STAKEHOLDER PARTICIPATION IN INVESTIGATING THE IMPACT OF E-COMMERCE UPON THE VALUE CHAIN.

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ABSTRACT

This chapter discusses qualitative and quantitative approaches to informing and validating ABMs. Research is introduced which addresses the question of how new e-commerce technology is leading to restructuring of value chains. A case study was undertaken within a major international organisation, focusing on exploring those issues identified as interesting and important by a small stakeholder group working in the company and actively participating in the research.

A central theme of this paper is the interaction and relationship with stakeholders during the project, with regards to the development of the ABM. The paper concludes that a multi-methodology approach is appropriate to simulation-based projects, and identifies stakeholder participation as being useful in several ways, in particular because it facilitiates model validation.

INTRODUCTION

This chapter presents work which is both multimethod, uniting qualitative and quantitative approaches with agent-based modelling, and highly stakeholder-orientated, involving senior managers from industry at different stages of the project. Whilst the latter point is going to be the main focus of this chapter, the first point remains important particularly where it concerns stakeholder validation.

A detailed case study was undertaken within the power and automation division of major international organization. The research question concerns the nature of the impact that electronic commerce (or e-commerce for short) technology is having upon the manufacturer, the downstream supply system and the nature of relationships with distribution partners. The case study was carried out in 2001-2003 during a period of business process reengeering (BPR). The transformation programme was intended to develop 'e-business' capability by integrating existing e-commerce systems with a new Internet-based electronic mall system specifically designed to improve links with customers. More precisely, it was thought that the transformation would improve information flow, customer service, and internal efficiency at the organisation. The paper describes managers' perceptions of the impacts of these changes upon the business and the implications for their traditional supply chain partners: the distributors.

Value chains and interorganisational systems (IOS) have been shown to be a fruitful area for the application of agent-based techniques (Parunak and Vanderbok 1998; Moss, Edmonds et al. 2000; Fioretti 2001). The approach is well-suited because the systems under investigation have certain properties (involvement of many heterogeneous actors, high interaction,

decentralised communication infrastructure) that are typical of systems developed and studied by researchers in this field. Continuing along this line of investigation, the current work considers the introduction of new ICT and models its impact upon the value chain. The research will be shown to illustrate that quantitative and qualitative methods can be usefully combined in formulating the model and that participation can help to target the objectives of simulation projects.

LITERATURE REVIEW

Essential to the creation and operation of supply systems is the provision of effective information flow between the various business processes: a frequent concern is that some of the links are not as good as others in this respect. Aimed at improving these networking aspects, one new information and communications technology (ICT) which appears to be impacting the supply chain is the Internet. The development of the Internet shows potential as a flexible 'transportation layer' for a new generation of e-commerce applications.

Internet-based e-commerce was foreshadowed by earlier applications developed using Electronic Data Interchange (EDI) protocols for linking together large departments, providing propriety platforms for high-volume business data, in secure, yet relatively inflexible arrangements. Nowadays the Internet is seen as bringing a new set of characteristics to the e-commerce domain and there has been a take-off of interest in the technology. There has been a rapid commercialisation of the Internet as a new channel for providing product information and availability, marketing, ordering systems and order tracking and powerful tools for handling customer relations management.

Research has identified new organisational and market forms, and new opportunities and risks (Timmers 1999; Turban, Lee et al. 1999; Berryman, Harrington et al. 2000), as well as suggesting industries in which e-commerce may have a large impact, eg. financial markets (Bakos et al. 2000), tourism and leisure (Chircu and Kauffman, 2000; McCubbrey, 1999), or car dealerships (Watson and McKeown, 1999; Marshall, Sor et al. 2000). Notably, these are mainly the services industries involving a concentration of information processing activities, which may be automated, decentralised, open to other potential improvements, or are subject to competition from Internet-only companies, the so called 'cybermediaries' (Jin and Robey 1999).

The problem of disintermediation in the context of technological change has been studied closely by generations of researchers. More recently, in the early days of electronic networking technologies, researchers argued that we would see much disintermediation (Malone, Yates et al. 1987) (Tapscott 1996) i.e. traditional intermediaries would be bypassed in the process of reshaping certain industrial sectors. Others have questioned whether this disintermediaton process is as universal as first suggested. For example, consider the more sophisticated model of Chircu and Kauffman (2000) who introduce the concept of the intermediation-disintermediation-reintermediation (IDR) framework which they argue applies to the introduction of new IT innovations that cause structural adjustments. The idea

is that changing market conditions also bring new opportunities for intermediation to which the threatened intermediary should adapt, or reintermediate:

'A disenfranchised traditional player is able to compete again by leveraging technological innovations with cospecialized assets.'(Chircu and Kauffman 2000)

Moreover, there are significant problems encountered by the initiators of technological transformations themselves. Experience with EDI implementation suggested that the value of e-commerce depends upon how well it can be integrated with existing business systems and processes, and with those of partnering firms (Riggins and Mukhopadhyay 1994). Comparing several case studies of trading partner uptake of EDI systems, Mukhodaphyay, Kekre et al. (1995) conclude that the initiators of such systems have the most to gain from the network, but that they also carry the largest risks. Riggins and Mukhopadhyay (1999) identify two types of risk. Trading partners might not adopt the system (adoption risk), and even if they do, may not carry out satisfactory implementation, so the full benefits may not be realised (implementation risk). Adoption risk might be due to a lack of organisational or technological readiness (Chau 2001). Some of these problems have been solved by the ubiquity of the Internet, its flexibility, and perhaps above all its low cost, but some of them remain. Fundamentally, the availability of new technological solutions creates a tension between the more technologically orientated companies wishing to coordinate more strongly, and their business partners, some of whom might be reluctant to change their existing processes.

METHODOLOGY

Case study research (Yin, 1994) was chosen for several reasons. Firstly, it would supply real problems and issues to address. Secondly, it would likely provide a good supply of qualitative and quantitative data with which to give empirical basis to the model. Thirdly, it would help establish stakeholders to evaluate the merit of ABM and research findings.

Large manufacturing companies based within the locality of the university were contacted, based on prior links and stated interest in e-commerce. Initial contact was made through a telephone call, followed up by a letter of introduction containing a project overview. The procedure was to obtain the names of relevant people from administrators by asking to speak to e-commerce managers. The main problem that had not been anticipated was that the decision-making on e-commerce matters was often found to take place at a national or European level rather than with the local managers that were approached.

