibility). Although, the significance and relevance of the supplier's flexibility factors have been justified in this research, there are other aspects of the supplier's performance which demand attention. Such aspects include the supplier's quality, capability in cost management, technology, and transport planning and management. These are among the additional influencing factors which require further study.

The outcomes of this research are coupled well with Saghiri and Hill (2014), which show the role of supplier relationship in postponement management. Supplier relationship management can be studied in future as an extensive platform which influences the buyer's strategies (i.e. postponement) and supplier performance. Regarding the respondents and sample frame, our focus has been explicitly on one person in each company from automotive manufacturing SMEs in one country. A wider range of respondents in each firm and other industries such as food, computer, pharmaceutical, and fashion should be considered as fruitful avenues for future studies.

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References

Ahire, S.L., Golhar, D.Y. Waller, M. A., 1996. Development and validation of TQM implementation constructs. Decision Sciences, 27 (1), 23-56.

Anbari, F.T., 2003. Earned value project management method and extensions. Project management journal, 34(4), 12-23.

Anderson, J.C., Gerbing, D.W., 1988. Structural equation modeling in practice: A review and recommended two-step approach. Psychological Bulletin, 103 (3), 411-423.

Armstrong, J., Overton, T., 1977. Estimating nonresponse bias in mail surveys. Journal of Marketing Research, 14 (3), 396-402.

Avittathur, B., Swamidass, P., 2007. Matching plant flexibility and supplier flexibility: lessons from small suppliers of US manufacturing plants in India. Journal of Operations Management, 25 (3), 717-735.

Bengtsson, J., Olhager, J., 2002. Valuation of product-mix flexibility using real options. International Journal of Production Economics, 78 (1), 13-28.

Bidault, F., Despres, C., Butler, C., 1998. The drivers of cooperation between buyers and suppliers for product innovation. Research Policy, 26(7), 719-732.

Boone, C. A., Craighead, C. W., Hanna, J. B., 2007. Postponement: an evolving supply chain concept. International Journal of Physical Distribution and Logistics Management, 37 (8), 594-611.

Brown, S., Bessant, J., 2003. The manufacturing strategy-capabilities links in mass customisation and agile manufacturing–an exploratory study. International Journal of Operations and Production Management, 23 (7), 707-730.

Brun, A., Zorzini, M., 2009. Evaluation of product customization strategies through modularization and postponement. International Journal of Production Economics, 120 (1), 205-220.

Boulaksil, Y., Fransoo, J.C., 2009. Order release strategies to control outsourced operations in a supply chain. International Journal of Production Economics, 119 (1), 149-160.

CAPS Research, 2013. Cross-Industry Metric Report July 2013. www.capsresearch.org/Research/Benchmarking/Cross_Industry.aspx, accessed on 15/09/2013.

Chaudhry, H., Hodge, G., 2012. Postponement and supply chain structure: cases from the textile and apparel industry. Journal of Fashion Marketing and Management, 16(1), 64-80.

Chiang, C. Y., Kocabasoglu-Hillmer, C., Suresh, N., 2012. An empirical investigation of the impact of strategic sourcing and flexibility on firm's supply chain agility. International Journal of Operations and Production Management, 32 (1), 49-78.

Chiou, J. S., Wu, L. Y., Hsu, J. C., 2002. The adoption of form postponement strategy in a global logistics system: the case of Taiwanese information technology industry. Journal of Business Logistics, 23(1), 107-124.

Chin, W. W., 1998. The Partial Least Squares Approach for Structural Equation Modeling. In Modern Methods for Business Research, edited by G. A. Marcoulides, 236-295. Lawrence Erlbaum, London.

Cohen, J., 1960. A coefficient of agreement for nominal scales. Educational and Psychological Measurement, 20 (1), 37-46.

Cronbach, L.J., Meehl, P.E., 1955. Construct validity in psychological tests. Psychological Bulletin, 52 (4), 281–302.

D'Souza, D.E., Williams, F.P., 2000. Toward a taxonomy of manufacturing flexibility dimensions. Journal of Operations Management, 18 (5), 577-593.

Davila, T., Wouters. M., 2007. An empirical test of inventory, service and cost benefits from a postponement strategy. International Journal of Production Research, 45 (10), 2245-2267.

Doherty, N.F., Ellis-Chadwick, F., 2009. Exploring the drivers, scope and perceived success of e-commerce strategies in the UK retail sector. European Journal of Marketing, 43 (9/10), 1246-1262.

Duarte, P. A. O., Raposo, M. L. B., 2010. A PLS Model to Study Brand Preference: An Application to the Mobile Phone Market. In Handbook of Partial Least Squares: Concepts, Methods and Applications, edited by V. Esposito Vinzi, W. W. Chin, J. Henseler and H. Wang, 449-485. Springer-Verlag, Berlin.

Duclos, L. K., Vokurka, R. J., Lummus, R. R., 2003. A conceptual model of supply chain flexibility. Industrial Management and Data Systems, 103 (6), 446-456.

Falk, R. F., Miller, N. B., 1992. A Primer for Soft Modeling. University of Akron Press, Ohio.

Faul, F., Erdfelder, E., Lang, A.G., Buchner, A., 2008. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods, 39 (2), 175-191.

Fornell, C., Larcker, D.F., 1981. Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18 (1), 39-50.

