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Journal of Operations Management 20 (2002) 729–745

JOURNAL OF OPERATIONS MANAGEMENT

www.elsevier.com/locate/dsw

Demand chain management in manufacturing and services: web-based integration, drivers and performance

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Abstract

This paper investigated the relationship between Internet-enabled supply chain integration strategies and performance in manufacturing and services. It summarizes the literature on demand and supply integration and describes four web-based strategies. A stratified random sample was collected from UK manufacturers and services, and there was strong evidence that demand chain management (DCM) led to the highest performance in manufacturing, but few signs of DCM in services. Manufacturers and services relying on only web-based demand or supply integration outperformed their low integration counterparts, but lagged DCM in manufacturing. The study also investigated DCM adoption drivers and found that rational efficiency and bandwagon effects drove change. The findings have some important implications for theory as well as for manufacturing and service companies interested in improving their performance.

Keywords: Demand chain management; Supply chain strategy; Empirical research

1. Introduction

The most admired (and feared) competitors today are companies that link their customers and suppliers together into tightly integrated networks using what is now commonly called demand chain management (DCM). DCM is defined as practice that manages and coordinates the supply chain from end-customers backwards to suppliers (Vollmann et al., 2000). Specifically, end-customers trigger actions up the supply chain and products and services are pulled (not pushed) from one link to the next based upon demand (Lummus and Vokurka, 1999).

Although we have know about the theoretical benefits of DCM for many years, making it work in practice was typically impossible before the Internet. DCM requires extensive up- and downstream integration between all business partners in order to succeed and these types of connections have only recently become possible due to the web. Notably, in pre-Internet days there were no great solutions to the tradeoffs between low cost, rich content, real-time data and broad deployment across supply chains using traditional methods, such as EDI and Kanban.

In contrast, the Internet effectively resolved these tradeoffs and allowed the types of integration necessary between every partner in the supply chain. Where real-time demand information and inventory visibility were once impossible, web-based technologies are now increasing indispensable for supply chain forecasting, planning, scheduling and execution. Real-time information travels immediately backwards though

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PII: S0272-6963(02)00037-2

these web-based, demand-driven supply chains while inventory flows swiftly forwards. Most importantly, goods and services are delivered quickly and reliably when and where they are needed. The more integrated the flow of data between customers and suppliers, the easier it also becomes to balance supply and demand across the entire network. Together, greater online coordination with associated reduced lead times helps defeat the bullwhip effect and contributes to higher performance (Lee et al., 1997a).

Given that DCM is potentially a powerful strategic weapon, there are still many unanswered questions about its use in practice. Notably, we know little about what differentiates manufacturers and services regarding demand-driven supply chains and our knowledge is especially weak concerning modern Internet-based integration in all sectors (Bowersox et al., 2000). Competitive advantage comes from seamlessly coordinating operations across demand-driven chains, but which web-based integration strategies lead to the highest performance?

Our investigation was especially motivated by the possibility that manufacturing and services are sufficiently different enough that it affects the need for DCM. This study, therefore, contributes to the field by simultaneously analyzing the relationships between demand and supply integration and performance in both a manufacturing and service context. The paper also extends our knowledge about the implementation of supply chain improvements and adds evidence to this emerging stream of literature on the adoption drivers behind the use of demand-driven chains.

2. Demand and supply integration, conceptual framework and hypotheses

2.1. Demand integration

Integration is “to make into a whole” (Oxford English dictionary) and substantial previous research highlights many opportunities separately associated with either demand or supply integration (Table 1). In terms of the demand-side of companies, major challenges are improving demand visibility and planning in supply chains (Fisher et al., 1994). “Distorted information from one end of the supply chain to the other can lead to tremendous inefficiencies: excess inventory investment, poor customer service, lost revenues, misguided capacity plans, ineffective transportation and missed production schedules” (Lee et al., 1997b, p. 93). One trend is integrating up- and downstream information to coordinate non-vertically integrated firms (Mabert and Venkataramanan, 1998). Since planning instability is magnified up supply chains,

Table 1
Summary of literature review: supply and demand integration

Types of integration/issue	Studies
Demand integration	
Efficient delivery	Cachon (1999), Cachon and Fisher (1997), Clark and Hammond (1997), Daugherty et al. (1999), Johnson and Scudder (1999), Kopczak (1997), Waller et al. (1999)
Delivery/logistics communication	Corbett et al. (1999), Kopczak (1997), Waller et al. (1999)
Speed of delivery/ route	Clark and Hammond (1997), Kopczak (1997)
Inventory stocking points	Kopczak (1997)
Demand planning	Fisher et al. (1994), Gavirneni et al. (1999), Gilbert and Ballou (1999), Hariharan and Zipkin (1995), Lummus and Vokurka (1999), Magretta (1998)
Supply integration	
Supplier reliability	Carr and Pearson (1999), Chapman (1989), Choi and Hartley (1996), Fawcett and Birou (1993), Freeland (1991), Grout (1998), Hill and Vollman (1986), Krause (1999), Krause et al. (1998), Narasimhan and Jayaram (1998)
Multiple sourcing	Bozarth et al. (1998)
Responsive/flexible supply base	Krause (1999), Narasimhan and Das (1999)
Inbound logistics communication	Grout (1998)
Supplier planning	Fisher et al. (1994), Magretta (1998)

controlling this amplification is vital for good demand management (Bhaskaran, 1998). Successful demand integration, therefore, typically relies on information technologies including the Internet (Bowersox et al., 2000) and involves shared data between planning and control systems (Bowersox and Daugherty, 1995; Narasimhan and Carter, 1998).

