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Letter from the editor

In this issue of the IMP journal two articles, both based on large case studies of technological development, are presented. One describes the development process taking part between two companies and the other, when the same appears on a country level, within a whole set of companies. In the first case written by Patrick Lynch and Thomas O Toole, we can follow the ups and downs in a process including two companies fighting for solving severe technical production problems. It is the buying company that identifies a problem as it is getting a high amount of waste when using the seller s product in its production process. This is the starting point for a complex process where a number of technical issues have to be identified and solved. In the process there are several critical moments where the conflict intensity between the two companies is very high and where the process could have ended. The case indicates that single persons and their personal relationships play an important role to handle at least some of these critical situations. The case also illustrates the opposite that single managers can not make decisions regarding the relationship in isolation. As an example, the heaviness of the existing relationship in terms of functional aspects; the importance of the product and how it functions in the

case is an excellent example of describing all those complexities that appear within business interaction processes going on between single companies and how the solving of these more or less continuous problems are a condition for the way the companies can function technically and commercially.

In summary the single relationship has both to function and to produce value in itself but it has at the same time to fit into the larger picture the two counterparts have to It is a long and often cumbersome process when the relationships are forged together into business networks. But when successful this process also gives them a much higher long term value which is exemplified in several ways in the article.

The case in the second article written by Tommy Shih is a description and analysis of the development of the Taiwanese semiconductor industry during thirty years. It is giving a very similar but also very complementary picture to the first article in picturing the development of a whole industry. In the same way as for the company case above there are also here single persons who play an important part. We have in this way crucial micro processes. At the same time there are important macro processes where the large international companies and the Taiwanese government together are combing resources into something useful and therefore also a powerful constellation. The single episodes and the combining of this large resource constellation slowly and stepwise are forming a total network structure. The role of the industrial policy by the Taiwanese government is never to control the development. That is impossible! Instead it has to mirror the development and become an integrated part of this development which includes a much more complicated combination of resources than any single actor can handle. The development in Taiwan has to be complementary to the development of some big actors and also complementary to the total development in some other regions. In this development a key issue is to take advantage of the resources already existing.

The two articles together give an interesting picture of how micro and more macro processes are related within networks. Single episodes within interaction processes between single companies are crucial for the development at the same time that the forming of the total network structure give a frame within which these single interaction processes have to develop. It gives a picture both of what can be achieved within relationships as well as how they become a frame within which the company has to develop.

Enjoy the reading

Håkan Håkansson

A Critical Episode Analysis of the Dynamics of the Interaction Atmosphere in a New Product Development Relationship

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Abstract

This paper deals with collaborative user involvement in the new product development (NPD) process. The purpose of this paper is to describe the dynamics of the interaction atmosphere that occurred in a long-term relationship between a packaging technology supplier and its food manufacturer partner in the development of a plastic film during the NPD process. Utilizing an interpretative case study approach, the empirical evidence is based upon interviews, reflective practices, observation and documents. The paper will detail seven critical interaction episodes and provides valuable insight into the dynamics of the interaction atmosphere that occur in close collaborative relationships. The findings showed that the interaction atmosphere between the two companies went through alternating cycles of divergence and convergence to maintain and re-negotiate an already established belief structure of expected and accepted behaviour.

Keywords: Critical episodes, dynamics of interaction atmosphere, user involvement in new product development, case study

1. Introduction

Within the new product development (NPD) literature there has been an emerging consensus that while certain success factors pertain to the development and commercialisation stages, the majority are determined much earlier in the project's life, explicitly in the early or pre-development stages (Stevens et al. 1999; Cooper and Kleinschmidt, 1996; Cooper, 1993; Booz, Allen and Hamilton, 1982). Developing a product that delivers superior benefits presupposes an understanding of user needs and wants, a process that should ideally be undertaken prior to the commencement of any actual development (Stevens et al. 1999; Cooper, 1988). Without this up-front user knowledge, significant problems in later stages of the development process can be expected including development activities taking longer than expected, increased costs, delayed time to market and even product failure (Cooper and Kleinschmidt, 2000; NICB, 1964). However, user need information can be costly, complex and often sticky (von Hippel and Katz, 2002; von Hippel, 2001). Moreover, in business markets, conventional research tools are often of limited utility and since these markets have relatively small numbers of users, leading edge companies such as 3M, HILTI and Johnson & Johnson are increasingly involving their users in the early stages of new product development (Lilien et al. 2002). This is done to enhance a firm's competitive advantage through the provision of innovative and appealing new product concepts (Stevens et al. 1999; Cooper and Kleinschmidt, 1996; Madique and Zirger, 1984; Cooper, 1979a; b; NICB, 1964). Others (von Hippel and Katz, 2002; Tidd et al. 2001; Cooper and Kleinschmidt, 2000; Voss, 1985) suggest that user involvement in front-end activities can also reduce need and market uncertainty by supplying manufacturers with a more accurate assessment of user requirements and consequently reduce the potential risks of misfitting buyer needs to a deficient or poor product idea (Johnsen and Ford, 2000).

However, despite the importance the literature assigns to user involvement in these predevelopment activities, there is also ample evidence to suggest that many firms do not bring their industrial users into the NPD process (O' Toole and Lynch, 2004: Adams et al. 1998; Cooper, 1996) and in most instances, projects enter the development phase lacking any clear definition, often as a result of superficial user involvement in these early stages (Lynch and O' Toole, 2006; Cooper, 1999; Biemans, 1992; Mahajan and Wind, 1992; Cooper and Kleinschmidt, 1986). Other evidence suggests that while most firms consider user involvement in predevelopment activities to be beneficial, they nevertheless felt that it complicated the development process and made it more difficult to control and manage (Olson and Blake, 2001). An alternative approach to activating user involvement in industrial new product development happens when partners collaborate to solve ongoing product and process problems in some part of their dyadic interaction, or indeed network (Håkansson, 1987; Ford and Saren, 1996). When this occurs it has the additional advantage of being a co-developed solution and thus gets over some of the user involvement challenges outlined. Nonetheless the reasons cited as to why user involvement in the early stages of NPD remains, for many, aspirational and difficult also apply to co-developed new product solutions. Hence there is still much to understand. Describing the dynamics of interaction of a NPD project will depend on the nature and urgency of the change required of the parties (Halinen, Salmi and Havila, 1999). In this paper, the problem is amplified in the atmosphere of the interaction.

The purpose of this paper is to describe the dynamics of the interaction atmosphere of a NPD project in a long term collaborative relationship. This goal was met in two ways: the authors first classified the data into a series of critical episodes which showed the development of the new product project in decisive stages. The episodes were labelled on the basis of major shifts in the relationship atmosphere in either a positive (convergence) or negative (divergence) direction. Secondly, each episode is described by interaction processes that are either pulling the relationship together or apart. Describing both the 'movement' of the project through critical stages and the related processes achieved the purpose of the paper. The bulk of the paper is given over to the case, the partners' story. The case description is in the processual research tradition and, as such, is contextual and situational (Pettigrew, 1997; Sminia, 2009). Its richness is evident in the insights into the dynamics of relationship atmosphere which was the dominant interaction process in the case. This case gives full exposure to the dynamics of interaction atmosphere which is relatively rare and unique in the new product development literature. The interaction atmosphere is often classified as an intervening variable moderating the relationship, or empirically measured by the interdependence of the parties at a point in time whereas in this paper it is the core dynamic during the period under investigation. Few studies outside the industrial markets-as-networks approach study underlying interaction process dynamics (Ring and Van De Ven, 1994; Doz, 1996; Welsh and Wilkinson, 2002) and much less that of interaction atmosphere especially in the context of a NPD project.

Given the lack of prior research into the interaction dynamics of a new product development project, the authors committed themselves to an inductive data gathering approach. However, related empirical and conceptual research literature was used to ensure that no obvious area was missed in data collection or analysis. The relationship atmosphere aspect of the interaction model provided the contextual setting for the data (Håkansson, 1982). The paper addresses the dynamics of the interaction atmosphere in the development of a new product. A multidisciplinary research literature on relationship and alliance development was used to identify processes that impact on this dynamic. From the industrial marketing and industrial network approach, relationship development models such as those by Ford (1980), Dwyer, Schurr and Oh (1987) and Ring and Van De Ven (1994) were used to identify processes that might be germane to the case setting. From the alliance formation and development literature work that focused on development dynamics also proved instructive, for example, Zajac and Olsen (1993), Büchel (2000) and Ariňo and de la Torre (1998). The insights from these works kept the data analysis on track and were used as a comparison base to sift through the data and eventually arrive at the final set of descriptors of each critical episode mentioned in the case narrative. Little of the prior literature addressed the atmosphere dynamics of an established relationship with the specific characteristics of the case companies but key processes such as expectations (Dwyer, Schurr and Oh, 1987), learning (Doz, 1996), problem solving (Powell, Koput and Smith-Doerr, 1994), negotiation (Dwyer, Schurr and Oh, 1987; Ring and Van De Ven, 1994), commitment (Ring and Van De Ven, 1994), personal and role relationships (Ring and Van De Ven, 1994; Welsh and Wilkinson, 2002) were central to framing the interaction dynamics specific to each episode.

The case is organised on the basis of critical episodes at a dyad level (Halinen, Salmi and Havila, 1999; Edvardsson and Strandvik, 2000; Schurr, 2007; Schurr, Hedaa and Geersbro, 2008). For an episode to be classified as critical in this case, it had to be a major shift in the relationship atmosphere. This shift had a cycle from positive to negative (Daft and Weick, 1984; Büchel, 2000, Schurr, 2007); convergence where a direction and mutual expectation was perceived to exist then the atmosphere became positive and reinforcing, to divergence where the dynamics of the interaction were negative, crises ridden and shared systems of understanding including personal relationships were under severe strain. The authors attempt to describe the dynamics of the interaction atmosphere during the NPD process across the cycle of convergence and divergence and in doing so narrate unique insights into the process.

The rest of the paper is organised as follows. In the next section, the methodology employed in this research and the data analysis is described. The research site and context of the new product development is then provided. The main section of the paper presents the seven critical interaction episodes between the collaborating partners. Case analysis is then addressed before a conclusion to the paper is drawn.

2. Research Design

2.1 Sample and Method

This paper reports on an in-depth case study of a long-term relationship between a packaging technology company and its food manufacturer partner in the development of a plastic film during the early stages of the NPD project. Data was gathered in real time, over a six-month period, between October 2005 and April 2006. Since this research was occurring in real time, care had to be taken not to influence the ongoing interaction process between the two companies. Indeed, as observed by Doz (1996), with “real-time process studies…it is extremely difficult to be sure not to influence ongoing processes and still maintain a legitimate presence in the field insofar as mangers would quickly be tempted to seek advice from the researcher and ask the researcher to intervene in the process, as a *quid pro quo* for allowing access” (58). To ensure the prevention of researcher bias on the case, from the outset, a boundary was firmly established and reasons explicitly stated to informants. In fairness to the case companies that boundary was not breached

Data was collected from four main sources: interviews, reflective practices, documents and observation. The variety of data collection techniques allowed for greater possibility of discrepancies or anomalies to be noted in research data, and should compensate for any limitations in individual collection techniques (Eisenhardt, 1989). Multiple sources also counteract potential validity concerns in relation to theory development, because multiple lines of enquiry converge towards a particular proposition or conclusion (Yin, 2003).

All in all, 15 interviews were conducted with the key members involved in the development project. Of these 9 were personal in-depth interviews and 6 were telephone interviews. The personal interviews ranged in length from 1 hour to 3 hours each. The telephone interviews lasted about 10 to 30 minutes, with the shortest of these aimed at collaborating existing information obtained via interviews, documents etc or at alleviating confusion over some point. The telephone interviews were mainly made after personal interviews had been carried out. An interview guide was made before each interview. Nevertheless, the interviews took an unstructured format. The individuals that were being interviewed were highly educated, competent executives and understood the cooperation process between their company and their partner. Thus, they talked freely, only to be interrupted by the researcher on some follow-up issue. The role the interviewer played was only that of a guide through the interviewees' stories. For instance when it was felt that a topic was exhausted, the researchers would introduce a new topic, based on the interview guide, or some issue that may have materialised in the interview. Thus, the interviews had a very relaxed feel to them, even conversational, and rich insightful data about the interaction processes involved in their cooperation emerged.

