

Chapter 6 Linking Fieldwork Data with the Agent-Based Model

Introduction

The purpose of this chapter is to explain the approach to stakeholder participation, and to demonstrate that this approach was central in linking the fieldwork findings of chapter five to the development and evaluation of the agent-based model presented in the following chapter. It shows how the research methodology outlined in chapter four was applied: combining qualitative and quantitative data collection methods with stakeholder participation and modelling.

Continuing on from the discussion in part 4.2, section 6.1 details the roles and responsibilities of the stakeholders and their relationship within the organisation. Also described is the relationship between the stakeholders and the researcher, and how this developed over the course of the case study. The input of the stakeholders on the research design, research questions, and model development is described. This is followed by a discussion of the feedback obtained from the stakeholders and their evaluation of the research findings.

Section 6.2 outlines the problem specification: to understand factors influencing customer adoption of electronic commerce, to discuss how the manufacturer can make efficiency savings, and how intermediaries can also realise the benefits. From this specification the research questions were developed. Section 6.3 discusses how an experimental design was produced to address these questions.

Section 6.4 introduces the ATLAS.ti software, and describes how it is used in the analysis of qualitative data, and then reflects on its usability in modelling research. Section 6.5 explains how model validation fits into the case study design. It provides an overview of the validation methods used, and to what extent they justify confidence in the model. Sections 6.6 and 6.7 provide more detail about the qualitative approach to validation: about how the fieldwork informed model development, and about how the stakeholder evaluation improved it, respectively.

6.1 Relationship with the Stakeholders

To recap, the definition of a ‘stakeholder’ being adhered to in this case study is that of a person who plays an interactive role in the social system under study, has expert knowledge about how that system works both in terms of its macro- and its micro properties, and of course, is involved in the research. It is necessary for stakeholders to have a wider perspective of the business so that they can answer any questions that arise during the course of the research. This role is therefore more suited to managers or other employees involved in overseeing activities across business operations.

In addition, some minimum level of understanding of ABSS concepts and techniques is necessary for validation of the model to be carried out. In this regard, presentations and demonstrations are good approaches to educating stakeholders in the principles of agent-based modelling, provided they are willing to participate. Ideally, stakeholders would be people who seek to gain some insight into the functioning of their business through the use of ABSS models, and would be prepared to invest in learning about the tools being used.

Stakeholders then, are distinguished from the respondent group in the interview stage by these several characteristics. In the context of an industrial collaboration, they are the people who are the first point of contact, who play a part in determining the scope of the case study, the objectives of the research project, the data collection methodology, the evaluation of the model, and they will also be the ones who will ultimately evaluate the success of the project, in terms of what value it has been to the organisation. It almost goes without saying that the stakeholders are very important to the project.

In this case study, there were two stakeholders, both of whom held managerial positions working in the area of e-commerce. One of the stakeholders had been only recently employed by the company as a project manager in charge of developing e-business. One of the projects he was responsible for overseeing was that of the electronic mall for smaller customers. The other stakeholder had been working for the company for many years. He had developed personal contacts with many of the

customers and therefore had plenty of first-hand experience with customer issues. He was responsible for advising the company's existing EDI customers as well as bringing up the subject of Internet-EDI with other customers during meetings with other customers. In fact, this stakeholder also was interviewed as a respondent during the qualitative data collection. Both stakeholders were present at all of the meetings with the author.

There were two other managers whom I met during my visits to the organisation, who had an input on the project but not sufficiently so that they ought to be classified as stakeholders. One was a very senior manager who had an interest in e-commerce and attended the first meeting, authorising that the interviews should go ahead. The second was a computer scientist who was responsible for the technical maintenance and development of the electronic mall. This manager attended the final meeting of the project and joined in the discussion about the future directions of Internet-EC.

Apart from the authorising of this one very senior manager, there wasn't much evidence of the effects of power relations amongst those people I spoke to within the organisation. This could be put down to the growing envelopment of the whole organisation under the imperative of e-commerce. The desks I visited were scattered across different departments where people had different sets of responsibilities. However, all of the staff who were involved in e-commerce seemed to share the view of the new technology that envisioned great potential advantages for the organisation.

Neither between the stakeholders and the interview respondents, nor amongst the respondents themselves, could I detect power relations. Given the greatly varied roles and responsibilities of respondents, this might nevertheless be considered a surprising outcome. One explanation could be the naïveté of the researcher in entering management research from a background of formal mathematics and computer science. The prior selection of a particular set of interview topics or questions may have led to the suppression of important clues to the functioning of structures of power and dominance. On the other hand, it is reasonable to assume a tendency for self-censorship of expression in work situations, on matters of such power relations.

It could also be argued that, whilst I spent only a few hours inside the organisation over three days of data collection, power relations would much more likely surface during a longer ethnographic study where the researcher and subject have more time to develop a closer relationship.

