Theoretical perspectives on the coordination of supply chains

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Abstract

Supply-chain coordination relies on the availability of prompt and accurate information that is visible to all actors in the supply chain. However, new demands on the supply-chain system require changes to information flow and exchange. We undertake a case study of three automotive supply chains that face such new demands resulting from the introduction of an order-driven supply-chain strategy. We use our case study findings to evaluate the applicability of three different theoretical lenses on the multi-faceted interactions between information, physical flow, and the complex rationales driving supply-chain evolution: the resource-based view (RBV), the concept of complex adaptive systems (CAS), and adaptive structuration theory (AST). We find that each theory has a separate realm of applicability and while complimentary in nature, provides distinct insight on the structural shift in the supply-chain system. More specifically, we find that AST, a theory prominent in the social sciences, provides novel insights to supply-chain research at the firm level, particularly with respect to the difficulties in using IT systems to drive systemic change. It complements both the system-level perspective offered by the complex adaptive systems theory, as well as the concept of dynamic capabilities originating in the resource-based view. The paper concludes with wider implications for future research in supply and value chain management.

Keywords: Supply-chain management; Value-chain management; MIS–operations interface; Information technology; Case study/research methods

1. Coordination across tiers in the system

Manufacturing and logistics operations are increasingly driven by customer needs rather than forecasts, increasing the importance of demand and inventory information visibility across the supply chain (Ganasekaran, 2005). However, supply chains are complex systems, and the assumption that organizations across tiers in the supply chain interact and behave as a unified entity with a common purpose is often violated (Choi et al., 2001). As a result, there is a great interest in the operations management (OM) literature in the coordinating mechanisms and the associated information technology (IT) systems that facilitate supply-chain integration and coordination, especially with respect to control and connectivity (Mukhopadhyay et al., 1997; Lee et al., 2000; Ye and Farley, 2006). At the same time, researchers in the supply-chain arena have noted the importance of considering cultural, organizational, and path dependence challenges in attaining IT system shifts, such as those needed to bring about customer responsiveness (Choi and Liker, 2002; Lewis and Suchan, 2003).

We undertake a qualitative exploration of the IT and information challenges associated with moving to a customer-driven order-to-delivery model in three
automotive supply chains. We use this qualitative work to evaluate three theoretical perspectives related to change in supply chains. Two of the theories have traditionally been used in the OM literature to study supply-chain coordination and change—the resource-based view (RBV) and complex adaptive systems theory (CAS). The third, adaptive structuration theory (AST), has been used as a theoretical lens on the effective deployment of IT systems to attain organizational goals in the social sciences. Despite calls for its use (Lewis and Suchan, 2003), it has seen little application in the field of operations management. Our efforts to link RBV, CAS, and AST in explaining changes in supply-chain strategy follow the call to extend the epistemological base of supply chain and operations management research, especially with respect to exploring the contextual issues surrounding the interaction of physical assets, humans, and technology (Melnik and Handfield, 1998). Extending analyses of supply-chain interactions to incorporate some of the complex dynamics that occur provides an opportunity to address the frequently noted shortage of theory testing and development in the OM field (see for example Schmenner and Swink, 1998).

In the resource-based view, the competitive advantage firms obtain in operational domains like manufacturing results from hard-to-duplicate resources that firms build up through external and internal learning processes (Andreu and Ciborra, 1996; Schroeder et al., 2002). Grant (1996) highlights how predictable activity and exchange between organizational members can be a key driver of convergence across organizational actors. However, the convergence on common practice and goals can be restrictive when environmental shifts place new demands on the relationships between actors (Andreu and Ciborra, 1996; Leonard-Barton, 1992). Firms require ‘dynamic capabilities’ to successfully respond to those new demands (Teece et al., 1997; Zollo and Winter, 2002).

Building on the notion that supply chains have acquired a level of complexity close to that of biological systems, CAS has been applied to focal manufacturing firms (McCarthy et al., 2000), as well as supply chains (Choi et al., 2001; Surana et al., 2005). This literature suggests that complexity remains largely hidden during normal operation and only becomes conspicuous when contributing to rate cascading failure or chronic fragility/complexity evolutionary spirals. Authors writing in this theoretical domain suggest that many supply chains emerge rather than result from purposeful design by a single controlling actor in the system, leading to structured collective behavior (Surana et al., 2005). CAS can thus aid our understanding of the organizational, functional and evolutionary dimensions of supply chains.

AST was first proposed by DeSanctis and Poole (1994) as a framework to examine the interplay between expected structures for behavior that the designers of IT systems had predicted or built into their systems and the structures that actually emerge. The latter is influenced by end-user thinking and behavior, and users may ultimately adopt, modify, resist, or even reject the intended use of the technology. While AST has received little attention in the operations management literature, some have argued it can elucidate how and why attaining desired objectives from IT systems can be challenging in the supply-chain context (Lewis and Suchan, 2003).

In the following section we systematically discuss the changes that took place when three automotive firms shifted to a build-to-order strategy. We use these cases to examine RBV, CAS, and AST. We explore what each contributes to our understanding of the challenges associated with fundamentally changing the strategic orientation of a supply-chain system. We explore each theory’s realm of applicability and limitations, complementarities between them, and the implications for future SCM research.

2. The case supply chains

To undertake our exploratory evaluation of RBV, CAS, and AST we use a multiple case-study design following the recommendation of Meredith (1998), and Voss and colleagues (2002). By examining multiple supply chains, we are able to explore differences in adaptations as firms respond to the same environmental shift. We undertook our data collection at three firms in the automotive industry. In this sector, vehicle manufacturers (OEMs) developed a range of customized (non-package) IT systems to facilitate coordination and information flow with the ultimate purpose of enhancing and optimizing their ‘mass production’ and ‘build-to-forecast’ production systems (Gunasekaran, 2005). The social and technological systems were designed, and then evolved to optimally match the needs of a build-to-forecast system (cf. Raturi et al., 1990).

The last decade has seen increasing market-driven pressures towards customer responsiveness and building vehicles to order (Holweg and Pil, 2004; Pil and Holweg, 2004). The result was a significant gap between the objectives the IT systems were designed to further, and the revised strategic goals espoused by
the vehicle manufacturers, leading all users of the IT system to examine the discrepancy between what is needed from the system, and what it can deliver.

Moving to build-to-order requires a collective paradigm shift for all core actors (Gersick, 1991). There are several key actors in the supply chain: first and foremost, the vehicle manufacturer (OEM). The OEM is responsible for the IT system architecture within its own organization, and commonly dictates the mode of interaction with the first tier suppliers, the distribution logistics operators, and retailers. Starting with the OEM and considering both its up- and downstream supply chain, we examine how the shift to build-to-order affects the linkages between these key partners in the system. A key interest is the extent to which these actors used the technology in the ‘objective spirit’ of the technology—the manner in which it was intended to be used (DeSanctis and Poole, 1994). While spirits may be anchored when the technology is first introduced, they may become inappropriate over time. In our cases, the spirit of the original technical system—developing and disseminating accurate forecasts, no longer met the competitive exigencies associated with build-to-order.