At Automata[i], initial meetings took place in February and March 2001 involving two managers, one of whom had been recently appointed as leader of the e-business team. The other manager was responsible for advising existing customers, with many of whom he had a long established relationship, on the new opportunities available for e-commerce. These managers were self-selecting participants based on them having a special interest in the subject. They shall be referred to as the 'stakeholders' since they occupy an important role in the research project, being co-investigators, domain experts, and project evaluators[ii]. At this

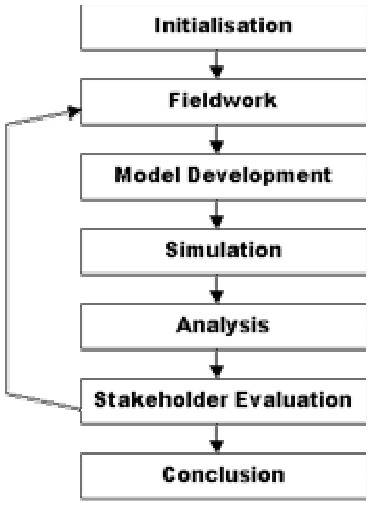
stage, their input was instructive in defining the problem, identifying research questions, and evaluating plausibility and practicality of the approach.

Later that year, semi-structured interviews took place with nine company employees. The interviewees were suggested by the stakeholders, and included people responsible for promoting e-commerce systems to business partners, and those using the EDI and Internet systems on a daily basis. Interview respondents were asked how they anticipated the impacts of Internet-based e-commerce on the function of the department and the likely benefits and problems associated with this transformation. Data were collected using a tape recorder, and transcripts were made which were imported into ATLAS.ti (2002) for analysis. [iii]

The model was programmed using the SDML (Wallis and Moss 1994) platform. SDML is based on Smalltalk, which is a declarative, object oriented, programming language. SDML was specifically designed for developing ABMs of social and economic scenarios, and has a large range of functionality that makes it highly suited to this task.

In order to improve the relevance and accuracy of the model, the findings were taken back into the field to involve the stakeholders in an iterative evaluation process. The objective is to create an interplay between data collection, model development and validation. The arrow on the left of Figure 1 indicates the iteration of the redevelopment cycle:

Figure 1: Methodology flow diagram



Case studies allow a perspective that is fundamentally inclusive because they permit collection of a wide spectrum of different data types. This study draws upon several different paradigms and combines individual methods, in particular integrating the qualitative with the quantitative. Integrative approaches are justified by the argument that flexibility in choice of research methods allows a richer understanding to develop of complex issues (such as the impact of technological change). This is what Mingers (2001) terms strong pluralism where

“all research situations are seen as inherently complex and multidimensional, and would thus benefit from a range of methods."

The methods (outlined in Table 1) are listed with the corresponding research approach (underlying philosophical perspective) and the data types involved. Interviews and stakeholder evaluation generated qualitative inputs; quantitative data consisted of sales and marketing data. By the definition of Mingers (2001), this design is multi-method.

Table 1: Summary of the research methods

Method	Approach	Data Type
In-depth Interviews & Analysis	Interpretive	Qualitative (emergent findings)
Simulation Modelling	Formal	Qualitative & Quantitative
Stakeholder Evaluation	Interpretive	Qualitative
Mall Statistics	Positivist	Quantitative

Both qualitative and quantitative data collection can be enhanced by stakeholder involvement. The role played by stakeholders is a type of participatory research method. Such methods involve other clients making significant contribution to the research process. Stakeholder involvement in ABM development is not entirely new, in particular it has been developed in natural resources and ecosystems management (see Bousquet and Le Page, 2004 for a review) where it has been well-received in a growing number of projects (Janssen 2002; Barreteau et al. 2003) in particular the role-playing experiments. However there is scarce literature concerning ABMs and participatory research within a *commercial* setting.

According to Easterby-Smith et al. (1991: p5-6), management research has three distinctive factors that must be taken into account: the practice of management is eclectic and cuts across technical, cultural and functional boundaries; managers are powerful and busy people; they are responsible for thought and decision-making and therefore capable of taking action based on new understandings or research results.

Both natural resources and commercial management research must be adaptable and sensitive to these three factors. Moreover, both endeavours are concerned with the existence of uncertainty (Simon, 1959; Cyert and March 1963) having been influenced by formal modelling techniques in the field of decision theory. Meanwhile there has been a parallel development of participatory or collaborative methods that combine experimental elements with cycles of learning and application to practice. Role-playing games, conceptual modelling, adaptive management research and action research have become popular social science methods.

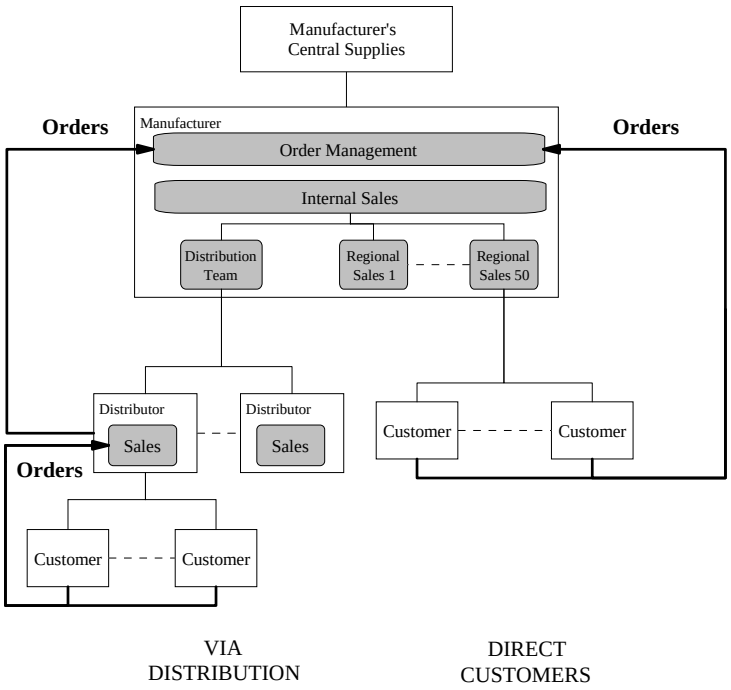
Participatory ABM-building issues are very similar for natural resources and organisational management and therefore so are the methodologies. The main difference could be related to, on the one hand, the strong commercial pressures on managers of firms and, on the other hand, managers’ difficulties in satisfying the many conflicts over limited natural resources. It

is not yet clear what, if any, differences this implies in design of social simulation research. However some insights gained from the current project will be discussed later.

CASE STUDY OVERVIEW

As part of a large multinational based in the UK, the company manufacture a range of products to equip factories with Industrial Automation equipment. The market is exclusively business-to-business: engineers work closely with customers who rely on their technological expertise to help design new production facilities. The company has thousands of direct customers who are supplied directly from a central European store. There are also a large number of independent distributing companies (distributors) who hold stock locally, covering every region of the UK. Unlike the manufacturer, they provide for credit card purchases and are willing to take the financial risk of dealing with smaller customers. The distribution arrangement is shown in Figure 2.

Figure 2: Market structure: heavy lines show the flow of orders and normal lines show the market relationships presenting all other kinds of information flow).