Forza, C., Salvador, F., Trentin, A., 2008. Form postponement effects on operational performance: a typological theory. International Journal of Operations and Production Management, 28 (11), 1067-1094.

Fu, Q., Lee, C.Y., Teo, C.P., 2012. Modified critical fractile approach for a class of partial postponement problems, International Journal of Production Economics, 136(1), 185-193.

Garavelli, A., 2003. Flexibility configurations for the supply chain management. International Journal of Production Economics, 85(2), 141-153.

Gil, N., Tommelein, I. D., Beckman, S., 2004. Postponing design processes in unpredictable environments. Research in Engineering Design, 15(3), 139-154.

Gosling, J., Purvis, L., Naim, M.M., 2010. Supply chain flexibility as a determinant of supplier selection. International Journal of Production Economics, 128(1), 11-21.

Gupta, D., Benjaafar, S., 2004. Make-to-order, make-to-stock, or delay product differentiation? A common framework for modeling and analysis. IIE Transactions, 36 (6), 529-546.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, 2014. Multivariate data analysis. Pearson Education, Essex.

Hallgren, M., Olhager, J., 2009. Flexibility configurations: Empirical analysis of volume and product mix flexibility. Omega, 37 (4), 746-756.

Handfield, R.B., Ragatz, G.L., Peterson, K., Monczka, R.M. (1999). Involving suppliers in new product development? California Management Review, 42(1), 59-82.

Hegde, V.G., Kekre, S., Rajiv, S., Tadikamalla, P.R., 2005. Customization: impact on product and process performance. Production and Operations Management, 14 (4), 388-399.

Inman, R. A., Sale, R. S., Green Jr, K. W., Whitten, D., 2011. Agile manufacturing: relation to JIT, operational performance and firm performance. Journal of Operations Management, 29 (4), 343-355.

Jack, E. P., Raturi, A., 2002. Sources of volume flexibility and their impact on performance. Journal of Operations Management, 20 (5), 519-548.

Jarvis, C. B., MacKenzie, S. B., Podsakoff, P. M., 2003. A critical review of construct indicators and measurement model misspecification in marketing and consumer research. Journal of consumer research, 30 (2), 199-218.

Kesen, S.E., Kanchanapiboon, A., Das, S.K., 2010. Evaluating supply chain flexibility with order quantity constraints and lost sales. International Journal of Production Economics, 126(2), 181-188.

Ketokivi, M., 2006. Elaborating the contingency theory of organizations: the case of manufacturing flexibility strategies. Production and Operations Management, 15 (2), 215-228.

Kisperska-Morona, D., Swierczek, A., 2011. The selected determinants of manufacturing postponement within supply chain context: An international study. International Journal of Production Economics, 133(1), 192–200.

Koste, L. L., and Malhotra, M. K., 1999. A theoretical framework for analyzing the dimensions of manufacturing flexibility. Journal of operations management, 18(1), 75-93.

Koste, L., Malhotra, M.K., Sharma, S., 2004. Measuring dimensions of manufacturing flexibility. Journal of Operations Management, 22 (2), 171-96.

Krajewski, L., Wei, J.C., Tang, L.L., 2005. Responding to schedule changes in build-to-order supply chains. Journal of Operations Management, 23(5), 452-469.

Krause, D.R., Handfield, R. B., Tyler, B.B., 2007. The relationships between supplier development, commitment, social capital accumulation and performance improvement. Journal of Operations Management, 25 (2), 528-545.

Lee, H.L., 2002. Aligning supply chain strategies with product uncertainties. California Management Review, 44 (3), 105-119.

Lee, H.L., Tang, C.S., 1997. Modeling the costs and benefits of delayed product differentiation. Management Science, 43 (1), 40-53.

Lettice, F., Wyatt, C., Evans, S., 2010. Buyer–supplier partnerships during product design and development in the global automotive sector: Who invests, in what and when? International Journal of Production Economics, 127 (2), 309-319.

Li, Q., Wu, X., Cheung, K. L., 2009. Optimal policies for inventory systems with separate delivery-request and order-quantity decisions. Operations research, 57 (3), 626-636.

Li, J., Cheng, T.C.E., Wang, S., 2007. Analysis of postponement strategy for perishable items by EOQ-based models. International Journal of Production Economics, 107 (1), 31-38.

Li, S., Rao, S.S., Ragu-Nathan, T.S., Ragu-Nathan, B., 2005. Development and validation of a measurement instrument for studying supply chain management practices. Journal of Operations Management, 23 (6), 618-641.

Lummus, R. R., Duclos, L. K., Vokurka, R. J., 2003. Supply chain flexibility: building a new model. Global Journal of Flexible Systems Management, 4 (4), 1-13.

MacCarthy, B. L., 2013. An analysis of order fulfilment approaches for delivering variety and customisation. International Journal of Production Research, 51 (23-24), 7329-7344.

MacCarthy, B., Brabazon, P.G., Bramham, J., 2003. Fundamental modes of operation for mass customization. International Journal of Production Economics, 85 (3), 289-304.

McQuitty, S., 2004. Statistical power and structural equation models in business research. Journal of Business Research, 57 (2), 175-183.

Milner, J. M., Kouvelis, P., 2002. On the complementary value of accurate demand information and production and supplier flexibility. Manufacturing and Service Operations Management, 4(2), 99-113.