2.1. Case selection

Our case selection was driven by the need to observe a fundamental shift in the demands on the IT systems. This limited the number of vehicle manufacturers eligible for the study. The three OEMs we examined had recently announced their intention to move away from their make-to-forecast strategy, towards a more responsive build-to-order strategy. We selected as focus point a manufacturing plant at each OEM that assembled a high-volume model in the C-segment (i.e. a mid-size compact car). Our goal was to assemble a representative picture of actors across all the main tiers of the supply chains related to that facility. Since the average assembly factory has, for example, several hundred first-tier suppliers, mapping a comprehensive set of linkages was not tractable. Furthermore, as Choi and Liker (2002, p. 202) argue: ‘[...] it is certainly easier to get data on dyadic relationships, but the more challenging and perhaps more interesting questions involve longer supply chains. This is where the key system dynamics will be revealed.’ In our effort to study connected systems (rather than dyads), we adopted an approach similar to previous multi-tier case studies (see for example Choi and Hong, 2002), aiming for representation of all tiers rather than a comprehensive picture of any one tier.

We selected suppliers on the basis of two factors: first, they had to have their manufacturing operations located in a geographical proximity of no more than 150 miles (i.e. within a single day’s logistics distance) to the OEM manufacturing facility. Second, they had to deliver a major volume component on at least a daily basis to the OEM customer. The inbound logistics providers were determined by the respective OEM-supplier arrangements. Each OEM identified for us one of their key outbound logistics operators willing to participate in the research. Lastly, we selected one main dealership per OEM in the market region. Given the sensitivity of the data provided by the companies, a non-disclosure agreement was put in place stating that no organization can be identified—placing some limitations on the data we are able to report.

Supply chain A is for a regional subsidiary of a large US automaker, with a history of more than a century of car production at the study site. This regional subsidiary carries a strong independent identity in the region, and has been designing vehicles independently from the parent company. The product range produced locally covers all main segments of the market. It has a high degree of local sourcing, with multiple sources for each component procured. The two first-tier suppliers that participated in this study are a local subsidiary of a multinational steel and pressed parts supplier, and the in-house engine supplier of the OEM. The distribution logistics is outsourced to a dedicated logistics service provider. The retail outlets were all part of independent franchised dealer groups, as is common under the regional legislation.

Supply chain B is that of a regional subsidiary of another US automaker, albeit with less history in the region. Unlike supply chain A, it focuses solely on vehicle assembly, and sources considerable component content from neighboring countries. The two first-tier suppliers we studied here are the subsidiary of the former in-house component arm supplying axles, and a regional exhaust supplier. Like with supply chain A, the retail outlets were all part of independent franchised dealer groups.

The third supply chain C is that of a regional subsidiary of a Japanese OEM. It has been assembling vehicles in the region for over 20 years. Vehicle design is largely imported from Japan. While local content is increasing, many key components are still sourced from Japan. The first-tier suppliers we studied at OEM C are both subsidiaries of Japanese suppliers supplying plastic extrusions and exhaust parts locally. The logistics operations are outsourced to independent third
party providers. The retail outlets were all part of independent franchised dealer groups.

While the companies are all large-scale vehicle manufacturers, they start from different process strategies, different core system capabilities, and different attitudes toward the effectiveness of IT system generated scheduling information. Having three cases allows us to compare and contrast the key operational differences between the OEMs.

2.2. Data collection

Following Meredith et al. (1989), we relied on an interpretive paradigmatic approach rather than a rationalist or positivist paradigm in examining the three supply chains. We relied on two methods that are well established in the OM research domain: value stream mapping (Gardner and Cooper, 2003) and semi-structured interviews (Flynn et al., 1990). A key challenge in the adaptive structuration literature is the difficulty of measuring core dimensions of the theory (Chin et al., 1997). Following the procedure proposed by DeSanctis and Poole (1994), we relied on detailed observations and documentation of the systems in use, and interviews with key implementers and representative users.

The core dimensions of information transfer reported here were those most comparable across OEMs. They were identified by our interviewees as critical to understanding the systems’ shift to build-to-order. We consider five key characteristics of the information flow, as outlined in Table 1.

While we focus on five dimensions – directionality, permanence, horizon, frequency, and accuracy – this is not an exhaustive list. We also investigated a range of other factors, such as the technology platform choice and commonality and distinctiveness in IT systems. However, we found these contributed little to the understanding of the evolution of the system. For example, the long-term capacity forecast, which is present in both the make-to-forecast (MTF) and build-to-order (BTO) systems, is not relevant for the order fulfillment process. The set of five dimensions we looked at across the supply-chain tiers allow us to follow the evolution of the system, even without continuous observation. In addition to core features of the information mediated by the technology, we also examined who originates and who receives the information exchange. However, our main focus rests upon the high-level system, i.e. the main information flows, their frequency, accuracy, directionality and the lead-times associated with these flows.

The literature highlights the importance of considering simultaneously both the input (supplier) and output (customer) relationships (Cooper et al., 1997; Lambert et al., 1998), as well utilizing multiple methods for triangulation (Jick, 1979; Lewis, 1998; Voss et al., 2002). To accomplish this, we undertook a two-step approach to developing our descriptive case studies (Myers and Avison, 2002; Yin, 2003). First, we created

Table 1
Information flow dimensions considered in the analysis

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Explanation</th>
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</thead>
<tbody>
<tr>
<td>1. Directionality of the flow</td>
<td>The information flow can be bi-directional, allowing for feedback, or unidirectional where information is sent without any feedback from the recipient. For example, a forecast production schedule might be sent from the OEM to the supplier, with no provision of feedback from the supplier as to whether the schedule matches optimal production capacity utilization</td>
</tr>
<tr>
<td>2. Permanence of the information flow</td>
<td>Due to the rolling scheduling that is commonly used, most demand information is continuously updated and refined as the actual product delivery date nears. Thus, an initial forecast may be given a month prior to delivery. That forecast might be superseded by a production schedule provided 1 or 2 weeks out. That schedule might be further updated with a final call-off given 1 or 2 days prior to delivery. Typically only the final call-off is commercially binding</td>
</tr>
<tr>
<td>3. The information horizon</td>
<td>The time frame the information flow covers; a forecast, for example, can cover anything from a few weeks, to several months (the latter is meant as a means for longer-term capacity and labor planning)</td>
</tr>
<tr>
<td>4. Frequency of information flows</td>
<td>The interval within a particular information is sent or exchanged; in our supply-chain cases we have observed information exchange frequencies ranging from forecasts sent once per month, to supplier call-offs that were sent every 20 min</td>
</tr>
<tr>
<td>5. Accuracy of the information</td>
<td>Comparing the initial information to the actual information that is acted upon. Scheduling information is continuously updated, and thus the actual call-off can deviate considerably from the initial forecast. Information that is less accurate and reliable, is not helpful in operational execution, and is thus more prone to substitution and modification</td>
</tr>
</tbody>
</table>
a value stream map of the information flows across three tiers, comprising of individual maps of the respective suppliers, OEMs, and logistics providers (Shapiro et al., 1992). We then triangulated the information obtained from these value stream maps with semi-structured interview using multiple informants.