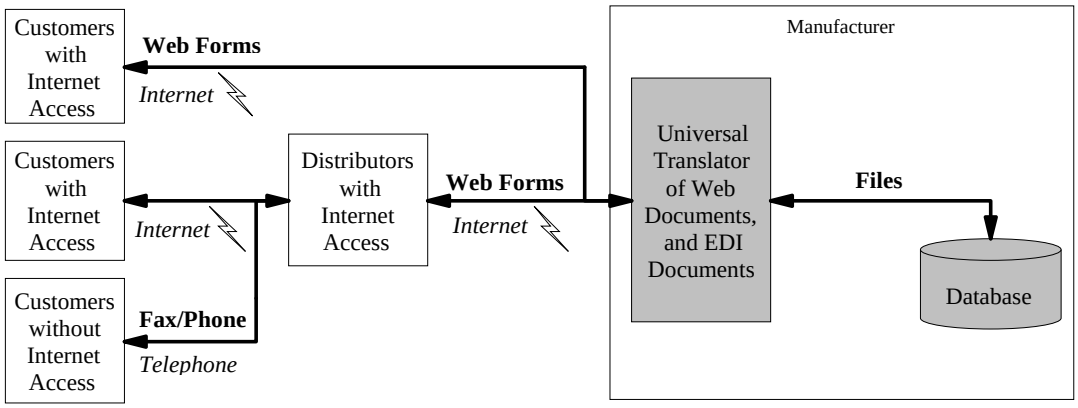
The factory automation and power supply sector has some well developed systems for business-to-business e-commerce, and its market leaders demonstrate an organisational culture very supportive of the new technology. From the point of view of the organisation,

which shall be known as Automata, e-commerce is seen as a critical set of opportunities to improve customer services provision in the short-term, and to provide key strategic advantages in the long-term.

The stakeholders' involvement helped to target the research towards relevant issues: initial discussions established that it would be appropriate to focus on Customer Services (CS), the area that was estimated to be the most affected in the short to medium term by the introduction of the electronic mall. Moreover, there was some degree of uncertainty over policy-making options in this area.

At Automata, EDI is well-established and has been used with business partners (some distributors and some large customers) for a number of years. The focus now is on providing e-commerce to the remaining partners through development of an Internet-based electronic mall tied into a gateway system, and operated in parallel with existing manual ordering systems. The proposed e-commerce system is shown in Figure 3. As the initiator, it is essential that the manufacturer set up processes to effectively manage the customer and distributor adoption of e-commerce. However, it appeared that the manufacturer was well aware of customer needs, carrying out customer readiness surveys, publicising and putting forward e-commerce to their distributors, and having a dedicated e-business team.

Figure 3: Proposed information infrastructure: type of document is shown in a bold font and transmission medium is shown in italics



MODEL DESIGN

The research design intended three areas where the model could be compared with the target: (1) model assumptions are informed by interview data, (2) simulation results are compared with statistical logs from the mall, and (3) stakeholders participate in an iterative evaluation and redevelopment process. Points (2) and (3) will be addressed in the discussion later.

Because (1) does not concern stakeholder participation, it be covered but briefly here while introducing the model.

An ABM of the supply chain described in the previous section was developed, in which direct customers are supplied by a (single) manufacturer, and other customers are supplied by independent intermediaries. The model is simulated through discrete time-steps, called trading cycles, in which agents interact via market transactions, and through various communication interactions.

Customer and intermediary agents are located on a grid where the concept of 'neighbourhood' is important in defining how interactions take place: a neighbourhood is defined as the area including eight squares in each of the cardinal directions (North, South, East, and West), and neighbours are all the agents lying within these squares. The geographical aspect is important because communication takes place exclusively amongst neighbouring agents. Secondly, local distribution services are highly valued by some customers.

It is assumed that technological competence of distributors varies:

"Some of our distributors are much better than others: some are more technically competent. They employ the right people with the right backgrounds and training. At this moment in time I have some reservations about the ability of some of our distributors to serve our customers in the way we would like."(P4)

High, low, and medium levels of technical competence are modelled (by coding with the integer values 1, 2, and 3 respectively). By comparison, it is assumed that the technical competence of the manufacturer (in terms of knowledge of the products, and product areas in which they operate) is at the medium level.

Intermediaries make a profit on their sales because they buy at a discounted price and sell on to customers at a higher 'selling price'. Intermediaries that are not profitable, having zero profits over the trading cycle, (i.e. they do not achieve any sales) are removed from the simulation in subsequent cycles.

Intermediary agents are therefore distinguished by geographical location, technological competence and selling price. In reality, distributors rarely run out of stock, and so for simplicity we assume that replenishment equals number of units sold in each trading cycle. Customer agents also differ in their demands. Demand was modelled with an exponential function This type of distribution was sketched by one of the interview respondents as a schematic approximation of the market: tens of thousands of small customers, but tens of very large customers.

Communication processes include *referrals communication*, where the customer receives information about the existence of alternate potential suppliers, and *'endorsements' communication* or influence processes. Referrals communication appears in two varieties. 'Customer referrals' is defined as the process where, each trading cycle, the customer has a 'word of mouth' communication interaction with one of its neighbours, chosen at random. The customer receives information about the existence of alternate suppliers through this

interaction: the neighbour communicates the identity of the supplier it used in the previous trading cycle. On the other hand, 'manufacturer referrals' describes the case where a customer contacts the manufacturer directly and requests a referral to an alternate supplier. Then the manufacturer informs the customer of the location another potential supplier, which the customer may subsequently contact and order from.

It was assumed that interactions take place among customers, in which information is passed about the characteristics of the supplier and about the nature of the electronic mall. Fieldwork analysis identified several hypotheses about e-commerce (HEC) and about distributors (HINT) considered by the interview respondents to be influential in shaping attitudes (see Table 2).

Table 2: The HEC and the HINT

HEC
It is extra work for us to use the mall compared to a manual system
Almost everybody will soon be using Internet-EC: we should be doing it too
Instantaneous and quick access to information (compared to traditional channels) is a benefit to us
The 24-hour availability of access provided by the mall is of benefit to my company
The provision of up-to-date and accurate information on the mall is of benefit to us
The digitisation of product data sheets and the availability of software updates is a benefit
The reduced possibility of errors occurring in orders going through the mall is a benefit
The provision of more user-friendly ways of accessing account information on the mall is a benefit
It is expensive for us to set up and maintain Internet-based systems compared to manual ones
I am concerned about security issues with Internet-based systems compared to manual systems
I am receptive to Internet-based EC because I expect we shall receive extra discounts if we adopt
I am concerned about the lack of technical support and experience within the company of using EC
I am receptive to EC because I expect we will receive more customer referrals if we adopt
HINT
The supplier offers a good discount on the selling price of the product
I am concerned that the distributor may lack technical competence
The location (ability to offer a local service) of the supplier is a benefit

This communicated information, which was labelled *statement* is one type of 'endorsement': agent reasoning is based on an 'endorsements scheme' derived from the work of Cohen (1985). Endorsements can be viewed as reasons to believe or disbelieve a hypothesis. In the model, agents collate data relating to hypotheses about intermediary performance, and about the benefits and disadvantages of using Internet-EC. Information is gathered through interactions with neighbouring agents, with the manufacturer, and through experience of using the Internet-EC system. The endorsements scheme uses a lexicographical ranking system whereby different beliefs are assigned a different level of importance: those regarded as more important take precedence over lesser ones when agents take decisions. The

advantage of an endorsements scheme is that it allows the use of qualitative data to initialise the model, and preserves the structure of that data throughout the course of the simulation.