Moore, G.C., Benbasat, I., 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. Information Systems Research, 2 (3), 192-222.

Mula, J., Poler, R., García-Sabater, J., Lario, F., 2006. Models for production planning under uncertainty: A review. International Journal of Production Economics, 103 (1), pp. 271-285.

Nahm, A., Solis-Galvan, L.E., Rao, S.S., Ragu-Nathan, T.S., 2002. The Q-sort method: Assessing reliability and construct validity of questionnaire items at a pre-testing stage. Journal of Modern Applied Statistical Methods, 1 (1), 114-125.

Nair, A., 2005. Linking manufacturing postponement, centralized distribution and value chain flexibility with performance. International Journal of Production Research, 43 (3), 447-463.

Narasimhan, R., Talluri, S., Das, A., 2004. Exploring flexibility and execution competencies of manufacturing firms. Journal of Operations Management, 22 (1), 91-106.

Nunnally, J., 1978. Psychometric Theory. McGraw-Hill, New York.

Pagh, J., Cooper, M.C., 1998. Supply chain postponement and speculation strategies: how to choose the right strategy. Journal of Business Logistics, 19 (2), 13-33.

Palani Rajan, P.K., Van Wie, M., Campbell, M.I., Wood, K. L., Otto, K.N., 2005. An empirical foundation for product flexibility. Design Studies, 26 (4), 405-438.

Petersen, K.J., Handfield, R.B., Ragatz, G.L., 2005. Supplier integration into new product development: coordinating product, process and supply chain design. Journal of Operations Management, 23 (3-4), 371-388.

Prasad, S., Tata, J., Madan, M., 2005. Build to order supply chains in developed and developing countries. Journal of Operations Management, 23(5), 551-568.

PricewaterhouseCoopers, 2013. Next-generation supply chains: efficient, fast and tailored. PricewaterhouseCoopers, www.pwc.com/GlobalSupplyChainSurvey2013, accessed on 15/08/2013.

Rabinovich, E., Evers, P.T., 2003. Postponement effects on inventory performance and the impact of information systems. International Journal of Logistics Management, 14 (1), 33-48.

Ringle, C.M., Wende, S., Will, A., 2005. SmartPLS 2.0 (beta). Retrieved January 11, 2008 from: http://www.smartpls.de

Ringle, C.M., Wende, S., Will, A., 2010. Finite mixture partial least squares analysis: Methodology and numerical examples. In: Vinzi, E.V., Chin, W., Henseler, J., Wang, H. (Eds), Handbook of Partial Least Squares: Concepts, Methods and Applications in Marketing and Related Fields, Springer Handbooks of Computational Statistics, Heidelberg, 195-218.

Rudberg, M., Wikner, J., 2004. Mass customization in the terms of the customer order decoupling point. Production Planning & Control, 15 (4), 445-458.

Rungtusanatham, J., Salvador, F. 2008. From Mass Production to Mass Customization: Hindrance Factors, Structural Inertia, and Transition Hazard. Production and Operations Management, 17 (3), 385–396.

Qrunfleh, S., Tarafdar, M., 2013. Lean and agile supply chain strategies and supply chain responsiveness: the role of strategic supplier partnership and postponement. Supply Chain Management: An International Journal, 18 (6), 571-582.

Saghiri, S., 2008. Time postponement: Modified models to improve delivery lead time. In: Edward, K. Blecker, T., Salvador, F., Hvam, L., Friedrich, G. (Eds), Mass Customization Service, Technical University of Denmark, Copenhagen, 171-181.

Saghiri, S., 2011. A structural approach to assessing postponement strategies: construct development and validation. International Journal of Production Research, 49 (21), 6427-6450.

Saghiri, S., and A. Hill. 2014. Supplier relationship impacts on postponement strategies. International Journal of Production Research, 52 (7), 2134-2153.

Salvador, F., Rungtusanatham, M., Forza, C., Trentin, A., 2007. Mix flexibility and volume flexibility in a build-to-order environment: Synergies and trade-offs. International Journal of Operations and Production Management. 27 (11), 1173-1191.

Samson, D., Terziovski, M., 1999. The relationship between total quality management practices and operational performance. Journal of operations management, 17 (4), 393-409.

Sanchez, A.M., Perez, M.P., 2005. Supply chain flexibility and firm performance: A conceptual model and empirical study in the automotive industry. International Journal of Operations and Production Management, 25 (7), 681-700.

Saunders, M. N., Saunders, M., Lewis, P., and Thornhill, A., 2011. Research methods for business students, Pearson Education, London.

Sawhney, R., 2006. Interplay between uncertainty and flexibility across the value-chain: towards a transformation model of manufacturing flexibility. Journal of Operations Management, 24 (5), 476-493.

Sharda, B., Akiya, N., 2012. Selecting make-to-stock and postponement policies for different products in a chemical plant: A case study using discrete event simulation. International Journal of Production Economics, 136(1), 161-171.

Sharifi, H., Zhang, Z., 1999. A methodology for achieving agility in manufacturing organisations: An introduction. International Journal of Production Economics, 62 (1-2), 7-22.

Schentler, P., 2009. Implementing mass customisation in the automotive industry: an analysis of requirements for procurement and procurement objects. International Journal of Automotive Technology and Management, 9 (3), 260-274.

