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**Postponement: an inter-organisational perspective**

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**Postponement: an inter-organisational perspective**

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## Postponement: an inter-organisational perspective

**Keyword(s):** postponement, organisational structure, capacity planning

**Abstract:** *In view of the slow rate of postponement applications, this paper attempts to examine postponement strategies from an inter-organisational perspective. The paper first reviews the literature on different postponement strategies (including logistics postponement, production postponement, purchasing postponement and product development postponement) mainly within the context of supply chain or supply network. Then, two research questions are formulated. This is followed by the investigation into the intra-organisational structure and capacity planning in postponement applications. The paper concludes with some suggestions for further research.*

### 1. Introduction

In the current business environment, there is an increasing tendency towards the outsourcing and globalisation of different types of operations. Many manufacturers are shifting production and sourcing to countries with lower labour costs often far from primary consumer markets. Some of them have even started to evaluate whether they must continue to assemble products themselves or whether they can outsource production entirely (Liker and Choi, 2004). The extension of production and distribution across diverse national boundaries does not merely reflect the development of global supply chains but also new orientation of companies towards core competencies. This reflects the idea of networks of relationships (Harland, 1996), where business organizations are moving to a borderless inter-dependence business

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3 environment. Consequently, a company can not develop or exploit its own resources  
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5 except in conjunction with of others. The optimisation of such a networked system is  
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7 determined by the effectiveness of supply chain relationships as well as delivery  
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9 performance and total supply chain costs. This paper contributes to the understanding  
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11 of this issue by focusing on an increasingly supply chain- and network- oriented  
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13 concept – postponement.  
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20 Postponement may be defined as a dimension of sequence and timing based on the  
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22 concept of substitutability (Bucklin, 1965), subsequently maintaining the opportunity  
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24 of interchangeability and irreversibility. The benefits of postponement mainly come  
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26 from changing the sequence of activities or delaying them in time: (1). Changing the  
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28 sequence of activities could lead to a demand aggregation effect where the planning is  
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30 based on aggregated demand (Zinn, 1990). The demand aggregation effect reduces the  
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32 forecasting horizon, resulting in better resource planning and allocation. It also  
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34 reduces risk by pooling the variance of the demand, which is aligned with the concept  
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36 of centralisation of inventories (Maister, 1976; Eppen, 1979). (2). Delaying activities  
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38 in time enables companies to learn from the behaviour of the demand and other  
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40 environmental factors (Aviv and Federgruen, 2001). This provides an opportunity to  
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42 incorporate more actual information (e.g. about customer demands) into companies'  
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44 decision-making processes (Lee, 1998). The forecast can also be improved after  
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46 observing some actual demand (Fisher and Raman, 1996). In this regard,  
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48 postponement may be viewed as an approach for synchronising the supply chain  
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50 (Goldratt, 1990). It introduces time buffers at those points where the lack of  
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52 information might destroy the synchronised flow. That is, it provides more time for  
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54 those processes which require further information. Much has been written in the  
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3 literature on how to implement postponement by re-designing product architectures  
4 and/or manufacturing processes. However, the implementation of postponement  
5 strategies also affects the structure of the supply chain, since postponed activities will  
6 be most likely to be placed closer to the time and locus of consumption. Consequently,  
7 these effects can be reflected in the design of supply chains from product development,  
8 to sourcing and on to final distribution of products. In recent times, the development of  
9 a postponement strategy has been managed from an integral supply chain perspective  
10 (Feitzinger and Lee, 1997; Pagh and Cooper, 1998; Yang and Burns, 2003). This view  
11 opens up more opportunities for postponement applications, since a company may  
12 make up a delay in the speed of one of the supply chain areas (resulting from a  
13 postponement strategy) by improving the others.  
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32 Now that the need for a higher level of postponement across supply chains is  
33 increasingly accepted, the challenge of implementation becomes critical. Despite the  
34 conceptual underpinnings of postponement, its applications are still not as widespread  
35 as expected. Surveying more than 350 supply chain professionals at mid-sized and  
36 large companies, Oracle Corporation (2004) finds that postponement is an  
37 underutilised concept. In a more recent questionnaire survey across the food, clothing,  
38 electronics and automotive industries, Yang *et al.* (2005) find most managers expect  
39 postponement to be less used in three years. They further reveal that most significant  
40 difficulties in postponement implementation are related to how a company manages its  
41 external networks (suppliers or customers). This concurs with Waller *et al.* (2000) who  
42 argue that, as an inter-organisational concept, postponement has received little  
43 attention. To address this, this paper attempts to investigate postponement strategies in  
44 the context of supply chains or supply networks. The paper precedes by reviewing the  
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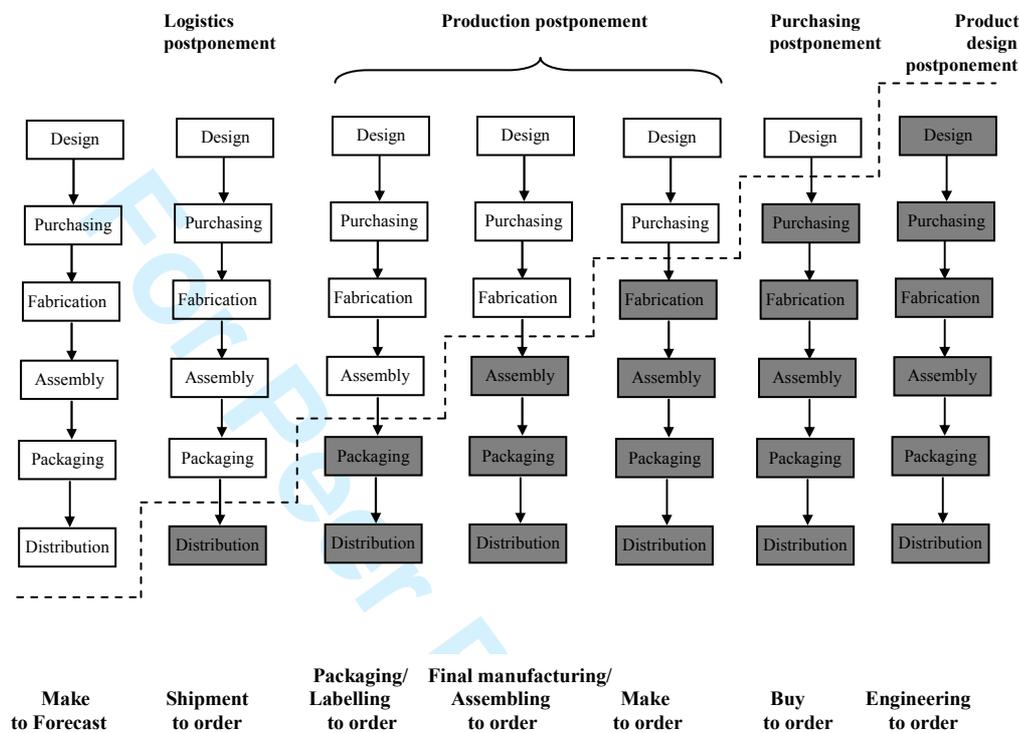
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3 literature on postponement mainly from an inter-organisational perspective. Then, two  
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5 research questions are formulated. This is followed by the investigation into the inter-  
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7 organisational structure and capacity planning in postponement applications. The  
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9 paper concludes with some suggestions for further research.  
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## 12 13 14 15 **2. Literature Review**