We spent 2 days on site at each of the three OEMs to trace the multiple departments that provide information to, or access information from the order processing and scheduling system, and the nature of the information that is exchanged. The result was a map of the IT systems and communication tools that were employed by each supply chain, and the information flows that were associated with them. Representatives from each focal company’s production department, scheduling and planning department, logistics and supply department, distribution and sales departments, and the IT department were present for the development and verification of the process map. With the help of key informants at suppliers, and logistics providers we then extended the maps up and down across the tiers of the supply chain. The result is a process map for each OEM showing the five key dimensions of information flows across the multiple tiers of its supply chain.

Next, we undertook open-ended interviews to explore how information structures were altered as a result of each OEM’s effort to move towards a build-to-order model. We discussed with each player how they reacted to the changes, and any further alterations to information flows and inter-firm relationships that resulted as the modified information systems were implemented. Our aim was to develop an understanding of the changes to the IT-driven information flows (in relation to the pre-existing structures), the misalignments in face of new organizational goals of increased responsiveness to customer needs, and the modifications, substitutions, and amplifications to the structures that resulted (Majchrzak et al., 2000). Lastly, we explored the performance implications of the changes.

Table 2 lists the interviews we conducted across the tiers of each supply chain. All interviews were recorded and transcribed for systematic analysis. Following the recommendations of Voss et al. (2002), mapping workshops and subsequent interviews were conducted over multiple visits. The research meetings were documented and detailed notes were shared with participants who reviewed them for accuracy. Across all three OEMs, we interviewed representatives from the production control department, the materials handling, purchasing and logistics department. We interviewed two senior management representatives from a supplier identified by each OEM as being a provider of a core component that is subject to customer ordering variability (one from production, and one from scheduling and/or planning), and finally, an operational representative each from inbound and outbound logistics and one national dealer for each OEM.

Table 2
Key informants across the three supply-chain systems (number of interviews per informant is given in brackets)

<table>
<thead>
<tr>
<th>Supply-chain system A</th>
<th>Supply-chain system B</th>
<th>Supply-chain system C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle manufacturer (OEM)</strong></td>
<td><strong>Vehicle manufacturer (OEM)</strong></td>
<td><strong>Vehicle manufacturer (OEM)</strong></td>
</tr>
<tr>
<td>Manager, vehicle scheduling and distribution, OEM Europe (2)</td>
<td>Manager, supply and logistics, OEM Assembly Plant (1)</td>
<td>Director, National Sales Company (1)</td>
</tr>
<tr>
<td>Systems analyst, central planning and scheduling, OEM Europe (1)</td>
<td>Manager, order fulfillment process, OEM Europe (2)</td>
<td>Order fulfillment improvement project leader (3)</td>
</tr>
<tr>
<td>Manager, vehicle programming, OEM Europe (1)</td>
<td>Production controller, OEM Assembly Plant (1)</td>
<td>Production planning manager, OEM Europe (1)</td>
</tr>
<tr>
<td><strong>First-tier Supplier</strong></td>
<td><strong>First-tier Supplier</strong></td>
<td><strong>First-tier Supplier</strong></td>
</tr>
<tr>
<td>Plant manager (1)</td>
<td>Plant manager (1)</td>
<td>Operations manager (1)</td>
</tr>
<tr>
<td>Material planning and logistics manager (2)</td>
<td>CEO, Supplier Group (2)</td>
<td>Logistics manager (1)</td>
</tr>
<tr>
<td><strong>Inbound logistics (component collection and delivery to vehicle assembly plant)</strong></td>
<td><strong>Inbound logistics (component collection and delivery to vehicle assembly plant)</strong></td>
<td><strong>Inbound logistics (component collection and delivery to vehicle assembly plant)</strong></td>
</tr>
<tr>
<td>Director and general manager, Automotive Division (2)</td>
<td>OEM contracts manager (key account manager) (1)</td>
<td>OEM contract coordinator (key account manager) (1)</td>
</tr>
<tr>
<td>Site manager (1)</td>
<td>Site manager (1)</td>
<td>Site manager (1)</td>
</tr>
<tr>
<td><strong>Outbound logistics (vehicle distribution from car assembly plant to dealer)</strong></td>
<td><strong>Outbound logistics (vehicle distribution from car assembly plant to dealer)</strong></td>
<td><strong>Outbound logistics (vehicle distribution from car assembly plant to dealer)</strong></td>
</tr>
<tr>
<td>Business development director (2)</td>
<td>Managing director (1)</td>
<td>Operations manager (vehicle routing and scheduling) (1)</td>
</tr>
<tr>
<td><strong>Dealership</strong></td>
<td><strong>Dealership</strong></td>
<td><strong>Dealership</strong></td>
</tr>
<tr>
<td>Franchised dealership representative (1)</td>
<td>Franchised dealership representative (1)</td>
<td>Franchised dealership representative (1)</td>
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</tbody>
</table>

**2.3. A structural shift in supply-chain strategy**

In this section we outline the strategic shift that was observed in the three automotive supply chains
following the implementation of build-to-order concepts. From there, we discuss the operational outcomes of this transition.

2.3.1. The base system under MTF

The basic supply-chain system analyzed is shown schematically in Fig. 1. The chart depicts the key actors and the established information flows that in place in the pre-existing IT system under the make-to-forecast regime at all three OEMs. We show the directionality of the flow, as well as parallel but functionally distinct flows between actors (e.g. #6 and #7, and #9 and #10). These parallel flows occur, for example, when multiple forms of information are exchanged at different intervals, such as daily orders and monthly forecasts.

The main attributes of these ten observed flows are shown in Table 3. The existing information system was intended to produce orders to forecast. The process fundamentally starts with the monthly sales forecast dealers submit to the National Sales Company (flow #1). There the forecasts are aggregated and sent to the OEM’s headquarters (#2). At the ‘programming meeting’, the aggregated orders are translated centrally into production schedules for each of the assembly plants (#3), taking into account the build constraints at each plant. The vehicle build schedule is also translated into a long-term volume-based forecast for the outbound logistics operators (#4). Headquarters converts the production schedule into supplier orders (by exploding the bill of materials, flow #6), and transmits these orders in the form of forecasts to the suppliers. Once the production schedule at the assembly plant is established, supplier schedules and daily call-offs (#6, #7) are issued. The forecast is also submitted to the respective inbound logistics suppliers by the OEM (#9), while the respective suppliers send ‘pick-up’ requests to the logistics company (#10). Outbound logistics suppliers receive a volume-based forecast of anticipated volumes by delivery region (#4). However, a secondary information system transmitting destinations of completed physical product dictates the ultimate role of outbound logistics suppliers (#8). Once the vehicle has been built, the assembly plant reports this back to the central headquarters, which updates the estimated-time-of-arrival in the system.