Skipworth, H., Harrison, A., 2004. Implications of form postponement to manufacturing: a case study. International Journal of Production Research, 42 (10), 2063-2081.

Squire, B., Cousins, P. D., Lawson, B., Brown, S., 2009. The effect of supplier manufacturing capabilities on buyer responsiveness: the role of collaboration. International Journal of Operations and Production Management, 29 (8), 766-788.

Straub, D., 1989. Validating instruments in MIS research. MIS Quarterly, 13 (2), 1, 47-169.

Su, J.C.P., Chang, Y.L., Ferguson, M., 2005. Evaluation of postponement structures to accommodate mass customization. Journal of Operations Management, 23 (3-4), 305-318.

Swaminathan, J.M., Lee, H.L., 2003. Design for postponement. In: Graves, S., de Kok, T. (Eds), Handbook of OR/MS on Supply Chain Management, North-Holland, Amsterdam, 199-226.

Tan, K.C., 2001. A structural equation model of new product design and development. Decision Sciences, 32 (2), 195-226.

Tan, C.L., Vonderembse, M.A., 2006. Mediating effects of computer-aided design usage: From concurrent engineering to product development performance. Journal of Operations Management, 24 (5), 494-510.

Tharenou, P., Donohue, R. and Cooper, B., 2007. Management Research Methods. Cambridge University Press, Melbourne.

Tong, C., 2010. Order postponement in a supply chain in the presence of exponential demand with gamma prior. Operations Research Letters, 38 (2), 97-103.

Trentin, A., 2011. Third-party logistics providers offering form postponement services: value propositions and organisational approaches. International Journal of Production Research, 49 (6), 1685-1712.

Trentin, A., Forza, C., 2010. Design for form postponement: do not overlook organization design. International Journal of Operations and Production Management, 30(4), 338-364.

Trentin, A., Salvador, F., Forza, C., Rungtusanatham, M.J., 2011. Operationalising form postponement from a decision-making perspective. International Journal of Production Research, 49 (7), 1977-1999.

Tsubakitani, S., Deckro, R. F., 1990. A heuristic for multi-project scheduling with limited resources in the housing industry. European Journal of Operational Research, 49 (1), 80-91.

UN, 2002. The international standard of industrial classification of all economic activities: ISIC Revision 3.1, available at: unstats.un.org/unsd/statcom/doc02/isic.pdf, visited on 10/10/2009.

Van Hoek, R.I., 1998. Reconfiguring the supply chain to implement postponed manufacturing. The International Journal of Logistics Management, 9 (1), 95-110.

Van Hoek, R.I., 2001. The rediscovery of postponement: a literature review and directions for research. Journal of Operations Management, 19 (2), 161-184.

Vokurka, R.J., O'Leary-Kelly, S.W., 2000. A review of empirical research on manufacturing flexibility. Journal of Operations Management, 18 (4), 485-501.

Waller, M.A., Dabholkar, P.A., Gentry, J.J., 2000. Postponement, product customization, and market-oriented supply chain management. Journal of Business Logistics, 21 (2), 133-159.

Wikner, J., Rudberg, M., 2005. Integrating production and engineering perspectives on the customer order decoupling point. International Journal of Operations and Production Management, 25 (7), 623–641.

Wong, H., Potter, A., Naim, M., 2011. Evaluation of postponement in the soluble coffee supply chain: a case study. International Journal of Production Economics, 131 (1), 355-364.

Yang, B., Burns, N., 2003. Implications of postponement for the supply chain. International Journal of Production Research, 41 (9), 2075-2090.

Yang, B., Burns, N.D., Backhouse, C.J., 2004a. Management of uncertainty through postponement. International Journal of Production Research, 42 (6), 1049-1064.

Yang, B., Burns, N.D., Backhouse, C.J., 2004b. Postponement: A review and an integrated framework. International Journal of Operations and Production Management, 24 (5), 468-487.

Yang, B., Burns, N.D., Backhouse, C.J., 2005a. An empirical investigation into the barriers to postponement. International Journal of Production Research, 43 (5), 991-1005.

Yang, B., Yang, Y., Wijngaard, J., 2007. Postponement: An inter-organizational perspective. International Journal of Production Research, 45 (4), 971-988.

Yang, J., Wong, C.Y., Lai, K., Ntoko, A., 2009. The antecedents of dyadic quality performance and its effect on buyer–supplier relationship improvement. International Journal of Production Economics, 120(1), 243-251.

Yang, B., Yang, Y., Wijngaard, J., 2005b. Impact of postponement on transport: an environmental perspective. International Journal of Logistics Management, 16 (2), 192-204.

Yeung, J., Selen, W., Deming, Z., Min, Z., 2007. Postponement Strategy from a Supply Chain Perspective: Cases from China. International Journal of Physical Distribution and Logistics Management, 37 (4), 331-356.

Zhang, Q., Vonderembse, M. A., Lim, J. S., 2003. Manufacturing flexibility: defining and analyzing relationships among competence, capability, and customer satisfaction. Journal of Operations Management, 21(2), 173-191.