Other important issues regarding demand integration include the need for efficient and rapid delivery (Cachon and Fisher, 1997; Clark and Hammond, 1997), as well as improved logistics communication (Corbett et al., 1999). At the core of demand-driven supply chains, therefore, are the basics of forecast integration, inventory reductions and the elimination of non-valued added activities (Claycomb et al., 1999).

2.2. *Supply integration*

Other studies have investigated the supply-side integration of companies (Table 1). Krause et al. (1998) pointed out that many companies seek supplier improvements in delivery and cost. As Handfield (1993, p. 290) noted, supply integration typically means “obtaining frequent deliveries in small lots, using single or dual sources of supply, evaluating alternative sources on the basis of quality and delivery instead of price, establishing long term contracts with suppliers, reducing buffer inventories and eliminating formal paperwork.” Integrated supply not only reduces costs but also improves lead times (Ansari and Modarress, 1990). Other benefits from supply integration include improved supplier reliability (Carr and Pearson, 1999) and communication (Freeland, 1991). Studies have, therefore, consistently linked supplier integration to greater performance (Chapman and Carter, 1990; Akinc, 1993; Lawrence and Hottenstein, 1995; Agrawal and Nahmias, 1997; Tan et al., 1998).

2.3. *Four web-based demand and supply integration strategies and hypotheses*

While it has always been theoretically possible to broadly integrate with customers and suppliers, it is only recently through a combination of theory and the Internet that it has become practical (Bowersox et al., 2000). Pre-Internet, real-time demand information and inventory visibility were typically impossible to achieve and most supply and demand “integration” involved a patchwork of telephoning, faxing and EDI. This has changed in the Internet era and widely available web-based technologies now permit strong customer and supplier integration for inventory planning, demand forecasting, order scheduling, targeted marketing and customer relationship management. New Internet technologies, overlaid on the traditional demand and supply integration practices discussed above, present four strategic options shown in Fig. 1.

At one extreme is a strategy of little or no web-based integration (model A). At the other end of the continuum is a strategy with high levels of web-based

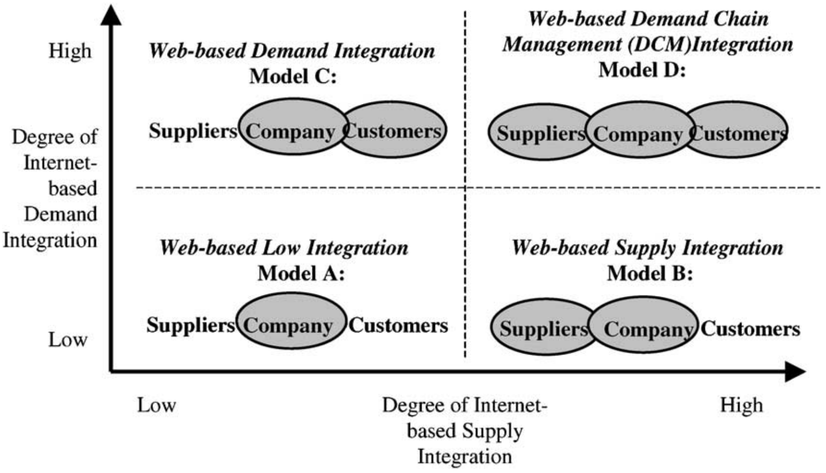

Fig. 1. Four web-based supply chain integration strategies.

integration coordinating the whole demand chain from customers backwards to suppliers popularly called DCM (model D). In between these polar extremes are companies whose strategies involve web-based integration with either their suppliers (model B) or customers (model C).

The DCM strategy (model D) should deliver the highest levels of performance. The higher the level of traditional integration with suppliers and customers the greater the benefits (Frohlich and Westbrook, 2001) and the Internet should only reinforce this relationship. Given the partial nature of their web-based integration, the performance for the supply integration (model B) and the demand integration (model C) strategies should logically fall between the low integration (model A) and DCM (model D) approaches. While integrating with the supply-side gives higher performance than for low integration companies (Germain and Droge, 1998; Tan et al., 1998) and demand-side coordination also improves results (Daugherty et al., 1999; Waller et al., 1999), partially deploying web-based technologies on one-side of a company should still only deliver limited benefits. Finally, as with the findings for traditional supply chain management (Narasimhan and Jayaram, 1998), a low integration strategy (model A) in the Internet era should deliver the fewest benefits. These arguments lead to the first set of hypotheses.

H1a. Manufacturers and services adopting a web-based DCM integration strategy (model D) will have the highest levels of operational performance.

H1b. Manufacturers and services adopting either a web-based supply (model B) or demand (model C) integration strategy will have medium levels of operational performance.

H1c. Manufacturers and services adopting a low web-based integration strategy (model A) will have the lowest levels of operational performance.

2.4. Three drivers of web-based demand and supply integration and hypotheses

While the adoption of new managerial techniques like Internet-based DCM seems faddish, there is strong theoretical evidence that companies actually adopt practices for both rational efficiency and bandwagon reasons (Abrahamson and Rosenkopf, 1993). Rational efficiency theory holds that if more organizations adopt a technique, then greater knowledge about the innovation's efficiency and benefits are created (Abrahamson, 1996). When this knowledge is shared between companies, eventually more and more non-adopters will rationally adopt the concept because of the innovation's inherent efficiency (Rogers, 1983; Mansfield, 1985).

The literature correspondingly suggests two rational efficiency explanations for DCM's adoption. The first driver is greater access to new markets. DCM is perceived in many industries as one of the most powerful tools presently available for creating real competitive advantage (Vollmann et al., 2000). By providing customers with unrivaled benefits, demand-driven supply chains not only allow companies to better satisfy existing clients but also to win over the most profitable customers in new markets. Widely-cited examples of using DCM to gain market share and dominate the competition include Zara's case in the fashion industry (Walker et al., 2000) and Dell's model in computers (Magretta, 1998). Companies, therefore, rationally adopt DCM in a quest to serve new markets and win customers.