The relation between researcher and stakeholders was a very good one, based on a shared interest in the new technology, an eagerness to know how e-commerce was perceived by those using it or considering using it, and an agreement to find out more through academic study. I enjoyed my role as researcher contributing expertise in the design of agent-based systems, analytical enquiry, and knowledge of substantive e-commerce studies. In return for this expertise, the stakeholders granted access to the organisation and freedom to publish the findings. The relation was also based on helpfulness with practical matters on the part of the stakeholders, and trust in the handling of sensitive information.

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, and it will also influence what amount of resources can be committed to the study. This can be problematic: businesses tend to have a conservative outlook which may mean they are less willing to commit to innovative approaches to R&D that have not yet been rigorously tested on industrial problems.

The stakeholders raised a number of questions relating to the research objectives, both at inception of the project, and during the evaluation phase. The main questions to be addressed are described in the next section.

However, in the process of carrying out the case study, the relationship changed because there were some unforeseen difficulties which arose. One issue was the changing circumstances within the company itself, which resulted in difficulties with the case study. For example, the model development cycle was hindered by the imminent arrival of a new director and by the approaching retirement of one of the key stakeholders, which 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 changing circumstance and more pressing commitments. For the case study research, 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.

A secondary problem we encountered was that the stakeholders did not deliver the data and access they had agreed to in the case study design, despite repeated requests. As was pointed out earlier, this is a typical pitfall of doing management research. Contacts are obviously very busy and have little time to spend involving themselves in research projects. Unfortunately, these data were useful information that would have benefited the case study greatly. Specifically, we were not able to obtain data on intermediary characteristics, or to gain access to customers for the quantitative survey. These were both very important aspects of the case study.

6.2 Research Questions

The research questions emerged from the enquiry: from the initial case study research design, from the fieldwork, and from the subsequent discussions between the stakeholders and myself. Some of the questions were best addressed through an interpretive analysis of the fieldwork, and some were to be addressed by simulation experiments with the model.

For example, the stakeholders were interested in understanding better the impact of e-commerce upon internal productivity. However, modelling productivity issues would involve simulating individual tasks and their consumption of resources, which would necessitate very CPU-intensive simulations. Therefore it was decided to address these questions through the fieldwork, by compiling and analysing the opinions of interview respondents. The stakeholders also wished to investigate the company's reputation amongst its customers, as well as the perception of its support strategies to encourage Internet take-up. and overcome adoption resistance amongst customers. This latter

question was one that was addressed through experimentation with the simulation model.

There were a number of good reasons for exploring the CS area. Firstly, there exists some degree of uncertainty over policy-making options in this area, thus it comprises a good test of the value of the modelling approach as a tool to aid managers in understanding some of the possible outcomes, and their implications for policy makers.

Secondly, focusing on issues within CS would be appropriate because it would facilitate a study of the interactions between the manufacturer and its many customers and distributors. Such interactions appear to be central to these research questions. These considerations also lead to a model design involving many agents, i.e. a Multi-Agent System (MAS) with decentralised architecture and composed of autonomously acting parts.

Thirdly, the scope of a CS-focused project appeared to be very rich and full of opportunity to explore different scenarios and test the research hypotheses discussed earlier. This investigation fits very well with the e-commerce issues discussed and reviewed in chapter two. Furthermore, CS employs a large number of people involved in using e-commerce in the workplace, and can therefore provide an abundance of qualitative data to inform the model building, in addition to having large amounts of sales and other actual data that could be made available.

After the main contextual factors had been identified and discussed (refer to section 4.2.3) the original research objectives were re-examined in the light of the analysis of fieldwork data, leading to six research questions centring upon:

1. Customer adoption of the electronic mall (the rate of uptake being one possible measure of the manufacturer's competitive success in a market environment where business is increasingly going electronic). Anticipating some potential problems that might arise during the transition to the electronic mall such as the impact of system failure upon adoption rates and upon the reputation of the technical system.

2. The role of ‘referrals’ incentives and extra discounts for distributors and other financial and technical support strategies for all trading partners adopting the mall. An important model objective was to explore which of these factors most hinder or encourage the adoption process.
3. Investigating the implications of the ‘preferential referrals’ policy that favours EC-enabled distributors: impact upon distributors’ market share and survivability⁷ (i.e. examining the disintermediation hypothesis). When the manufacturer plays the dominant role in referring customers to suppliers, what are the implications of this type of favouritism?
4. The effect upon market outcomes of alternative communication processes⁸. Comparing communication amongst customers with communication directly involving the manufacturer, and examining the implications for intermediaries, and for the adoption process.
5. The significance of reputation mechanisms such as ‘word of mouth’ communication, here modelled as ‘endorsements’. Do these mechanisms result in sociologically observed phenomena such as power law distributions of market share and s-shaped adoption curves?
6. The anticipation of increased competition amongst distributors for business, and evidence of customer dissatisfaction with suppliers suggests a ‘shake-up’ of the supply chain. Projected intermediary success might therefore be increasingly correlated to, for example, pricing strategy and technological expertise.