Appendix 1: Measured variables for the postponement research constructs

A number of recent studies (Waller et al., 2000; Chiou et al., 2002; Rabinovich and Evers, 2003ł; Li et al., 2005; Nair, 2005; Yang et al., 2005a; Davila and Wouters, 2007; Kisperska-Morona and Swierczek, 2011; Trentin et al., 2011) has provided various measured variables for postponement. Saghiri (2011) has reviewed those variables and provided a detailed measurement instrument for postponement application level, which are briefly described below:

- *Length of time of the postponement*: the more the activity that is delayed in terms of time, the higher the level of postponement implemented. The impact of the time length of postponement on its cost/benefit has been outlined by Lee and Tang (1997). To reflect the postponement status in a firm as a whole – rather than for individual activity or product – the *average of delays in postponements applied to activities/products* is considered as a measured variable.
- *Share of activities which are delayed:* the higher the number of delayed activities (compared to the total number of actives for a particular operation), the more the postponement is put into operation.
- *Overall size (in terms of time) of the delayed activities* (i.e. duration of the delayed activities) compared to the total time spent in an operation (e.g. product design): the greater the duration of the delayed activities, the higher the level of postponement applied. Postponement is all about delaying activities, where an activity consists of time and value. Hence, postponement of an activity means delaying a package of time (e.g. a 45 minute task) and value (e.g. a $3 value-adding task). Apart from operations management, the project management literature also supports this view to activities and their postponement (Anbari, 2003). Activity duration has been considered as a measure of postponement implicitly in a number of studies such as Tsubakitani and Deckro (1990) and Trentin (2011). Accordingly, it makes sense to say that the higher the duration of a delayed task

the higher the level of postponement. This rationale is also consistent with the role we expect from postponement in mitigating risk. If lengthy activities are done in advance (i.e. not postponed) and the product output does not match the customer order that arrives later, a prolonged rework may be required. To alleviate this risk, more work (in terms of operation time) can be delayed. To reflect the postponement status in a firm as a whole (rather than for an individual activity or product), this measured variable should be considered as an average for all products in a firm.

- *Total value of the delayed activities:* the more the adding of value is delayed the higher the level of postponement that is applied. This variable is defined based on the similar rationale provided for the third variable, where instead of time, the value added by activities is considered. Lee and Tang (1997) analyze this variable of postponement in detail, and argue that to increase the level of postponement the value of the delayed product differentiation activity should increase.
- *Share of products which postponement applies to:* the higher the number of products (compared to all products in a firm) that postponement applies to, the more the postponement strategy is deployed in an operations system.
- *Share of customers for which postponement is used*: the application of a postponement strategy for a wide range of customers indicates a high level of implementation of postponement.
- *Deployment of the postponement strategy in the firm's planning activities*: the more that postponement is considered in a firm's planning, the higher the level of postponement implementation that is expected. The highest level can be achieved when postponement is considered in the strategic planning of a firm. Deployment of a strategy or policy in the firm’s decision making and planning processes has typically been one of the measures of the implementation level of that strategy (see, for example: Ahire et al. 1996, Samson and

> Terziovski 1999, Doherty and Ellis-Chadwick 2009). When an operations strategy is embedded in planning decisions (including production planning, resource planning, capacity allocation planning, and ultimately strategic planning), it can be an indication of the implementation level of that strategy.

It should be noted that these measured variables are reflective in nature, and are manifestations of postponement constructs. Postponement concept can be reflected in at least some of the measured variables, which meet Jarvis et al. (2003) criteria for reflective constructs: *(a)* changes in the postponement level causes changes in some or all measured variables (e.g. decision on applying a higher level of manufacturing postponement may lead to application of postponement to more products and more manufacturing activities); *(b)* dropping a measured variable does not change the conceptual domain of postponement (e.g. when MP6 is dropped, manufacturing postponement still retains its identity); *(c)* measured variables of each construct have a high level of correlation; and *(d)* the measured variables are expected to have similar antecedences (e.g. supplier flexibility).

Based upon these seven measured variables suggested for postponement, seven initial items for each type of postponement construct were identified as follows.