The second rational efficiency argument for adopting DCM is the anticipated internal performance improvement. In theory, better coordination reduces uncertainty throughout networks (Davis, 1993; Lee et al., 1997a) and lets inventory and finished goods move more efficiently. This better coordination translates into reduced variability and eliminates non-value-adding activities, which in turn leads to greater operational performance (Metters, 1997; Lee and Tang, 1998; Grout, 1998). Famous examples of such improvements include Hewlett-Packard's dramatic decrease in printer inventory carrying costs due to DCM and postponement (Billington, 1994) as well as National Semiconductor's large reductions in delivery times and distribution costs (Henfoff, 1994). Based upon these (and other) early adopter success stories, subsequent companies may have rationally adopted DCM to improve their own internal performance.

The other main driver of new practice adoption is the so-called "bandwagon" effect. Bandwagons are diffusion processes whereby organizations adopt innovations, not because of any rational efficiency

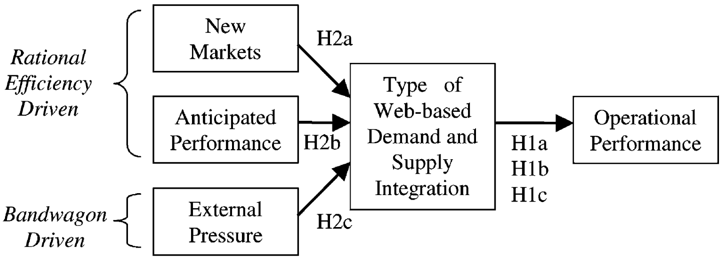

Fig. 2. Conceptual framework and study hypotheses.

assessment of the practice, but because of external pressure caused by the large number of organizations that have already adopted (or are considering adopting) the concept (Tolbert and Zucker, 1983). In some cases, even after companies have assessed new methods as highly inefficient and likely to cause losses, they are still adopted because of bandwagon pressures (Abrahamson and Rosenkopf, 1993). The pursuit of legitimacy (Scott, 1995) leads to a technique's adoption because management is more afraid of being perceived by customers, suppliers, investors and competitors as industry laggards than any legitimate fears about misapplying the practice. When innovations are new or poorly understood, following the lead of other organizations (whether right or wrong) is often the simplest way forward (March and Olsen, 1976). External pressures can thus drive the adoption of web-based methods like DCM, regardless of their inherent benefits. Rational efficiency and bandwagon theory together support this study's second set of hypotheses and the overall conceptual framework shown in Fig. 2.

H2a. Access to new markets drives the adoption of web-based demand chain integration.

H2b. Anticipated benefits drives the adoption of web-based demand chain integration.

H2c. External pressure drives the adoption of web-based demand chain integration.

3. Methods

3.1. Data collection

The survey was developed in three stages. In the first stage, we identified relevant measures of web-based demand and supply integration, drivers and performance in the literature and drafted the instrument. We held a series of meetings with managers in the second stage to gauge the content and face validity of the instrument. In the final stage, we pre-tested the survey with 30 manufacturers and service firms to further gauge its content validity and overall readability.

Data were collected from a stratified random sample of manufacturing and service companies from across UK. The research design proportionally represented large and small companies, and we sampled from all 13 regions of the UK including Scotland and Wales. In terms of external validity, the UK is the world's fourth largest economy (behind the US, Japan and Germany) and the nation's e-business adoption rate generalizes well to North America and continental Europe. By sampling an entire country, the research design also controlled for many confounding factors like telecommunication infrastructure, technology costs, government programs and the overall economy.

Typical respondents were VPs of Operations or General Managers and therefore, the data were collected from managers with enough seniority to know about their companies' up and downstream integration, DCM drivers and performance. The data collection was completed in early 2001 and followed Dillman's (1978) total design method. The industry breakdown of the sample is shown in Table 2. In total, 890 usable surveys were returned and the survey response rate was 20%.

3.1.1. Differences between manufacturing and services

According to Standard Industry Classification (SIC) definitions, manufacturing establishments (SIC Division D) are engaged in the mechanical or chemical transformation of materials or substances into

Table 2
Sample breakdown for manufacturers and services by sector[a]

Manufacturers			Services		
Sector	Count	Percent	Sector	Count	Percent
Aerospace	14	7.5	Banking/insurance	70	23.5
Automotive	24	12.8	Entertainment/tourism	16	5.4
Chemicals	14	7.5	Groceries/food	12	4.0
Computers/hi-tech	16	8.6	Hospitality/travel	6	2.0
Consumer appliances	12	6.4	Healthcare services	12	4.0
Food/beverages	26	13.9	Professional services[b]	112	37.6
Furniture/household	4	2.1	Retail/merchandising	6	2.0
Industrial products	22	11.8	Telecommunications	4	1.3
Medical products	6	3.2	Transport/distribution	26	8.7
Other Manufacturing	27	14.4	Utilities	4	1.3
Mixed industries	22	11.8	Other services	24	8.1
			Mixed industries	6	2.0
Total	187	100.0		298	100.0

[a] Based on the company's primary product/service lines.
[b] Accounting, consulting, engineering, legal, etc.

new products while service establishments (SIC Divisions E–I) are engaged in providing a wide variety of services for individuals, business and government establishments, and other organizations. Perhaps most importantly, the literature has long noted important differences between manufacturing and services firms (McColgan, 1997). Notably, service operations have unique characteristics that are rarely found in manufacturing including customer participation, intangibility, inseparability of production and consumption, heterogeneity, perishability and labor intensity (Nie and Kellogg, 1999). The direct participation of customers in the service process adds complexity that is generally not found in manufacturing (Chase and Tansik, 1983). Moreover, direct customer participation means that service firms tend to have many more physical sites than manufacturers along with the unique challenges presented by wide geographic dispersion.

