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Summary

This paper describes a new modelling technique to visualise and assess the impact of EDI enabled process redesign options for a supply chain and its participants, both in terms of flexibility and costs. Flexibility is defined here as the ability to meet a wide variety of customer demand (versatility) in a short period of time (agility). The research claim is that supply chains and organisations are better capable of meeting a wide variety of demand, when EDI enabled process redesign options are implemented which both increase flexibility and reduce costs. Four applications of the new modelling technique, which is called the modular design approach, in the air cargo transportation industry support this claim.

Introduction to research problem

The recent trend of customisation challenges organisations in many industries to increase their flexibility, without losing their current levels of economies of scale. Being flexible in this respect can be described as the ability to meet a wide variety of customer requirements (versatility) in a short period of time (agility).

This paper examines whether the adoption of Electronic Data Interchange (EDI) can help organisations to redesign their intra- and inter-organisational processes to become successful in their production and delivery of customised goods and services. The capabilities of EDI, i.e. speed of information exchange, avoidance of ambiguity, ease of data capture, and reliability (after Van der Heijden (1995)), indicate a positive impact of EDI adoption to the increase of flexibility and the decrease of operating costs. However, organisations still seem reluctant to implement EDI (see for instance Hoogeweegen & Wagenaar 1996). Iacovou et al. (1995) developed an EDI adoption model, consisting of three main factors to explain EDI adoption behaviour. These factors are: (1) perceived benefits of EDI; (2) organisational readiness; and (3) external pressure. This paper focuses on the assessment of expected benefits of EDI implementation in order to help organisations to perceive EDI benefits more accurately, and thus, support them in the process of making the EDI adoption decision. The assessment will be concentrated on how EDI can be used at the supply chain level to increase flexibility, and to reduce current cost levels. This is referred to as the strive towards 'cost efficient supply chain flexibility' (see title of paper).

This paper is organised as follows. First, the research approach is described. Second, four case studies are discussed. Finally, results are presented and conclusions are drawn.

Research approach

There are several research methods available for MIS research. Based on conditions set by Yin (1989) and Eisenhardt (1989), the case study method suits our requirements best. The three main conditions are (after Yin 1989): (1) the type of research question; (2) the control the investigator has over actual behavioural settings; and (3) the focus on contemporary as opposed to historical phenomena. In case of our research, the research question is of the 'how' type, the investigator will have little control over the actual behavioural settings and the research will focus on contemporary phenomena.

Our case study is composed of multiple cases (in order to find evidence for 'literal replication' (after Yin 1989)), and involves two levels of analysis: supply chains and supply chain members (organisations). The case study protocol for our case study research consists of six steps to be applied in a particular supply chain. Step one consists of modelling those intra- and inter- organisational processes of the supply chain and its members that contribute to order fulfillment. Step two consists of the formulation of EDI

implementation proposals. Step three deals with the modelling of an alternative process layout of the supply chain and its members, based on the formulated EDI implementation proposal(s). In step four these two process models are compared in terms of process layout, levels of costs and flexibility. The results are depicted in step five in a decision framework. The sixth step consists of the decision of the members of the supply chain whether to implement the proposal, to evaluate another proposal (repeat steps two to five), or terminate the evaluation process. We will continue with a further elaboration on the first three steps of this protocol.

Steps one and three of this protocol are supported by a new modelling technique. This technique has been developed after evaluation of available ones. Based on the contributions of Creemers (1993) and Kim (1995), the modular design approach (MDA) has been developed. This approach focuses on (1) the visualisation of the processes of the supply chain members, which are together responsible for the fulfillment of one single order and (2) the assessment of operating costs and throughput time of this order fulfillment. The approach consists of four steps (see figure 1).