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17 Postponement, once only a strategy for differentiating a product, has matured into a  
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19 way of global thinking in product design, production, logistics and marketing  
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21 (Bowersox and Morash, 1989; Van Hoek, 2001). A main distinctive principle of  
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23 postponement is to obtain more actual information in order to define and translate the  
24  
25 customer's needs into a concrete product or service specification. Four types of  
26  
27 postponement strategies can be formulated based on the state of inventories (see  
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29 figure 1): (1). Logistics postponement (finished goods): It seeks postponement  
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31 opportunities in the final movement of products, which have taken their final form in  
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33 advance of customer orders, to the customer. This is facilitated by the emergence of e-  
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35 commerce, where virtual inventories are independent on the inventories' physical  
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37 location at the time orders are placed. Internet retailers can thus manage inventory to  
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39 fulfil customer orders by postponing the location of inventory to upstream supply  
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41 chain echelons (their suppliers) until the arrival of customer orders (Bailey and  
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43 Rabinovich, 2005). In practice, Amazon.com usually chooses to work closely with its  
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45 vendors and the United States Postal Service to ensure that it can use such a  
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47 postponement strategy (drop-shipping) to handle the volume and delivery timing of a  
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49 popular product; (2). Production postponement (work-in-process): Keeping  
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51 undifferentiated semi-finished products for as long as possible will increase a  
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53 company's flexibility in response to changes in customer demand. In addition, the  
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3 company can reduce supply chain cost by keeping undifferentiated inventories, e.g. on  
4 a basis of material profiles (Umble and Srikanth, 1990; Yang and Burns, 2003); (3)  
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6 Purchasing postponement (components or raw materials): This strategy allows  
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8 companies to postpone the purchase of incoming components or raw materials until  
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10 demand is known, eliminating the risk of holding obsolete inventory in stock. The  
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12 strategy, together with production postponement, allows companies to avoid building  
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14 up inventories of finished goods in anticipation of future orders. In parallel with this  
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16 postponement strategy, the practice of vendor managed inventories (VMI) calls for  
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18 the vendors to take responsibility for replenishing the retailer's customers, thus  
19  
20 delaying the ownership of inventory; and (4). Product development postponement (no  
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22 inventory): One such case is the Drive Test system from Agilent Technologies, which  
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24 measures the coverage, effectiveness and quality of wireless phone base stations  
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26 (Elliott and Hughes, 2000). They face the challenge of bringing together three  
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28 different sets of rapidly changing knowledge to provide a valuable test solution for  
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30 cell manufacturers and operators. For example, new and existing wireless  
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32 communication standards emerge rapidly. Traditionally, they have focused on  
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34 maximising resource utilisation over all parts of the project while often not properly  
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36 co-ordinating different knowledge streams. The controller has to be re-developed later  
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38 on due to the very latest information. Following the postponement philosophy, they  
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40 assign most resources to the riskiest and longest lead-time knowledge development  
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42 first, and postpone low-risk subprojects as late as possible so that all pieces of the  
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44 total knowledge package come together simultaneously. The lower risk subprojects  
45  
46 also take into account the latest knowledge from high-risk subprojects, suppliers,  
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48 customers and other sources to minimise integration risks. The dotted line in Figure 1  
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50 reflects how postponement is associated with the customer decoupling point (CODP),  
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where in the supply chain the customer order penetrates and that distinguishes forecast and order-driven activities.