The reflective practice involved the researchers analysing data gathered from in-depth interviews and documents, and putting it into a story, and then presenting that story to the respondents. Gaps of understanding about what was going on, where evident in the narrative, were subsequently filled in by the respondent. In one way, the participants became, in part, the analyst of the data and in the act of writing the narrative and listening to the respondent, the researchers were able to immerse themselves in their experiences and get at *what is going on* (Denzin, 2001). The routine that emerged in conducting reflective interviews was that at the start of a scheduled in-depth interview the researchers would present the narrative about the data collected to that point and discussion would ensue, errors would be highlighted and understanding would emerge on issues. When the discussion was exhausted, the interview would then revert back to gathering and uncovering the next episode of the story. At the next meeting, the same process would occur as just outlined, the researchers would show the updated narrative, including new data, and the respondent would be asked to fill in the blanks. Once understanding was arrived at, the next episode would be investigated.

Documentary data, printed as well as electronic, was collected from various sources such as annual reports, academic databases, commissioned company reports and product design specifications. In total 25 documents were used. In most instances, documents were studied in preparation for interviews. Finally, secondary data such as government reports were assessed to understand the specific nature of the industry context and policy during the period of the study.

Observations influenced and contributed to casework to the extent that *a picture paints a thousand words.* It facilitated the researchers in observing the products and production process "in use", and so, provided a greater contextual understanding of the product concepts and development issues under research. For instance, the researchers were brought onto the factory floor and were able to see how the packaging was made, what a packaging sealing issue was and what slippage means. The observation allowed the researchers to gain insight into knowledge that was hard to communicate without actually experiencing it, and in this fashion, fertilised the researchers' understanding of concepts that the participants were talking about.

2.2 Data Analysis

In order to categorise and identify the processes that occurred in the interaction atmosphere between the manufacturer and user in the early stages of new product development, this research builds upon the analytical ideas of Pettigrew (1997), Fox-Wolfgramm (1997), and Lincoln and Cuba (1985) which incorporates a constantly iterating cycle of deduction and inductive category coding and pattern recognition across categorised phenomenon. In this analytical model, social phenomena were continuously being compared across categories so that new dimensions could be discovered. The identification of the dynamics of interaction atmosphere began with the analysis of initial observations. However, these initial observations underwent continuous refinement throughout the data collection and analysis process, because data collection, analysis and interpretation were occurring simultaneously, and so continuously fed back into the process of category coding. Category codes and their content were continuously compared with previous events and so new insights were discovered (Lincoln and Cuba, 1985). Finally, it was possible to group the data into critical episodes and describe the process dynamics of the interaction atmosphere at each of these points.

Nvivo, qualitative analysis software, was utilised to manage the process of coding, retrieving, memoing and data linking. In the domain of coding, text chunks of transcribed data were unitised and categorised by giving them a code. The code that was assigned resulted from keywords or labels that were used by the research subjects to describe the phenomenon under discussion. When unitising, each unit was coded according to the source, site, date, label etc. This coding process allowed the researcher to retrieve information when needed, thus facilitating the refining and regrouping of knowledge units through the linking of ideas and sources, identifying contradictions in arguments and comparing dissimilarities (di Gregorio, 2000).

2.3 Research Site and Context

Starting in 1985 and continuing today, Packfex and Farmfresh collaborated closely in developing packaging film for Farmfresh's food products. The relationship began in 1985, when both companies co-developed an innovative and revolutionary film (Chubb X1) that actually became the cooking vessel, in that the raw meat entered the packaging and is cooked. Indeed, the innovativeness of the packaging is still evident today as only a few companies have been able to produce a similar film. Presently Chubb X1 is Packfex's biggest selling product and as Packfex is currently becoming more global, new applications for the plastic are emerging such as plastic covering for army artillery and sales of the film are expected to increase exponentially. Over the past twenty-one years, the relationship between Packfex and Farmfresh has become close and can be characterised as being highly integrative, with high levels of trust, commitment, and cooperation. Communication between the two companies is high with a considerable amount of information sharing. In addition, there are a number of close professional and interpersonal relationships between individuals in both companies.

However, in late October 2005, in two of Farmfresh's production facilities, Chubb X1 was uncharacteristically causing significant wastage, approximately 33 per cent. To put this into perspective, in production terms, the golden rule is that production efficiency running in to double figures is totally unacceptable. The problem was communicated when one of the Farmfresh plant directors contacted Packfex to request that someone come down to their plant and rectify the situation as it was costing a significant amount of money.

Assurances were given that the problem would be dealt with. However this did not materialise and Farmfresh got extremely upset at the lack of response from Packfex in solving the wastage issue. Tension between the two companies was evident when the Engineering Manager (EM) contacted Packfex and very aggressively demanded that they come down to the plant at 6am the following morning to witness the wastage first hand for themselves and a meeting with Farmfresh's management board was to be scheduled after the production run to discuss how this quality issue was going to be solved.

> *I wasn't happy overall…there were a lot of questions being asked [about Packfex] like what's happening now. There could have been a quicker reaction time (Farmfresh: EM).*
>
> *You have got to show quite a lot of commitment at that particular point to handle the situation. When Farmfresh rang up and said that we are going to run at 6 o'clock tomorrow morning and as unreasonable as it sounds and in relation to what other appointment or meeting you have got, I had to jump in and bite the bullet, because they would not be interested in talking to us if we didn't turn up. If we didn't turn up, Farmfresh would have thought that there was no commitment from us to solve the issue we were having (Packfex: TD).*

When Packfex's Technical Director (TD) and Account Manager went to the site the next morning at the agreed time, the first thing that both of them noticed was that none of Farmfresh's management team were present. In fact, they did not arrive until 9am, three hours later. For Packfex, that was quite an amazing statement. They felt that Farmfresh were trying to show them that they were the dominant actor in this relationship. However, the Packfex representatives did not mind being left on the factory floor with Farmfresh's operatives because it allowed them to observe the production process in real time. It also allowed them to interact with the operatives and to get first hand illustrations and explanations of the problems that were occurring in the production process.

When Farmfresh's management came in at 9am a conflict immediately ensued between EM and TD, in that the former was blaming the film for the high wastage and the latter was blaming a catalogue of mechanical errors with the packaging machine.

> *We stated to them that the machine had a catalogue of mechanical problems. At this particular point EM is angry because here am I going through the issues, the problems with his machine. He had worked on this machine for the last 7 years trying to get wastage down and here am I jumping all over his toes. And the conflict at this particular point is intense. The anger and the facial expressions in his face as I was going through this is really visible… The tension at that moment was very high. We were standing on his territory, discussing his machines in such a manner that he is going to find it extremely aggressive. The only way to describe that interaction is that the guy took a pasting from me (Packfex: TD).*

At the formal meeting between the two companies Packfex reiterated the technical faults that they had discovered with the machine and stated that no alterations to the film would be made without these mechanical issues being fixed. Within Farmfresh, the production and engineering departments were not happy with Packfex's assessment of their machines because it meant that production would have to be stopped and there was now an internal conflict from other departments demanding to know why these technical issues were not resolved before. However, EM was claming that it had to be Packfex's film since other packaging ran on the machine with no faults. However, despite Farmfresh's arguments that the film was to blame for the high wastage, Packfex was adamant that the mechanical issues had to be dealt with before any product alterations were contemplated. The meeting ended with an agreement that the technical faults would be rectified.

> *When we went into the meeting, we stated that before any changes are to be made to the product, they had to fix the machine and we gave them 5 faults that needed to be corrected before we would get involved. EM did not agree with us and had stated that the machine manufacturer had been here last week and that the machine was in pristine condition. They were telling us that our film had faults and that when they put on our roll they got 33% wastage, however, whenever they put on other rolls they were getting none. First of all alarm bells were ringing. We knew we were not been told the truth. We knew the wastage was high on the other rolls as well. So we told them that there were 5 faults with the machine and that they needed to be corrected before we would even contemplate adjustments to the product. In fairness, to EM, he agreed and the production line was shut down until the faults were corrected (Packfex: TD).*

To resolve some of the tension between the companies TD and EM worked out a methodology to fix the technical faults in the fastest time possible so as not to delay production.

> *TD stayed with us when we were trying to figure out how to solve the problem and gave us ideas on how to fix the machine. I found him very good…We actually had to do a full diagnostic on the machine and it meant that we had to spend a lot of money changing parts and there was the time, the labour and production had to be stopped (Farmfresh: EM).*

Also at this time, Farmfresh's corporate buyer with whom Packfex had a very close relationship with for a number of years retired and the new corporate buyer began rationalising his supplier base. For the new buyer Packfex was a small packaging supplier with a small spend (number 10) and was informed that due to the significant ongoing quality issues with their film it was been de-listed. Packfex did not argue with the new buyer and told him that it understood his rationale and that its services were always available to him if he so needed.

> *He was showing his metal, it is all about pecking order and we knew that if he was going to upset the apple cart with us, he was probably going to do it with all the rest of the suppliers. What he was doing was very controversial and most companies would adopt a stance that I will teach him and so a conflict would ensue. We didn't see it like that at all. We saw it as an opportunity to move up the supplier list, even though we were technically de-listed. We knew that our product was very unique to Farmfresh and that they would have a hard job replacing us…we had to be patient. He couldn't de-list us, but he had not realised that yet (Packfex: TD).*

The buyer found that because Chubb X1 is such a unique and complicated product that he was unable to locate an alternative supplier to Packfex. Indeed, he found that he was dependent on Packfex. Moreover, the buyer found significant resistance from other departments such as marketing within Farmfresh to the de-listing decision. Thus, while Packfex was technically de-listed they were still supplying Farmfresh with the Chubb X1. This also meant that the quality issues at Farmfresh had to be resolved. As a result of the corrections to the machine the wastage level on Packfex's film dropped from 33% to 15%. Packfex was also informed that wastage on competitor's films had also significantly been reduced and was now running at approximately 9%. Despite the ongoing wastage issue Farmfresh were ecstatic. They had a significant drop in wastage, not only on Packfex's film, but also on other suppliers. At this point, Packfex knew there was a problem with the film. The waste figure was very high at 15% and the fault was not with Farmfresh's machine.

> *In the beginning there was a machine issue and a film issue. When the machine issue got sorted, the film was still causing unacceptable levels of wastage. So for a while, there was a grey area there when there was not a definitive problem with the film…however when the machine was fixed we knew there was something wrong with the film (Farmfresh: EM).*

Packfex travelled to Farmfresh's factory floor to witness the wastage. What they found was that the packaging film, filled, it sealed, it clipped, it cooked and it was during the chilling stage, which is at the very end of the process, the fault appeared. The film actually split. Since the film was in Farmfresh's cooking process for four days when the packaging split, it meant that besides the high wastage and the extra production time needed to compensate, it also meant serious time delays in Farmfresh's delivery of its product to customers.

> *So the second time we went back. EM has now fixed the machine and got less than 9% wastage with other films on the machine and we were still getting 15-20%. EM put the roll on and we saw it run. It was quite clear now, black and white that it was now a film issue. Now the situation changed the other way around and now EM was saying that there is something definitely wrong with the film and that he had accepted everything I said about his machine and so what was going to be done about the film. Now this wasn't a conflictual meeting at all, because the EM is now a hero in Farmfresh, because following the conversation with me over the issues with the machine, after 10 years of waste, he had got the waste level down on his machines to between 8-10%. If you are turning several million euros, you are talking about serious cost savings for the company. EM got an awful lot of respect from his colleagues (Packfex: TD).*

Although a professional and personal relationship had existed prior to the problems with the film, the consequential effect of both individuals working together to fix the machine was that the personal bond between the EM and TD had deepened. Since both had similar engineering backgrounds, interacting with each other was relatively fluid and a relational trust had formed between the two. Both TD and EM agreed that the film had to be altered and a co-development meeting was scheduled. Also at this time the buyer, having realised that it would be difficult to de-list Packfex, offered them a substantial increase in orders and Packfex moved up the supply chain to the number five supplier.