In the next section, the above research questions are built into specific model scenarios, and the simulation experiments to explore them are then described.

⁷ It should be clear from CS fieldwork that direct customers can order through the Internet whereas intermediated customers can not. In fact the Mall was ‘specifically designed’ for direct customers, although both intermediated customers and distributors can access the Mall to collect information. The fact that intermediated customers will still purchase through traditional channels implies no direct impact upon intermediaries of adoption and use of the Mall. However, the manufacturer may favour intermediaries that do use the Internet, and this favouritism may be manifest through the strategies of *preferential referrals* and *extra discounts*, which would have an indirect impact upon intermediaries’ profitability and market share.

⁸ In this regard, the fourth (contextual) factor above is important because it suggests much interaction between manufacturer and its many trading partners, via several different communication channels.

6.3 Experimental Design: Model Scenarios

An outline of the company's e-commerce operations, its structure, business processes, and identification of the units of analysis (customers, distributors and suppliers etc.) and their basic characteristics was provided by the stakeholders. Before describing the scenarios and how they were built into the model, some terms which will be used widely in the remainder of this chapter and in the next chapter are explained.

Communication processes include referrals communication, where the customer receives information about the existence of alternate suppliers, i.e. the customer is *referred* to a potential supplier. This process can take place in either of two ways.

1. Each trading cycle, each customer communicates with one of its neighbouring agents, chosen at random⁹. In this case, the customer receives information about the existence of alternate suppliers via 'word of mouth' communication with its neighbouring customers. The neighbour communicates the identity of the supplier it used in the previous trading cycle. We define this process as '*customer referrals*'.
2. The alternative situation is called '*manufacturer referrals*'. This describes referrals of previously direct customers to distributors, and also referrals of existing intermediated customers. In the latter case a referral only takes place with a certain probability¹⁰: the 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.

Another type of communication involves interpersonal interactions in which qualitative information is passed about the characteristics of suppliers and about the nature of the electronic mall. These are value judgements known in the model as '*endorsements*' indicating whether or not the item in question is appropriate.

⁹ No distinction is made between direct customers and intermediated customers when neighbours are chosen to interact with.

¹⁰ This probability is inversely proportional to the number of known suppliers, and is governed by a Fermi function, as described in section 7.3.

Endorsements are therefore communicated in the form of statements which result from persuasion interactions.

'Preferential referrals' describes the situation where the manufacturer is making a referral and has a preference for using Internet EC-enabled distributors, i.e. it is a policy followed by the manufacturer. On the other hand, the lack of such a preference implies that, all other things being equal, suppliers are equally likely to receive the referral.

Moving onto a discussion of scenarios, the remainder of this section will explain how the scenarios are based on contextual factors that link the research questions to the model specification. The scenarios are based upon plausible but hypothetical supply chain situations, or upon actual and observed processes. They are particular instantiations of the same model, and are useful in assessing and comparing different aspects of the behaviour of the model.

The main objectives of the scenario analysis are to examine some likely market trends and explore what might be the implications of a range of policy decisions. What these aims have in common is that they address poorly understood areas: about which little is known and prediction is difficult. By comparing the outcomes of the simulations, it is possible to measure the impact and identify qualitative changes in model behaviour. The section ends with a discussion about what the analysis of simulation results implies for the modelled e-commerce system, and what conclusions there are for e-commerce policy.

A total of four different experimental set-ups were run: these scenarios are labelled S1 to S4. Below it is explained how they address the research questions, here abbreviated to 'RQ' and identified by the numbers used in section 6.2, making the link explicit.

S1: In the first scenario, there are no interactions between customers; they must build up knowledge based only on their own experience. Manufacturer referrals are, however, specified. Two sets of simulations are run, one where the manufacturer has adopted a strategy of preferential referrals (and is more likely to refer the customer to an EC-enabled supplier) and one where there is no such preference. This scenario

explores the impact of preferential referrals upon adoption patterns (RQ 2) and upon market share and survivability (RQ 3) of distributors.

S2: In the second scenario customer-customer interactions are specified in the model. Customers communicate the existence of alternative intermediaries, ones that are not within the customer's immediate neighbourhood (i.e. customer referrals). We also investigate interactions where customers give and receive endorsements. These are modelled as qualitative reasons for believing or disbelieving hypotheses about suppliers and about the electronic mall (which will be discussed in section 6.4). We run one set of simulations with and one set without communication of endorsements, and compare outcomes of this word of mouth reputation system (RQ 5).

Sets of results from S1 and S2 are compared to see how model behaviour changes with the specification of different communication processes (RQ 4). We analyse which intermediary strategies are most successful in terms of the rate of survival of intermediaries, and in terms of generating average high intermediary sales and profits (RQ 6), and examine the distribution of market share under these different scenarios of market structure and interaction processes.

The remaining two scenarios aim to explore the effect of communication processes and model parameters relating to EC system performance and the impact of manufacturer support strategies upon the rate of uptake.