**Figure 1. Postponement strategies and positioning the customer order decoupling point (adapted from Yang and Burns 2003)**

Too often, postponed activities may not happen within an organisation within unified ownership. Success of a postponement strategy increasingly relies on a supply chain wide thinking. For example, production and purchasing postponement should be exploited to reduce inventory levels throughout the supply chain rather than simply shift inventory burden to the lower tiers of the chain. This is attributed both to shorter forecast cycles and shifting inventory upstream the supply chain to a less expensive generic state. Therefore, in postponement applications, downstream players must be concerned about possible order fulfilment problems occurring upstream in their supply chains. Otherwise, downstream players order as late as possible to avoid the lack of flexibility associated with giving an order at an early stage, while their

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3 suppliers do not have the opportunity to better plan and schedule their production and  
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5 distribution (e.g. even out operation load), and the utilisation of their resources system  
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7 drops to the disadvantage of the performance of the whole supply chain. In a supply  
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9 chain setting, postponement draws attention also because it is relevant to the  
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11 positioning the customer order decoupling point (Yang and Burns, 2003), as  
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13 mentioned earlier. Similarly, postponement may contribute to a globalisation strategy,  
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15 where the organizational type can be centralised upstream whereas a decentralized  
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17 approach is for downstream activities focusing on delivering a customized product on  
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19 time. In the apparel-manufacturing industry, Jin (2004) also exploits how apply  
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21 postponement to achieve benefits of both global and domestic sourcing methods, thus  
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23 reducing inventory risk arising from market uncertainties. However, this stream of  
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25 research mainly focuses on the spatial/functional dimension of the supply chain and  
26  
27 fails to address its organisational dynamics. Determining the right level of  
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29 postponement depends not only on appropriate analysis of customer requirements but  
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31 also existing organisational capabilities. Here we pose the following research  
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33 question: *what organisational structures may facilitate the implementation of*  
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35 *postponement in an inter-organisational context?*  
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46 Further, as demonstrated in our classification of postponement previously,  
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48 postponement may be considered as a way of substituting additional capacity for  
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50 investment in inventory. Postponement delays the irreversible commitment of capacity  
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52 to certain activities until the last possible moment. It may, to some extent, improve the  
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54 utilisation of capacity through the effective re-allocation of assets or resources to the  
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56 appropriation locations in the supply chain (Van Hoek *et al.*, 1999). However,  
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58 optimisation models and techniques for resource allocation and capacity utilisation  
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3 under conditions of uncertainty, bottleneck and congestion are typically encountered  
4 in postponement strategies. Postponement highlights a need for greater customer-  
5 central activities, thus drastically reducing the possibility to optimise the process in  
6 general (Olhager, 2003). Given the variability of customer demands, this implies a  
7 reduction in the utilisation of resources. For example, production postponement may  
8 require short delivery times, changeovers increase and production batch decrease to  
9 provide more product variety over shorter periods. It may also require more resources  
10 to provide quick throughput times, since throughput can only be satisfied by  
11 production resources and not inventory of final goods. Too often the implementation  
12 of postponement requires certain levels of capacity and resources to be reserved for  
13 those activities that benefit most from the additional information gained by the delay.  
14 Capability of the postponed transformation process to respond to high demand  
15 variability requires excess capacity and high throughput efficiency (Skipworth and  
16 Harrison, 2004). This requires creating and maintaining slack resources, thus placing  
17 enormous demands on capacity planning. That is, a challenge arises regarding *how to*  
18 *determine optimal resource requirements to support a postponement strategy.*

### 3 Organisation Structure

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46 It has been suggested in the literature that postponement is relevant to networked and  
47 modular organisational forms (Van Hoek *et al.*, 1998 and Yang *et al.*, 2004a). Van  
48 Hoek *et al.* (1998) reveal that the implementation of postponement strategies may be  
49 key to the creation of a network organization, which can in turn compete on all three  
50 dimensions of global competition: global efficiency, local responsiveness and  
51 worldwide learning. In fact, the principle of postponement generally provides a basis  
52 for understanding the evolution of different channel structures. In comparing the  
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3 internationalization literature and the network literature, Ford (2002) notes that an  
4 international business has its roots in speculative production and the need to export or  
5 dispose of existing production overseas to achieve economies of scale or to generate a  
6 return on development expenditure, while a network organization is concerned with  
7 many new types of companies entering the network to provide a wider range of  
8 offerings, relating much more closely to postponement and flexibility in production.  
9 Note that the accelerated infusion of e-commerce (e.g. e-marketplaces) into business  
10 operations is drastically changing the way businesses operate. In e-commerce, buyers  
11 and suppliers are offered a chance to easily find a partner for spot purchases. The  
12 resultant more visibility implies more potential partners in a less stable network. To  
13 complicate matters further, switching costs in e-commerce are likely to be lower than  
14 they are for traditional ways of doing business. The buyer can often switch suppliers  
15 with just a few mouse clicks. Therefore, postponement generally reflects the push  
16 towards the idea of companies as networked organisations in the current business  
17 environment, where profits are increasingly gained from collaborations both within an  
18 organisation and across organisational borders.

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44 Considering the role of product and production modularisation in a successful  
45 postponement strategy, modular organisations also come no surprise in postponement  
46 (for a thorough discussion see Yang *et al.*, 2004a). A recent development on  
47 postponement research - exploiting postponement in response to uncertainty (Yang *et al.*,  
48 2004b), also brings its relevance and interest to modular organisations.  
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3 modular organisations are characterised by different elements like dynamic teaming  
4 (Tu *et al.*, 2004), dynamic community (Galunic and Eisenhardt, 2001), and contract  
5 manufacturing, alternative work arrangement and alliance (Schilling and Steensma,  
6 2001). Obviously, the above organisational structures all have potential of  
7 recombining their resources in a variety of configurations to rapidly respond to  
8 changing business conditions (Galunic and Eisenhardt, 2001). Therefore, they should  
9 not merely positively link to postponement, but all other strategies which rely on  
10 gaining access to necessary components through strategic alliances and outsourcing.  
11 Here, we consider more specific inter-organisational dimensions in different  
12 postponement strategies. To facilitate our discussion, we take a manufacturer  
13 perspective in the subsequent subsections.