3. Critical Interaction Episodes

The following project narrative traces the dynamics of the interaction atmosphere inherent in the product development collaboration between Packfex and Farmfresh in the development of a new packaging film. As is clearly evident from the above description, an established close relationship already exists prior to project initiation. Table 1 presents a chronological map of the interaction episodes between the interactants, detailing both actions and perceptions.

3.1 Episode 1. Convergence: Shared Expectations

Both companies entered the first development meeting with the expectation that the adjustment to Chubb X1 would be rectified within a relatively short period of time, approximately one week. The urgency to rectify the problem stemmed from two main rationale. First, Packfex faced a potential consequential loss claim for the wastage which can amount to ten times the cost of manufacturing the film and second, Farmfresh were in a situation where they had to use the faulty film until the problem could be rectified and the film up-lifted and replaced. For Farmfresh, this meant a period of high wastage, delayed production, and unsatisfied customers and they were willing to accept this while the problem was been corrected.

> *Part of the problem was the film had to be fixed, but we still had to produce. It meant that we had to work more to reach our quotas. We really had to have great patience. The wastage was still going on while the film was been fixed…but the ultimate goal at the end of the day is that the problem is fixed (Farmfresh: EM).*

The meeting evolved into a brainstorming session in which both actors discussed, in detail, the problem and potential solutions. As both parties were familiar with each other, the level of engagement from both sides to solving the issue was said to be very high and intense. Both parties openly communicate and shared ideas. As a show of commitment, Packfex agreed to take corrective action and sent a team to Farmfresh to go through their stock of Chubb X1 film and any product that was deemed not fit for process was removed.

3.2 Episode 2. Divergence: Problem Ambiguity and Expectations Suffer

Expectations suffered. The initial goal of a quick product improvement was diminished as the problem with the film was not easily identifiable.

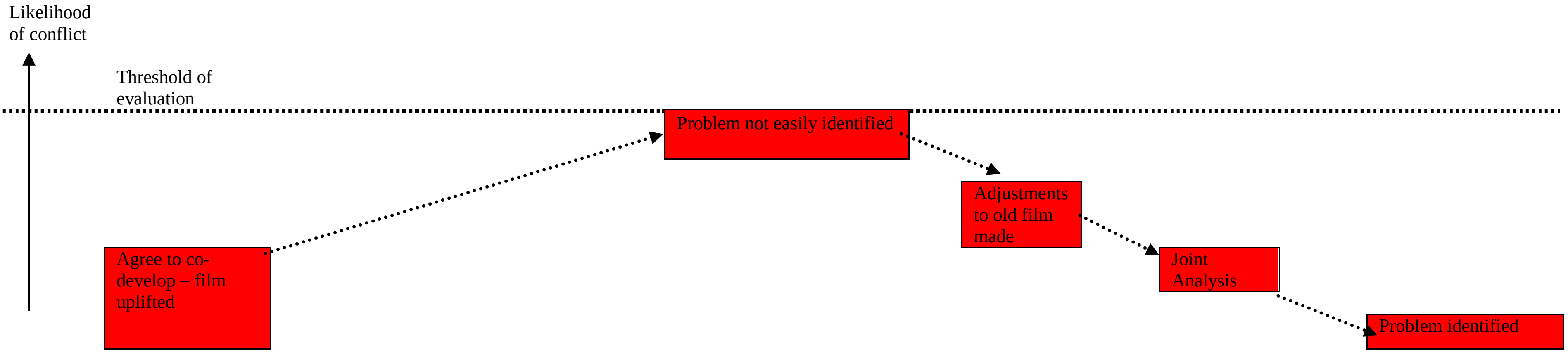
> *We thought perhaps a week… What we did was that we broke down the film and did a technical analysis on it. The problem is that there are about 5 million parts to a film and locating what is specifically wrong is very difficult…but when we did the analysis on the film we knew that this was not a simple problem and we had to confirm to Farmfresh that to get a resolution would take a minimum of 4 weeks (Packfex: TD).*

The tension between the two companies was very high. Farmfresh had an expectation that the fault with the film would be resolved in a quick period of time and from their perspective Packfex had let them down. Farmfresh were extremely frustrated as it meant that the high wastage and the costs associated with it would continue into the near future.

Table 1. Interaction Episodes

Legend ⋰→ = Divergence ⋱→ = Convergence ✷ = Exit threat

Packfex	**Episode 1. Convergence: Expectations of Cooperative Development** Assumption of a relatively easy task Short time frame expected Potential consequential loss claim for the wastage See Farmfresh as partner, close ties Level of engagement high Intensive interaction Bilateral communication of ideas	**Episode 2. Divergence: Problem Ambiguity and Expectations Suffer** Expectations suffer Realises that interaction is going to be more difficult than previously expected Concern over consequential loss Reassurances given that problem will be resolved	**Episode 3. Convergence: Problem Identified** Expectation high that the problem is resolved Engage in intensive interaction and communication Joint decision making is undertaken

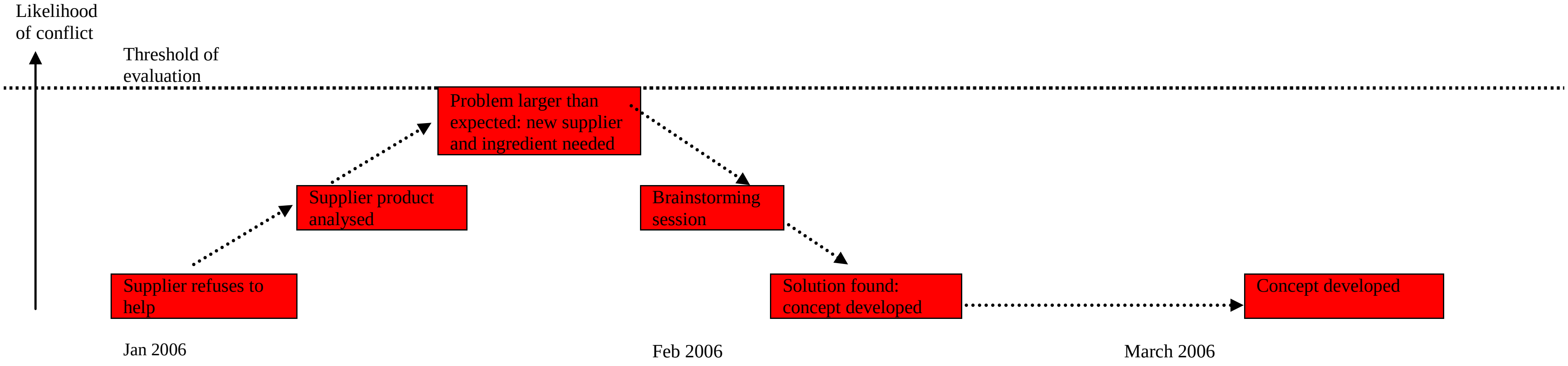


	Nov 2005	Dec 2005	Jan 2006
Farmfresh	Assumption of a relatively easy task Short time frame expected Nervous over high wastage – patience See Packfex as partner, close relationship Level of engagement is high Meaningful communication Perceived up-lift as an illustration of commitment	Expectations suffer Perceive Packfex has let them down Frustrated at lack of progress	Expectation high that the problem will be resolved Engage in intensive interaction and communication Joint decision making on all activities Kept up-to-date of all development

Table 1. Interaction Episodes (Cont.)

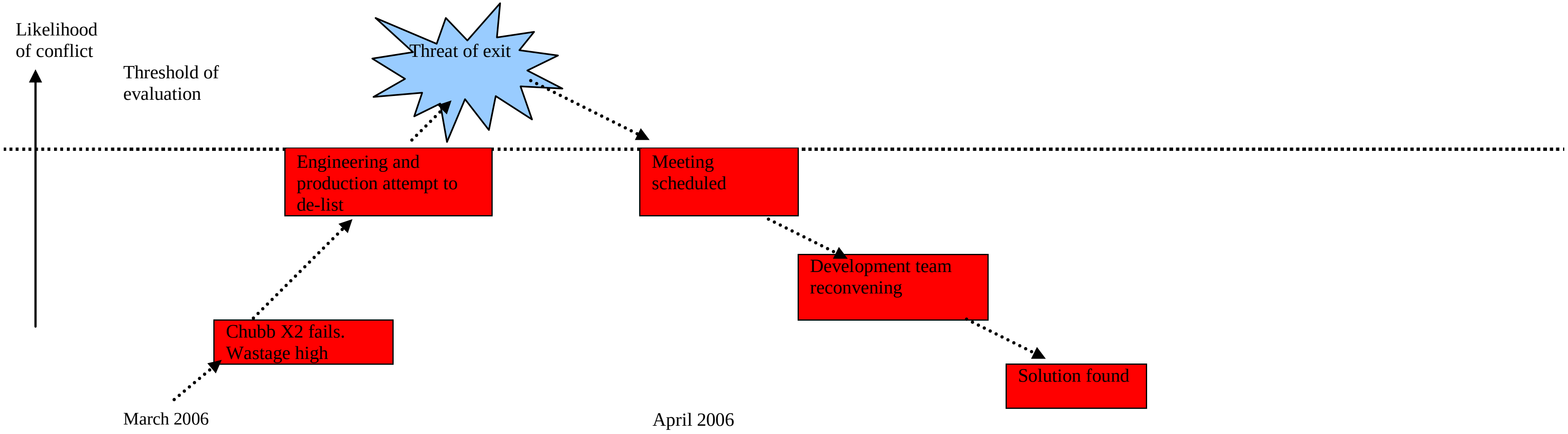
Legend ↗ = Divergence ↘ = Convergence ✷ = Exit threat

Packfex	**Episode 4. Divergence: Expectations Suffer over Problem** Realises the difficulty involved Empathizes with Farmfresh's situation Concern over lack of progress Concern over the threat of consequential loss Time pressure is critical	**Episode 5. Convergence: Solution found** Interaction is extensive, brainstorming sessions Intensive communication Past history facilitates efficiency No relational ambiguity Sense of relief over threat of consequential loss being removed Sense of closeness with Farmfresh



Farmfresh	Frustrated at the lack of progress Becomes worried at the degree of difficulty Concern at the mounting cost Questioned whether Packfex appreciated the cost endured Felt that Packfex's reaction times could be quicker Is appreciative of Packfex's dilemma Discontentment communicated	Engaged in brainstorming sessions Intensive interaction and communication Sense of relief and euphoria Expect cost and wastage to decrease Sense of relational closeness with Packfex

Table 1. Interaction Episodes (Cont.)

Legend	↗ = Divergence ↘ = Convergence	✹ = Exit threat
Packfex	**Episode 6. Divergence: Expectations Suffer. Tensions reach a new high** Expectations suffer Concerned over tensions Communication is perceived as aggressive Concerned about the future of the relationship Realised confidence most be restored in EM and PM Reliance on interpersonal and professional relationship Concerns over interpersonal relationships	**Episode 7. Convergence: Solution Found** Conflict must be resolved Reliance on interpersonal relationship with EM Communication perceived as intense Perceive high commitment from Farmfresh to resolve concept problem Concerns over interpersonal relationship resolved Expected continuity of the individual and inter-organisational relationship
		
Farmfresh	Expectations suffer Perceived that Packfex and TD let them down PM felt that Packfex should be de-listed Psychological contract for cooperation decreases Production and engineering stop communication with Packfex Internal conflict emerges over de-listing	Shared commitment Quality of communication increases Limited conflict at both inter-organisational and interpersonal level Resolution of conflict is seen as part of doing business Compatibility exists Expected continuity of the individual and inter-organisational relationship

> *Farmfresh were saying to us that had they known that the problem could not be solved quickly; that they would have went to another supplier. If the person's expectations are not met, conflict will occur and we had to try and reduce the conflict by reassuring them that their expectations will be met to a certain degree but that they might not be what they initially thought - at that point we had to change their perception of what was feasible (Packfex: TD).*

To alleviate some of the conflict Packfex did make some adjustments to the film that would reduce the wastage slightly, however the film could not be up-lifted as there was nothing to replace it with. This meant that Farmfresh had to keep using the existing film while the solution was being developed. Nevertheless, pressure was been exerted on Packfex from all departments in Farmfresh to fix the problem. At this stage, the tension and the conflict between both companies was extremely dense.