S3: The third scenario explores the effect of hypothesised system performance failures on the rate of uptake and level use of internet-based EC by customers and intermediaries (RQ 1) under different communication scenarios. We experiment with security failures and with problems of speed of access that result in the generation of negative experiences amongst customers, and test how this impacts on e-commerce adoption.

S4: In the fourth scenario, the manufacturer support strategies for providing customers with incentives to adopt are varied and compared in terms of their effect on the rate of adoption and level use of internet-based EC (RQ 2).

Additionally, we carried out a sensitivity analysis to test the robustness of the model to changes in program implementation: in the non-validated model assumptions, and in the parametric values used. If simulation results are robust to these kinds of changes, then we can conclude that these details are not critical to the model. If not, then the conclusion is that the model sensitivity is problematic, and that particular attention needs to be paid to validation issues in these areas. In section 7.5.5 we investigate the effect of changing the initial distribution of customer attitudes on rate of adoption. Whilst many important perceptions have, through the fieldwork, been identified, far less is known about the distribution of those attitudes. The sensitivity analysis will therefore test the robustness or sensitivity of behaviour with respect to initial customer perceptions. For example, we might suppose that a higher number of initial perceptions would lead to a faster convergence of attitudes, or to lower tendencies for agents to be influenced. Another sensitivity test will be carried out to vary the density of agents upon the grid (by changing the grid size parameter), thus investigating this aspect of network cohesion.

The aim of the model was to explore the scenarios described above: the research questions and the contextual factors served as a guide to the model design. Clearly, the model was closely based on the data collected during the fieldwork stage. There was a large amount of qualitative data collected during interviewing, as well as quantitative data supplied by the manufacturer. The ATLAS.ti (2002) software was used to aid organisation of interview data, uncover patterns in that data, write up the findings of the study, and also to link the data to the model.

6.4 Use of the ATLAS.ti Software

ATLAS.ti (2002) is widely used by researchers in management science to organise their primary data and to facilitate the qualitative analysis. Text files containing the primary data are loaded into the workspace. The first task using ATLAS involves identifying '*quotations*' or pieces of text with particular significance. This is done by selecting them and tagging them with '*codes*' that are concise mnemonics for concepts that relate to the text. Codes and quotations do not have a one-to-one

relation; rather, codes are used to link together sets of quotations which discuss the same concept. In doing so, codes act as very useful aids to navigation of the primary data, because they allow user to click backwards and forwards among sets of quotations. ATLAS also uses the idea of *networks* that the user can construct by linking codes together. It is necessary to specify the nature of the relationship between codes, for example A implies B, or A 'is a' B. Finally, different windows open on network views (or on parts of the network), providing a means to visualise these semantic relationships. Some examples of these 'semantic diagrams' which were produced and found to be useful during the course of this research can be found in the appendix.

From a methodological point of view, it would be valuable to know if such software could be useful in the development of ABSS models informed by qualitative data. The requirements for integrating ATLAS with modelling are that quotations or sections of the primary data should be identified and linked with program rules. We suggest that there are two aspects to this. Firstly, that model assumptions can point towards parts of the text where the validating evidence lies. This would reduce the ambiguity between the model specification and the data that inform it, and would allow additional data to be easily compiled with the earlier data. Secondly, these links should also establish which type of agent the primary data are pertinent to, as well as which time stage in the model they are applicable. For example, are they relevant to the initialisation stage, do they identify recurring processes (and define how often they occur), or do they identify singular events? The links might also relate the outcomes to the circumstances under which they occur. Finally, data constitute different types of evidence, e.g. evidence on which to base a rule of behaviour, or to suggest an important agent characteristic.

For these aspects of model development ATLAS performs very well. The organisational benefits are also clear: it was useful in comparing passages of text and analysing what was sometimes conflicting evidence, and then writing up the emergent findings of the case study (chapter 5). However, experimental design is a more difficult process, one in which ATLAS was not found to be useful. Indeed, model design relies upon the experience and intuition of the modeller, in deciding what

elements of the target system to put in the model, and how to represent them. As described in the last section, this was done through the use of scenarios.

The main difficulty with producing the experimental design was the lack of problem definition. Fundamentally, we did not suffer from conflicting study objectives because the stakeholders were in agreement in their approach, and because their interests fitted well with the author's. Nevertheless, it was still quite difficult to produce the design from the initial research objectives, and the set of interview topics, which were drafted very early on in the project. It is worth pointing out that the amount of data collected was very large: we had over 100 pages of transcripts from the interview recordings. Although constrained by the interview topics, the data were very wide-ranging in scope, covering many different aspects of the business. We struggled with the problem familiar to researchers working in the area of soft systems methodology, that it was difficult to pin down the case study with a specific problem definition. The scenario approach described in the previous section arose from this process of defining what questions the model should explore. Ultimately, this was decided in agreement with the judgement of the stakeholders and of the author. The preceding phases of data collection and interpretation ensured that the author had by now a good understanding of the target system to be modelled.