A key element to all these flows is that they are largely unidirectional. There is no institutionalized feedback loop built into the system. Furthermore, as the system is geared at make-to-forecast (MTF) production, the frequency of the flows is geared at long-term and stable planning. This is further reinforced by the long horizon of the information given. The perceived information accuracy ranges from as little as 50%, to perfectly reliable information (i.e. 100%). Even though it is forecast information, the forecasts and schedules are continuously updated based on the latest available production schedule at the plant.

The mapping of the existing information flows across the order-to-delivery process revealed no significant structural differences between the three supply chains studied. As a result, we are able to use a standard framework to examine the supply-chain process for each OEM.

2.3.2. The amended system under BTO

Revisiting the systems after the shift towards BTO, shown in Fig. 2 below, a first observation was that the formal inter-organizational structure did not change unless the OEM as central and powerful actor dictated a change. In other words, we found that the OEM dictates much of the structure. Only those features that peripheral actors (i.e. suppliers and logistics providers) have control over, evolve visibly. These features are inventory buffers and additional informal information flows. This is an important issue we will return to in Section 3. To understand how the relationship between IT system and users evolved in response to the efforts to introduce build-to-order, we relied on our semi-structured interviews with all key actors. We used our documented information flows through the IT system as a starting point; here our aim was to understand core dynamics and processes driving how technology and social systems interact when faced with
an environmental shift that alters on multiple dimensions the information that is needed. Through interviews with our key informants, we were able to triangulate the key shifts that took place, and discern meaning from the unilateral and bi-lateral adaptations through the eyes of core actors directly affected by the evolving informational needs. Fig. 2 highlights the changes that took place following the efforts to move towards a more responsive system.

We observed key differences between the three systems analyzed. To illustrate these, Table 4 shows the modified and new flows, as well as the buffers, by OEM.

Table 4 shows that after the introduction of build-to-order, the information flows that are forecast-based, low-frequency and low-accuracy, are either replaced or amended with flows that are more frequent as well as accurate. More specifically, three main observations can

![Diagram](image-url)
be made. First, four key information flows in the existing system had to be modified in the build-to-order setting. Modification for two of these flows meant that the existing systems were used to convey new types of information—actual customer orders, in this case. These modified information flows (flows #1a and #2a) take place under much shorter horizons, and very high frequencies. Furthermore, these modified flows tend to be bi-directional, whereas the original flows were mostly one-directional.

Second, an entire new flow has been added to the system (#11), which represents an informal contingency measure to cope with the structural deficiencies of the system (adjust for flows #9 and #10). The additional flow represents an informal telephone call by the materials controller at the OEM assembly plant, informing his counterpart at the supplier of a late amendment of the parts requirements that is not featured in the original schedule. Here, both lead-time and horizon are very short in comparison to the flows #9 and #10, to which it adds late amendments.

Third, we can observe three distinct physical buffers that are added to the system at the supplier, OEM and distribution level. These reflect the inability of the IT system to meet the responsiveness goals placed on the overall system. In the case of Buffers A and B, these physical inventories buffer against information uncertainty. Buffer C reflects the system’s inability to provide customized vehicles on a short lead-time at the customer end of the supply chain.

It should be noted there is no flow #11 in the system of OEM C. Unlike the systems of OEMs A and B, C’s system is capable of responding to the changing requirements without adding a further, informal flow from the assembly plant to the suppliers. OEM C, a subsidiary of a Japanese manufacturer, has a strong tradition in lean manufacturing. In introducing build-to-order, OEM C’s planning and scheduling routines

<table>
<thead>
<tr>
<th>Flow #</th>
<th>Actual (a) or forecast (fcast)</th>
<th>Horizon (days)</th>
<th>Frequency (days)</th>
<th>Accuracy (%)</th>
<th>Directionality (1=one-way, 2=bi-directional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEM A</td>
<td>Modified existing flows</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1a (for original flow 1) Actual</td>
<td>N/A</td>
<td>1.0</td>
<td>100.0</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>2a (for original flow 2) Actual</td>
<td>1.0</td>
<td>1.0</td>
<td>100.0</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>New informal flows</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>11 (augments original flows 9 and 10) Actual</td>
<td>0.1</td>
<td>3.5</td>
<td>100.0</td>
<td>1.0</td>
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<tr>
<td>Buffers</td>
<td>A Buffer of finished components at first tier level</td>
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<tr>
<td></td>
<td>B Buffer of finished components, held in logistics chain</td>
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<td></td>
<td>C Buffer of vehicle stock at the distribution center</td>
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<tr>
<td>OEM B</td>
<td>Modified existing flows</td>
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<tr>
<td>OEM C</td>
<td>Modified existing flows</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1a (for original flow 1) Actual</td>
<td>21.0</td>
<td>7.0</td>
<td>100.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2a (for original flow 2) Actual</td>
<td>21.0</td>
<td>7.0</td>
<td>100.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>New informal flows</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buffers</td>
<td>A Buffer of finished components at first tier level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B Buffer of finished components, held in logistics chain</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>C Buffer of vehicle stock at the distribution center</td>
<td></td>
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</tr>
</tbody>
</table>
remained mostly unchanged. This raises an interesting issue: the emphasis on stability and level scheduling at OEM C resulted in very rigid constraints in supplier scheduling, limiting the system’s ability to respond to changes in demand. As a result, OEM C was also limited in the extent to which it could cope with a higher degree of BTO vehicles. This could be interpreted as an indication of strong path-dependence, and will be subject to further discussion in Section 3.

2.3.3. Performance outcome of the structural shift

We observed the three supply chains within a 2-year window of moving from a predominantly forecast-driven vehicle supply strategy towards a more responsive build-to-order strategy. The respective changes in overall system performance are shown in Table 5 below. We obtained the outcome performance data from ICDP, a consulting firm specializing in assessing dealer and distribution system performance.

As can be seen, OEM A’s progress has been more rapid than OEM C’s—while both have similar delivery times and accuracies, OEM A makes many more products to order. Interestingly, while OEM B had the technical capacity to shift towards building-to-order, the strategy was never adopted to the full extent. Part of this may have reflected a corporate decision to not permit higher levels of customization. However, it does raise a ‘chicken and egg’ question: factory representatives at OEM B indicated that the lack of transformation in the IT system was signal enough that the company did not embrace build-to-order as a significant goal.

3. Theories in practice: applying RBV, CAS and AST

Section 2 introduced the three case supply chains, and the shifts that took place in each of these cases. In the following we apply the ‘theoretical lenses’ offered by RBV, CAS, and AST—to examine how these three theories can help in understanding the evolution taking place in the supply chains of OEMs A, B, and C. We will show how these theoretical perspectives provide different yet complimentary insights with regards to the decision to change the overall system, the changes that are made at the dyadic level between key actors, and the unanticipated consequences of undertaking directed change.