### 3.1 *Product development and purchasing postponement*

34 With a purchasing postponement strategy, little inventory exists to cushion production  
35 or scheduling problems. Raw materials or components must be replenished quickly  
36 and arrive where and when they are needed. Manufacturers thus need to realize the  
37 potential benefit and importance of strategic and cooperative buyer-supplier  
38 relationship. That is, purchasing postponement emerges as manufacturers  
39 experimented with strategic partnerships with their immediate suppliers. Some  
40 manufacturers go even farther to taking advantage of the immediate supplier's  
41 capability and technology during the product design stage through early supplier  
42 involvement. This is relevant to product development postponement, which provides  
43 an opportunity to reduce design lead times and costly redesigns. By initially focusing  
44 on product specification decisions that are likely to remain stable, design decisions

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3 about less stable portions of the product can be postponed until better information is  
4 available (Yang *et al.*, 2004b).  
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10 In the literature, much has been written regarding how improving supply management  
11 provides organisational coordination required in the implementation of postponement.  
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13 In the automotive industry, for example, Van Hoek and Weken (1998) investigate the  
14 effects of postponed manufacturing in the supply chain where suppliers manage part  
15 of the inbound complexity associated with material flows (by providing standardized  
16 modules) while the final modular assembly is extended into distribution centres and  
17 even customer sites. This development is likely to require suppliers to determine the  
18 changes and strategies necessary to accommodate production operations within a  
19 modular context. Consequently, suppliers need to acquire new technological know-  
20 how and more strategic supply chain management activities. This also underscores the  
21 need for a complete re-shaping of supply networks. It is the interactions and  
22 interrelationships among supply chain players that enable the successful exploitation  
23 of the postponement strategy. Postponement requires the adoption of more  
24 collaborative working practices based on the integration of business processes within a  
25 wide community of business partners. At this point, postponement cannot be  
26 successfully leveraged without considering the organizational relationships.  
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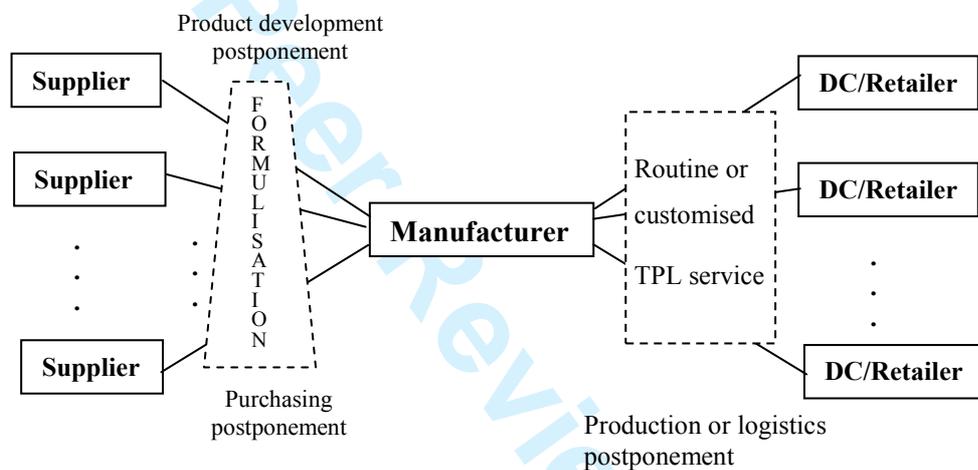
50 Among those, formalisation is a key dimension to capture an inter-organisational  
51 structure. In an inter-organisational context, formalisation refers to the degree to  
52 which the supply chain and network is controlled by explicit rules, procedures and  
53 norms that collectively prescribe the rights and obligations of the individual  
54 companies (Choi and Hong, 2002). It may require the development of well-defined  
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3 interfaces (e.g. through rules, procedures, norms and values) between organisation  
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5 units. Formalisation is closely associated with explicit and codified standardisation  
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7 (Mintzberg, 1979). Standardization of business processes is necessary to allow  
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9 communication and integration between business partners within the supply network  
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11 due to the complexity of processes in the supply chain (Gunasekaran *et al.*, 2001).  
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13 Here we propose that the implicit yet clearly understood norms lead to flexibility  
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15 required for product development postponement, while the explicit and formalized  
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17 procedures and rules regarding the tight restriction on the magnitude and frequency of  
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19 allowable quantity changes are positively to the implementation of purchasing  
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21 postponement. In its implementation of product development postponement, Toyota  
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23 relied on its suppliers in their product development: its suppliers (designers) deeply  
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25 and simultaneously explored broad regions of the design space, and provided a set of  
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27 possibilities, while Toyota continuously compiled information on the market and  
28  
29 technological developments, various constraint and trade-offs between the alternatives  
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31 (Ward *et al.*, 1995). This reflects the long-term based manufacturer-supplier  
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33 relationship involving Toyota's suppliers' investment in developing ideas and plans  
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35 for a new product before the design is finalised. That is, product development  
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37 postponement calls for a clear understanding necessary for the continuation of the  
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39 relationship. This is also in line with the exiting literature that addresses explicitness  
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41 as the characteristic of formalisation associated with clarity and fairness. Furthermore,  
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43 product development postponement leads the decision (on critical dimensions about  
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45 the vehicle) to delay until the last possible moment, ensuring that its suppliers have  
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47 deeply and simultaneously explored broad regions of the design space. To this end,  
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49 Toyota continued compiling information on the environment, the market,  
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51 technological developments expanding the known feasible region, and various  
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3 constraint and trade-offs between alternatives, gradually narrowing the set of  
4 possibilities and converging slowly toward a single solution (Ward *et al.*, 1995). This  
5 implies that implicitness is also necessary for flexibility necessary to make changes to  
6 design specifications.  
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15 A manufacturer can also choose its level of purchasing postponement, which is the  
16 choice of the decoupling point (work-in-process or finished goods) at which the  
17 manufacturer responds to a specific customer request. Meanwhile, the manufacturer  
18 needs to provide advanced warning to a supplier for a change to an order quantity's  
19 size or timing, but the warning may come within the effective lead time horizon,  
20 leaving the supplier to somehow cope with the change. This is reflective of not only  
21 the capabilities of the manufacturing process but also the nature of the supply contract  
22 (Krajewski *et al.*, 2005). Flexible supply contracts and thus relatively frequent  
23 schedule revisions require a supplier to frequently deal with changes in production  
24 volumes and delivery schedules. It has been well documented in the postponement  
25 literature that the above practice (i.e. massive reductions in inventories and the  
26 pushing of responsibility and cost further up the supply chain) may have significant  
27 consequences for supply chain performance. In the automotive industry, Sako *et al.*  
28 (1994) observe that purchasing postponement (JIT deliveries) have resulted in a shift  
29 in inventories from the assembly plant to the supplier in a number of cases. This also  
30 underscores the need for a complete re-shaping of supply networks. By contrast, the  
31 supply contract restrictions (as a manifestation of formalisation in the supply chain  
32 and network) on allowable changes to the timing and size of component orders allow  
33 those suppliers to stabilise their manufacturing environments by improving the  
34 accuracy of the production and shipping information. Such an environment allows  
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these suppliers to better time the manufacture of their components with the buyers need for them, thereby reducing the need for finished goods inventories and reducing inventory costs (Krajewski *et al.*, 2005). The tighter restrictions on changes to order quantities improves production schedules, and consequently leads to less safety stocks often moving the decoupling point between process inventories and buyer demands closer to the raw materials level. It can thus be proposed that restrictive supply contracts and infrequent schedule revisions are positively related to the implementation of purchasing postponement.