	Measured items↓ scales→	(1: Lowest)	(2)	(3)	(4)	(5: Highest)
Product Design Postponement	DP1: Average postponement time in product design	no delay in development/ modification of product design				delay until receiving the latest customer instruction✧
	DP2: Number of postponed product design activities	Less than 20% of activities				More than 80% of activities
	DP3: The amount of postponed design works (<u>in terms of time</u>) compared to the total time spent in design	Less than 20% of time				More than 80% of time
	*DP4***: The amount of postponed design works (in terms of value they add) compared to total value made in the product design	Less than 20% of added value				More than 80% of added value
	DP5: Percentage of products, postponement is applied to their design	Less than 20% of products				More than 80% of products
	*DP6**: Percentage of customers, postponement in design is applied to their product(s)	Less than 20% of customers				More than 80% of customers
	*DP7**: Level of deployment of postponement in the firm's design planning tasks/decisions	Postponement is only an operational decision, made by product design engineers				Postponement is embedded in the top management's strategic decisions on product design
Ordering Postponement	OP1: Average postponement time in ordering purchasing items	no delay				delay until receiving the latest customer instruction ✧
	OP2: Number of postponed ordering activities	Less than 20% of activities				More than 80% of activities
	OP3: The amount of postponed ordering works (<u>in terms of time</u>) compared to the total time spent in ordering operation	Less than 20% of time				More than 80% of time
	*OP4***: The amount of postponed ordering works (in terms of value they add) compared to total value made in the ordering operations	Less than 20% of added value				More than 80% of added value
	OP5: Percentage of products, postponement is applied to their ordering operations	Less than 20% of products				More than 80% of products
	*OP6**: Percentage of customers, postponement in ordering is applied to their product(s)	Less than 20% of customers				More than 80% of customers
	*OP7**: Level of deployment of postponement in the firm's ordering planning tasks/decisions	Postponement is only an operational decision, made by the firm's buyers				Postponement is embedded in the top management's strategic decisions on sourcing & supply
Manufacturing Postponement	MP1: Average postponement time in manufacturing	no delay				delay until receiving the latest customer instruction ✧
	MP2: Number of postponed manufacturing activities.	Less than 20% of activities				More than 80% of activities
	MP3: The amount of postponed manufacturing works (<u>in terms of time</u>) compared to the total time spent in ordering operation	Less than 20% of time				More than 80% of time
	MP4: The amount of postponed manufacturing works (in terms of value they add) compared to total value made in the manufacturing	Less than 20% of added value				More than 80% of added value
	MP5: Percentage of products, postponement is applied to their manufacturing operations	Less than 20% of products				More than 80% of products
	*MP6**: Percentage of customers, postponement in manufacturing is applied to their product(s)	Less than 20% of customers				More than 80% of customers
	*MP7**: Level of deployment of postponement in the firm's manufacturing planning tasks/decisions	Postponement is only an operational decision, made by production planners				Postponement is embedded in the top management's strategic production & capacity decisions

*The item was dropped during the Q-sort pre-pilot stage. ** The item was dropped during the pilot study.

✧ Any request from the customer about any change in the product is considered as customer instruction too.

Appendix 2: Measured variables for the supplier flexibility research constructs.

	Measured items↓ scales→	(1)	(2)	(3)	(4)	(5)
Volume Flexibility (VF)	VF1- Ability to change the aggregate output volume frequently to meet demand fluctuations (R-N)	Very low				Very high
	VF2- Ability to provide a wide range of output volumes at which the company can perform (R-H)	Very low				Very high
	VF3- Ability to change output volume quickly and easily (M)	Very low				Very high
	*VF4***- Cost of changing volume of output (M)	Very low				Very high
	VF5- Operations efficiency at different output volumes (U)	Very low				Very high
	VF6- Stability of the products quality at different production volumes (U)	Very low				Very high
	*VF7**- Quickness of changing the output volume (M)	Very low				Very high
	*VF8**- Operation profitability at different production volumes (U)	Very low				Very high
Mix Flexibility (MF)	MF1- Ability to vary product combinations frequently to meet demand fluctuations (R-N)	Very low				Very high
	MF2- Ability to provide high differentiation between different products mixes (R-H)	Very low				Very high
	MF3- Ability to change product mix quickly and easily (M)	Very low				Very high
	*MF4***- Cost of changing product mix (M)	Very low				Very high
	MF5- Operations efficiency at different product mixes (U)	Very low				Very high
	MF6- Stability of the products quality in different product mixes (U)	Very low				Very high
	*MF7**- Quickness of changing product mix (M)	Very low				Very high
	*MF8**- Operation profitability when product mix changes (U)	Very low				Very high
New Product Development Flexibility (NF)	NF1- Ability to introduce high number of new products into production each year (R-N)	Very low				Very high
	NF2- Dissimilarity (in terms of design, material and manufacturing process) of new products with existing products (R-H)	Very low				Very high
	NF3- Quickness of new product development and full-scale production for that (M)	Very low				Very high
	*NF4***- Start-up cost of introducing new products into a full-scale production (M)	Very low				Very high
	NF5- Stability of the production system efficiency when a new product is introduced to the production system (U)	Very low				Very high
	*NF6***- Stability of the quality of existing products when a new product is introduced to the production system (U)	Very low				Very high
	*NF7**- Stability of the average cost of products when a new product is introduced into the production system (U)	Very low				Very high
Product Modification Flexibility (PF)	PF1- Ability to modify different features of different products to the customer's specifications (R-N)	Very low				Very high
	PF2- Ability to make substantial changes in product modifications - compared to existing products (R-H)	Very low				Very high
	PF3- Quickness and Ease of product modification and changes in production line for the modified product (M)	Very low				Very high
	*PF4***- Low cost of product modification and introducing it into a full-scale production (M)	Very low				Very high
	PF5- Stability of the production system efficiency when a modified product is introduced to the production system (U)	Very low				Very high
	*PF6***- Stability of quality of existing products when a modified product is introduced to the production system (U)	Very low				Very high
	*PF7**- Ability to modify different features of existing products frequent (R-N)	Very low				Very high
	*PF8**- Ease of product modifications (M)	Very low				Very high
	*PF9**- Stability of the average cost of products when a modified product is introduced into the production system (U)	Very low				Very high

Note: Each items is measured based on the average performance of the (up to) top three major suppliers of the firm.
*The item was dropped during the Q-sort pre-pilot stage. ** The item was dropped during the pilot study.

Table 1: Sample profile.