> *There appeared to be no progress, we were still getting the same film, the same wastage. There just wasn't any progress. Whatever way you look at it. I don't think Packfex came across this problem before and so there was a good bit of confusion. The process for figuring out what was wrong with the film was a bit all over the place. I don't think that they were following any real guidelines in identifying the problem (Farmfresh: EM).*

Moreover, from Packfex's perspective the threat of consequential loss was ever present.

3.3 Episode 3. Convergence: Problem Identified

Despite the tension between the two companies, both needed the problem with the film to be rectified. The conflictual tension was reduced through continuous engagement and a joint analysis of the problem was undertaken. The dialogue between the two companies and the level of intertwinement among various departments was very regular and frequent, to the point where they were jointly making decisions in relation to the course of action been taken. They uncovered that a supplier was guaranteeing its raw material would meet particular sealing requirements but analysis showed this not to be the case.

> *It worked out that one of our suppliers changed an ingredient in the formula without actually informing us. Once we got into it we identified the problem within 24 hours (Packfex: TD).*

Having identified the problem, the supplier was contacted and insurance was given that requirements would be met. Both Packfex and Farmfresh felt that within a relatively short period of time, the film would be rectified and the production issues at Farmfresh eliminated.

3.4 Episode 4. Divergence: Expectations suffer over Problem

However, it was soon realised that the problem was far greater than was anticipated. First, the supplier refused to admit that it made any alterations to the sealing layer and refused to engage in any discussion on the matter, mainly due to the possibility of consequential loss. This dramatically delayed the progress as it meant that Packfex had to analyse their supplier’s product to identify which ingredient was altered.

> *If they had to turn around to us and say the fault was actually theirs we could have been able to work with them and Farmfresh to ensure that the film worked. But instead they opted not to inform us of any change. Which ended in the fact that we had to make a new product, when probably slight adjustments would have only been needed…and we had to de-list them (Packfex: TD).*

Having identified the ingredient, it was then discovered that new regulations prohibited the ingredient from being utilised in a sealing layer and hence, the reason why the supplier had removed the ingredient from its product in the first place. However, this finding caused a significant problem in that an alternative supplier and alternative ingredient to the formula had to be located. What is more, tensions began to mount significantly between the two companies due to the ever increasing catalogue of setbacks that were been experienced on the project. Farmfresh were getting frustrated at what appeared to be a lack of progress. They felt that the film should have been rectified by now and that perhaps Packfex did not fully appreciate the cost to Farmfresh, which was clearly expressed to them through several communication mediums at that point. While consequential loss was not explicitly threatened, it was nevertheless implicitly implied. Farmfresh were increasingly becoming worried that the problem could not be solved.

> *At this particular point, we had to solve the problem; we had to solve it today. There just wasn’t any question of that at all, we had to solve it. Time was now the constraint. Farmfresh could not stop producing and so our back was up against the wall. The clock is ticking and the sense of urgency becomes absolutely critical from the point of view that the tensions between the two companies is intensifying and about to boil into a full conflict (Packfex: TD).*

It has to be stressed that Farmfresh understood and empathized with the difficulties Packfex were experiencing, they still needed the problem to be solved as fast as possible. For Packfex, the threat of consequential loss was real.

> *There could have been quicker reaction time on some issues. This was a big headache for us, especially production…but how do you put a time limit on something that has never happened before. It was new to both of us (Farmfresh: EM).*

3.5 Episode 5. Convergence: Solution Found

A concept solution was developed through a series of formal and informal brainstorming sessions. At the formal sessions, all suggestions were documented, discussed, and eliminated if not appropriate. Informal sessions occurred over the phone or on Farmfresh’s factory floor. Three main individuals involved in this process were TD, EM and Framfresh’s production manager (PM). The level of interaction between these people was extensive and intensive.

> *To get to the point of developing a concept solution, there was a lot of*

> *brainstorming between Farmfresh and ourselves. I had so many conversations one to one and over the telephone. Most of the time it was between myself and the production manager or the engineering manager…In relation to Farmfresh, brainstorming didn't necessarily have to take place around a table…often we were on the factory floor hammering out ideas…that is brainstorming and sometimes the most valuable ideas comes from that informality. These brainstorming sessions are invaluable because you are filtering out what concepts or ideas you are going to use (Packfex: TD).*

Because there was an existing working relationship and personal relationships between these individuals, they understood how the other operated and so the communication of ideas, what they felt did not work, or did, was clearly expressed, and taken on board as a valid input. In essence, because of their relational history, there were no relational ambiguities surrounding the issue of trying to solve the problem. All ideas in relation to changing the sealing formula were clearly communicated and decisions were jointly made. Indeed, it was stated by both companies that their interactions were characterized by a sense of honesty and openness.

> *Our relationship with Packfex is good. Interacting with TD is good. There is honesty there. We know them and we work well together (Farmfresh: EM).*

As a result, an innovative solution to the problem was devised and tested for requirements. It was felt by both parties that the problem had been solved. Indeed, there was a sense of euphoria amongst the people involved and the relationship between the two companies was said to get even tighter. Moreover, there was a sense of relief for both Packfex and Farmfresh. The threat of consequential loss was removed for Packfex and for Farmfresh, the high cost and wastage would be reduced.

> *What we did in Farmfresh was very controversial. We changed the sealing layer completely away from traditional practice (xx) to what it is now - yy. What happened was that we created a brand new product. So what we did was that we took that old product apart and rebuilt it as if it were the ideal utopian product for Farmfresh. Rather than using xx as a sealing layer we used yy. The idea for using yy instead of xx came as a result of new product that we were developing with a European manufacturer and in the course of testing suitable ingredients we discovered that one of the properties of yy was that it was a good sealing layer (Packfex: TD).*

At this stage it would appear the NPD project was concluded. However, in this particular instance, this is not the case. The film solution, Chubb X2, devised by both companies was developed but when the film ran in Farmfresh's cooking process the wastage was higher than ever before, approximately 50%. Although Chubb X2 had resolved the sealing issue, another problem materialised as a result of the changes to the sealing formula. In essence, the new film was thicker and not as smooth as the original and as a consequence, the film moved slower through the packaging machine causing it to be misplaced.

> *What happened was that when we sorted out the sealing issue, because we changed the formula, we found a completely different problem materialised. What happened was we sorted out the sealing issue but now there was a problem with the slip … they [the film] were out of place –the product was misplaced- it was not where it should have been. We did alter the feel of their product (Packfex: TD).*

Thus the narrative continues of the development process of Chubb X3.

3.6 Episode 6. Divergence: Expectations suffered. Tensions reach a new high

When Chubb X2 failed, the tension between the two companies and the key individuals TD, EM and PM, escalated to an extreme intensity. The communication between the two companies was said to be very aggressive and threatening. As far as EM and PM were concerned, Packfex and TD had let them down, and worse, had made them look bad within Farmfresh. Indeed, both EM and PM were under fierce internal pressure for the failure of Chubb X2. The animosity between the key individuals was clearly evident when EM and PM would not even communicate to TD in relation to rectifying the new problem and as far as they was concerned Packfex should be de-listed.

> *It was like we had made no progress at all. There was a lot of patience on our part when the problem with the film was been sorted…because of the fault we had a lot of waste…there just wasn’t any progress and that is the way we looked at it. It really wasn’t what we expected (Farmfresh: EM).*

However, internal conflict broke out between other departments in Farmfresh, when engineering and production tried to de-list Packfex. As was mentioned earlier, Packfex had multiple working and personal relationships in different areas of Farmfresh and now they relied upon those multiple relationships to stem the conflict from engineering. It has to be stressed that although communication broke down between production and Packfex, communication was still ongoing between Packfex and other departments within Farmfresh. However, TD knew that if he did not get EM and PM involved, the project would fail. They were key individuals.

> *Sometimes you have a situation where one person in their company is your provocateur, he is the one with the issue. So you have to surround him with people within Farmfresh that like your product and your company (Packfex: TD).*

In relation to resolving the conflict TD eventually contacted EM with whom he had a very close bond. EM reluctantly took the call and stated that while he would like to keep working with TD he was under pressure from other factions in Farmfresh not to have dealings with Packfex anymore.

> *EM was telling me that there was no reason for me to be phoning him, we had our chance, we would*

be de-listed and that I was wasting his time. I told him that innovation is an iterative process and that this was an engineering situation. I was trying to relate the whole situation back to his experiences so

3.7 Episode 7. Convergence: Solution Found

Like before, the level of interaction and communication between the two companies was intense, especially between TD, PM and EM. Within a relatively short period of time the problem with the film was located and a simple alteration to the sealing formula was devised that would rectify the current problem. Both parties were confident that the Chubb X3 film would work. In addition to solving the misplaced product problem the development team also came up with an additional innovative alteration to the film that would not only reduce waste but speed up the rate at which the film went through Farmfresh's production process significantly increasing efficiency. The alteration also dramatically sped up Packfex's actual production of the film and stock turn around thus eliminating Farmfresh's need to hold vast quantities of stock.

3.8 Epilogue

Chubb X3 film was developed and far exceeded the expectation of both companies running at efficiency levels between 2 and 4 per cent, far surpassing other films at an industry average of approximately 8 per cent. Due to the success of the product and the strong relationship between both companies, Farmfresh's corporate buyer (with whom many interpersonal relationships have now been formed) asked Packfex to become their joint number one supplier on all packaging. For Packfex it meant that their sales would increase by at least €7-9 million in 2006. Both companies are currently in the planning stages of collaborating again on Farmfresh's other packaging films.

4. Analysis

The purpose of the paper was to describe the dynamics of the interaction atmosphere in a collaborative NPD relationship. The process was categorized into seven episodes based on major shifts in the interaction atmosphere in a positive or negative direction. The interaction dynamic at these convergent and divergent points was presented. Relationship new product development doesn't require any of the classic structures for working out processes of collaboration where parties do not trust each other or are developing an agreed framework for interaction for the first time. Given the relationship's long term nature, 21 years, it had an inbuilt structure of close collaboration for new product development. Therefore, the product was developed in response to solving a problem rather than by negotiation and agreement around how this might be done, the roles of the parties, the resources required, and how benefits would be shared. The case context appeared to have no specific structure for the new product being developed – there were no clear boundaries between the firms, continuous interaction between the parties just happened, there was no official new product development team as people got involved according to the demands of the problem, the process appeared fluid. This type of NPD is only possible in a collaborative relationship and facilitates a shortening of the time it takes to set-up mechanisms and to define the character of the NPD process. The relationship approach to NPD with existing users in a problem setting is about the process of interaction as the parameters of the new product development, so much a feature of the NPD-specific literature, are set-up for better or worse. The case can be contrasted with other forms of user involvement in NPD where structures and processes of cooperation have to be negotiated in advance by the parties to the project, or where projects are driven and controlled by one actor who aims to keep ownership of the entire process. Therefore, this case, as structures and systems for collaboration were set, provided insights into the interaction process dynamics which are rare in the findings of previous NPD studies.