3.1. Resource-based view (RBV)

The resource-based view of the firm perspective starts from the position that resources are heterogeneously distributed across firms, and resource differences persist over time enabling firms to sustain their competitive advantages (Penrose, 1959; Barney, 1991b; Peteraf, 1993). These resources are useful when they are valuable, rare, imperfectly imitable, and have no equivalent substitutes (Barney, 1991a).

The resource-based view is vague with respect to where the resources originate that lead to competitive advantage (Williamson, 1999; Priem and Butler, 2001). The literature on routines helps develop that understanding. Routines are embedded, often tacit, ways of doing things that encompass organizational knowledge. They often have a strong element of path dependence. Competitors find it difficult to replicate advantages originating from configurations of tightly woven and synergistic routines (Milgrom and Roberts, 1990; Collis and Montgomery, 1995). This may result, for example, from extensive communication and exchange between different actors leading to a convergent knowledge base, and common vision and perspective (Dierickx and Cool, 1989; Ghemawat, 1991). While this may be a source of strength in a static environment, the resultant stability can be a liability in the presence of new environmental imperatives. As noted by Andreu and Ciborra, ‘[...] competitive environment changes can render a highly efficient (in the static sense) capability worthless because it becomes irrelevant to the competition under the new conditions’ (Andreu and Ciborra, 1996, p. 127). Indeed, the very factors that provide strength in a particular environment can generate rigidity, hampering adaptability to new circumstances (Leonard-Barton, 1992).
extended the resource-based perspective to the problematic of successful firms’ reaction to a shifting competitive environment (Teece et al., 1997). They argue that dynamic capabilities enable firms to ‘[...] integrate, build, and reconfigure internal and external competencies to address rapidly changing environments’ (Teece et al., 1997, p. 516; see also Grant, 1996). Dynamic capabilities are thus the antecedents to shifting strategic routines and also emerge from path dependent processes (Teece et al., 1997; Zollo and Winter, 2002). The challenge for firms rests in leveraging capabilities residing in path dependent processes to facilitate responsiveness to shifting competitive demands of the environment.

Andreu and Ciborra argue that shifts in information systems can be used by organizations to transition to a new organizational structure, or to alter competitive positioning in the face of inertia (Andreu and Ciborra, 1996). When firms shift from a forecast-driven model to a build-to-order driven one, for example, the common vision, perspectives and collective understandings that have developed among the key actors in the supply chain can be incompatible with the demands placed by build-to-order. The tightly woven and intertwined coordination and control routines, organized around a forecast imperative need to be refocused on customer orders. Firms can use the IT system to re-align incentives and shift the focus to the new collective purpose of delivering products to customer order.

RBV thus suggests that firms have established routines and capabilities that result in path-dependent change. IT system changes can be used to bring about changes in focus and to re-align organizational imperatives to respond to environmental change. Both OEMs A and B used the IT system for this purpose, establishing novel information flows and patterns of responsiveness in the supply chain. However, OEM C was a clear outlier. Rather than use the IT system as an enabler for complete re-alignment, it focused instead on reconfiguring its existing information flows to accommodate build-to-order efforts. We found that OEM C started from a baseline information exchange with its supply-chain partners that was faster and more accurate than that of its two competitors and decided to leverage its existing resources and routines by modifying its forecast systems rather than introducing new information pathways. Its experience with lean manufacturing endowed it with the ability to cope with small batch production and high product variety. Thus, the step change from the make-to-forecast system, to the new requirements under the build-to-order system were felt much more in the IT systems landscape, than on the operational level.

One place where we did observe OEM C shifting its technology use was its efforts to improve inbound logistics and parts delivery via a barcode-driven material control system that facilitated real-time, two-way communication between the OEM and inbound logistics company. The system connected the OEM assembly schedule to the supplier and logistics companies. It allowed both the supplier and the logistics company to follow any changes in the assembly schedule at the OEM, and to amend its component delivery and collection accordingly. The new system replaced a system that in structure and intent was very similar to what we had observed at OEMs A and B, where paper-based shipping notifications were still in use, with planning cycles of up to 2 weeks (as opposed to real-time). In our interviews, the benefits of the new system in terms of its ability to react to changes and problems were emphasized by several interviewees, and the overall acceptance was very high throughout all tiers in the supply chain. An interesting feature was that, although the IT system was entirely new in this case, the existing advanced shipping notifications (ASN) were kept and built into the new system. In our interviews we found this allowed for continuity with the supplier accounting departments, which had adjusted their procedures to suit these forms—either in electronic form, as in the present, or in paper, as was the case of the old system. Thus, path dependence originating from the original technology had a clear impact on the design of the new inbound logistics control system.

The system at OEM C was successful in the forecast model, and as such, path-dependence was a strong driver towards modifications rather than fundamental change. However, OEM C also possessed the dynamic capabilities, in the form of social and structural flexibility to adjust to the new requirements. While, like OEMs A and B, it drove production by a forecast-based production program set months in advance, we found in our interviews that what mattered was not the information exchanged, but the perceptions key firm staff held of that information. In the case of OEMs A and B, it was widely accepted by the production planning and control staff at the assembly factory that the forecast was inaccurate, and most likely would be amended in some form over time. As such, operational staff rarely looked at the information originating from the system. In case of OEM C however, the perception was very different. The production schedule was set within tight constraints dictated by the manufacturing equipment and contracted supplier capacities, and the factory was evaluated on achieving this schedule. As a result, the discipline of working to a firm schedule, coupled with the small batch operation under the lean
manufacturing system, provided the base-line capabilities from which to bring about change. However, these base-line capabilities are not enough to ensure the capabilities will actually be used. Our interviews with all external partners suggest that because OEM C made no structural or IT system changes, they did not view as credible OEM C’s indications that it was interested in moving to an order-driven model. To quote one of the inbound logistics providers:

‘We first thought this was just another fad. We had been through the JIT transition with them a couple of years back, and they did not seem to want to make any major changes to the system’.

A dealer representative stated it as follows:

‘The idea of operating with less stock has been around for a long time, and for as long as I have been selling [OEM C] cars, we have sold them from stock’.

This highlights one of the key shortcomings of the RBV/dynamic capabilities perspective: the focus on a focal firm masks the complexity involved when considering capabilities, routines, and resources, in a broader system of organizations. OEM C’s unique capabilities and common vision and expectation of its employees enabled it to encourage in-house actors to shift towards a build-to-order model. However, the capabilities a firm possesses in-house do little to help us understand the challenges the firm faces in the broader supply-chain system—an area where complex adaptive systems thinking provides additional insights.