	Large-scale survey	*Pilot study*
ISIC Group:*		
D17: Manufacturing - textiles	33	3
D25: Manufacturing - rubber and plastics products	31	7
D26: Manufacturing - other, non-metallic mineral products	28	3
D27: Manufacturing - basic metals	22	4
D28: Manufacturing - fabricated metal products	28	8
D31: Manufacturing - electrical machinery and apparatus	29	9
D32: Manufacturing - communication equipment	20	9
D34: Manufacturing - motor vehicles, and trailers/semi-trailers	28	2
Response mode		
Manual	117	19
Email	102	26

See UN (2002)

Table 2: Intercorrelations, AVE and reliabilities (square-root of AVE in italic on diagonal).

Constructs	AVE	CA	CR	Intercorrelations						
				DP	MF	MP	NF	OP	PF	VF
DP	0.822	0.928	0.949	*0.907*						
MF	0.857	0.958	0.968	0.059	*0.926*					
MP	0.790	0.934	0.950	-0.073	0.369*	*0.889*				
NF	0.795	0.916	0.939	0.256*	0.083	-0.074	*0.892*			
OP	0.879	0.954	0.967	0.528*	0.321*	0.205*	0.183*	*0.936*		
PF	0.836	0.935	0.953	0.311*	0.073	-0.106	0.171*	0.211*	*0.914*	
VF	0.835	0.951	0.962	0.153*	0.208*	0.310*	0.020	0.345*	0.157*	*0.914*

Note: CA= Cronbach's α; CR=composite reliability; AVE=average variance extracted.
* : Significant at $p<0.05$

Table 3: Loadings and cross-loadings in the final research model

	Loading	t-value	Std. Err.	DP	MF	MP	NF	OP	PF	VF
DP1	0.910	47.791	0.019	**0.910**	0.048	-0.103	0.215	0.453	0.286	0.069
DP2	0.928	49.653	0.018	**0.928**	0.099	-0.049	0.251	0.460	0.277	0.146
DP3	0.931	64.254	0.014	**0.931**	0.073	-0.032	0.199	0.457	0.250	0.176
DP5	0.857	23.281	0.036	**0.857**	0.005	-0.074	0.256	0.527	0.305	0.163
MF1	0.927	66.749	0.013	0.081	**0.927**	0.345	0.106	0.324	0.090	0.262
MF2	0.945	91.821	0.010	0.018	**0.945**	0.390	0.071	0.308	0.026	0.146
MF3	0.891	40.881	0.021	0.041	**0.891**	0.322	0.040	0.288	0.053	0.218
MF5	0.943	90.327	0.010	0.075	**0.943**	0.335	0.130	0.302	0.109	0.190
MF6	0.923	38.860	0.023	0.058	**0.923**	0.310	0.029	0.259	0.063	0.140
MP1	0.870	28.674	0.030	-0.095	0.351	**0.870**	-0.104	0.178	-0.064	0.224
MP2	0.917	64.077	0.014	-0.008	0.375	**0.917**	-0.054	0.226	-0.151	0.321
MP3	0.893	43.458	0.020	-0.046	0.252	**0.893**	-0.062	0.173	-0.066	0.295
MP4	0.877	36.118	0.024	-0.055	0.276	**0.877**	-0.104	0.214	-0.142	0.247
MP5	0.887	38.720	0.022	-0.121	0.366	**0.887**	-0.017	0.123	-0.049	0.283
NF1	0.881	23.044	0.038	0.259	0.160	-0.022	**0.881**	0.235	0.237	0.114
NF2	0.908	13.151	0.069	0.162	0.021	-0.108	**0.908**	0.094	0.079	-0.090
NF3	0.886	16.121	0.054	0.237	0.027	-0.059	**0.886**	0.121	0.098	-0.074
NF5	0.891	14.891	0.059	0.222	0.046	-0.101	**0.891**	0.156	0.145	0.058
OP1	0.931	48.060	0.019	0.484	0.274	0.169	0.187	**0.931**	0.209	0.276
OP2	0.940	64.156	0.014	0.494	0.320	0.206	0.172	**0.940**	0.210	0.335
OP3	0.949	82.592	0.011	0.492	0.292	0.224	0.155	**0.949**	0.183	0.367
OP5	0.929	56.700	0.016	0.508	0.318	0.169	0.171	**0.929**	0.188	0.313
PF1	0.919	59.303	0.015	0.289	0.083	-0.078	0.163	0.194	**0.919**	0.137
PF2	0.918	41.063	0.022	0.330	0.087	-0.081	0.123	0.230	**0.918**	0.179
PF3	0.926	47.834	0.019	0.285	0.087	-0.109	0.170	0.189	**0.926**	0.142
PF5	0.894	28.409	0.031	0.203	-0.017	-0.135	0.184	0.135	**0.894**	0.098
VF1	0.903	35.274	0.025	0.137	0.222	0.317	0.019	0.270	0.082	**0.903**
VF2	0.922	57.070	0.016	0.106	0.206	0.287	0.014	0.348	0.149	**0.922**
VF3	0.927	74.283	0.012	0.152	0.174	0.266	0.052	0.333	0.206	**0.927**
VF5	0.913	62.298	0.014	0.175	0.153	0.265	0.014	0.315	0.147	**0.913**
VF6	0.902	43.806	0.020	0.130	0.193	0.283	-0.010	0.306	0.130	**0.902**

Figure 1: Research model and hypotheses.