Care had to be taken not to make the model too big in terms of the size and complexity of the program. The objective was to focus upon the set of research questions and avoid tangential issues. Indeed, it was only possible, within the given timeframe, to model a small fraction of those issues discussed by the respondents in the interviews. This is demonstrated by the fact that the majority of ATLAS codes were linked only to specific parts of very few of the primary documents.

Analysis of the data often highlighted issues which, although interesting, were not really relevant to the research objectives. A good example is the situation of the direct customer who is referred by the manufacturer to a distributor. It was clear from the accounts of the interview respondents that there was reluctance on the part of some customers to accept this. It would be interesting to explore the social influence mechanisms and attitude formation processes affecting an issue such as this.

ATLAS provides important documentation of the qualitative fieldwork. It is important for future reference, or for other researchers who will thus be better able to understand the analysis. This documentation process may well be carried out retrospectively, i.e. first of all the data are assimilated into the model with the writing of program rules, and then those rule-names are used to code (and to link) the relevant pieces of text.

In summary, the main benefits of using ATLAS are in making explicit the validation of model assumptions with primary data, and the standard organisational benefit in working with large amounts of qualitative data and in documenting and writing up the emergent findings. However, in terms of producing the model design and experimental design, the ATLAS.ti package was not found to be very useful because this aspect of a case study relies too heavily upon the researcher's judgement and interpretation.

6.5 Validation of the Model

Validation was centred upon three main areas where the model, and its outputs, could be directly compared with the manufacturer's e-commerce system. These are the points numbered on the methodology diagram of Figure 4.1 and described in section 4.1.4. Number one on the diagram is the point at which the model rules were informed by the interview data. This took place early on in the case study and was an integral part of developing the model design. In the following section we provide more details about how concepts were taken from the fieldwork. Point number two marks the comparison between simulation results and mall statistics, which aims to assess the characteristic macro-behaviour of the model in terms of that of the empirical system. This comparison is made in the results section of chapter seven. The third validation point relies upon the participation of the stakeholders in an iterative evaluation and redevelopment process. This involves assessing both the assumptions upon which the model is based, and the micro behaviour of agents in the simulation experiments, in terms of their plausibility.

In actuality, besides the three validation methods mentioned above, there are several others that are not marked on Figure 4.1 since they are more trivial points or they were not used in this project and therefore require less discussion. Firstly, the beliefs and attitudes of customers could be informed by surveys carried out using a questionnaire. This had been planned but changing circumstances meant that it was not possible (see sect 4.2.4). The survey responses would have been used to validate model assumptions about the relative importance of different factors in the formation of customer attitudes about e-commerce. Secondly, quantitative data about the customers (the number of customers, their demand distribution, their information systems) and the distributors (their characteristics and strategies) were used to validate the agent initialisation rules. Further methods of validation involved the expertise of the stakeholders. Thirdly, the stakeholders evaluated the macro- or system-level behaviour of the model as plausible or consistent and recognisable with their own knowledge of characteristics of their supply chain. In summary, there are various different ways in which an ABSS model could be validated. The main validation points of this case study are identified on the diagram of Figure 4.1, and will be detailed further in sections 6.5 (qualitative fieldwork informing the model) and 6.6 (stakeholder evaluation of model assumptions).

There are strengths and weaknesses in the validation of any model: some parts of the model will be well validated and some will be more exploratory. It can be suggested that this model is well-validated in terms of the nature of the value chain and of the issues facing the manufacturer (as the fieldwork was carried out with their members) but perhaps less the behaviour, attitudes, and expectations of customers and distributors. As the latter are less well known, they form the subject of simulation scenarios. Of the different methods of validation, stakeholder evaluation should be the most reliable because stakeholders are sensitive to results that ‘do not look right’, i.e. are not like anything they have observed. However, potential problems with qualitative data are that respondents may be misinformed in their assertions, or they may surmise something which is taken to be a certainty. Quantitative data are more reliable but are limited to those concepts which can be easily measured. This is why qualitative methods are also used: a model involving qualitative semantic structures requires qualitative methods of validation.

The other main problem with qualitative research is related to the vagueness of qualitative data. Taking as an example, the fieldwork data that refers to the policy of preferential referrals, where the manufacturer may preferentially refer customers to distributors that are using the Internet e-commerce system:

'It is quite important in encouraging our distributors that we provide referred business.' (P6)

Now, although it is understood (see chapter five) that the 'encouraging' is going to be done through, among other things, manufacturer referrals, the difficulty with the above statement is that it could have several different interpretations, and these would be formalised into very different rules. For example, suppose there is a preference for any Internet – enabled distributor which is manifest in a much greater probability to recommend such a distributor to a customer than one not having an EC facility. This idea is expressed in the following rule:

Alternative 1: *in any trading cycle each customer requiring a referral will be referred to a distributor chosen at random, but with a three times higher probability for distributors that have previously adopted Internet-based EC than for those which have not.*