Intangibility is often cited as another fundamental difference between goods and services since a service cannot be seen, touched or tasted in the same manner as a manufactured product (Fitzsimmons and Fitzsimmons, 1997). Services also tend to have higher heterogeneity and thus can be either deliberately or accidentally customized between different service providers and customers in comparison to the greater process standardization of a typical manufacturer's production. Services are likewise more perishable than physical products given that unused capacity is lost forever. This perishability leads to difficulties in managing demand, utilizing capacity, planning services and scheduling labor. Finally, services are typically more labor intensive in comparison to manufacturing (Heskett, 1986) and hence manufacturers can often realize more productivity gains through technological innovations (Quinn and Gagnon, 1986).

3.1.2. Data classification procedure and response accuracy tests

In order to best isolate the differences between manufacturing and services, this study focused on the predominately manufacturing only ($n = 187$) and predominately services only ($n = 298$) sub-samples of the 890 total responses collected. The other 405 cases, involving both mixed manufacturing/services and unclassifiable companies, were not used for this analysis. This three-group classification follows Nie and Kellogg's (1999) logic when they investigated service research and teaching in OM and categorized 167 members of 'Decision Sciences' and 'INFORMS' into manufacturing, service or mixed types.

We sorted the data into the correct groups based upon a multi-step process. First, the research team classified each case into either: (1) predominately manufacturing; (2) predominately services; or (3) mixed manufacturing/services and unclassifiable companies based upon an objective database called 'financial analysis made easy' (FAME) that holds 10 years data on 2.7 million UK companies including their industry, company type, SIC codes and trade descriptions. Where necessary, we also triangulated with other databases, such as LEXIS-NEXIS and PROQUEST and at times even logged onto companies' websites in order to determine which classification that they belonged in.

Second, we set up an acceptance sampling plan for directly telephoning a random subset of all the respondents in order to ensure that we had correctly classified them into one of the three groups. We followed a conservative sampling plan with AQL $= 0.01$, LTPD $= 0.05$, type-I error $(\alpha) = 0.05$, and type-II error $(\beta) = 0.10$. This plan required us to telephone 137 (n) respondents with a critical value (c) of three and ask them to self-classify their own organizations. All but one company was correctly classified, which suggested that we had successfully isolated the predominately manufacturing and predominately service companies in our subsamples.

As an additional test, we had embedded in the survey several randomly spaced questions related to the design of products and new product development that only applied to companies which manufactured products. As expected, based upon ANOVA and the Scheffé method, there was an overwhelmingly significant difference ($P < 0.001$) in the mean emphasis on designing products and new product development between the predominately manufacturing and services groups. This further supported our data classification.

Three months after the original sample was collected, 150 of the responding companies were re-contacted and asked to complete a second survey with a different respondent to help test response accuracy. Thirty-seven companies participated, there were no differences ($P < 0.05$) on selected measures and the inter-rater reliability was satisfactory per Boyer and Verma's (2000) guidelines. Similar to the above acceptance sampling, we again checked in this second survey to ensure that the companies were correctly classified as predominately manufacturing versus predominately services. All of the 37 responses were correctly classified.

We also compared a matched random sample of 60 responding and non-responding companies to assess non-response bias and found no differences ($P < 0.05$) in terms of size, age, location or industry. Since a single respondent rated integration, drivers and performance, this may have led to common-method bias that we checked for using Harmon's one-factor test (Podsakoff and Organ, 1986). Six factors with eigenvalues greater than one were extracted from all the measures in this study and in total accounted for 67% of the variance. The first factor accounted for 23% of the variance. Since a single factor did not emerge and one-factor did not account for most of the variance, this suggested that the results were not due to common-method bias.

3.2. Scale development

Respondents were asked to rate on multi-item scales (Appendix A) their degree of web-based integration with suppliers and customers, DCM drivers and performance. These scales were grounded in the literature (O'Leary-Kelly and Vokurka, 1998) and confirmatory factor analysis was used to ensure reliability (Kim and Mueller, 1978). All scales were unidimensional using principal components as shown in the Appendix A. The scales were summed averages of the measurement items and reliability (Table 3) was acceptable (Nunnally, 1968). Table 3 also shows the measures' Pearson correlations.

The reliability and validity of each scale and objective measure were further analyzed following Flynn et al.'s (1995) example. Construct validity was established by testing whether the items in a scale all loaded on a common factor when within-scale factor analysis was run. Appendix A shows that the eigenvalues all exceeded the threshold of 1.0, which supports each scale's dimensionality. Divergent or discriminant validity was tested three ways. Bivariate correlations were checked between each of the scale's measures and other potentially confounding variables included in the instrument such as location, company age, lack of previous demonstrated benefits and adequate external advice (Table 4). There were no significant correlations ($P < 0.05$), which helped establish that the scales were not measuring other unintended constructs. Second, we compared the average inter-scale correlations in Table 4 to the α's in Table 3. Acceptable divergent validity is shown when the α's are greater than the average inter-scale

Table 3
Model measurement and correlation matrix[a]

Scale	Measure[b]	#1	#2	#3	#4	#5	#6
1. Demand integration	Scale	*0.78*					
2. Supply integration	Scale	0.62	*0.91*				
3. External pressure	Scale	0.34	0.32	*0.65*			
4. Anticipated benefits	Scale	0.55	0.38	0.50	*0.85*		
5. New markets	Scale	0.52	0.46	0.50	0.49	*0.76*	
6. Performance	Scale	0.44	0.45	0.34	0.39	0.39	*0.83*

[a] Cronbach's α's are in italics on the diagonal. All correlations significant at $P < 0.05$.
[b] See Appendix A for scale measures.

correlations. Finally, the average correlations between scale and non-scale items were lower than between scale and scale items that helped support discriminant validity.