Not all the dynamics of interaction atmosphere from the relationship and alliance development literature were dominant in the case. As the relationship was already long established, processes such as negotiation (the structures for collaboration were already there), learning (the parties already knew each other), commitment (interdependence in the relationship was high), were not the critical dynamics of interaction atmosphere in the case. However, expectations, problem solving, personal relationships and communication appeared to be more critical process dynamics across most of the episodes. Mindsets around expectations at a personal and organisational level were major triggers of episode change and challenge. Parties were felt, at individual and organisation level, not to be meeting what was expected and promised thus letting the relationship down. Problem solving followed a parallel cycle. It was almost a natural feature of the relationships and thus the focus for the NPD – the solution to the film problem. The ebb and flow of the problem was part of the dynamic of each episode. The role and personal relationships also were core aspects of the cycle of atmospheric high and low. The density of ties often held what was at times near breakdown in personal relationships. Goodwill trust was often challenged where a “loss of faith” was evident. The critical relationship in the case and the one that held the process together, that between the engineering manager in Farmfresh and the technical director of Packfex, further exhibits the importance of personal relationships in a time of relationship crisis. Many of the episodes and quotes in the case illustrate personal frustrations and empathy trailing the highs and lows of the interaction atmosphere. The communication dynamic, both its absence and presence, were revealing of the atmosphere of the NPD relationship. At times there was no communication and at other times high quality communication systems occurred without huge thought – open access across both organisations, idea sharing, and meetings labelled “brainstorming” to focus on maximising ideas and solutions. The descriptors of these dynamics of the interaction atmosphere are illustrated in table 1 of the case and provide a comparator for other such relationships especially where parties cooperate intensely. The dynamics were heightened in the seven critical episodes.

The cycles of convergence and divergence in the case were evident in the seven episodes and in the interaction dynamics in each one. The descriptors of the dynamics, as in table 1, illustrated the convergence and divergence, for example, the euphoria in meeting expectations when they converged and the near breakdown in expectations with suspicion and blame in another. It was where several of the dynamic processes of interaction atmosphere reach a high or low that convergent or divergent episodes were grouped. The severity of conflict across the relationship atmosphere led to an episode of divergence and likewise the highs of the parties coming together on a solution or agreement in an episode of convergence. Convergence and divergence were not discrete processes. Indeed, without them would rich solutions emerge? They appeared to make the interactions richer and the parties to the relationship work harder. The conflict in the divergent cycles was related to the task at hand and forced more creativity and innovation. The relationship appeared well able to handle vast amounts of task related conflict in the interaction atmosphere dynamics. This was especially so given the lack of prescribed outcomes, except for solving the problem with the film, in the case. The range of outcomes finally reached was much higher for both parties and would not have happened without the cycle of convergence and divergence. Only once in the case, illustrated in table 1, did the divergence become too great (episode 6). This episode saw many of the interaction dynamics at breaking point but also conflict became affective, it became interpersonal and this affected the social fabric of the relationship (Ariňo and de la Torre, 1998). This was particularly evident in the near collapse of the personal relationship between two key actors – the engineering manager in Farmfresh and the technical manager in Packfex. Even in this episode the actors were capable of managing the conflict within the relationship.

The long term nature of the partnership and the security and stability this provides sustained the parties throughout the progressive turmoil the uncertainty threw up. The substance (Ford and Håkansson, 2006; Håkansson and Ford, 2002; Ford, Håkansson and Johanson, 1986; Håkansson and Snehota, 1995) of the interaction between the parties was really only threatened once in what was a highly charged engagement. The actor bonds in the case were very strong on many levels. The resolve of the actors to solve the problem was sustained throughout the case and acted as a bridge to resolution in times of deep crisis. The interdependencies between Packfex and Farmfresh were visible in the case on many levels. The relationship was buyer-supplier with the supplier's product being part of the final consumer packaging. The nature of the supplier's product brought additional interdependencies into the relationship. The two firms are specialised and their interdependent activities reinforced through the case. Farmfresh's buyer changed and tried to de-list Packfex – an action resisted by other actors within Framfresh and by the nature of the product specialisation achieved by Packfex over time. Packfex is much smaller than its buyer and could be disproportionately affected by its decisions. In this way, it can be argued that Farmfresh has a dominant power position in the relationships if it tried to use it. However, the joint activity built up over time with Farmfresh has embedded a culture of mutuality and reciprocity in the relationship. Both parties have committed much resource to the relationship. They seemed to do it to solve the current crisis without question of cost or clear solution patterns. The resources of both parties were different but it was the resources embedded in people that appeared to ultimately solve the problem in the relationship and smooth over, potentially deleterious, conflict. The ability to commit people, spend large amounts of time, do analysis work, test solutions without assessing risks, make clear the interdependency of the parties. The learning from each other is a well understood dialogue from deeply connected patterns of activity and resource sharing readily switched on. The pattern of what is there is almost not emphasized in the interaction as it is taken for granted. Routines and processes long established are part of a unique context-specific structure. Joint problem solving was a major feature of the case and a major relationship-specific resource. As outlined at the beginning of our paper solving innovation problems is usually complex and not linear with few clear solution pathways (Powell, Kogut, Smith-Doerr, 1996; Håkansson and Waluszewski, 2007). The solution in this case was far from certain and evolved in a messy unstructured way. Problem solving was facilitated by the nature of the relationship and open sharing of information which deemphasized the extent of the almost natural joint problem solving behaviour which took place. While we cannot, due to the specific nature of the collaboration, generalise, the case shows how actors co-create and solve new product problems.

The NPD problem in the case created the need for change in what was a stable relationship. The critical event, unacceptable levels of wastage, started the cycles of episodes in which the parties ultimately resolved the problem and further strengthened their relationship. The critical episode classification provided the structure for organising the case data and for revealing the interaction atmosphere, as a whole at heightened points of convergence or divergence. Critical episode classification seeks out major points of inflexion which gives an overall picture of how the underlying processes of interaction work in cycles, reinforcing each other, compensating for each other and leading to enhanced relationship value as perceived by the parties. The episodic classification demonstrates how solutions focused the companies were and the jumps to solutions and the trails and errors involved rather than any planned approach. There were no clear stages or development patterns to the NPD process. Potential solutions at the manufacture's site were followed until a major solution (Chubb X3) was found. Many of the classic cooperative mechanisms for NPD were embedded in the relationship but more importantly in the dynamic processes that connected each episode such as communication, problem solving, and personal relationships. Critical episode classification facilitated the authors' analysis of the dynamics of interaction atmosphere which, in turn, will enable firms further integrate and increase the level of user involvement in NPD and enhance its success.

5. Conclusion

This paper describes the dynamics of the interaction atmosphere in a case study of a dyadic NPD project. The description of the dynamics, whilst context and situation specific, is novel. Two main aspects of dynamics were considered. The first was movement or change in the interaction atmosphere. These changes were classified using critical episodes on the basis of major shifts in the relationship atmosphere across a number of processes. The second level of analysis was the identification of the process dynamics that most impact in the case. The understanding of these processes can be used in other settings to handle the NPD interaction atmosphere by collaborating parties. The case clearly underlies the strength of relationship NPD as an approach, even in a severe test of the relationship where, among the process failures, personal relationship also broke down, the parties found a way back to an ultimately successful outcome.

References

Adams, M., Day, G. & Dougherty, D. (1998). "Enhancing New Product Development Performance: An Organisational Learning Perspective", *Journal of Product Innovation Management,* 15, 403-422.

Ariňo, A. & de la Torre, J. (1998). "Learning from Failure: Towards an Evolutionary Mode of Collaborative Ventures", *Organizational Science*, 9 (3), 306-325.

Biemans, W. (1992). *Managing Innovation Within Networks,* London: Routledge.

Büchel, B. (2000). "Framework of Joint Venture Development: Theory-Building Through Qualitative Research", *Journal of Management Studies*, 37 (5), 637-661.

Booz, Allen and Hamilton, (1982). *New Products Management for the 1980s,* Booz, Allen and Hamilton Inc., New York, NY.

Cooper, R. (1979a). "Identifying Industrial New Product Success: Project New Prod", *Industrial*

Marketing Management, 43, 93-103.

Cooper, R. (1979b). "The Dimensions of Industrial New Product Success and Failure", *Journal of Marketing,* 8, 124-135.

Cooper, R. (1988). "Predevelopment Activities Determine New Product Success", *Industrial Marketing Management,* 17, 237-247.

Cooper, R. (1993). *Winning at New Products: Accelerating the Process from Idea to Launch,* 3rd edition. Cambridge, MA: Perseus Publishing.

Cooper, R. (1996). "Overhauling the New Product Process", *Industrial Marketing Management,* 11, 3-14.

Cooper, R. (1999). "From Experience: The Invisible Success Factors in Product Innovation", *Journal of Product Innovation Management,* 15 (2), 115-133.

Cooper, R. & Kleinschmidt, E. (1986). "An Investigation into the New Product Process: Steps, Deficiencies, and Impact", *Journal of Product Innovation Management,* 3, 71-85.

Cooper, R. & Kleinschmidt, E. (1996). "Winning Business in product development: The critical success factors", *Research Technology Management,* 39 (4), 18-30.

Cooper, R. & Kleinschmidt, E. (2000). "New Product Performance: What Distinguishes the Star Products", *Australian Journal of Management,* 25 (1), 17-45.

Daft, R. & Weick, K. (1984). "Towards a Model of Organizational as Interpretation Systems", *Academy of Management Review*, 9, 284-295.

Denzin, N. (2001). "The Reflexive Interview and A Performative Social Science", *Qualitative Research,* 1 (1), 23-46.

di Gregorio, S. (2000). "Using NVivo for your Literature Review", *Conference for Strategies in Qualitative Research: Issues and Results from Analysis using QSR NVivo andNUD*IST*, Sept 29-30, Institute of Education, London.

Doz, Y. (1996). "The Evolution of Cooperation in Strategic Alliances: Initial Conditions or learning Processes?", *Strategic Management Journal,* 17, Special Issue, 55-83.

Dwyer, F. R., Schurr, P. & Oh, S. (1987). "Developing Buyer-Seller Relationships", Journal of Marketing, 51, 11-27.

Edvardsson, B. & Strandvik, T. (2000). "Is a Critical Incident Critical for a Customer Relationship?", *Managing Service Quality*, 10 (2), 82-91.

Eisenhardt, K. (1989). "Building Theories from Case Study Research", *Academy of Management Review,* 14 (4), 532-550.

Ford, D. (1980). "The Development of Buyer-Seller Relationships in Industrial Markets", *European Journal of Marketing*, 1, (5/6), 339-354.

Ford, D. & Håkansson, H. (2006). "The Idea of Interaction", *The IMP Journal*, 1 (1), 4-27.

Ford, D., Håkansson, H. & Johanson, J. (1986). "How do

Companies Interact?", *Industrial Marketing and Purchasing,* 1 (1), 26-41.

Ford, D. & Saren, M. (1996). *Technology Strategy for Business*, London: International Thomson Business Press.

Fox-Wolfgramm, S. (1997). "Towards Developing a Methodology for Doing Qualitative Research: The Dynamic-Comparative Case Study Method", *Scandinavian Journal of Management,* 13 (4), 439-455.

Håkansson, H. (1982). Ed., *International Marketing and Purchasing of Industrial Goods*, New York: Wiley.

Håkansson, H. (1987). Ed., *Industrial Technological Development, A Network Approach,* Kent, UK: Croom Helm.

Håkansson, H. & Ford, D. (2002). "How Should Companies Interact in Business Networks", *Journal of Business Research*, 55, 133-139.

Håkansson, H. & Snehota, I. (1995). "Analysing Business Relationships". In Håkansson, H. & Snehota, I. (Eds.). *Developing Relationships in Business Networks*, 24-49, London: Routledge.

Håkansson, H. & Waluszewski, A. (2007). (Eds.). *Knowledge and Innovation in Business and Industry – the importance of using others*, London: Routledge.

Halinen, A., Salmi, A. & Havila, V. (1999). "From Dyadic Changing Business Networks: An Analytical Framework", *Journal of Management Studies*, 36 (6), 779-794.

Johnsen, T. & Ford, D. (2000). "Managing Collaborative Innovation in Complex Networks: Findings from Exploratory Interviews", *16th Annual IMP Conference,* Bath*,* England.

Lilien, G., Morrison, P., Searls, K., Sonnack, M. & von Hippel, E. (2002). "Performance Assessment of the Lead User Idea Generation Process for New Product Development, *Management Science,* 48 (8), 1042-1059.

Lincoln, Y. & Cuba, E. (1985). *Naturalistic Enquiry,* London: Sage Publications.