3.2. Complex adaptive systems (CAS)

Complex adaptive systems theory builds on the concepts of general systems theory (Bertalanffy, 1968; Ackoff, 1971). A complex adaptive system consists of a network of interacting, independent and adaptive agents. In the case of supply-chain systems, the agents interact by exchanging information and physical goods. Agents scan their environment and develop schemata representing interpretive and action rules. These schemata are subject to change and evolution (Holland, 1995). The main distinguishing feature compared with the traditional systems view is that the adaptive system expresses a degree of emergence and self-organization, based on the system’s history. From the standpoint of supply-chain management, this highlights the need to develop coordination systems that lead towards ‘[...] adaptive, flexible and coherent collective behavior in supply chains’ (Surana et al., 2005, p. 4235).

Complex adaptive systems theory was formally proposed by Holland (1995) as a means of studying the dynamic behavior and response of systems that have the capacity to change and learn from experience. As such, CAS has been applied not only to management systems, but to the study of biological systems (e.g. the brain or immune system) and sociology (e.g. group behavior). Following the tenets of CAS theory, Choi and colleagues define supply networks ‘[...] as a system that emerges over time into a coherent form, and adapts and organizes itself without any singular entity deliberately managing or controlling it’ (Choi et al., 2001, p. 352). The process of change and adaptation helps elucidate why the actual use of technology can deviate from its intended purpose, and equally importantly, why the overall performance of an IT system may fall short of intended objectives.

With respect to our cases, the changes brought about in the supply systems of all three OEMs were centrally driven by the OEM producing finished vehicles. However, both suppliers and outbound logistics providers indicated the system was not nuanced enough. These external actors also felt the OEM was not interested in the challenges and opportunities they faced. In the case of suppliers, the general feeling was that the system did not adequately capture internal constraints on efficiency and opportunities to leverage scale. For example, one supplier of axle modules said:

‘Every problem they [the OEM] have in paint or assembly means that we have to change our schedule’.

However, these challenges were present, even in the build-to-forecast model. We learned the key difference was that in the build-to-forecast model, the problems were less acute since there was no customer waiting on the final product. In spaces between actors where no technology had been put in place to disseminate forecast information, we see the emergence of physical inventory buffering with the shift to build-to-order. For example, we find that physical storage becomes the buffer for incomplete constraint specification in the IT system. The physical buffers permit lose coupling, allowing local actors to adjust to the uncertainty inherent in the broader system driving the build-to-order demand (Orton and Weick, 1990). From a complex adaptive systems perspective, these physical buffers are an important means by which actors in the system cope with their inability to control product flow via information exchange in the technical system. In particular, we see physical buffering between the
supplier and the assembly plant (buffers A and B), as well as in the distribution chain (buffer C). The emergence of buffers provides an empirical illustration of why inventory emerges in relation to structural deficiencies in the supply-chain system. While the use of inventory buffers as a mechanism of coping has been well described in relation to demand uncertainty, long lead-times, and supply constraints (Lee and Billington, 1992), these discussions are often limited to qualitative description. The complex adaptive systems lens allows for a detailed explanation of why buffers emerge, and the inadequacies in the system that lead to them.

Buffering is one way in which the broader supply-chain system adapts and organizes itself without a managing entity. However, even within the managing entity, on-going adaptation and change is a key driver of adaptability and coherence in the presence of build-to-order. For example, the actual submission of customer orders was in all cases executed on the same IT system that was used to submit the forecast orders in the old system. For forecast stock orders, lead-time was not critical, so the order submission from the dealer to the national sales company and on to the OEM headquarters used to take place on a monthly basis. With an increasing number of customer-sold orders however, this delay was no longer acceptable, and the process was changed to weekly, and in some cases, bi-weekly order submission. As a result, the entire planning and scheduling process and the resulting flows #3, #4, and #6 had to be executed in the same timeframe. The entire ‘time structure’ of the order-to-delivery process was thus changed in order to accommodate the need for greater operational responsiveness. These changes were initially met with great skepticism by the planning staff at the national sales companies and central planning departments at the OEM headquarters, yet over time, the new scheduling regime led to a considerable change in behavior. Whereas it was previously common practice to batch orders for certain markets in order to use logistics resources efficiently (for example, the ship used to export to North America takes about 3000 vehicles at a time), this was no longer feasible as it introduced unpredictable additional delays for the customer orders. The misalignment to the goal of increased responsiveness sparked a series of new features (shorter system updates) and behavior (shorter scheduling cycles).

While CAS helps us understand the adaptive nature of the overall system, it does mask the co-evolution of behavior and technology that accompanies a dominant player’s efforts to use technology to drive system change; for this specific purpose adaptive structuration theory is highly applicable.

3.3. Adaptive structuration theory (AST)

Adaptive structuration theory was proposed as a framework for studying variations in organization change that occur as advanced technologies are used. The central concepts of AST are structuration (Giddens, 1979), and appropriation (Ollman, 1971); together these provide a dynamic picture of the process by which people incorporate advanced technologies into their work practices (Walsham and Han, 1991).

AST argues that there is ‘duality’ of structure whereby there is interplay between the types of structures that are inherent to advanced technologies (and, hence, anticipated by designers and sponsors) and the structures that emerge in human action as people interact with these same technologies (Orlikowski, 1992; DeSanctis and Poole, 1994). The latter can be found in reporting hierarchies, standard operating procedures, and the like. Barley (1986, p. 81) argues that organizational structures related to technology are socially constructed, whereby ‘[… ] technologies exist as objects in the realm of action’. But AST goes beyond this, arguing for the importance of understanding technology in use as various processes intervene in the relationship between technology and the outcomes of its use (DeSanctis and Poole, 1994; Orlikowski and Yates, 1994).

Understanding technological evolution is not always easy, in part because the link between technology and organizational need is not always a deterministic one. The structuration process can be gradual, or it can be discontinuous. Leonard-Barton (1988) describes how misalignments between actor needs and technology can be gradually corrected, while Tyre and Orlikowski (1994) suggest that technological adaptation follows significant discontinuities. Part of the difference in perspective may derive from the specific technologies and situations under consideration. We focus on technological change in response to a discontinuity in organization need. In the absence of such a change in need, it is hard to distinguish shifts in technology that happen naturally during a technology’s life cycle, and technical change that is driven by a shock that provides a clear occasion for ‘structuring’.

As a result of the perceptions and behaviors of the actual IT system users, the information technology itself is adapted into organizational practice. The type and degree of adaptation will vary across firms, depending on the organizational structures in place. The differences in organizational structures and procedures determine the degree of change triggered by the technology implementation, and whether the change
enhances or undermines organizational effectiveness (Lewis and Suchan, 2003). Lewis and Suchan (2003, p. 296), identify AST as ‘[…] a useful theoretical framework that can help understand the relationship between technologies, the people who interpret them, and the patterns of use that stem from that interpretation’. They suggest that AST provides a potentially significant lens on how change in information technology affects supply-chain evolution, in the intra as well as inter-organizational contexts. While AST has been applied largely at the intra-firm level, the advantages to coordinating, transferring, and integrating information, extend beyond the level of the individual employee or groups, but also across business units and business partners (Ghoshal and Moran, 1996).