Or it could be interpreted as meaning that the manufacturer would *never* refer to a non-EC-enabled distributor if there is at least one that is enabled. A second alternative would therefore be:

Alternative 2: *in any trading cycle each customer requiring a referral will be referred to an Internet-EC-enabled distributor chosen at random. If there are no such distributors, choose at random from amongst all distributors.*

In another example, it could be hypothesised that some referrals are specifically linked to an adoption decision. In other words, the manufacturer refers the business to a recently adopted distributor:

Alternative 3: *in any trading cycle each customer requiring a referral will be referred to the most recent intermediary-adopter. If there are several recent adopters, then choose at random from amongst them, and if there are no such distributors, then choose at random from amongst all distributors Internet-EC enabled distributors.*

Whilst there may appear to be little difference among these alternative specifications, it is likely that even a small difference could have a significant impact upon the result. This vagueness or uncertainty can be overcome with the involvement of stakeholders to clarify issues such as this by direct querying. However, there are also weaknesses inherent in the stakeholder approach.

Whilst there is no doubt that the stakeholder participation approach has many advantages in terms of improving validation of the model, particularly with qualitative aspects of the research, in practice these procedures are very consuming of the time available to collaborate with stakeholders. In this project, I found that a particular problem was arranging time with the stakeholders to evaluate the agent micro-behaviours. This validation process involves investigating the path of individual agents through the simulation, in view of behavioural explanations derived from the agent database.

During demonstration of the SDML platform, this approach was taken to explaining the structure of the model and the concept and utility of the agent-based approach. The response was positive and suggested the viability of the technique. However, I feel that the validation of micro behaviours was unsatisfactory because it is not known whether agent behaviours are recognisable to the domain experts, the stakeholders. Furthermore, with this being one of the most promising avenues for validation, it was a missed opportunity that I was not able to carry it out. It can be argued, however, that such a technique is appropriate and would be beneficial in model validation processes. An example of how this type of explanation might be developed is presented in section 7.3.1.

The next section introduces several hypotheses known to factor in customer and distributor attitudes towards e-commerce. It therefore demonstrates how the fieldwork can inform a key area of the model design.

6.6 Hypotheses in the Model: HEC and HINT

From the accounts of respondents interviewed at the company (i.e. employees of the manufacturer), we identified a number of hypotheses about e-commerce (HEC) that were thought to be held by their customers and intermediaries. The same respondents also identified a number of hypotheses about distributors (HINT).

HEC:

1. It is extra work for me to use the electronic mall compared to a manual system
2. Almost everybody will soon be using Internet-EC: I should be doing it too.
3. The instantaneous and quick access to information provided by the mall (compared to traditional channels of communication) is of benefit to my company.
4. The 24-hour availability of access provided by the mall is of benefit to my company.
5. The provision of up-to-date and accurate information on the electronic mall is of benefit to my company.
6. The digitisation of product data sheets and the availability of software updates through the electronic mall is of benefit to my company
7. The reduced possibility of errors occurring in orders on the mall is a benefit.
8. The provision of a more user-friendly way of accessing customer account information on the mall is a benefit.
9. It is expensive for the company to set up and maintain Internet-based systems compared to manual systems.
10. I am concerned about security issues with Internet-based systems compared to manual systems.
11. I am receptive to Internet-based EC because I expect the company to receive extra discounts if we adopt.

12. I am concerned about the lack of technical support and experience within the company of using EC.
13. I am receptive to Internet-based EC because I expect the company shall receive more customer referrals if we adopt.¹¹

HINT¹²:

1. The supplier offers a good discount on the selling price of the product.
2. I am concerned that the distributor may lack technical competence.
3. The nearby location (thus, ability to offer a local service) of a supplier is a benefit.

We classify hypotheses into two types: *communicated-type hypotheses* and *inference-type hypotheses*. The first type can be characterised as *verifiable beliefs*, objectively true or false. These could be, for example, characteristics of a technology upon which industry experts, stakeholders, etc generally agree. The second type are non-communicated hypotheses, that are inferred by the agent. They are *subjective beliefs* that are wholly dependent upon the circumstances or characteristics of the agent. It is therefore less meaningful to communicate them since individual situations are very different. Rather they are inferred to be true or false depending on evidence gathered personally by the individual. Each hypothesis is *qualified* by a Boolean ‘True’ or ‘False’, that denotes whether it is a hypothesis that is supportive (True) or dismissive (False) of the decision to adopt / choice of supplier.

During the next chapter, we adopt the bracketed pair notation to express a hypothesis:

Communicated-type HEC: [Instant Access, True], [Up To Date Information, True],
 [Wide Acceptance, True], [24-Hour Availability, True],
 [Digitisation, True], [User Friendly Access, True],
 [Fewer Errors, True], [High Security, False].

Inference-type HEC: [Inexpensive Set-Up, False], [Extra Discounts, True],
 [Labour Saving, False], [Tech. Support Avail., False].