Lynch, P. & O'Toole, T. (2006). "Involving External Users and Third Parties in the New Product Development Process", *Irish Marketing Review,* 18 (1&2), 29-37.

Madique, M. A. & Zirger, B. J. (1984). "A Study of Success and Failure in Product Innovation: The Case of the U.S. Electronics Industry", *IEEE Transactions on Engineering Management,* 31 (4), 192-203.

Mahajan, V. & Wind, J. (1992). "New Product Models – Practice, Shortcomings and Desired Improvements", *Journal of Product Innovation Management,* 9 (2), 128-139.

National Industrial Conference Board (1964). "Why New Products Fail", *The Conference Board Record*, NCIB, New York.

Olson, E. & Blake, G. (2001). “Implementing the Lead User Method in a High Technology Firm: A Longitudinal Study of Intentions versus Actions”, *Journal of Product Innovation Management,*18 (6), 388-395.

O’Toole, T. & Lynch, P. (2004). “A Study of the Practice of User Involvement in the Early Stages of New Product Development”, *11^{h} International Product Development Conference,* Dublin, Ireland.

Pettigrew, A. (1997). “What is Processual Analysis?”, *Scandinavian Journal of Management,* 13 (4), 337-348.

Ring, P. & Van De Ven, A. (1994). “Developmental Processes of Cooperative Interorganisational Relationships”, *Academy of Management Review*, 19 (1), 131-145.

Powell, W. W., Koput, K. W. & Smith-Doerr, L. (1996). “Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology”, *Administrative Science Quarterly*, 41 (1), 116-145.

Schurr, P. H. (2007). “Buyer-Seller Relationship Development Episodes: Theories and Methods”, *Journal of Business and Industrial Marketing*, 22 (3), 161-170.

Schurr, P. H., Hedaa, L. & Geersbro, J. (2008). “Interaction Episodes as Engines of Relationship Change”, *Journal of Business Research*, 61, 877-884.

Sminia, H. (2009). “Process Research in Strategy Formulation: Theory, Methodology and Relevance”, *International Journal of Management Reviews*, 11 (1), 97-125.

Stevens, G., Burley, J. & Divine, R. (1999). “creativity + Business Discipline = Higher Profits Faster from New Product Development”, *Journal of Product Innovation Management,* 16 (5), 455-468.

Tidd, J., Bessant, J. & Pavitt, K. (2001). *Managing Innovation,* London: Wiley.

von Hippel, E. (2001). “Perspective: User Toolkits for Innovation”, *The Journal of Product Innovation Management,* 18 (4), 247-257.

von Hippel, E. & Katz, Ralph (2002). “Shifting Innovation to Users via Toolkits”, *Management Science,* 48 (7), 821-833

Voss, C. (1985). “The Role of the user in the Development of Applications Software”, *Journal of Product Innovation Management,* 2 (June), 113-121.

Welsh, C. & Wilkinson, I. (2002). “Idea Logics and Network Theory in Business”, *Journal of Business-to-Business Marketing*, 9 (3), 27-48.

Yin, R. (2003). *Case Study Research: Design and Methods,* Thousand Oaks, CA: Sage Publications.

Zajac, E. & Olsen, C. (1993). “From Transaction Cost to Transaction Value Analysis: Implications for the Study of Interorganizational Strategies”, *Journal of*

Management Studies, 30, 131-145.

The emergence of a successful business network – What was the role of public policy?

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Abstract

To promote industrial development and economic growth is a vital issue for governments all over the world. The ideals guiding policymakers in their endeavours, strongly influenced by traditional economics and the innovation system approach, are that innovations based on new and advanced knowledge are central for industrial and economic development. As is exemplified through the quote below policymakers have no problem with finding inspiration from regions such as Silicon Valley.

> The idea that so much could grow in so short time within such small geographical area sent planning bodies from Albuquerque to Zimbabwe scrambling to grow the next Silicon Valley on their own backyard. Sturgeon (2000: p.15)

But although the identified “generic” features have been copied, there are few examples of how ambitions to “artificially” create policy supported high-tech based business networks and industries have succeeded. One of the few successful examples of policy created high-tech industries often mentioned is the Taiwanese semiconductor industry. The story of the Taiwanese semiconductor industry is impressive as the one of Silicon Valley; in just a few decades a booming industry developed from scratch. One of the most common explanations to the transformation addresses the governing role of the state in coordinating industrial development and creating a successful semiconductor business network. Some of the major factors mentioned were for example the creation of public research institutes, the public provision of R&D, and the subsequent transfer of technologies to a downstream sector created by Taiwanese policy. This envisioned development scenario has been strongly supported in Taiwanese policy circles and forms a foundation of contemporary Taiwanese industrial development policy. However this model of business creation applied to other industrial areas has been widely criticized for not fulfilling it promises.

To investigate this issue, this paper takes a different and complementary view of the emergence of a Taiwanese semiconductor business network. Based on a resource interaction perspective the study aims to increase the understanding of forced network creations. The findings argue that the understanding that a network was created by policy is clearly an over-simplification which omits several important factors in the emergence of the semiconductor business network.

1. Introduction

The promotion of industrial development and economic growth is a vital issue for governments all over the world. The ideal that guides policymakers in their endeavours, strongly influenced by traditional economics and the innovation system approach, is that innovations based on new and advanced knowledge are central for industrial and economic development (OECD, 1996; Eklund, 2007). This observation is explained by the OECD (2007: p5):

> Today, innovation performance is a crucial determinant of competitiveness and national progress. Moreover, innovation is important to help address global challenges, such as climate change and sustainable development. But despite the importance of innovation, many OECD countries face difficulties in strengthening performance in this area. […] Governments can also play a more direct role in fostering innovation. Public investment in science and basic research can play an important role in developing ICT and other general-purpose technologies and, hence, in

> enabling further innovation. This highlights the importance of reforming the management and funding of public investment in science and research, as well as public support to innovative activity in the private sector.

To support development of advanced knowledge and to create a system that facilitates the transfer of the results from research to industry has consequently been a main concern in contemporary policymaking. However, empirical evidence suggests that commercializing knowledge is a cumbersome task with few traces of linearity. That it is not that easy to support artificially the development of new high-tech solutions which will lead to knowledge-based industries and business clusters has been experienced by many governments. An editorial in *The Economist* (2007: p4) gave the following opinion on this experience:

> EU officials, like government bureaucrats everywhere, are obsessed with creating geographic clusters like Silicon Valley. The French have poured billions into *pôles de compétitivité*; and Singapore, Dubai and others are doing much the same. There are dozens of aspiring clusters worldwide, nicknamed Silicon Fen, Silicon Fjord, Silicon Alley and Silicon Bog. Typically governments pick a promising part of their country, ideally one that has a big university nearby, and provide a pot of money that is meant to kick-start entrepreneurship under the guiding hand of benevolent bureaucrats. It has been an abysmal failure.

Despite these disappointing results there are examples of high-tech business networks and industries that are presented as successful creations of policy. A salient example is the Taiwanese semiconductor industry based in Hsinchu. The development of this industry is intimately linked with Taiwan's economic success. In just a few decades, the Taiwanese economy transformed itself from being dependent on agriculture to become one of Asia's high-tech centres. In short the story commonly told is that in the early 1970s Taiwan was a backwater economy. The country was dependent on agricultural production and labour-intensive manufacturing of textiles, electronic components and plastics. At that time, Taiwanese policymakers decided that it was time to direct industrial production towards more knowledge-intensive sectors and move up a step on the economic development ladder. A field that was identified by the government as a future industry which would allow Taiwan to take this development leap was semiconductors. Public policies were implemented to speed up development in a hitherto non-existent semiconductor industry. The focus on semiconductors turned out to be beneficial for the Taiwanese economy. Since the 1980s the economic growth of Taiwan has been closely associated with the development of the semiconductor industry located in Hsinchu, also known as the Silicon Valley of Taiwan. Two decades after the emergence of the first few semiconductor businesses in the early 1980s, the Taiwanese semiconductor industry was ranked the fourth largest in the world[1] and consisted of nearly 400 companies[2]. At the end of 2005 the Taiwan Semiconductor Industry Association (TSIA) estimated that 60 per cent of worldwide semiconductor foundry, package and testing revenue, 25 per cent of worldwide semiconductor design revenue and 25 per cent of worldwide DRAM revenue were generated by Taiwanese companies. The total economic value generated by the Taiwanese semiconductor industry totalled 1118 billion New Taiwan Dollars (roughly

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[1] Defined in terms of production value, surpassed only by the USA, Japan and Korea.

[2] The companies can be classified as: 268 IC design houses, 6 wafer suppliers, 4 mask makers, 13 fabrication companies (fabs), 33 packaging houses, 35 testing houses, 15 substrate suppliers and 19 chemical suppliers (TSIA, 2006).

33 billion USD) at the end of 2005 (TSIA, 2007).

Regardless from what vantage point the development of the semiconductor industry and the Hsinchu region is viewed, it appears impressive. Within a few decades, a new industry and a flourishing business network resting on high-tech and innovation emerged in a country which had previously relied on traditional industries and small and medium-sized companies with weak R&D capacity. The most common interpretation of the Taiwanese semiconductor development is that it was a result of public policy engagement in coordinating industrial development (see, e.g., Liu, 1993; Mathews & Cho, 2000), a view which is also heavily stressed by Taiwanese public policy (MOEA, 2003). Hence the picture of a dynamic semiconductor business network created in the hands of foreseeing government bureaucrats has come to serve as an important role-model for how to create new industries in Taiwan (Liu, 1993). As has been interpreted by e.g. Liu (1993) or Chang et al., (1994) the main policy measures undertaken were aimed at the foundation industries and business networks can be created, and the components necessary for their development identified. However empirical evidence of how industries or networks emerge often shows a messy and non-linear picture (Håkansson & Waluszewski, 2002; Shih, 2009). As suggested by Wedin & Waluszewski (2003: p4) the development of a technology or industry is a myriad of "expected outcomes as well as unexpected effects, where new and old solutions are tried and retried". With this understanding, the creation of networks is logically also an intricate issue which offers few certain pre-destined outcomes.

The reason, as described by Håkansson and Snehota (1989) is that companies interact with suppliers, customers, competitors, authorities and non-governmental organizations in order to create value. There are always anticipated and unanticipated effects from interaction, as neither the motives of people nor the content of the resource combinations and activity links they represent can be fully known in advance (Håkansson & Waluszewski, 2002; Ford et al., 2002). Thus interaction between various actors creates effects with both positive and negative consequences (Håkansson et al., 2009). The effects of prolonged interaction are that relationships between actors are established and interdependencies created between actors and resources. A result of the formation of relationships over time is that companies and organizations become increasingly dependent on each other, on their customers, suppliers and other counterparts. Thus actors, material and immaterial resources, and activities are systematically related to each other (Ford et.al., 2003). As relationships are systematically developed, Håkansson et al. (2009: p2) conclude that "they do not only connect dyads, but they do also connect indirect related companies in network-like structures".

From the IMP perspective the dictum holds that networks cannot be managed, however firms manage within networks (Ford et al., 2002; Öberg. et al., 2007). How firms manage in networks has been described in the IMP literature (e.g. Håkansson & Waluszewski, 2002; Harrison & Waluszewski, 2008; Baraldi & Strömsten, 2009; Öberg & Brege, 2009). Few studies within the IMP tradition, however, have followed actual attempts of forced network creations and the involvement of policy. In this study we will follow the case of a business network in the semiconductor field, which has been argued to have been artificially created and managed by Taiwanese policy. The case will provide an opportunity to investigate an example of a forced network and the role of policy in creating and supporting a network. The paper is structured as follows in the section 2 the research design is presented. This is followed by the empirical case description in section 3 and an analysis in section 4. In section 5 the conclusions are discussed.