A key question in a complex environment is where to draw the distinction between implementation and adaptation (Rogers, 1995). There is a significant discontinuity in the corporate strategies that render the existing technology inadequate. In each of the case OEMs, changes to the formal IT system originated at headquarters, and were aimed at capturing actual customer order flows and transferring them through the system. Drawing on the AST framework, we are able to generate several insights regarding the role of information and transformation of supply chains. AST predicts an adaptive iteration between technology and the system. We find that within organizations, changes in the information flow were straightforward, and involved at most the addition of new or revised information flows. However, outside of the core organization (i.e. within the supply chain), we see several different outcomes of the IT system—most do not involve iteration between technology and the users of the system, but instead led to clear responses to the new IT system: these included ignoring, supplementing, and circumventing the technology’s intention.

A key dimension in the AST domain, centers on organizational structures and the power dynamics that accompany them. In our three cases, the power dynamics in the system determine the directionality of information flows. New information flows are generally accepted only if they are beneficial to the core organization. Otherwise the other firms in the supply chain (i.e. suppliers and logistics operators) are forced to rely on buffers to protect against information inadequacies. This finding is consistent with previous contributions on power constellations in supply chains (Cox, 1999), which postulate that the most powerful entity in the system will favor local optimization of their respective processes over a solution that marks a compromise derived from a systemic perspective. In all three cases we analyzed, changes emanated from a central, powerful actor. While we see efforts on the part of less powerful actors to bend the modifications in the technology to their own advantage, the opportunities for such modifications were limited by the vertical information flows that dominate in this setting. We did not see a single instance of OEMs taking supplier constraints into account in the information system.

In the case of outbound logistics providers, the information system did little to meet either the needs of the logistics companies or the OEM: each logistics provider indicated that they understood the system’s purpose as being to indicate what products were available for shipment. While they also understood that the OEM was emphasizing building products to customer order, each was skeptical for different reasons. One of the logistics providers indicated that since the system did not identify which products had been custom ordered, it could be inferred that such products should not receive preferential treatment. The logistics provider to company A, which did have indicators for customer ordered vehicles suggested the OEM did not believe the distinction was important as the payment scheme in place did not distinguish between products that were made to stock versus those made to customer order. He went further to indicate that custom built vehicles were not consistent with the optimal loading of the trailers, and so a key determinant of profitability was to focus on consolidating finished product by destination—rather than place priority on one vehicle or other. The dealers we spoke with all indicated that they had no control over logistics providers, and that they had no way to let the latter know if an order were particularly urgent.

While the build-to-order imperative behind the new IT system linkages was clear, there was often little scope for changing the system once it was in place. We have discussed the emergence of physical buffers. We also noted the emergence of informal information flows where formal flows were either not adequate for attaining basic performance goals, or where the powerful actor found informal flows enabled it to augment its operational performance. These new flows are interesting, because they take place independent of the IT system. Thus, while AST would suggest that technology would evolve, we see technology remaining unchanged, but new structures emerging to handle issues that are not manageable in the existing technical system. When we explored this with our informants, we received a range of answers: at one level, we find that key actors across organizations who shared common experiences with the earlier system also developed a
sense of mutual obligation and worked to circumvent the IT system where necessary to attain what both parties believed would be beneficial outcomes. This circumventing left out the OEM’s units that were involved in the design and push for the new technology. As one factory manager at a supplier to OEM B put it:

‘[

]...often we solve these operational problems locally, without reporting back to our contracts people [referring to the Key Account Manager for the OEM at the supplier’s headquarters]. If we reported every little hick-up with [OEM B] back to our central planning office, we would be busy all day long. [...] We don’t have time for that’.

When asked why they did not push to have deviations formalized in the technology, one production manager suggested that:

‘We do get some say in how the deliveries are organized. [...] We have discussed several improvements with them, but quite frankly we’d rather do it our way’.

He went on to express concern that control would shift from production to the IT system—control that he was not willing to relinquish. A manager at a supplier for OEM B had a different perspective—he argued that by not specifying everything in the planning system, there was still some room for flexibility.

Also in line with AST’s predictions are a number of instances where the IT system is appropriated and manipulated for uses that were never anticipated when the technology was put in place. For example, suppliers chose to by-pass technology because the digital representation of information missed key capabilities, as well as constraints that they faced. There were also instances where the technology changes conflicted with the goals and perceived benefits players in the value chain hoped to gain from the system. This was observed, for example, when outbound logistics providers felt that customer-driven order flows conflicted with the optimal loading of their transporter trailers. In all such instances, physical linkages were inserted in the form of in-process and finished goods inventory, and additional (often informal) information flows emerge.

As DeSanctis and Poole (1994, p. 124) point out, ‘[

]...there is no doubt that technology properties and contextual contingencies can play critical roles in the outcomes of advanced information technology use. The difficulty is that there are no clear-cut patterns indicating that some technology properties or contingencies consistently lead to either positive or negative outcomes’. We found that the strengths of AST lie in its emphasis on the nature of social structures within information technologies, and the key interaction processes that underlie their use.

3.4. Synthesis

We have reviewed the key tenets of RBV, CAS, and AST, as well as the specific application to our case supply chains. Table 6 summarizes and contrasts these theories on three dimensions: their respective foci, the approach to control and coordination mechanisms offered, and a summary of the main explanatory power that each theory provides.

By integrating the RBV, CAS, and AST perspectives, we are able to develop a number of novel insights: RBV helps us understand the role of path dependence and ‘lock-in’ of supply-chain partners, but its main focus is the OEM itself—not the supply-chain system. The complex adaptive systems perspective broadens the perspective to the supply chain as a system. Taking this more integrative lens helps us understand the emergence of physical buffers—as time demands increase in the overall supply-chain systems, physical buffers emerge to cope with information flows that are inadequate because of short lead times, insufficient accuracy, or inadequate feedback loops. This suggests it is important to consider not just the interplay between technology and social structure, but also the physical correlates of inter-organizational information exchange and coordination.

AST helps us understand the unintended uses of technology, in particular with regards to deviation of actual from intended use. It also highlights the importance of taking into account power dynamics: IT system modifications were limited by the centrally directed information flows that dominated in this supply-chain context. As Heckscher (1994) points out, tighter connections with partners does not necessarily mean greater dialogue between the partners. This highlights the importance of future research in this area to more explicitly assess and model the power of key actors in the overall system.

While the re-engineering of the order-fulfillment strategy was a dramatic one, the above perspectives highlight the difficulties in accomplishing radical change, even in the presence of coping mechanisms such as buffers and informal information flows. As outlined in Section 2, over the 2-year period under observation, the BTO content increased at all OEMs but even the highest, at 37%, can be considered a partial
transition at best. While the tensions that emerge during the technological shifts result in the emergence of several alternative information flows as well as physical buffers, these were only partly effective in helping the OEMs attain their responsiveness goals.