**Figure 2. An inter-organisational structure for postponement strategies**

### 3.2 Production and logistics postponement

Postponement can also be extended (from production) further downstream in the delaying of order delivery. For example, if an order's delivery could be postponed to a later time and the truck is not loaded to capacity, the order can be held for later delivery in the hope of consolidating it with other orders that might arrive in the future. At this point, production and logistics postponement may be involved in production, logistics and marketing. However, the need for accurate management of manufacturing-logistics and marketing interfaces is likely to be a bottleneck in achieving the potential benefits of postponement strategies (Van Hoek *et al.*, 1998).

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3 Along the same line, Daugherty and Pittman (1995) state that potential advantages  
4 from speedy manufacturing are diminished if the merchandise gets tangled in the  
5 distribution chain, since the customer's primary concern is how long it takes to  
6 receive the merchandise following order placement.  
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15 Here we focus on the relationship between postponement and service strategies for  
16 third-party logistics (TPL) providers. Based on complexity of service and type of  
17 customer relationship, service relationships can be distinguished between routine TPL  
18 service and customised service. This classification is also characterised by economy  
19 of scale and scope, coordination and co-operation of operations with the TPL provider  
20 (Bask, 2001). For example, customised TPL services demand closer relationships  
21 between manufactures and TPL providers than routine TPL services. The  
22 manufacturing postponement matches with customized logistics services where  
23 final/light manufacturing, together with after-sales services, can be carried out by a  
24 third-party logistics provider, e.g. final assembly and packaging of a computer, printer  
25 and manual by country. Standard logistics services may include some easy  
26 customized operations e.g. centralised warehousing. This matches with logistics  
27 postponement which takes the advantages of a centralised inventory, from where  
28 finalised products are distributed to a larger geographical area. In this case,  
29 inventories can be reduced, and the advantage is high in-stock availability. Similar to  
30 this, another emerging practice is virtual warehousing with the development of e-  
31 commerce (Matthews and Hendrickson, 2002), where companies may actually hold  
32 no physical inventory of supplies or parts. They contract with partners or third-party  
33 vendors, who manage an overall level of inventory. The contract companies can  
34 centrally manage similar inventories of products for many companies at once. In  
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3 summary, tailoring logistics service to production and logistics postponement need to  
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5 be responsive, aiming at supply chain flexibility and speed (Bask, 2001).  
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#### 10 **4. Capacity planning**

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12 A major aspect of capacity management is the control of actual and potential  
13 bottlenecks (Blackstone, 1989). Based on the assumption of bottlenecks in obtaining  
14 information, the drum-buffer-rope (DBR) in theory of constraint (Goldratt, 1990) can  
15 be used to explain why postponement should be applied. The DBR is about dealing  
16 with bottleneck: The drum is the bottleneck constraint and its pace should be the pace  
17 of the entire system; The buffer is inventory held in front of the bottleneck constraint  
18 to avoid idleness on the bottleneck constraint; and the rope is a prioritisation  
19 mechanism which pulls materials towards the bottleneck. Any time lost at the  
20 bottleneck is the time that can never be made up. Traditionally, the supply chain run a  
21 rate based on forecast to push the mix of (semi-) finished product downstream the  
22 supply chain. However, with constantly changeable demands this cannot improve the  
23 effective system throughput. Conversely, it only increases the finished product  
24 inventory (running high risk of obsolescence) or reduce necessary throughput  
25 (running high risk of out-of-stock). With the growth in demand uncertainty, supply  
26 chains now need to strategically locate inventory and capacity to enable both timely  
27 and efficient delivery in line with market demands. That is, the most important  
28 bottleneck is the market demand. This constraint determines the effective throughput  
29 for the supply chain. At this point, postponement enables activities to be performed  
30 based on the actual market demands, thus synchronising the entire system to the real  
31 demands. It can therefore improve the coordination of resources and the optimisation  
32 of activities across the supply chain (Pagh and Cooper, 1998; Yang and Burns, 2003).  
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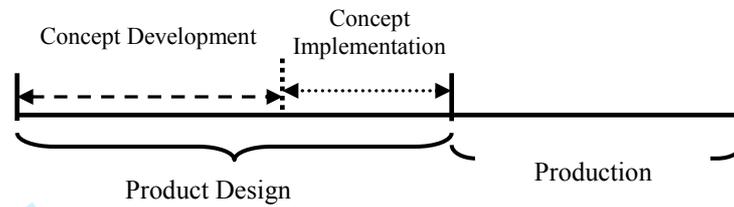
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3 In merging the concept of de-coupling and the customisation of the product, the  
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5 concept of postponement has further been discussed. Translated into capacity  
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7 planning, postponement is a risk-based sequencing strategy whereby low-risk  
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9 activities employ speculative capacity and higher-risk activities are postponed until  
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11 additional market information has been available (Fisher *et al.*, 1994). The speculate  
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13 capacity should be made the furthest in advance in order to have greater capacity  
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15 available for postponed activities.  
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#### 22 *4.1 The Customer Order Decoupling Point*