¹¹ This hypothesis is relevant to distributors only.

¹² This set of hypotheses is relevant to intermediated customers only.

Communicated-type HINT: [Low Price, True], [Tech Competent, False].

Inference-type HINT: [Local Service, True].

Now, if the second argument (the qualification) is ‘True’ and the agent believes the hypothesis to be true, then this belief will have a positive impact upon the attitude of the agent. Similarly, if the qualification is ‘False’ and the agent believes the hypothesis to be true, then the belief will have a negative impact upon the attitude of the agent. If, however, the hypothesis is *not* believed to be true, then it will not contribute towards the attitude of the agent. For example, the hypothesis [High Security, False], if believed to be true, can be interpreted as the agent believing there is a security risk. This may inhibit use of the system. However, if the hypothesis is believed to be false, then it will not have the equivalent positive impact on the attitude. This formulation is intended to capture the idea that customers are risk-averse. In other words, what this means is that a belief relating to a particular hypothesis can have either a positive or a negative impact, but not both.

The hypotheses quoted above were all identified during analysis of the primary data. What remains unknown is the distribution of beliefs about EC. We did intend to obtain quantitative data about customer and distributor beliefs and attitudes through a survey planned by the stakeholders, but as explained later, this did not take place. However, the above hypotheses were later clarified through discussions with the stakeholders and also through reviewing the e-commerce literature (Timmers 1999, pgs. 9-19).

This section explained how the fieldwork was used to inform the model. Continuing our discussion of validation, the next section details the stakeholder participation.

6.7 Using Stakeholder Participation in Conjunction with ABSS modelling

The role of the stakeholders in defining the case study context and the research questions was already discussed in section 6.2. This section will focus mainly upon how the evaluation of model assumptions and behaviour was carried out.

The most important ability desirable of a stakeholder in this type of project is that the person should be able to recognise model behaviour that is consistent with his or her own observations. Models of behaviour are more naturally suited to participatory projects than are purely numerical models. Behaviour is important because the stakeholders can more easily identify it, reason with it, and thereby explain outcomes in terms of behaviour.

Furthermore, it can be argued that, when stakeholders are involved, fine grain and detailed models would be a more natural choice than coarse grain ones. This is because stakeholders can more easily recognise fine-grain behaviours than aggregate ones. The more closely the models are based on observed systems, for example in a case study, the easier it should be for the stakeholders to understand or conceptualise them. In this case study it was found that fine grain explanations were preferred by the stakeholders. They wanted to know about customer attitudes towards, and the potential opportunities and pitfalls of, e-commerce.

On the other hand, more general models would be more difficult for them to relate to. Coarse-grain models that aim to represent distribution systems, market institutions etc, would be appropriate for other groups rather than the stakeholders. Groups of people that may be interested in more general large-scale models might be, for example, other researchers interested in theories about the impact of EC on market structures, distribution channels, etc.

The role of stakeholders in ABSS modelling is described in (Moss, Downing et al. 2000) and is summarised below. The role of stakeholders is important because:

- They are best able to validate model assumptions concerning the behaviour of decision-makers (for example, how agents form expectations of the outcomes of their decisions) because they are themselves involved in these processes or

because those actors (individuals or organisations) involved are well known to them.

- Unanticipated consequences which arise during simulation should be interpreted with the help of the stakeholders to identify reasons for the outcomes
- They can identify issues of importance for the project. This is particularly important for case study research because stakeholders have the unique insight and understanding of their particular businesses.
- They can identify discrepancies between their own actual observations of the phenomena and the model behaviour during simulation experiments.
- The results of these consultations with stakeholders will be used to revise the model.

To involve the stakeholders with the modelling project, the modeller must:

- Clarify the understandings of stakeholders and to ascertain whether or not those understandings and beliefs are coherent across different stakeholders.
- Develop models that are seen as plausible by the stakeholders, and that accurately capture important social and natural relationships.
- Develop models with structure and specifications that can be well understood by stakeholders.
- Develop models to improve the stakeholders' understandings of the processes which lead to outcomes they observe or believe to be plausible.
- Develop models which are useful to stakeholders, and allow them to use the model explore the consequences of their actions.
- Ensure that they can see how the information they supply during consultations is implemented in models.

After a satisfactory initial interchange of ideas with the stakeholders, during which time the research design was drafted (see section 4.2.4), the fieldwork was carried out and research questions devised for analysing the data and developing the model (see section 6.2). At one of the first meetings, the author gave a presentation about ABSS modelling and its applications. This was later followed by a demonstration of the SDML modelling platform during a quiet period of one of the days of interviewing. It was found that although the stakeholders initially had very little preconception of

what an agent is, they were able to easily grasp the key concepts and principals of agent-based modelling. Later on, as they became more familiar with the technique, they were able to validate the model, as well as contribute ideas about its design.