Cluster analysis was used to confirm the four web-based integration strategies predicted in Fig. 1. Methodologists advocate using a two-stage cluster procedure whereby a hierarchical algorithm determines the number of clusters and starting means, and then a non-hierarchical method is run for final clustering (Punj and Stewart, 1983; Ketchen and Shook, 1996). This combined approach was used with SPSS's hierarchical Ward's method (squared Euclidean distance) and *K*-means (quick cluster) non-hierarchical algorithm. The most appropriate number of clusters were determined using multiple methods (Ketchen and Shook, 1996). First, the dendogram for the cluster analysis was inspected to confirm the number of major groups (Aldenderfer and Blashfield, 1984). Second, the incremental changes in the agglomeration coefficient were checked for relatively large increases that implied dissimilar clusters were merged (Ketchen and Shook, 1996). Third, a split-half analysis was conducted to assess the reliability of the four-cluster model. We selected a six-cluster solution as the starting point for the split-half analysis and tested six-, five-, four-, three- and two-cluster models. The four-cluster solutions in each of the two split-halves shared the most uniform similarities. Finally, the decision to employ a four-cluster solution was based on interpretability. Moving from five- to four-cluster solution combined similar clusters, whereas moving from four- to three-cluster solution forced together dissimilar clusters.

Table 5 shows the results for the service and manufacturing companies. As expected, the manufactur-

Table 4
Measurement analysis: model and performance measures

Measure	Average inter-scale correlate	Correlations[a] between measures and other implementation-related variables				Average item total correlation	
		Company location[b]	Company age[c]	Lack of proof[d]	External advice[e]	Non-scale items	Scale items
1. Demand integration	0.43	0.06	0.05	−0.09	−0.07	0.35	0.60
2. Supply integration	0.45	0.07	0.05	−0.07	−0.03	0.34	0.79
3. External pressure	0.47	0.07	0.11	0.02	0.06	0.38	0.46
4. Anticipated benefits	0.44	0.01	0.02	0.00	−0.04	0.35	0.69
5. New markets	0.43	0.11	0.07	0.02	0.06	0.36	0.57
6. Performance	0.47	0.04	0.08	0.05	0.04	0.33	0.50

[a] No correlations significant at $P < 0.05$.
[b] Company location in UK (0: north; 1: south).
[c] Company age: actual age in years.
[d] To what extent was lack of previous demonstrated benefits a major barrier to this implementation? (1: insignificant; 5: highly significant).
[e] To what extent was inadequate external advice a major barrier to this implementation? (1: insignificant; 5: highly significant).

Table 5
Total sample for manufacturing and service companies

Integration strategy	Manufacturers		Services		Manufacturers + services combined	
	Count	Percent	Count	Percent	Count	Percent
Model A (low integration)	73	41.0	225	77.0	298	63.0
Model B (supply integration)	36	20.0	0	0.0	36	8.0
Model C (demand integration)	52	29.0	66	23.0	118	25.0
Model D (demand chain integration)	18	10.0	1[a]	0.0	19	4.0
Valid cases	179[b]	100.0	292[c]	100.0	471[d]	100.0

[a] A large transportation and distribution company.
[b] Eight excluded missing values reduced the valid manufacturing sample of 187 cases to 179.
[c] Six excluded missing values reduced the valid services sample of 298 cases to 292.
[d] Fourteen excluded missing values reduced the total valid sample of 485 cases to 471.

ing sample contained all four integration strategies. Surprisingly, the service sub-sample contained only one DCM (model D) company and no supply integration (model B) organizations. Although confidentiality prevents us from naming the one DCM service company, it is a large and well-known transportation and distribution company.

We ran discriminant analysis to ensure that the four integration strategies were correctly classified following Miller and Roth's (1994) example. The demand and supply measures were entered as independent variables with cluster membership (models A to D) as the dependent. Table 6 shows that 92.78% of the cluster groups were correctly classified indicating extremely good differentiation and well above the 25% correct classification expected by chance.

4. Results

4.1. Supply and demand integration strategies and performance in manufacturing and services

We tested the first set of hypotheses, concerning the relationships between web-based integration strategies and performance in manufacturing and services, using ANOVA and the Scheffé method. Table 7 shows significant ($P < 0.01$) differences between the four strategies.

There was good support for H1a that manufacturers adopting the DCM strategy (model D) have the highest levels of performance. Though few in absolute number, as seen in Table 7 the DCM manufacturing companies consistently matched or exceeded the other three groups' performance. H1a for services, however, was rejected. While the performance of the lone DCM service company was higher than the other three strategies the sample size was not large enough to draw a meaningful statistical conclusion.

There was also good support for H1b that manufacturers adopting either web-based supply (model B) or demand (model C) integration strategies would have medium levels of performance. As shown in Table 7, while the web-based supply and demand integration strategies statistically equaled or exceeded the low integration group (model A), the DCM manufacturing companies outperformed them. There was only mixed support for H1b among the service companies. No web-based supply integration service companies were discovered in our sample, but the demand-integrated (model C) services significantly ($P < 0.01$) outperformed the low integration group.

Hypothesis H1c, that manufacturers and services adopting the low integration strategy will have the lowest levels of performance, was strongly supported. As seen in Table 7, the low integration strategy in both manufacturing and services had significantly worse performance in comparison to the supply, demand and DCM integration groups.