1.2 Research Design

The Taiwanese semiconductor business network has often been portrayed as one of few examples of how policy has managed to create and control the emergence of an industry. In this context the example provides an opportunity to study forced network creations and to investigate the role of policy. The methodology used in this paper is a single case study (Yin, 1994). The material has been based on a number of secondary sources. Initially a number of interviews were made that gave me

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timelines, and have given me varied perspectives of the development processes. For example historical accounts have provided extensive development descriptions and analyses of the Taiwanese economy and, industrial and technological policies from the 1970s onwards. There are also a large number of publications, in academic journals, aimed at describing the Taiwanese economic miracle and the emergence of the semiconductor industry. The analyses made in the articles mostly discuss the role of the government and policy related research institutes in the development processes.

By using the above mentioned sources a case was constructed of how the Taiwanese semiconductor industry and a business network emerged. To structure the case and the analysis this study will apply the resource interaction model developed in Håkansson & Waluszewski (2002). It will be used to capture the processes in which heterogeneous resources[3] have been combined in the Taiwanese semiconductor industry and investigate the role of policy in the creation of the network. The resource interaction model investigates direct and indirect interaction between resources, on the basis that it is possible to catch interdependencies even when they are not represented through direct relationships (Håkansson & Waluszewski, 2002). The model has been applied to areas such as product, technological, logistics, and industrial development (see, e.g., Wedin, 2001; Håkansson & Waluszewski, 2002; Baraldi, 2003; Gressetvold, 2004; Jahre et al., 2006, Håkansson & Waluszewski, 2007, Waluszewski et al., 2009, Shih, 2009).

In the resource interaction model, resources are separated into four categories where two are mainly tangible or physical: (a) products and (b) facilities or equipment. The other two types of resources are mainly intangible or organizational: (c) organizational units and (d) organizational relationships. Below is an overview of the four types of resources (for a more detailed description see Håkansson & Waluszewski, 2002; 2007).

In the context of resource interaction, the identification of the resources that are relevant to study is a matter of choosing a focal resource through which ties to other resources can be identified. How the resources affect each other are investigated through the interfaces that are created between resources which are defined by Strömsten and Håkansson (2007: p29) as follows:

> No resource is used in isolation. Every resource has interfaces to both physical and organisational resources. […] "interface" is defined as "a place or area where different things meet and have an effect on each other".

As can be seen in Figure 1, both material (physical) and immaterial (organizational) resources are combined into a larger resource structure, connected through interfaces. The attention is directed to the interaction between resources, how they are combined and, developed over and beyond time, organizational and spatial boundaries. In the search for resource interfaces there are no ex-ante distinctions made concerning technological sectors, spatial or organizational borders. Instead the focus is on the search for related resource interfaces that occur across various technological, spatial and organizational fields (Strömsten & Håkansson, 2007). In this study the focal resource is an organizational unit, namely Taiwanese policy. By originating from the *focal resource* the interaction with other relevant resources creates a context

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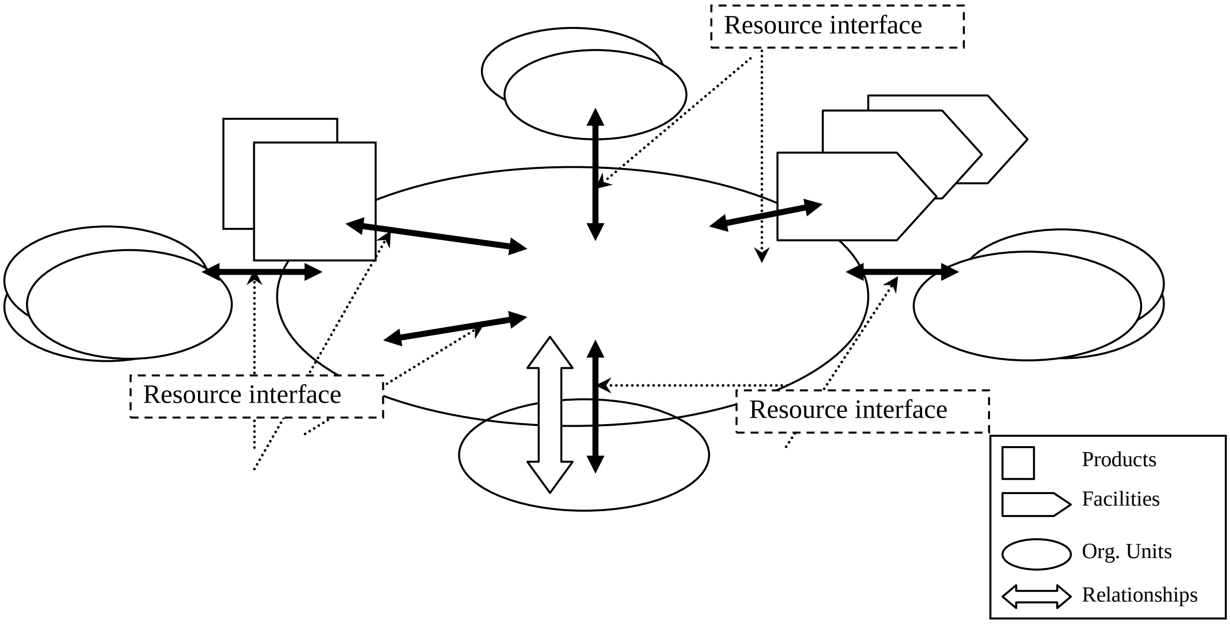
[3] An important assumption of resources is that they are heterogeneous. The notion of resource heterogeneity was early on suggested by Penrose (1959) who argued that a resource is "a bundle of possible resources per se but the services they create that make them valuable. In the IMP setting these ideas were adopted by Hägg and Johanson (1982) who proposed that the value of a resource depends on how it is combined with other resources. Hence resources alone are not productive and have no value unless they have a use or a function to fulfil in combination with other resources, i.e., forming a network-like structure.services". In other words, it is not the



Source: Modified from Waluszewski et al. (2009)

Figure 1
An illustration of the resource interaction model and interfaces

(which is discussed in section 4). We can also investigate if the resource combinations occurred consciously or unconsciously. What follows hereafter is the empirical case describing the emergence of a Taiwanese semiconductor business network.

1.3 The emergence of the Taiwanese semiconductor business network

Taiwan has been considered one of the economic miracles of the twentieth century (World Bank, 1993; MOEA, 2005). The annual growth rate from 1952 to 1993 was 8.7 percent, an impressive number which few other countries have surpassed over such a long period of time (Chuang, 1999). In just a few decades, the Taiwanese economy went from being dependent on low-tech agricultural production to become a technological powerhouse and one of the leading semiconductor manufacturers in the world. How this was achieved has been studied extensively and often it is attributed to the government's active role in economic planning and coordination (Wade, 1990).

Today Taiwan is the twenty-fourth largest economy and has the fourth largest semiconductor industry in the world (TSIA, 2007; IMF, 2008). Based on the economic success of the industry, the government has lately been vigorously promoting a knowledge-based economy and aimed to transform Taiwan into a *green silicon island*. With the hopes of creating a second economic miracle, the semiconductor industry has played an important role as an inspiration and model to follow (MOEA, 2003). What now follows is an empirical account of how a Taiwanese semiconductor business network emerged. In the chronology below, some major events leading to the development of a Taiwanese semiconductor industry are outlined.

Table 1
Chronology: major events in the Taiwanese semiconductor industry

1961	The first foreign electronics companies, such as Philips and IBM, establish a presence in Taiwan.
1964	National Chiao Tung University establish the first semiconductor laboratory in Taiwan
1966	Texas Instruments establish the first semiconductor assembly operation in Taiwan.
1973	The Taiwanese government decides to develop a semiconductor industry.
	The first public research institute, Industrial Technology Research Institute (ITRI) is founded through the merger of three government laboratories in Hsinchu.
1974	The Electronics Research Service Organisation (ERSO), a sub-department of ITRI, aimed at developing semiconductor technology is founded.
1976	A technology transfer of a mature technology to ITRI from US semiconductor producer RCA Semiconductor and Materials.
1978	A special government expert committee created, known as the Science and Technology Advisory Group (STAG).
1980	Taiwan's first semiconductor company, United Microelectronics Company (UMC), a spinoff from ITRI, is founded.
	The Hsinchu Science Based Park is established.
	UMC is the first company to locate in the Hsinchu Science Based Park.
1986	The second spinoff from ITRI, Taiwan Semiconductor Manufacturing Company is founded.
	Semiconductor foundry as a business model is established with the emergence of TSMC.
1988	The Taiwanese semiconductor industry starts to grow rapidly.
2004	The Taiwanese semiconductor industry the fourth largest in the world.

2. The Taiwanese electronics industry – paving a way into semiconductors

The ambition of the Taiwanese government to make the transition into technology-intensive sectors formally appeared in the 1970s. The move was believed to be needs driven for reasons such as industrial development and international recognition (Chang et al., 1994). Prior to that, public policies had been aimed at measures which would build up a military capacity in Taiwan in order to launch an attack to retake mainland China. Initially, production on the island had been directed towards agriculture, but after the Kuomingtang[4] (KMT) assumed control over the former Japanese colony[5] in 1949 an import substitution policy was adopted. This stimulated the growth of new industrial sectors, such as plastics and textiles. In the 1960s, the Taiwanese leaders started to promote the export industry in order to increase national income and earn foreign currency as a result of reduced US financial aid.[6] The government policies encouraged the development of labour-intensive light industries (Wade, 1990; Chen, 1999).

By the 1970s the import substitution and export subsidy policies

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[4] The Kuomintang was the first political party of the Republic of China. During the Second World War, the KMT was the ruling party in China, but after the war internal conflicts and the growing strength of Communist party led to the defeat of the KMT, which had to flee into exile. The KMT leader Chiang Kai Shek brought over to Taiwan a whole administration and an army in 1948; a total of 2 million people moved.

[5] Taiwan was a Japanese colony between 1895 and 1945

[6] In the 1950s it was financial aid from the United States that helped Chiang Kai Shek to maintain a large military force without overheating the weak economy.

had turned the trade deficits into regular trade surpluses. The momentum was however temporarily brought to halt due to competitive pressure from emerging neighbouring economies and political crisis as a result of China taking over Taiwan's mandate at the United Nations in 1971. The global oil crisis in 1973 also brought an economic downturn. These events forced the Taiwanese government to search for new avenues through which sustainable economic and political development could be created. To realize these goals it was believed that the focus had to shift from the labour-intensive consumer goods industry to technology intensive manufacturing industry. The industries that were targeted for export promotion to attract foreign currency and investments had been identified with the help of Stanford Research Institute (SRI) in the early 1960s (Wade, 1990; Chen, 1999; Hsu & Cheng, 2002). As noted by Ernst (1997: p7): "SRI chose those product groups where American companies had strong interests: certain petrochemical intermediates, plastic resins, synthetic fibres, transistor radios, electronic components, watches and clocks". To motivate foreign investments, an export processing zone was also established in Kaohsiung in Southern Taiwan in 1965[7]. As a result, increased amounts of investment by US, Japanese and European electronics companies started to flow in. The operations, taking advantage of the low-cost labour, were concentrated towards the manufacturing of electronics and electronic components (Mathews & Cho, 2000).

As mentioned, an active export promotion policy was implemented in the 1960s. A reason for this was the reduced financial aid from the US, which prompted the Taiwanese government to seek income and foreign currency through other means. Generous incentives were given to foreign companies willing to invest in Taiwan. The foreign direct investments came in the field of consumer electronics and the pioneers were IBM and Philips. IBM had set up operations in Taiwan in the late 1950s, and also established an affiliate producing core wires by the early 1960s. The business model was geared towards moving labour-intensive stages of final assembly to low cost countries. Similarly, Philips took advantage of low cost manufacturing by establishing a subsidiary in Taiwan in 1961, manufacturing TV sets, audio equipment and related components. Soon an inflow of Japanese direct investments came, the first was Matsushita that set up a majority owned joint venture in 1962. Up to the mid-1980s this venture was one of Matsushita's major production facilities in South East Asia. Sanyo followed in 1963, Hitachi in 1965, and Sony in 1967. By the 1970s, most of the leading Japanese electronic producers had established a presence in Taiwan or were engaged in labour intensive assembly with a growing share of output going to Japan or Japanese affiliates in Asia. American companies had also realized the benefits of being in Taiwan. For instance, in 1964 General Instruments directed production of transistor radios to Taiwan (Ernst, 1997; Mathews & Cho, 2000).