Agents are endowed either with a manual-card-based or IT-computer-based system. Two IOS also exist for placing orders - FAX-telephone or EDI. They can subsequently adopt the Internet mall system for ordering (direct customers) or for collecting information (intermediated customers).

Automata's e-commerce strategy is to ensure that customers and distributors are informed of new possibilities for doing business electronically, and moreover to encourage and provide incentives to use their systems. These incentives would include offering financial support (funding and equipment) to help with setting up EC, technical support and training for use of EC systems, and a discount incentive, as became clear through the fieldwork:

"*We are starting to incentivise them by giving them an extra percent [of discount] if they can trade with us electronically.*" (P8)

"It may be a case of getting somebody to get in his car and go round and see everybody and promote it and say "this is how to do it" and get people in there and help customers set it up because they haven't always got the resources to put time into setting it up at their end." (P7)

SDML clauses were defined to represent EC Set-Up, EC Technical, and EC Discount support strategies, providing arguments for the amount of support and trading cycle when the offer is made. This permits flexibility for exploring the role of manufacturer interventions in shaping customer attitudes.

SIMULATION OF SCENARIOS

The scenarios presented here include different specifications of agent interaction and communication, with manufacturer strategies for the support of EC adoption. Taylor (2003) includes further results including sensitivity analysis of model outcomes to initial conditions and different parameterisations of the model.

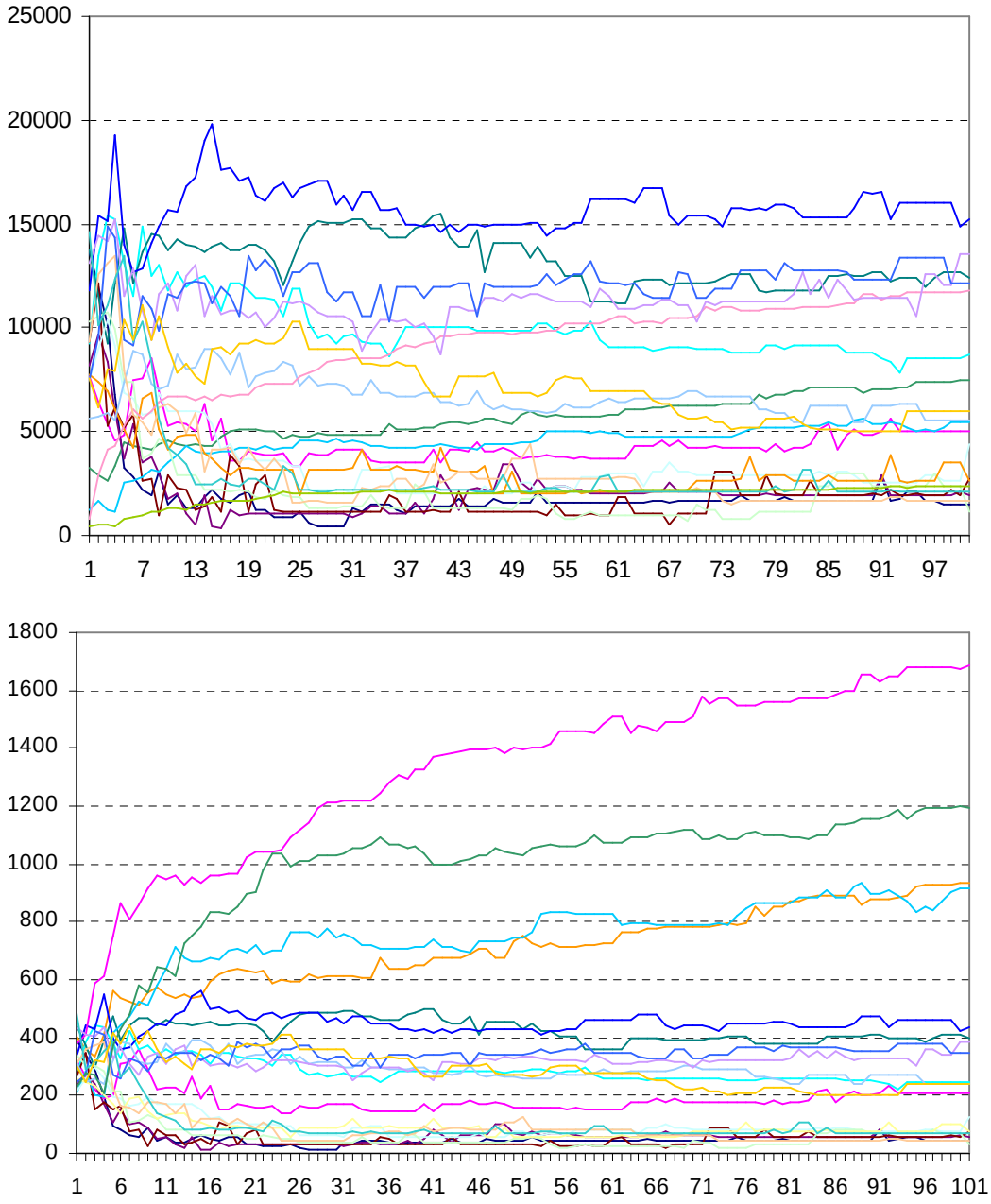
The first two scenarios, S1 and S2, compare two different communication processes. S1 explores customer referrals via 'word of mouth' communication, whilst S2 explores manufacturer referrals. The addition of new links (i.e. possible choices of supplier) can be interpreted as a trend of increasing competition for customers. For illustration, Figures 4 and 5 show comparison of single runs initialised with the same random seed.