One way in which the stakeholder evaluation of model assumptions improved the model design relates to the specifications we made about interaction processes amongst customers. In the model, we have the following assumption:

Rule: *Customer-to-customer interactions take place: every trading cycle, each customer interacts with one of his neighbours chosen at random. One of the neighbour's beliefs is selected at random, and communicated to the agent in the form of a statement-type endorsement.*

The reasoning behind this assumption was that communication could take place amongst neighbouring customers in informal networks. The stakeholders said that such interactions might take place, though they didn't have much knowledge about that. However, they then suggested 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 manufacturer's sales team (i.e. the engineer might report what other customers are doing), and secondly through staff turnover (employees move from company to company, and bring new ideas with them). This demonstrates how stakeholder participation can improve and strengthen the model development.

Issues that arise during the stakeholder evaluation process can also have an effect upon the choice of research methods used in the case study. For example, one of the key design issues was how to model the attitudes of customers and distributors towards Internet-EDI and the way these attitudes were changing over time. A reasonable amount of information about these attitudes was derived from the interview data: the interview respondents had described those hypotheses they thought were a factor in the formation of these attitudes. However, it was not clear how important these factors were in a relative terms, except that some were more frequently mentioned than others and were forcefully highlighted by a respondent. The analysis served as a guide to ranking these hypotheses in terms of importance.

The ranking was necessary in order to use the endorsements scheme described in section 7.2.4.

Perhaps a more reliable way to validate the ranking of hypotheses was to describe them to the stakeholders and seek their opinions, since they were the domain experts and would be familiar with the beliefs of their customers. The stakeholders said that to the best of their knowledge the assumptions were plausible, but they suggested carrying out a further validating survey of users and potential users. This would involve designing a questionnaire, which the stakeholders would distribute to a sample set of their customers and obtain quantitative data about their beliefs concerning e-commerce. As explained in section 4.2.4, changing circumstances did not allow this suggestion to be carried out. Nevertheless, this does not weaken the finding that the evaluation process can lead to the design or redesign of methods of model validation. In the case study, the stakeholders' suggestion for the design of a quantitative survey is a good example of this.

Clearly here are two additional benefits of stakeholder evaluation in addition to the planned validation methods. Firstly, there is an opportunity to clarify the empirical basis for model assumptions, as illustrated by the customer-to-customer communication example. Secondly, the ability to suggest particular research methods for the case study is of benefit because it can further strengthen the validation.

The other method of validation suggested by Moss and Edmonds (2003) involving the stakeholders is based on identifying and understanding agent micro behaviours. In this case study there was a mixed result in employing this strategy. Where it was possible to carry it out, the response was a positive one. Demonstration showed that this is a viable approach, although not by any means an easy one. From experience, it is worth noting that cognition would be much improved with consideration given to presentation and visualisation of simulation data. The idea is to track the trajectory of individual agents through the simulation, building up accounts of agent perceptions, interactions, and decisions, and thereby providing explanations for behavioural outcomes (see section 7.3.1 for an illustration of this). The approach can certainly guide the modeller in the development process. Unfortunately however, it was not possible to validate in this way the simulation results presented in the next chapter.

Further validation, discussed in the following chapter, centres on comparison between simulation data and electronic mall data, which was supplied by the stakeholders. This quantitative validation involves direct comparison and statistical comparison, and aims to affirm or disaffirm the existence of statistical characteristics such as power law distributions and s-shaped curves.

Conclusion

This chapter described how the fieldwork data were linked to the model, and emphasised the validation procedures that were used. This linking involved considering the case-study context and problem area definition, in order to develop a set of targeted research questions. These questions were then built into experimental ‘model scenarios’ to be investigated by setting up simulation experiments. The details of the experiments and analysis of the results are presented in the next chapter (ch. 7).

More information was provided on the role of the stakeholders within the organisation and the nature of the relationship with the researcher. This relationship was based on shared issues of interest and a keenness to investigate them, and was very good. It was observed that there was very little formal permission needed for the project. Wider involvement was only necessary in seeking an initial approval, and in judging the potential data sensitivity issues and the right to anonymity in disseminating the research findings. However, the relationship produced some unforeseen difficulties. Changing circumstances within the company itself led to a lessening involvement of the stakeholders in the project in the face of more pressing commitments.

Section 6.5 discussed stakeholder contributions in terms of validating model assumptions. In addition to being initially involved in defining the research questions, providing background information, mall data and field access, the stakeholders were also able to clarify issues raised by the fieldwork analysis and by model development. They were part of the ‘qualitative approach’ to validation by virtue of their expertise, and their contributions greatly facilitated an iterative process of model development, which was the aim described earlier in the methodology section (4.1.4).

To illustrate the qualitative aspects of the model, section 6.6 drew upon the fieldwork to identify those ‘hypotheses’ considered by the interview respondents to be important factors governing the behaviour of customers. Beliefs held by the customers about these factors are later integrated into the model structure. The next chapter details the model of the case study, which was designed and improved by tapping into all of the available sources of knowledge and information discussed in this chapter.