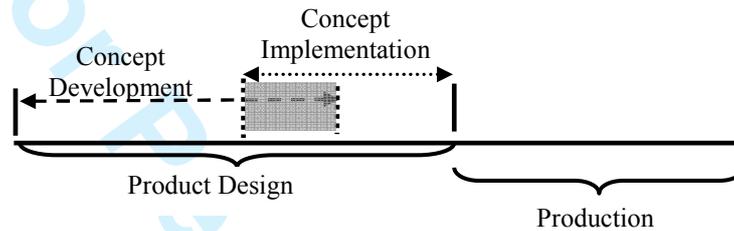
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24 The decision options on capacity planning can be divided into those trying to modify  
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26 demand to match the production constraints, and those modifying supply to match the  
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28 market demand. Olhager *et al.* (2001) note that, when discussing capacity planning  
29  
30 strategies, it is of great importance to distinguish different market environments  
31  
32 reflected by different positioning of the customer order decoupling point (CODP). As  
33  
34 illustrated in figure 1, the degree of postponement relates to the rationale behind the  
35  
36 choice of CODP (Hoekstra and Romme, 1992; Olhager, 2003), where product variety  
37  
38 usually increases significantly in the chain. The necessary organisational changes  
39  
40 (result from different positioning of CODP) have been extensively discussed in the  
41  
42 literature (e.g. see Lampel and Mintzberg, 1996; Gilmore and Pine, 1997; Duray *et al.*,  
43  
44 2000). This is also relevant to the concept of P: D ratio (Shingo, 1981), where p  
45  
46 represents the production lead-time and D represents the delivery lead-time. In this  
47  
48 sense, postponement facilitates capacity planning by utilising the opportunity to  
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50 stabilise the process upstream the supply chain and invest in a responsive capability  
51  
52 downstream in response to market demand variation. This can be highlighted by the  
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54 role of postponement in shifting the position of CODP.  
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6 In Lee's (1998) pull postponement, it is proposed to make the decoupling point earlier  
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8 in the process so that the differentiation tasks can be delayed to the point when more  
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10 information about the actual demands is available. Here, the driving force for shifting  
11  
12 CODP upstream is to increase the knowledge of the contents of customer orders at the  
13  
14 time of production (Olhager, 2003). In a study in the Japanese bicycle industry, Kotha  
15  
16 (1996) reveals that capacity planning in pull postponement can be appropriately  
17  
18 conducted through the interaction between mass production and mass customization.  
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20 By the development of the supply network it is also possible to move CODP upstream.  
21  
22 This can help to reduce the size of the order specific inventory significantly, but will  
23  
24 increase the demands for precision throughout the specification processes including  
25  
26 selling, order management, product configuration and service. By contrast, in their  
27  
28 definition of leagility, Naylor *et al.* (1999) utilise postponement to move the CODP  
29  
30 downstream and increase the efficiency and the effectiveness of the supply chain.  
31  
32 Investment in (sometimes additional) capacity to protect material flow rather than  
33  
34 inventory is central to the postponement strategy. To optimise the bottleneck  
35  
36 operations, it may also need to have the bottleneck upstream the CODP, rather than  
37  
38 using them to respond to volatile demands. The bottleneck capacity can thus be run  
39  
40 based on forecast, instead of being postponed (Olhager, 2003; Yang and Burns, 2003).  
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42 If capacity is constrained it is beneficial to hold stock before the bottleneck, which can  
43  
44 be built during slack periods. In practice, companies may separate different strategies  
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46 in time or place. They may separate out early and late production runs based on the  
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48 predicted level of uncertainty (Gattorna and Walters, 1996). For products with highly  
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50 seasonal demand, for instance, a company may manufacture some products to stock in  
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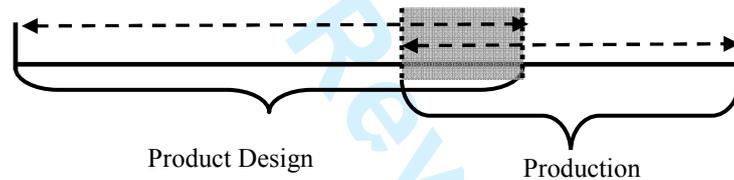
periods with low demand in anticipation of peak demand (Olhager, 2003). Production is thus levelled and plant utilisation increases.



(a) Traditional product development



(b) Delaying the point of freezing the product concept within the product design process



(c) Delaying some product design activities after production starts

### Figure 3. Product design postponement

However, when linking postponement strategies to different supply chain strategies (also see figure 1), it is implicitly assumed that product design, production and distribution takes place in sequence, even in engineering to order. This might not always be true in practice. In their discussion of product development postponement, Yang *et al.* (2004b) also note that, in extremely uncertain markets, companies may not be able to build the perfect product and then get it just right. They may have to get the product to market quickly and then attain feedback from real users. As such, companies can modify the new product idea early in their product development better to meet customers' needs. This implies production activities are initiated while some