4. Conclusion

We examined three theoretical perspectives in SCM research—complex adaptive systems theory, the resource-based view, and adaptive structuration theory. We use these as lenses to understand changes in information flows that accompanied a shift to build-to-order from build-to-forecast in three automotive supply chains. While none of these theories originate in the OM field, the RBV and CAS are well established in the OM literature. AST in contrast, has received little attention in supply-chain research so far. This is partly due to a very different epistemological stance that departs from the positivistic research that predominates in supply-chain research in particular and operations management more generally.

4.1. Broadening the theoretical base of SCM research

Introducing theories from related fields is bound to be difficult: differences in language, epistemology, and even more importantly, the different research methodologies they favor pose serious challenges for conducting and publishing these studies within the remits of a different field. On the other hand, research environments in OM are characterized by a high level of static and dynamic complexity; as McCutcheon and Meredith (1993, p. 247–248) argue, ‘[...] OM involves complex interplays of people, technological systems, and organizational physical processes, most of which change in nature over time’. New theory development in OM has to cope with this issue, incorporating and embracing the complexity as a source of insight and opportunity. This complements the proposals by Stock (1997), Schmenner and Swink (1998), and others, for the field to broaden the scope of research tools and methods that are used to study core OM and SCM research questions. There is indeed a history of supply-chain management researchers borrowing theoretical frameworks from other fields (Stock, 1997; Amundson, 1998; Melnyk and Handfield, 1998). As such, we argue that it is important to maintain an open mind and question the extent other theories complement, or in some cases possibly even challenge, existing OM research. We have shown how the three theories we considered in this study, all with origins outside of the OM field, provide different, yet overall complementary insights in supply-chain research.

4.2. Applicability, limitations, and complimentarity

In applying the three theoretical lenses we have illustrated not just their explanatory power with regards to SCM research, but also highlight more broadly their applicability and limitations. For example, our findings highlight one of the key shortcomings of the RBV/dynamic capabilities perspective: its focus on a focal firm masks the complexity involved when considering capabilities, routines, and resources, in a broader system of organizations. Capabilities at the firm level provide little understanding of the challenges a firm faces in its supply-chain system. It is here that the concept of complex adaptive systems that adapt to external influences provides important insights. CAS promotes the notion of ‘emergence’ which helps explain
deviations from intended use of technology, and subsequently, inferior performance. It also provides an explanation for the emergence of substitute information flows and buffers in the system, and the system features that cause them. CAS fails however to explain the co-evolution of behavior and technology that follows from a structural shift in the supply chain. Here, AST – with its emphasis on the nature of social structures within information technologies, and the key interaction processes that underlie their use – provides additional insights that cannot be obtained through either RBV or CAS. In encouraging researchers to examine these processes and determining their impacts, AST opens opportunities for a richer and more comprehensive understanding of the IT system—organization relationships that enable supply-chain operations. It also provides a useful lens to examine the root causes for deviation from an IT system’s intended use and projected performance.

We also identify two limitations of AST: first, it is generally internally focused (on the firm or even group level), and as such may be limited in its ability to address broader supply-chain problems. Second, AST requires identifying a fundamental shift in the IT system; the challenge here is to not only to observe such a major shift in the system, but also to determine whether the system under investigation is actually changing, or whether the researcher is simply observing a ‘steady state’ where inertia of the past system still dominates the current state. As Thompson (1967) argues, the initial response to manage change could be through alterations of the periphery, leaving the core of the system unchanged. Lastly, we see the focus on ‘step changes’ in technology as the main limitation of AST when applied to OM in general. OM places great emphasis on the concept of continuous improvement, with gradual evolution in practice—evolution that is purposeful and guided (e.g. in the form of kaizen activities). AST is conceptually unable to capture and study the continuous effort to fine-tune and improve that ultimately leads to change in the system, even in the face of the complex interplay between technology and the social structure.

In applying three theories to the same problem, we show how the strengths of each complements the weaknesses of the others: AST’s focus on the complex interplay between social and technical systems complements the CAS view, which provides a broader understanding of the system and its dynamic evolution. RBV on the other hand explains why some systems resist change, by outlining how strong path dependence precludes a willingness and/or ability to change.

4.3. Implications for SCM research

The past two decades of SCM research have highlighted many dysfunctions that occur when coordination of multiple tiers occurs in connected, complex systems. A common feature in resolving supply-chain ‘ills’ is to transfer or share information without delay between partners in the supply chain, in order to avoid dynamic dysfunctions such as such as the famous bullwhip effect (Forrester, 1958; Lee et al., 1997). Examples of tools used to attain the requisite information exchange and synchronized value added activities include the exchange of point-of-sales data (EPOS), electronic demand transmission via electronic data interchange (EDI), and collaborative planning, forecasting and replenishment (CPFR) (Gunasekaran et al., 2002). Generally these are enabled via IT systems, and this is a driving argument for the importance of information technology in enabling advanced manufacturing and supply-chain operations (Hendricks et al., 2007). As Surana et al. (2005, p. 4243) note, ‘[...] Many improvements have occurred in supply-chain management because IT enables dynamic changes in inventory management and production, and assists the managers in coping with uncertainty and lead-times through improved collection and sharing of information between supply chain nodes’.

However, providing information visibility as such is not sufficient. Information and capabilities provided by multiple tiers in the supply chain must be used in an integral fashion as otherwise system-wide performance does not follow (Holweg and Pil, 2004). Not surprisingly, the value of such shared information has been a central topic of a lively ongoing debate whereby critics point out that providing information that either is too unreliable, or provides little or no additional content above and beyond existing information, does not lead to performance improvements in the supply chain (Cachon and Fisher, 2000; Lee, 2000; Sahin and Robinson, 2005).

There is a general recognition that coordination between suppliers, actors in the organization, and customers can be enhanced via IT systems (Nidumolu, 1995; Lewis and Suchan, 2003), but this does not mark a sufficient condition. It has been argued that the effect of advanced technologies is less a function of the technologies themselves than of how they are used by people: actual behavior in the context of advanced technologies frequently differs from the ‘intended’ impact (Kiesler, 1986; DeSanctis and Poole, 1994). People adapt systems to their particular work needs, and in some cases, may even fail to use them entirely. As IT systems become a critical driver for strategic advantage,
it is important to understand how their role evolves in inter-organizational contexts, and ultimately, their impact on performance.

Future research into improving supply-chain performance must not assume that providing an IT system, or any advanced technology in general, provides guaranteed improvement. Technology implementation and adaptation is a process that has a strong bearing on the overall performance outcome of the new technology, and here novel, qualitative theories are required to explore the complex interaction between humans and technology. In this paper we provide a first step towards expanding the theoretical base of SCM research to encompass not just technology’s intended functionality, but also its actual use.

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