As a further evaluation of H1a, H1b and H1c, the manufacturing and service sub-sets were merged together and general factorial ANOVA was run to test the effect of web-based integration (models A–D) on mean performance. As shown in Table 8, the overall model was significant ($P < 0.01$) and the higher the

Table 6
Results of discriminant analysis for cluster membership

Cluster	Number of cases[a]	Predicted group membership			
		1	2	3	4
Model A (low integration)	298	285 (95.6)	5 (0.0)	11 (3.7)	2 (0.7)
Model B (supply integration)	36	0 (0.0)	36 (100.0)	0 (0.0)	0 (0.0)
Model C (demand integration)	118	8 (6.8)	12 (10.2)	98 (83.1)	0 (0.0)
Model D (demand chain integration)	19	0 (0.0)	1 (5.3)	0 (0.0)	18 (94.7)

Percent of “grouped” cases correctly classified: 92.78%. The values given in parenthesis are in percentage.

[a] Four hundred and seventy-one valid cases; 14 cases were excluded that had at least one missing discriminating variable.

Table 7
ANOVA for performance by integration strategy and company type

Integration strategy	Mean[a]	
	Manufacturing companies[b]	Service companies[c]
Model A (low integration)	1.81 (2, 3, 4)	1.47 (3)
Model B (supply integration)	2.93 (1, 4)	–
Model C (demand integration)	2.57 (1, 4)	**2.19** (1)
Model D (demand chain integration)	**3.75** (1, 2, 3)	3.00[d]

Numbers in parentheses shows which other integration strategy type the cluster’s means performance is significantly different from. Bold print highlights the highest mean score for manufacturing and service performance.

[a] Range 1–5 (see performance scale in the Appendix A).

[b] F ratio $= 36.34$; probability of F ratio $= 0.00$.

[c] F ratio $= 28.72$; probability of F ratio $= 0.00$.

[d] Sample size too small for ANOVA ($n = 1$) (see Table 5).

level of integration (overall and towards the customer) the greater the performance ($P < 0.01$). Interestingly, the significant t-test ($P < 0.01$) for the co-variate suggests that the effect of DCM integration is greater in manufacturing than in services.

4.2. Drivers of supply and demand integration strategies

The second set of hypotheses, concerning the drivers of web-based supply and demand integration,

Table 8
General factorial ANOVA: dependent performance by independent integration strategy with manufacturing and services co-variate

Source of variation	SS	MS	F	Significance of F	
Within + residual	216.55	0.50			
Regression	10.44	10.44	21.06	0.00	
Integration Strategy (models A–D)[a]	90.56	30.19	60.91	0.00	
Overall model	161.00	40.25	81.22	0.00	
Total	377.55	0.86			
Co-variate	B	β	Standard error	t-Value	Significance of t
Manufacturing or services[b]	−0.36180	−0.19045	0.079	−4.589	0.00

$R^2 = 0.426$; adjusted $R^2 = 0.421$.

[a] Model A: low integration coded 1; model B: supply integration coded 2; model C: demand integration coded 3; model D: demand chain integration coded 4.

[b] Codes: 0, manufacturing; 1, services.

was tested using logistic regression. Logistic regression estimates the coefficients of a probabilistic model of independent variables that best predict the value of a dichotomous dependent variable. This procedure was used because the dependent variable is dichotomous (adoption/non-adoption of a web-based integration strategy) which violates a basic assumption of multiple regression. Three separate logistic regression analyses were done using the combined data ($n = 471$) for manufacturing and services in Table 5. For example, to test for the drivers of web-based supply integration (model C) the 36 adopters were first coded “1” and the 435 non-adopters “0”. This dichotomous dependent variable was then tested with the three predicted independent drivers of web-based integration (anticipated benefits, new markets and external pressure). The logistic regression runs for web-based demand (model C) and DCM integration (model D) were similarly coded 1/0 for adopters and non-adopters.

Table 9 shows the results. The non-significant χ^2 goodness-of-fit statistics for the three analyses (0.796 for supply, 0.322 for demand and 0.889 for DCM integration) supports the null hypotheses that the logistic regression models were not significantly different from the perfect model that correctly classifies all respondents into their respective adopter/non-adopter groups. Given the relatively large sample size and R^2, the statistical powers (with 1% type-I error) for all three logistic regression models were >99%. These statistical powers all exceeded the recommended 80% threshold (Cohen, 1988) and further suggest a high degree of accuracy in identifying important drivers (i.e. predictors) of the three integration strategies.

The logistic regression coefficient (β) indicate the direction and magnitude of each variable’s influence on the odds of adopting that integration strategy. If β for a variable is significant and greater than zero, an increase of one unit in the variable increases the odds of adopting that integration strategy. As for individual factors, the β coefficients of anticipated benefits were significantly different from zero ($P < 0.01$) for all three strategies. The β of new markets were significant for demand (model C) and DCM (model D) integration, but it was not a driver of supply integration. External pressure was significant ($P < 0.05$) for DCM integration and had a borderline significant effect ($P = 0.054$) for supply integration. The overall rank order of the β’s suggests that the rational efficiency hypotheses of anticipated benefits and new markets mainly drove demand chain integration. External pressure and the bandwagon effect was a somewhat less important driver.

5. Discussion and suggestions for further research

In this section, we discuss the main findings in this order: the relevance or otherwise of DCM for service organizations, the relationship of integration strategy and integration drivers, and the importance of DCM in manufacturing.

5.1. DCM in services

While these findings suggest that DCM is an important development for manufacturers, they do not support a similar claim for service companies. There are three possible explanations for our results. First, it may simply be the case that services are lagging several years behind manufacturing in terms of DCM and thus nothing showed up in our sample. Assuming that services lags manufacturing in adopting practice, however, is dangerous. While manufactures may have pioneered programs like TQM, JIT and cells in the 1980s, many services were just as aggressive as manufacturers at implementing ERP, re-engineering and the Internet in the 1990s.