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3 engineering is still going on. Figure 3 further illustrates this overlap. When applied  
4 within the product design process, product development postponement is in line with  
5 its definition proposed by Yang *et al.* (2004b), as illustrated in figure 3 (b). When  
6 further extending it to include the production process in figure 3 (c), the product  
7 development postponement strategy may not match any supply chain strategies which  
8 treat product design activities as something finished before any production take places.  
9 Such a postponement strategy is somewhat analogous to current engineering  
10 addressing coordination and integration of functionally different product and  
11 production activities. This also reflects Wikner and Rudberg's (2005) view that the  
12 increasing pressure on lead-times and customisation highlights the need for some  
13 product design activities to be carried out in combination with production activities. It  
14 should be noted that a combined product design and production perspective pose a  
15 challenge to involve resources from production in the product development process  
16 (Wikner and Rudbert, 2005).  
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#### 39 *4.2 Reactive Capacity Planning*

40 From a manufacturing strategy perspective, postponement is preferable in that the  
41 overall demands (the aggregate items number) are relatively easy to accurately  
42 forecast. This can be translated in to a capacity requirement plan in terms of aggregate  
43 resources. In this sense, postponement reduces costs by allowing some capacity to be  
44 held at average demand rather than peak demand. It often allows companies to  
45 separate the customization of products from the primary or basic manufacturing of  
46 generic (semi-finished) products. This separation also frees primary manufacturing to  
47 focus more on large economical runs, while secondary or final manufacturing can be  
48 focused on responding to customer wishes. Following Fisher *et al.* (1994) we divide  
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3 production capacity into two distinct parts: speculative product capacity (employed  
4 before the observation of early indicators of market demand) and reactive production  
5 capacity (employed after early demand indicators are observed). We focus on the  
6 latter for a postponement strategy.  
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15 A manufacturer can simply take the option to stay with a fixed capacity that is capable  
16 of handling peak demand or unexpected increases in requirements (Fisher and Ittner,  
17 1999). For example, reactive capacity is set at peak demand, while speculative can be  
18 set at average demand. The rationale is that the greater its reactive capacity, the greater  
19 the proportion of production it can reserve until early demand indicators have reduced  
20 demand uncertainty. Companies like Zara intentionally have extra capacity on hand to  
21 increase the supply chain's responsiveness to new and fluctuating demands while using  
22 postponement to gain more speed and flexibility (Ferdows *et al.*, 2004). By tolerating  
23 lower capacity utilisation in its factories and distribution centres, Zara can increase the  
24 supply chain's responsiveness to peak or unexpected demands. Zara can thus carry  
25 less inventory than its rivals like Benetton, H&M, and Gap (Ferdows *et al.*, 2004).  
26 Because the company can sell its products just a few days after they're made, it can  
27 operate with negative working capital. The cash thus freed up helps offset the  
28 investment in extra capacity. Off-peak periods with excess capacity provide an  
29 opportunity to rest, plan for the peak, train new employees and accomplish required  
30 maintenance. Additionally, building slack capacity can improve a company's ability to  
31 recover from supply chain disruptions quickly, which is of growing interest and  
32 importance both from an academic and a practitioner perspective.  
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3 However, excess and thus underutilized capacity hurts financial performance  
4 particularly at soft demand. To respond to actual customer orders within short  
5 delivery lead times, the literature suggests numerous ways of planning reactive  
6 capacity like using flexible working hours (including working overtimes and  
7 enforcing working days off) and employing contract and temporary workers. A  
8 manufacturer can also lower excess capacity risks by making existing capacity more  
9 flexible, e.g. training workers for different tasks. Flexibility is a form of pooling that  
10 allows use of the same capacity for a variety of products, which decreases the total  
11 capacity required. It may enable some of speculative capacity to become reactive, as  
12 orders begin filter in. At Sport Obermeyer, it also reduces reactive production  
13 capacity by delaying the reactive production commitment (Fisher *et al.*, 1994). More  
14 specifically, it focuses on the timing of capacity changes, e.g. by securing market  
15 information earlier. To support a production postponement strategy, the company  
16 keeps raw materials and factory-production capacity undifferentiated as long as  
17 possible. For example, in addition to warehousing raw materials, the company books  
18 factory capacity for the peak production periods well in advance but does not specify  
19 the exact styles to be manufactured until a later date.  
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46 Further, the manufacturer can exploit external sources (e.g. by contract manufacturing)  
47 to augment reactive capacity, without changing the internal production rates. Beyond  
48 outsourcing, Hagel III (2002) proposes a leveraged growth strategy tapping into a  
49 broad existing base of assets of other companies for the benefit of a company. Under  
50 this strategy, Li & Fung can stay responsive to future technological and market shifts  
51 while owning none of the facilities involved in processing the raw material into  
52 finished goods. As an orchestrator, Li & Fung manages the process network, e.g.  
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3 dividing the process into finer and finer segments, having additional providers  
4 populate each segment, and facilitating the collaboration of different companies. To  
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6 minimise disruption, Li & Fung can re-configure the network (e.g. by calling in  
7  
8 another service provider) to get the process back on track. Within a week of the 9/11  
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10 event, for example, it shifted production out of facilities based in potentially unstable  
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12 countries to more secure plants to avoid disruption in supply (Hagel III, 2002). The  
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14 constant reconfiguring of processes also ensures that the overall network operates with  
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16 optimum productivity and responsiveness.  
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24 A manufacture should also seek to identify opportunities for smoothing the peaks and  
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26 valleys through active management of demand, e.g. taking active steps to deflect some  
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28 of peak demand to other time slots at the same facilities. It can develop pricing  
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30 strategies to encourage its business customers to place their orders earlier, where  
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32 customers might only need to specify the total volume requirements early. Relevant to  
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34 this is a commonly practiced method in service - yield management. It creates a partial  
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36 priority queue by segmenting customers by their willingness to pay and, then,  
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38 allocating capacity by segment (Kimes, 1989). Yield management also allows  
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40 overselling of capacity (Biyalogorsky *et al.*, 1999) when demand is uncertain. It gives  
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42 the seller the potential to make very profitable buyback transactions during the spot  
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44 period. When capacity is insufficient, sellers can buyback capacity at lower prices than  
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46 the expected spot price. In the same vein, to solve the problem of temporary capacity  
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48 shortage, some manufactures may arrange a capacity exchange, through which  
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50 production capacity (originally assigned to prescheduled orders) is transferred to the  
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52 rush orders in question (Huang *et al.*, 2005). The promised premium associated with  
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54 the capacity exchange may be particularly attractive for the urgent capacity  
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3 demanders. Meanwhile, original capacity holders may be willing to release the  
4 capacity (through delaying their prescheduled orders) in exchange for compensation,  
5 which comes from either premiums paid by the capacity demander or allowances  
6 provided by the manufacturer (Huang *et al.*, 2005). Van Mieghem and Dada (1999)  
7 also argue that before going for production postponement, it may be worthwhile to  
8 consider flexible ex-post pricing, which typically falls under marketing's  
9 responsibilities. More specifically, they recommend the deferral of the pricing decision  
10 until demand uncertainty resolved. For example, a traditional automobile dealer must  
11 decide how many cars to buy and hold on its lot before market demand is known and  
12 then must negotiate a price with each customer (Van Mieghem and Dada, 1999). They  
13 also show ex-post price flexibility can make optimal capacity decisions more  
14 insensitive to uncertainty than production postponement.  
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### 34 **5. Conclusion and Further Research**