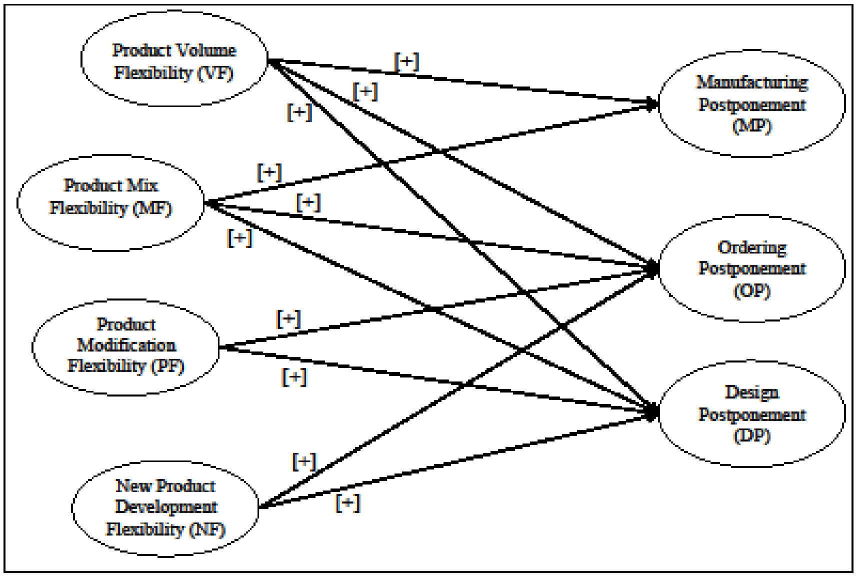

Figure 2: Overview of instrument development process in the study.

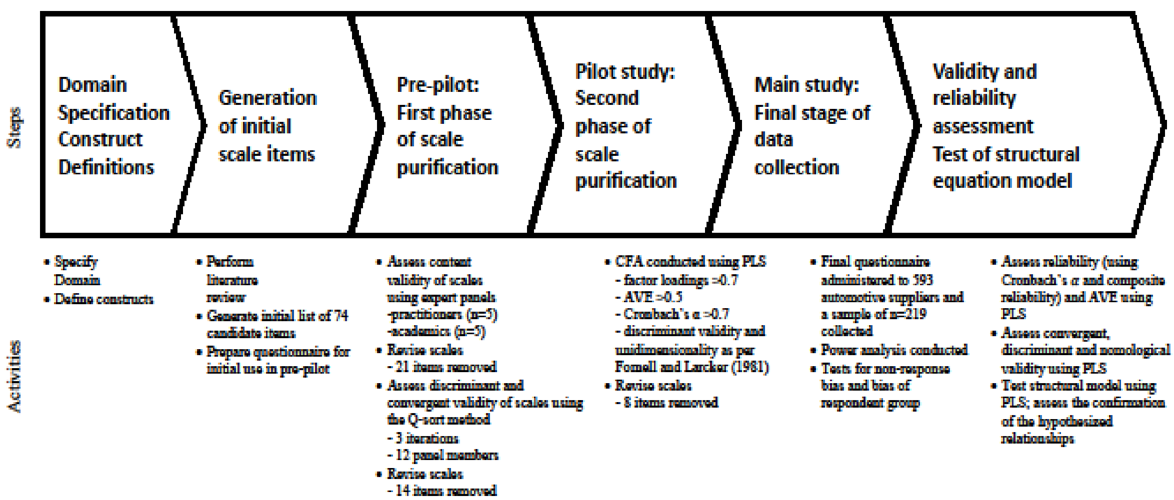

Figure 3: Results of testing the final structural model (*: p<0.05; **: p<.01; ***: p<.001).

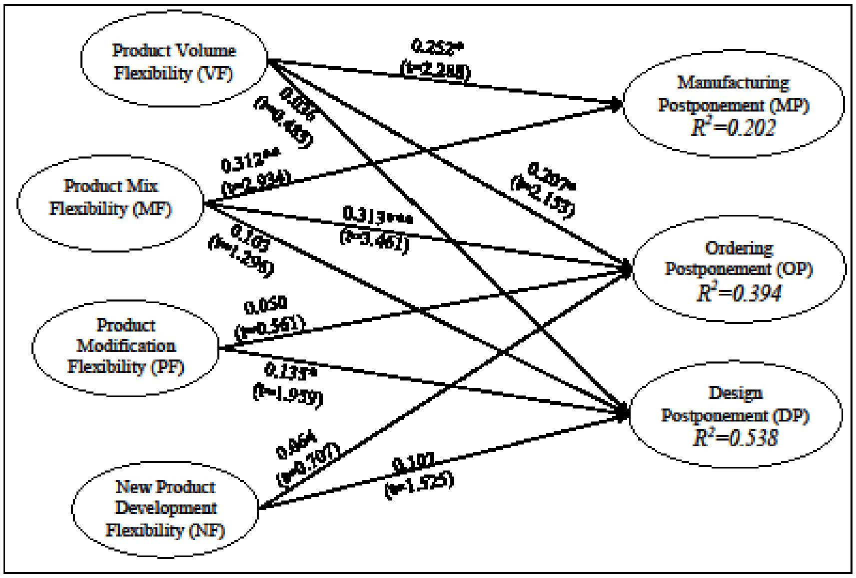

Figure 4: The range and breadth of the supplier's flexibility impacts on postponement strategies.