The second possible reason for our finding may be a limitation in the data. The sample contained a wide variety of service companies, but only a relatively few total number of retailers ($n = 6$) and grocery/food distribution companies ($n = 12$). Many of the examples in the practitioner literature of DCM in services seem to be from these sectors (e.g. Wal-Mart or Tesco), and if our sample was considerably larger then we might have found more evidence of this strategy. While our findings suggest that DCM does not readily apply in services, future research merits investigating DCM in a larger stratified sample of retailers and grocery/food distribution companies.

Certainly services should not in this context be seen as a single homogeneous category. There are differences between retailers that hold some physical inventory and consulting firms whose costs are

Table 9
Logistic regression for integration drivers

	Model B (supply integration)			Model C (demand integration)			Model D (chain management)		
	B	Wald	Significance	*B*	Wald	Significance	*B*	Wald	Significance
Anticipated benefits	0.590	7.468	0.006	0.538	17.816	0.00	2.107	18.647	0.00
New markets	0.238	1.962	0.161	0.441	13.019	0.00	1.355	20.093	0.00
External pressure	0.353	3.635	0.054	−0.139	1.238	0.266	0.671	5.648	0.017
Model fit and statistical power	Hosmer and Lemeshow test: $\chi^2 = 4.635$ with d.f. $= 8$; significance $= 0.796$ Nagelkerke $R^2 = 0.182$ Statistical power $\alpha > 99\%$ ($P < 0.01$)			Hosmer and Lemeshow test: $\chi^2 = 9.241$ with d.f. $= 8$; significance $= 0.322$ Nagelkerke $R^2 = 0.123$ Statistical power $\alpha > 99\%$ ($P < 0.01$)			Hosmer and Lemeshow test: $\chi^2 = 3.633$ with d.f. $= 8$; significance $= 0.889$ Nagelkerke $R^2 = 0.475$ Statistical power $\alpha > 99\%$ ($P < 0.01$)		

dominated by personnel expenditures. While our findings suggest that DCM does not readily apply in services, future research which used a richer classification scheme like Chopra and Meindl's (2001) implied uncertainty and responsiveness dimensions, might reveal a greater range of DCM benefits and relevance.

The final plausible reason for this finding may be that DCM does not matter in services. The bane of physical products is inventory build-up due to the bullwhip effect in the supply chain. Does the bullwhip phenomen on really exist in a service context? Services are simultaneously produced and consumed and cannot be inventoried. If something cannot be inventoried, does the bullwhip effect apply?

Typically for manufacturers, materials are often over 60% of costs while labor is under 15% so many supply chain savings naturally come from inventory reductions and transportation efficiencies. Similarly, manufacturing delays and stockouts are frequently caused by a few late inbound raw materials so most manufacturers can benefit from sharing real-time demand information with their upstream partners. In services, the materials/labor ratio is often the reverse of that in manufacturing and service supply chains normally involve human skills over material flows (Cox et al., 2001). Service stockouts are, therefore, mainly driven by underestimating future demand and lacking sufficient capacity (i.e. service providers) on the day that customers actually arrive in the process. While no doubt staffing levels and queue sizes between partners in service supply chains are important, is sharing real-time demand data with suppliers and improving inventory visibility over relatively few materials really that strategic in services?

Although beyond the scope of this paper, the bullwhip effect in services needs to be more thoroughly documented. If there is a significant bullwhip in services, then DCM probably makes sense. If the bullwhip is not a significant factor, then service providers may have the luxury of only concentrating on the web-based demand integration (model C) that 23% of the service companies in this study pursued. This parallels Watson's (2001, p. 41) services finding that for insurance companies, while downstream customer integration was straightforward, upstream integration "remains little more than an unfulfilled desire".

5.2. *Integration strategy and integration drivers*

The next major finding is that the drivers of integration vary depending on the type of strategy. While all three integration strategies were partially driven by the anticipated benefits of the practice, the demand-driven strategies (models C and D) were also strongly motivated by the rational access to new markets. Conversely, the supply-driven integration strategies (models B and D) had external pressure driving their adoption. This suggests that demand integration is more driven by proactive rational efficiency factors like performance and market share, while reactive bandwagon pressures are an important driver behind web-based supply integration.

This finding is important given the relatively little evidence that our field has accumulated so far concerning the process of implementing supply chain strategy. Marucheck et al. (1990) noted that OM researchers often tend to pay less theoretical attention to the process of formulating and implementing strategies in comparison to their definition and content. Findings in this study suggest a dual context behind the process of implementing coordinated up- and downstream strategies. If only upstream supplier-side pressures are present, then companies will evolve their supply chain strategies in that direction. Conversely, if the opportunities from integrating on the downstream demand-side outweigh the costs then a company's supply chain strategy will naturally develop in that direction. It seems likely that only when upstream supply pressures and downstream market opportunities collide that companies take the ultimate step and implement DCM. This is an important insight for managers—the time may not be right to implement broad supply chain integration until upstream pressures and downstream opportunities are both present.

5.3. The importance of DCM for manufacturing

This study strongly suggests that DCM is currently the most powerful web-based integration strategy that a manufacturer can adopt. Although this has been an assumption behind much of the recent DCM literature, this is the first time that it has been demonstrated empirically with a large group of companies from the integrated perspective that Narasimhan and Jayaram (1998) argued for. The results in particular suggest that DCM has the strong potential to differentiate manufacturing performance. The low integration manufacturers recorded the lowest performance, while the highly successful DCM group enjoyed the powerful benefits of up- and downstream integration.