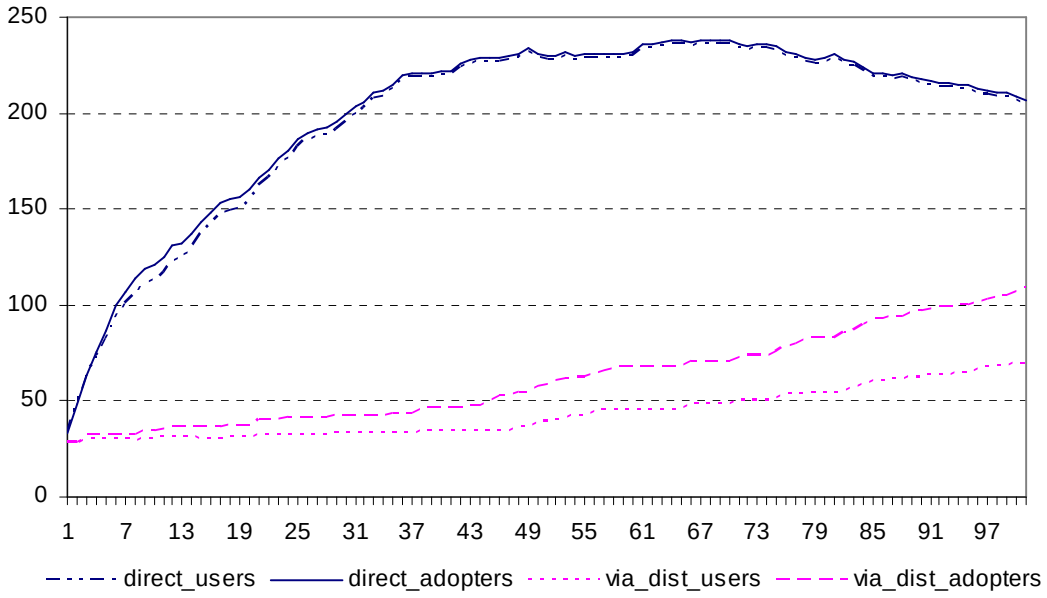
Examining intermediaries market share (Figure 4a), it is noticeable the large variation in the first few cycles of the simulation. Then, from around TC40, a group of four distributors having high volume of sales can be observed clearly separating from the rest. Whereas the largest distributor, intermediary-14 reaches 1687 units at TC100, and the second, third and fourth largest all manage sales of 900+ units, there is a clear cut-off point between these four and the rest of the distributors, all of which manage sales of under 500 units per cycle, from TC 20 onwards. In fact, in the later stages of the simulation, the four larger distributors receive orders for more than twice as many units than the next largest distributor. Profits are

more evenly distributed, however, with five large distributors sharing a similar amount of profits, at around 10-15,000 each, but also with a group of six medium-sized distributors making profits of 5-10,000, and the rest making between 1-5000 profits. In this simulation, all intermediaries survive until TC100. Seventeen of them are consistent users of Internet-EC.

The number of users of EC is high for direct customers, reaching a maximum of 236 at TC64. As illustrated in Figure 4c, the number of users gradually drops after TC70. This is because the addition of new adopters is slower than the decline in total number of direct customers: shifting direct customers to distributors was a parallel manufacturer policy being simulated. The graph also illustrates a notable gap between the number of adopters and the number of users via distribution, revealing that some customers after having adopted the mall subsequently stop using it.

Figure 4: Manufacturer referrals scenario (S1) results showing time series of intermediary sales (a:top panel), intermediary profits (b:middle panel) and number of adopters/users (c:bottom panel)

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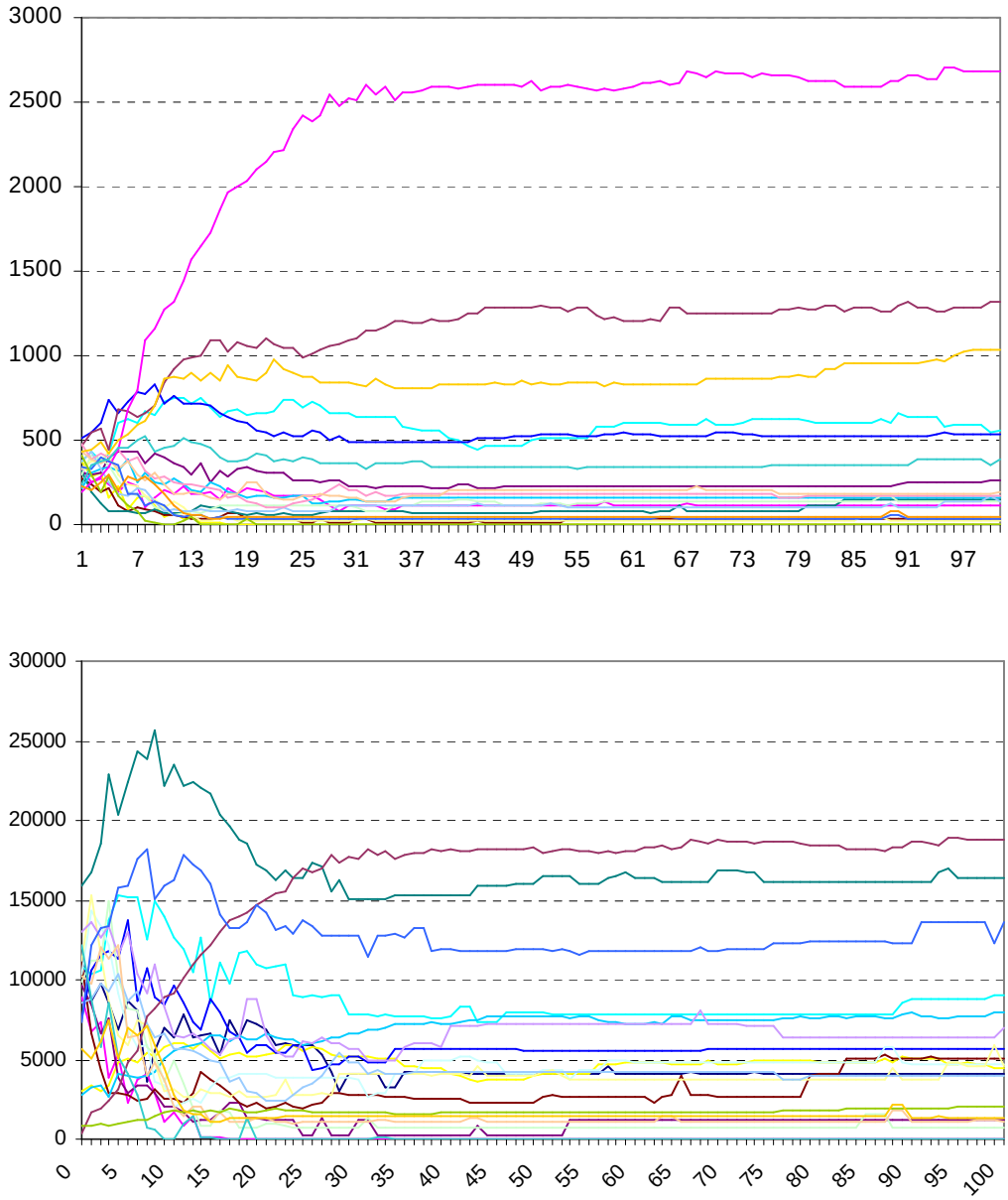
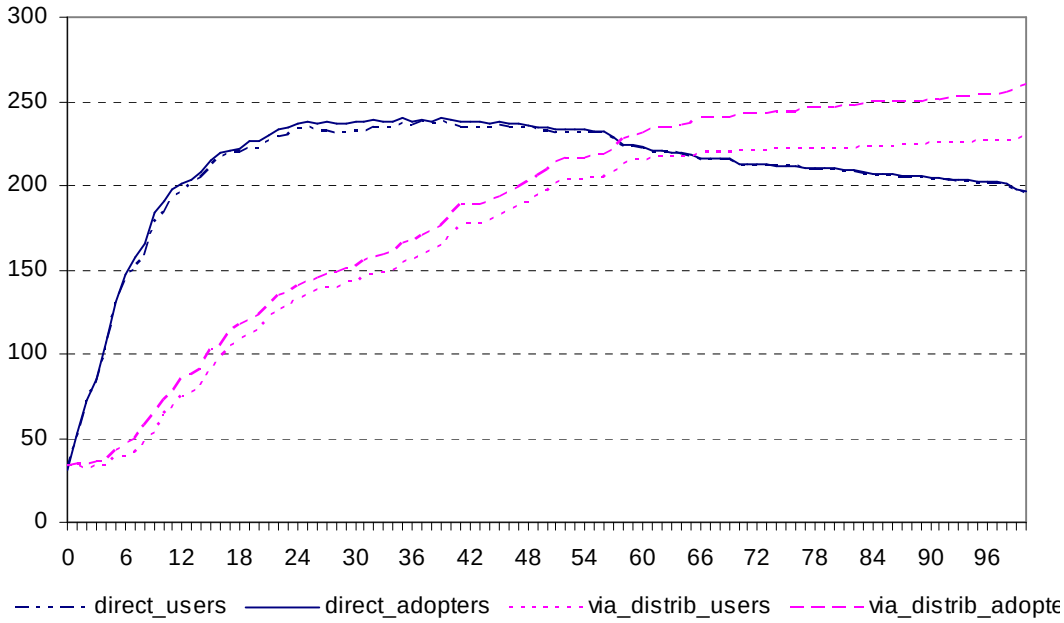
In contrast to the first scenario, in S2 customer referrals are specified rather than manufacturer referrals. Figures 5a and b were obtained from the same simulation run, specifying customer referrals but no communication of endorsements. The results in Figure 5a show the domination of the intermediation function by a single intermediary, intermediary-14, obtaining more than twice the volume of sales of the second largest (2685 units compared to 1319 units). Although five intermediaries manage sales volumes of greater than 500 units, there is high inequality. The majority have sales of less than 200. This inequality is also reflected in the result that there is one intermediary casualty: intermediary-2 survives only up until TC19. The largest intermediary also makes a profit of more than 18,795 in TC100 (an increase of 24% over S1). In fact, Figure 5b shows a sharp decline in profits for many distributors, whereas other distributors grow quickly in terms of profitability. Intermediary-18 is the most visible example of this: starting with a very low profitability in the early part of the simulation, int-18 overtakes many other distributors that are experiencing declining profits, rapidly increases to a profitability of more than 15,000 by cycle 20, and becomes the most profitable intermediary in TC27. Compared to S1, this simulation exhibits greater short to medium-term variation. The path of adoption of Internet-EC is not shown for S2. It is virtually identical to that of the first scenario: high adoption amongst direct customers but low adoption amongst customers supplied via distribution.