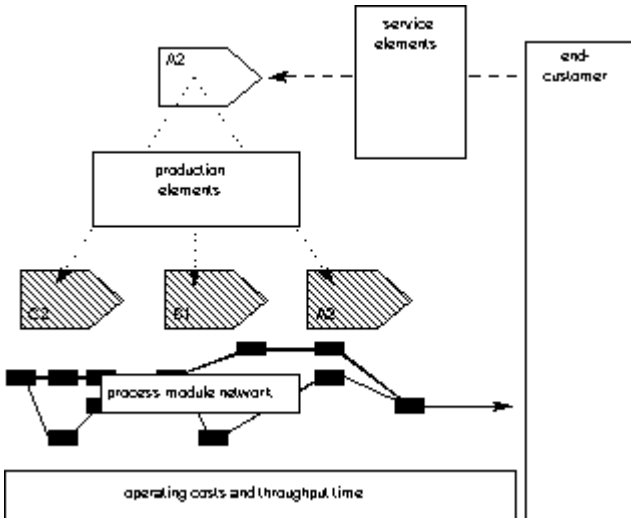

Figure 1: The modular design approach

First a particular customer order is translated in a set of service elements. This translation is executed by the organisation that receives the order, i.e. the coordinator (in figure 1 this is organisation A2). Service elements describe specific features of the total product and/or service range offered by an organisation or supply chain. In different combinations, they describe different types of orders. Second, the coordinator translates the selected service elements into a set of production elements. Production elements also describe specific features of the product and/or service range, but they are formulated in terms of production. Whereas production elements describe what an organisation is able to produce, the service elements describe what customers want. The coordinator assigns the selected production elements to one or more sub-contractors (in figure 1 these are organisations C2, B1 and A2 (which is the coordinator itself)). In step 3 the sub-contractors select process modules to produce the requested production elements. A process module can be described as a standardised, atomic, and not further divisible, process step. Process modules can either refer to information processing or physical activities. Based on the dependencies between the process modules a process module network can be designed. This network indicates in what order the modules need to be executed to fulfill the customer order. Finally, in step 4 operating costs and throughput time are computed based on the Activity Based Costing (ABC) technique (see Lalonde & Pohlen 1996).

The second step of the case study protocol, i.e. the formulation of EDI implementation options, is based on redesign guidelines derived from literature. For Business Process Redesign (BPR) guidelines Davenport & Short (1992) was consulted. Venkatraman (1994) and Clemons et al. (1993) were consulted for the Business Network Redesign (BNR) guidelines.

Case study research

The case study research was conducted in the air cargo industry. The major developments within this industry, i.e. customisation, the rise of integrators and the erosion of yields, particularly make this a relevant industry for applying the MDA. The MDA has been automated in a Decision Support System (DSS) called 'Chain Moduling'. This tool facilitates our case study research.

Four export orders, from moment of placing the order by a shipper, till the moment of departure of the plane, have been analysed. In all cases the forwarder acts as the coordinator, since he received the requests for (air) transport. After translation of the four orders in service elements, the forwarder selected four sets of production elements and assigned parts of these sets to a road carrier, an air carrier and to himself. Then four process module networks were constructed and operating costs and throughput times were computed. In the current situation no EDI is used.

Based on the analysis of the process module networks and the quantitative results, four scenarios were defined and analysed. These scenarios were: (1) a BPR scenario: internal processes were redesigned without changing the roles of the supply chain members and without changing the structure of their communication links; by means of a critical path analysis, the intra-organisational redesign proposals were shaped: how to remove process modules of the critical path by feeding them as early as possible with electronic data?; (2) a BNR scenario: the road carrier is disintermediated; the scenario evaluates whether the air carrier is able to realise lower road transport times, when the forwarder informs the air carrier in time with an EDI message; (3) another BNR scenario, but now the role of the coordinator is shifted from forwarder and air carrier; the air carrier will execute the whole process module network; (4) a third BNR scenario, in which a new service element is offered to the four shippers: to deliver their order information electronically: this scenario tries to illustrate the (supply chain) benefits to be expected, when the shipper is willing to invest in EDI; however, an important question is of course: will the shipper also benefit? Since the first three scenarios all depart from the same set of service elements, nothing can be said about the versatility aspect of flexibility. However, the possible reductions in throughput time measured, do say something of the agility aspect of flexibility. The fourth scenario is added in order to provide a first indication of how to analyse an increase of versatility. Versatility is said to be increased when a relevant, i.e. of interest for the customer (or: shipper), new option is added to an existing set of service elements.

Results and Conclusions

The results of the first scenario showed a reduction of operating costs between 3.5 % and 8.4 %, and a reduction of throughput time of 2.8 % to 6.3 %. The savings were not equally distributed between the supply chain members: the road carrier being best off, and the air carrier worst. The results improved even further in scenarios and 2 and 3 (up to an average of 10 % reduction in cost and 8 % in reduction in throughput time). However, in these scenarios the road carrier and the forwarder (in scenario 3), lose their business. Finally, the results of scenario 4 illustrated a further decrease of operating costs (up to an average of 15 %), and a modest saving for the shippers.

The four case studies have illustrated how EDI can be used in a supply chain to decrease operating costs and throughput times (being an indicator of the agility aspect of flexibility). The last scenario illustrated a first attempt to increase versatility, by evaluating the service element 'electronic delivery of order information'. However, further research is required on the versatility aspect of flexibility.

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