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36 The result of postponement implementation in the current business environment is  
37 often outsourcing operations and building partnerships and alliances that foster the  
38 networking of relationships. A successful application of postponement thus requires  
39 agreements that strengthen buyer–supplier cooperation in supply chain and network.  
40 To meet the challenges of a demanding marketplace and the need for more cost-  
41 effective use of resources it is also imperative that a better way be found to balance  
42 supply and demand in postponement. In this context, this paper has highlighted two  
43 issues in a successful implementation of postponement to address the slow rate of  
44 postponement applications: inter-organisational organisational structure and capacity  
45 planning. As companies begin to take on the appearance of networks embedded in  
46 larger networks, postponement helps companies rethink and overhaul the  
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3 configuration of relationship networks (beyond product and production design). We  
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5 have also considered different strategies in production capacity planning for a  
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7 postponement strategy. Any company that chooses to implement postponement  
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9 should obviously tailor them to its own situation. This study can also be of value to  
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11 companies focusing on the CODP strategies. Empirical studies would complement  
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13 and add to the conceptual work in this study. In addition, this paper has only  
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15 examined the formalisation dimension of supply chain and network from a  
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17 manufacturing perspective. Further research could be focused on other elements such  
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19 as centralisation and complexity. To avoid dysfunctional organisational behaviour  
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21 from the perspective of channel power influence on postponement decisions taken by  
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23 a dominant player, there is also a need to develop appropriate indicators to monitor  
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25 the postponement performance in supply chain and network.  
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34 In Section 2, the scope of postponement strategies in the existing literature has been  
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36 discussed including production design, purchasing, production and logistics. The  
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38 increasing focus on service quality (particularly in the rapidly growing e-commerce)  
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40 may open up a research opportunity to apply postponement into a service context  
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42 beyond the above scope. The attributes commonly used to distinguish from physical  
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44 goods and production activities, such as intangibility, inseparability and perishability,  
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46 lead to special challenges to design the structure of the service process (Sasser, 1976;  
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48 Hill *et al.*, 2002). For example, inseparability (i.e. there is a high degree of producer-  
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50 customer interaction in the production of service) and perishability (i.e. services  
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52 cannot be inventoried) create uncertainty for managers about the process's time, the  
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54 product's quality and the facility's accommodation of the consumer's needs. These  
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56 differences, however, may increase the importance of applying postponement in  
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3 service, similar to just-in-time in service (Duclos *et al.*, 1995). This is also echoed by  
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5 Van Hoek's (2001) view on the customisation element of postponement. To this end,  
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8 substantial work is needed to develop and apply the postponement concept to the  
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10 service process.  
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15 In an e-commerce environment, direct contact with suppliers and customers and  
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17 provision of direct enhancement of information-based services are often used to  
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19 customise service offerings (Peppers and Rogers, 1997; Bitner, *et al.*, 2000). However,  
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21 since the Internet is an open system, many companies appear to offer almost identical  
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23 services, and struggle to generate a large enough customer base just to survive  
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25 (mainly through promotion and competitive price). This is relevant to the strategy on  
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27 how to design a service delivery system. For the purpose of ensuring consistency of  
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29 quality and lowering costs, the de-coupling of back-office activities from the front  
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31 office has been a predominant strategy in a service delivery system (e.g. Chase, 1978;  
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33 Chase and Tansik, 1983; Metters and Vargas, 2000). Operationally, this de-coupling  
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35 strategy divides high- and low-contact activities, segregating/departmentalising and  
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37 centralizing low-contact activities (Chase, 1978). Within a global context, the de-  
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39 coupling processes may mean that back-office operations are in different countries  
40  
41 than the front office. Recent years have also witnessed that the line between front- and  
42  
43 back-office are being blurred, with on- and off-line activities becoming more  
44  
45 integrated in some situations and more de-coupled in others (Metters and Vargas,  
46  
47 2000). The level of back- and front- office de-coupling can thus take the form of the  
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49 degree of interaction and customisation. All the above characteristics are fitting well  
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51 in the conceptualisation of postponement in a supply chain (Yang and Burns, 2003).  
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60 However, a challenging question arises regarding how postponement should be

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3 defined in the service production and delivery process with the relatively high level of  
4 customer participation or interaction in service. Addressing the above question may  
5 also provide insight into the impact of customer contact and the existing services  
6 linkage in the supply chain and network.  
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