The extent of the market domination by few large distributors in these simulations gives us an important result: it suggests that customer referrals, a local, ‘word of mouth’, customer-to-customer communication, leads to more distributor inequality compared to manufacturer referrals. It results in large majorities of customers choosing the same (few) suppliers.

In the simulation shown in Figure 5c, where agents collate endorsements, the number of customers via distribution reaches a maximum of 260 agents in TC100. This is approximately three times as many as in the case without endorsements (83) or in S1 (109), whilst the number of direct adopters is approximately the same. This suggests the increase in intermediated customers adopting must be attributed to the communication of endorsements during those interactions. Communication of endorsement drives the high level of adoption: through customer-to-customer persuasion interactions, intermediated customers can collect information relating to the benefits (and disadvantages) of e-commerce. In this case, many of them are persuaded to adopt.

Figure 5: Time series of intermediary sales (top panel), intermediary profits (middle panel) of customer referrals scenario (S2) and number of adopters/users (bottom panel) of customer referrals with endorsements scenario (S3)

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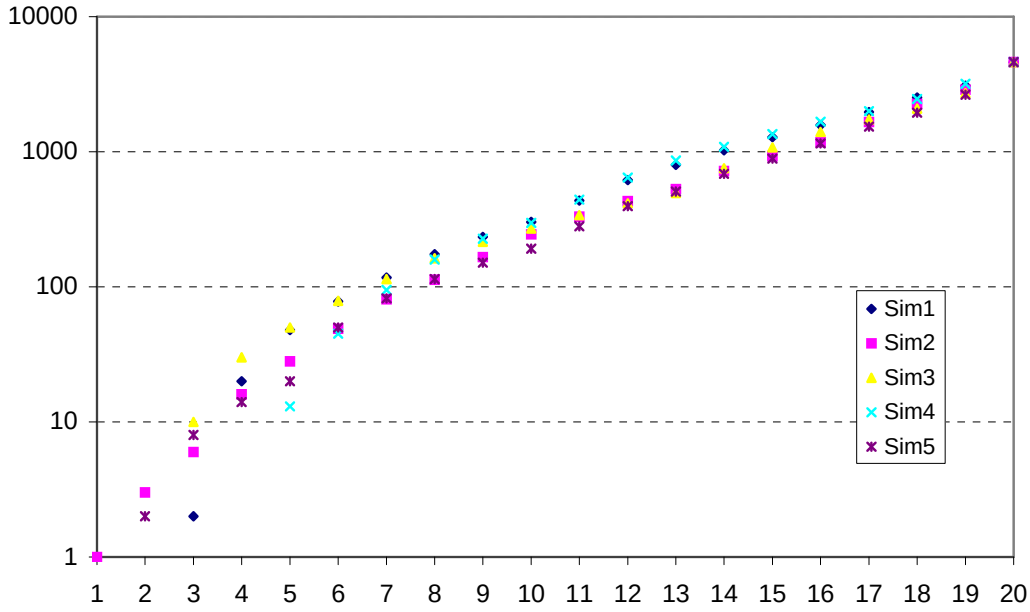
Finally, Figure 6 shows the results of a test for the existence of the Pareto Power Law distribution, which states that there is a logarithmic relationship between the cumulative frequency of events (in this case, number of units sold) and the smallest to largest ordering of objects to which those events are ascribed (in this case, intermediaries). The figure shows five plots for the small simulations[iv] with customer referrals without endorsements communication. Excepting the first two or three data points, there appears to be a linear relationship.