The companies in this group are unlikely of course to owe all their performance achievement to DCM; such a high degree of integration is typically an extension of earlier initiatives, such as JIT and other supply chain improvements, which give performance enhancements of their own. But the extra performance edge found in this group can reasonably be associated with the use of the Internet and DCM to give that superior supply chain coordination which reduces uncertainty throughout networks (Lee et al., 1997a), lets inventory move more efficiently, and reduces variability (Metters, 1997).

6. Conclusions

In conclusion, we offer some reflections on the implications for managers of our study. First, the DCM strategy appeared to be the best overall approach for manufacturers to follow and the relatively few manufacturers that are already following this approach should, therefore, continue holding the course and perhaps even increase integration with suppliers and customers wherever possible. Conversely, for most services the best approach right now is to focus on demand integration. Although this study's findings need replication before any final prescription can be made, it may be a waste of resources for services to chase either supplier integration or full-blown DCM integration.

Manufacturers already pursuing the supply and demand integration strategies have the simplest next steps. Although easier said than done, these groups need to make the final leap and begin integrating the up or downstream sides of their supply chains using the Internet. The low integration manufacturers and services, on the other hand, have a much harder task. They need to start implementing the web-based supply and demand integration that unlocks performance. Although this is a daunting task, the alternative of trying to compete without integration is worse since their survival may ultimately be at stake. Enhanced competitiveness requires that companies ceaselessly integrate within a network of organizations—manufacturers and services ignoring this new challenge are destined to fall hopelessly behind their more Internet-enabled rivals.

On the other hand, in the 21st century manufacturers may be seriously jeopardizing their performance by continuing to follow a low integration approach. Schmenner and Swink's (1998) theory of swift, even flows postulated that the most successful operations smoothly move raw materials and subassemblies through processes and into finished goods. Materials and finished goods only move swiftly if there are no flow impediments in the way and productivity rises proportionally to the speed that materials move through processes. By extension, manufacturers not exploiting the Internet and DCM have little hope of achieving the swiftest and most even flows.

As expected, results for the web-based supply and demand integration strategies show that focusing on only the inbound or the outbound sides provide marginal benefits. Lee and Billington (1992) and Hammel and Kopczak (1993) reached similar conclusions concerning the dangers of fragmented traditional supply chains—the same rules apply in the Internet era.

Acknowledgements

This research was supported in part by Deloitte Consulting and London Business School's Center for the Network Economy. The authors gratefully acknowledge the comments of the anonymous referees and, in particular, the guest editors for this special issue.

Appendix A. Scale measurement

A.1. Independent measures

A.1.1. Supply Integration

To what extent have you implemented web-based processes for any of the following with suppliers?

	Not at all				Fully	Factor loading
Integrated inventory planning	1	2	3	4	5	0.9134
Integrated supply chain management	1	2	3	4	5	0.9025
Integrated demand/forecasting	1	2	3	4	5	0.8798
Integrated order scheduling and tracking	1	2	3	4	5	0.8630
Eigenvalue						3.17
Percent of variation						79.20

Kaiser–Meyer–Olkin measure = 0.80; Bartlett test of sphericity = 1396.44; significance = 0.00.

A.1.2. Demand Integration

To what extent have you implemented web-based processes for any of the following with customers?

	Not at all				Fully	Factor loading
Targeted marketing/customer profiling	1	2	3	4	5	0.8412
Online order taking/receipt	1	2	3	4	5	0.7988
Integrated demand/forecasting	1	2	3	4	5	0.7439
Customer relationship management	1	2	3	4	5	0.7322
Eigenvalue						2.43
Percent of Variation						60.90

Kaiser–Meyer–Olkin measure = 0.78; Bartlett test of sphericity = 525.54; significance = 0.00.

A.1.3. Drivers of change

What were the main factors driving your web-based integration?

	Not at all	Fully	Factor loading		
			Anticipated benefits	New markets	External pressure
Improving speed of response	1	2 3 4 5	0.8576	0.1381	0.0974
Improving service/support	1	2 3 4 5	0.8226	0.2195	0.0187
Improving reliability and delivery	1	2 3 4 5	0.8142	0.1930	0.2001
Anticipated cost reduction	1	2 3 4 5	0.6740	0.1921	0.2146
Access to European single market	1	2 3 4 5	0.1639	0.8313	0.0464
Access to global markets	1	2 3 4 5	0.1722	0.7251	0.1811
Lack of local partners	1	2 3 4 5	0.0701	0.6337	0.3580
Greater market valuation	1	2 3 4 5	0.3606	0.6291	0.1155
Peer pressure “to get onboard”	1	2 3 4 5	−0.0584	0.0952	0.7543
Pressure from suppliers	1	2 3 4 5	0.1882	0.1921	0.6162
Pressure from customers	1	2 3 4 5	0.4909	0.1053	0.5637
Threat from traditional competitors	1	2 3 4 5	0.3819	0.2518	0.5463
Eigenvalue			4.77	1.41	1.08
Percent of variation			39.8	11.8	9.0

Kaiser–Meyer–Olkin measure = 0.87; Bartlett test of sphericity = 1667.36; significance = 0.00.

A.2. Dependent measure

A.2.1. Performance

What benefits have you had from your web-based integration?

	None				Extensive	Factor loading
Faster delivery time	1	2	3	4	5	0.8514
Reduced transaction costs	1	2	3	4	5	0.8370
Greater profitability	1	2	3	4	5	0.8047
Enhanced inventory turnover	1	2	3	4	5	0.7746
Eigenvalue						2.67
Percent of Variation						66.80

Kaiser–Meyer–Olkin measure = 0.81; Bartlett test of sphericity = 673.69; significance = 0.00.

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