Figure 6: Log of cumulative sales - customer referrals with communication of endorsements (S3)



The following simulation experiments consider manufacturer support strategies for Internet-based EC: support with EC set-up, with technical knowledge, and extra discounts. All of these simulations are carried out with customer referrals and endorsements communication, without preferential referrals. Results of the four simulations are shown in Figure 7, where number of users is plotted against time cycle on a single graph. It is clear that in the simulation runs where no support is offered to direct customers usage is the lowest (43 customers in TC 100) whereas offering some kind of support always results in a higher level of usage. This is not surprising since the model assumed that the customers always view these support interventions positively. In the 'Set-Up Support Only' simulation there is a small increase to 56 customers, and in 'Technical Support Only' there is an increase to 62 customers. The 'Extra Discounts' incentive resulted in the largest increase in level of usage to 69 customers (a 60% increase over 'No Support').

Figure 7: Time series of simulation of manufacturer support strategies (S3)

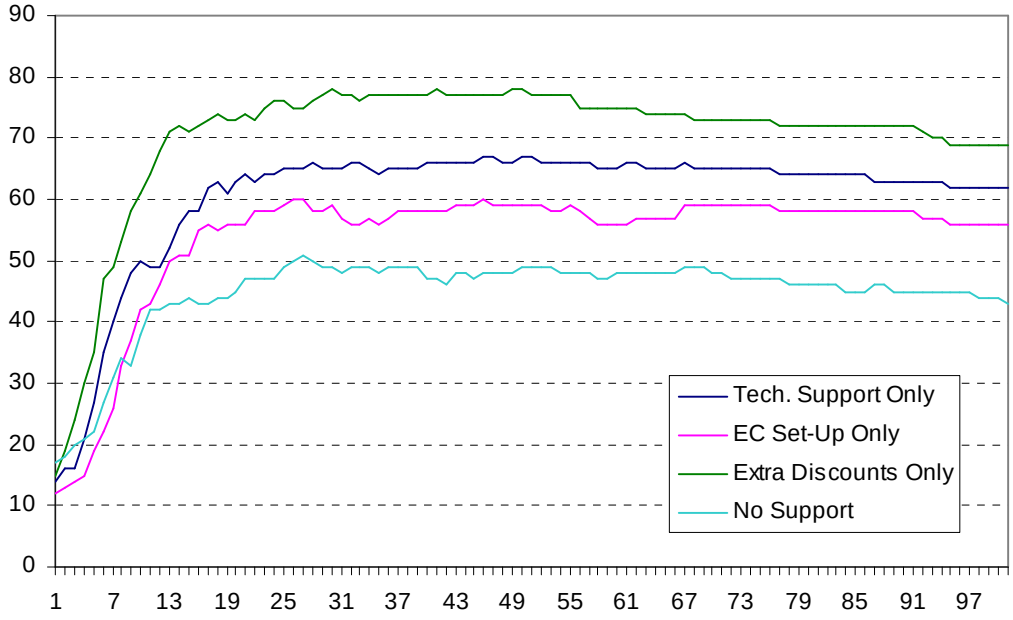


Figure 7 also demonstrates s-shaped adoption and usage curves, indicating a slow initial take-up, moving into a period of faster adoption, and gradually slowing to a saturation point after about thirty cycles. This is an important result because it shows that the model exhibits an outcome resembling a pattern identified in empirical studies of technology diffusion. Further model details and analysis of simulation experiments can be found in Taylor (2003).

DISCUSSION

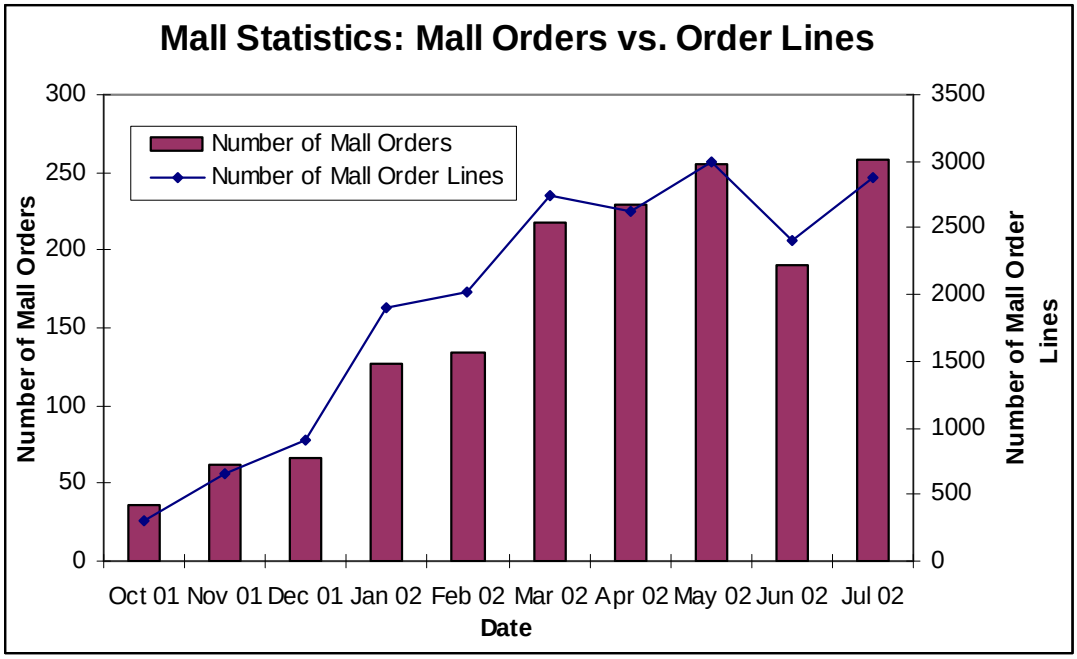
The earlier section showed how the interview data were used to inform model assumptions. This section discusses the points (2) and (3) concerning model validation, reintroducing the stakeholders to do so.

Collaboration between the researcher and the stakeholders entailed frequent e-mail, telephone and face-to-face discussions, and presentations. The aim was to develop the partnership and an understanding of the project. The participation was organised as it could best fit into the agendas of the stakeholders, according to the research needs at the time.

Consultation always took place at the headquarters of Automata, using their facilities. The model was not intended to be used directly in these sessions, although on one occasion a demonstration was given. This experience showed that it was quite difficult to explain, in one sitting, details of the implementation. Also, the set of input parameters were too large and the visualisations in this case, not particularly helpful. A simpler model, linked to some conceptual modelling beforehand could have been more successful.

To one of these meetings, the stakeholders brought some statistical data detailing the recent performance of the Internet mall. Figure 8, a chart produced by one of the stakeholders, shows the number of mall orders and the total number of order lines included in those orders.

Figure 8: Mall Statistics chart produced by one of the stakeholders



Order lines specify type of product and number of units required. Orders therefore range from the very large (many units of many different types of product) to the very small (a single line requesting one unit) so the mall statistics therefore only give us an estimation of the value of Internet sales. The chart illustrates an increasing number of orders and order lines over the period October 2001 to July 2002. In addition, there were increasing numbers of customer adopters (i.e. registered users on the web site) over this period. There were 35 customers submitting a total of 36 orders during the month of October 2001 (1.029 orders per customer) compared with 201 customers submitting 258 orders during July 2002 (1.284 orders per customer) which represents an increase of 25% orders per customer. They submit an increasing number of order lines: from 306 lines in 36 orders (average 8.5 lines per order) to 2882 lines in 258 orders (average 11.17 lines per order), an increase of 31%. This represents a significant increase in transaction volumes and indicates that customers may feel increasingly at ease with the new system.

In the research design, point (2) marks the comparison between macro outputs of the model and empirical data of similar nature. The mall statistics provided a general outline of what

macro-level behaviour the model should be capable of producing. Statistical testing, as exemplified in the cross-validation approach (Moss and Edmonds, 2005), cannot be carried out using such a dataset. That the ABM generated textbook patterns of adoption and use of e-commerce does not constitute a strong validation of the simulation. It does, however, show that the simulation system behaves plausibly across different scenarios.

The more stringent test of validation is the qualitative validation of *micro-level behaviour*: point (3) mentioned earlier. This aspect relies upon the participation of the stakeholders in an iterative evaluation and redevelopment process. It involves assessing both the assumptions upon which the model is based and the micro-behaviour of simulated agents, in terms of their plausibility, as outlined in Downing et al. (2003).

In the participatory sessions, model assumptions were discussed, for example, the set of hypothesised drivers and inhibitors of Internet e-commerce (Table 2). During the fieldwork some factors were more frequently or emphatically highlighted by a respondent. Responses guided an initial ranking of these hypotheses in terms of importance. Discussing these findings with the stakeholders and describing the model that was being developed, then helped to refine the rankings used in the endorsements model. Whilst Automata thought they had identified many of these factors, they realised that they knew very little about breadth of perceptions across a very heterogeneous range of customers. It was then planned that the researcher would carry out an independent customer survey to better ascertain this. For reasons to be shortly explained, the survey did not take place. However, the plan illustrates the role of the stakeholder also in the design of the research.

There was some discussion of the idea that ‘referrals communication’ could take place locally and informally amongst customers. The stakeholders said that such interactions might take place, though they were not well informed about that. However, they did suggest what could be stronger reasons to support the assumption: firstly that customer-customer interactions might also take place indirectly through visits from members of the Regional Sales teams (i.e. the engineer might report what other customers are doing), and secondly through staff turnover (employees move from company to company, bring new ideas with them). These discussions provided additional factual and nuanced information and demonstrated how stakeholder participation can improve and strengthen the process of model development.

The participation of the stakeholders enabled iteration of the evaluation loop described in Figure 1. However there were some unforeseen difficulties, related to the changing circumstances within the company, which hindered the redevelopment cycle. The imminent arrival of a new director and of the approaching retirement of one of the stakeholders would, it was anticipated, provoke changes both in the way the department was run and in the focus of development for the e-commerce team. After the initial high level of enthusiasm for the project, these factors led to a lessening of involvement in the project in the face of more pressing commitments. Stakeholder evaluation meetings were therefore shorter and fewer than had been expected. The consequences of this reduced involvement were: lack of access to data, difficulties in completing the model evaluation process, and eventually an abrupt

ending to the project. As stated earlier, this is a typical pitfall of doing management research: contacts are very busy and can commit little time to involvement in research.

The stakeholders were satisfied regarding the plausibility of model assumptions and with the preliminary findings of simulation experiments. In this study, the two stakeholders were familiar with most aspects of operations, being involved in those processes and with those (individual and organisational) actors. They also have to consider different strategic alternatives as well as future planning beyond the short-term. The stakeholders at Automata, it would be expected, are sensitive to results that 'do not look right', i.e. not like anything they have observed or, in the case of scenario development, believe to be plausible. The stakeholders did not understand the model in the fullest sense of tracing the microbehaviours of embedded agents and building up accounts of agents' perceptions, interactions and decisions. Providing explanations for behavioural outcomes in this manner (see Taylor 2003:187 for an example) was the intended approach for the participatory sessions, but was not carried out. Method (3) of comparing the simulation model with the target was therefore only partially realised, in the iterative evaluation of model assumptions and agents' rules and preferences.

CONCLUSION

Methodological issues have been addressed about the nature of stakeholder involvement in agent-based simulation projects, and about the possible ways to validate a model with different kinds of empirical data. Questions arising from case study inquiry concerned the impact of Internet-EC on the supply chain, and in particular the implications for the traditional intermediaries: the distributors. Fieldwork analysis was supportive of a weak disintermediation hypothesis - that some limited disintermediation could be expected, and that this could form part of a manufacturer strategy to improve information flow throughout the value chain.

The approach used was base model development on qualitative and quantitative information provided by the stakeholders and interview respondents identifying the main units of agency and processes involved. Subsequently the ABM was employed to explore the areas of uncertainty concerning the nature and effects of communication among customers. Automata knew very little about these processes, it being problematic to collect such information. Further uncertainty existed over the kind of support strategies that would need to be employed.

The model development cycle was reported, wherein the stakeholders also contributed to evaluation of the research in several ways. These validation procedures were carried out inorder to help establish confidence in the plausibility and relevance of the model to the case. It is worth noting that the number of stakeholders involved here was very small. This illustrates the fact that the success of a research project involving industrial partners depends critically upon getting the attention and interest of one or two key managers. Indeed it may be difficult to get an initial 'foot in the door' of the organisation. But once this can be secured it can illustrate the principle, described by Hammersley and Atkinson (1983, pg. 60),

of informal ‘sponsorship’ that serves to validate the presence of the researcher and pave the way for access. Furthermore, as in this case study, the sponsoring individual(s) are likely to be willing to fulfil the stakeholder role. There are difficulties associated with this methodology which have also been seen: obtaining required access to these people can be problematic and changing circumstances can curtail the research.

Whilst it should be emphasised that formal models cannot substitute for multiple case studies informed by qualitative research, it appears that is much to be gained from using ABM in parallel. In essence, this is the argument for multimethodology: a debate which is attracting much attention in the area of management of information systems. On the basis of findings reported in this paper in commercial or organisational research settings, ABM can be proposed as one such alternative.

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[i] For marketing reasons, the organisation did not wish their identity to be known, so the organisational pseudonym Automata has been adopted here.

[ii] Stakeholders can be distinguished from other industry contacts by their participatory role in determining the scope, objectives, and methods of the research, as well as in its evaluation.

[iii] ATLAS is widely used by researchers in the social and management sciences to organise their primary data and to facilitate the qualitative analysis. The main benefit of using ATLAS for model development lies in making explicit the mapping of case data to model assumptions.

[iv] Large and small simulations were carried out, where the size of grid and number of agents differed. Unless noted otherwise, all simulations reported here refer to the large simulations.