While several companies had set up subsidiaries, others acquired a direct stake in existing local companies. The latter strategy was for example used by Toshiba, which had in the 1950s acquired a 5 percent equity-share in Tatung Co. Taiwan's only integrated electronics company at the time. Initially, Tatung was only a distributor, selling various electronic products produced by Toshiba. In the 1960s the cooperation deepened and Tatung also received technology licenses from its Japanese partner, allowing the company to become a supplier of key components, such as high-end compressors, picture tubes and LCDs. Other Japanese companies such as Fujitsu followed with a similar approach when it in 1973 established a joint venture with Tatung. The deal gave Tatung the rights to both sell and service Fujitsu computer systems and peripherals. These events eventually led to a number of joint ventures and OEM (Original Equipment Manufacturing) contracts with Taiwanese companies. Thus the investments made by foreign manufacturers of consumer

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[7] The first in the world; various tax incentives were given to local as well as foreign companies interested in investing in the zone.

electronics gave rise to a rapid growth in demand for electronic components produced in Taiwan. Although most of the high value-added key components were imported, both local production and capacity were increased (Ernst, 1997; Tu, 2001).

The foreign direct investments played an important catalytic role for the emergence of a Taiwanese electronics industry. For example, the Japanese companies offered intensive on-the-job training as well as developing close links with local suppliers that focused especially on the domestic market. A significant scale of local linkages was created by the foreign investments. Furthermore, the companies that invested provided the local employees and suppliers with education, knowledge and technology, although not advanced. Some of the employees also started new local companies. For instance General Instruments' Taiwanese affiliate itself gave rise, through former employees, to the founding of 11 local companies. In addition to being an incubator for local suppliers, foreign companies also established other facilities. Matsushita for instance created the Matsushita Electric Institute of Technology in 1981 with a work force of around 40 researchers (Ernst, 1997; Lin, 2003).

The events mentioned above preceded the growth of a domestic semiconductor industry. The first company to introduce semiconductor related business to Taiwan was General Instruments, who established a semiconductor assembly plant in Taiwan in 1967. Between 1969 and 1973, other multinational companies such as Philips, RCA and Texas Instruments followed suit and established their semiconductor assembly operations in Taiwan (Mathews & Cho, 2000). By contrast, the first semiconductor related research activities in Taiwan had local roots as discussed by Chang & Tsai (2000: p186): "The theory and technology of semiconductors was first systematically introduced in Taiwan when National Chiao Tung University started a course in 1960. The university built a semiconductor laboratory in 1964 that succeeded in manufacturing its first integrated circuit in 1965. National Chiao Tung University then chose semiconductor technology as the main focus of its curriculum, with the aim of training more high-tech manpower". According to Chang & Tsai (2000), National Chiao Tung University later also cooperated with governmental units and provided a foundation for the semiconductor industry in terms of basic research and human resource development.

3. A government initiative to create a new industry

Foreign direct investment was a factor that contributed to the emergence of a Taiwanese electronics manufacturing industry. Although the manufacturing of electronics products brought income to the export sector, those activities were believed by Taiwanese policymakers to be isolated from the rest of the economy and to have little value in terms of industrial development. The reason expressed by Lin (2003) was that the foreign companies saw Taiwan only as a low cost manufacturing resource. Furthermore, there were no local companies conducting any technologically advanced R&D. However, the fast growth and the volume of applications possible, in for example consumer electronics, telecommunications and industrial electronics, made the electronics industry an attractive sector for Taiwanese policymakers to promote. With this ambition, the main issue became to find a key technology that would help the Taiwanese electronics industry to develop in the direction of technology-intensive products. Hence, expert advisors suggested that Taiwan should develop semiconductors, specifically integrated circuit design and manufacturing technology in order to stimulate innovation throughout the island's electronics industry. Chang et al. (1994: p163) provide the following explanation for why the Taiwanese government decided to concentrate on semiconductors:

> Since the integrated circuit was introduced in 1958, its

> small size, low power consumption, rapid operating speed, reliability, and low cost per electronic function have led to significant changes in all electronics products, including consumer electronics. If the IC industry were developed in Taiwan, a spillover effect would be generated for industries which use ICs. The IC was thus selected as the key technology to be developed.

Taiwanese companies had however no experience in making semiconductors. Beside the foreign manufactures there were no local companies with experience or knowledge concerning semiconductor design or manufacturing. A task force, The Technology Advisory Committee (TAC), funded by the Ministry of Economic Affairs (MOEA) was therefore set up with the mission of investigating how to carry out a development strategy for the semiconductor industry. The TAC was formed by Y.S. Sun[8] (at the time the Minister of Economic Affairs) and P.W. Yuan, an engineer at RCA, in Princeton. The formation of TAC had been preceded by the belief that the key to a successful technological upgrading was to leverage the experience and knowledge of overseas Chinese engineers working in the US (Mathews, 1997). It was this group of highly skilled Chinese engineers, and academic scholars, working at various semiconductor companies and universities in the US that became the recruiting base for the TAC. Eventually the TAC also provided the guidelines concerning how to develop a semiconductor industry (Tung, 2000). The main areas of the strategy are highlighted below (Chang et al., 1994: p163):

1. TAC became responsible for the planning of the development. This was decided because there was no local experience in integrated circuit design and manufacturing available.
2. Since the gap between advanced semiconductor producing countries and Taiwan was very large, the main strategy to quickly develop an industrial base was through technology transfer.
3. The purpose of introducing semiconductor technology was to create an industrial base and to establish this kind of technology in Taiwan. The technology would have to be assimilated and developed. For this purpose a new research institute, ITRI was formed to reach the initial goals.
4. Over a period of 4 years, 410 million NTD (13 million USD) was to be invested by the government to purchase the manufacturing technology, product design and training personnel

4. The creation of a public research institute and technology acquisition

Who would take the lead in developing a new industry? The private sector companies, the majority of them being small or medium sized[9], were not technologically sophisticated enough. Neither did those companies place much emphasis on increasing R&D activities and investments (Liu, 2002). The few large companies, all involved in traditional industries, were reluctant to invest in new unproven industries (Mathews & Cho, 2000). Consequently it was believed by policymakers and experts that “no existing

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[8] Sun was responsible for laying the foundations for Taiwan’s technological upgrading. Both he and Yuan agreed that the electronics industry would be the key to Taiwan’s transformation, and that semiconductors should be a key technology. Furthermore, they believed that the required knowledge needed to be leveraged from abroad.

[9] According to Saxenian (2000), SMEs make up 95 percent of all companies in Taiwan. MOEA states that 90 percent of all Taiwanese companies in the 1950s were enterprises with 10 or fewer employees. In the 1960s the proportion of SMEs was 95 percent.

industry in Taiwan could lead the way in developing future high-tech industries for more than ten years" (Chang & Hsu, 1998: p350). In addition, the Taiwanese capital market was underdeveloped and financial institutions were conservative in lending out capital for risky ventures (Saxenian, 2000). Due to these circumstances, there was no other choice than for the government to assume the responsibility of being in the frontline in building up a semiconductor industry. In order to commence semiconductor related activities, the Ministry of Economic Affairs merged three government laboratories located in Hsinchu to form ITRI in 1973.[10] The government commissioned the newly founded research institute to carry out the introduction and assimilation of semiconductor technology. ITRI was thus the sole institution in Taiwan chartered to develop a semiconductor industry. With that purpose, ITRI established in 1974 the Electronic Research and Service Organization (ERSO)[11], a unit specifically concentrating on semiconductor technology. The responsibility for planning and coordination was however still in the hands of the TAC. Since no domestic proprietary technology existed. TAC decided to acquire it from abroad (An, 2001). What technology would be suitable to license?

The first integrated circuits had already been developed in 1959[12], and by the 1970s a large number of integrated circuits with various features and technology platforms existed. In the mid 1970s the most advanced integrated circuit designs had a 3.0 micron bandwidth. After some initial enquiries however, no companies were interested in transferring cutting-edge technology to ERSO. The only technologies available for licensing were 7.0 micron chips. After lengthy discussions concerning the opportunities, the conclusion reached by the TAC was to obtain low power, high density technology that would provide submicron development potential. The main points in the discussions of the TAC were according to Chang et al., (1994: p164) as follows:

1. It would be very difficult to license an advanced technology. Either the companies that possessed that technology would not agree to a transfer or the price would be very high. It was believed by the TAC that it would be more feasible to license a mature technology with lower competitive advantage.
2. The 7.0 micron technology was mature, and thus also held several advantages for a country which had no prior experience in semiconductor manufacturing and development, including higher consistency, complete technical documents, many skilled technicians, and effectiveness in the operation of the equipment.
3. Products manufactured with 7.0 micron technology were already out on the market and feedback was available concerning process technologies, product development, design technology and marketing channels. Acquiring the 7.0 micron technology would therefore allow Taiwan to learn about all aspects of integrated circuit technology from R&D to commercialization.

The search for partners was conducted by ITRI which believed that American semiconductor companies were the ones most suitable to license technology from. Hence, over twenty requests to companies in the US were sent out and a handful of companies returned a proposal for a technology transfer. After the Taiwanese selection committee had visited the prospective

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[10] Union Industrial Research Laboratories, Mining Research and Service Organization, and Metal Industrial Research Institute were donated to ITRI by the Ministry of Economic Affairs

[11] At the time the lab was known as Electronics Industrial Research Center, in 1979 the name ERSO was adopted.

[12] By Kirby, at Fairchild Semiconductor

companies, two were selected as potential partners, RCA Semiconductor and Materials (hereafter RCA) and company X. The cost for RCA's deal was twice as high as the one given by company X, but the terms of the company's proposal were better. RCA's proposal included technology, process design and manufacturing management skills for integrated circuit fabrication, whereas company X's proposal consisted of process design and design technology. However, another dimension that came into play was also that RCA could provide a year-long training for 35-40 ITRI engineers at its laboratories in the US. In contrast company X only suggested training for 3 months for 3-4 persons. Since it was believed by TAC that the success of the project would be reliant on the extensive training of human resources, the difference in the suggested training of Taiwanese engineers came to be the critical factor in the decision-making. RCA's proposal was considered as the better choice. Although the guiding principle had been to select the deal with the lowest price, the technology content and personnel training proposed by company X was believed not good enough to achieve the goal of introducing semiconductor technology in Taiwan. The technology that was licensed to Taiwan was the so called Complementary Metal Oxide Semiconductors (CMOS), which originally was developed by RCA[13]. The technology corresponded to the goals of TAC to acquire a "low power, high density technology that would provide submicron development potential". Targeting this technology meant also that ITRI would not be competing directly with established manufacturers (Chang et al., 1994; Chen & Sewell, 1996; Hung et al., 2005).

Responsible for coordinating the technology transfer was ERSO. While the agreement with RCA was being negotiated talented young Taiwanese engineers were recruited and trained at ERSO for a period of time while waiting for the pending transfer. After the agreement with RCA had been finalized in 1976, 37 engineers were sent to different laboratories and plants in the US operated by the company for one year of technical training. Many of these engineers would later become the corporate leaders of Taiwanese semiconductor companies (Chang & Hsu, 1998). The agreement with RCA included the transfer of a 7.0 micron CMOS process technology, product specifications, design and testing technology for a digital electronic watch. Assistance in building a semiconductor plant and training of personnel were also included in the licensing agreement. While the engineers were sent to the US for training, ERSO were setting up a 4 inch wafer pilot plant for semiconductor manufacturing back in Hsinchu, Taiwan. When the engineers returned in 1977 the plant was already operational for test runs. The same year the first integrated circuits were produced by the pilot plant. The standard of the product complied with what had been agreed in the licensing contract (Chang et al., 1994).

ITRI had accomplished the introduction of semiconductor technology to Taiwan. Of course Taiwan was still far from catching up with advanced nations but the main goal was to learn more about semiconductor technology, and to accumulate knowledge. For this goal, a pilot plant, with design, manufacturing and testing capabilities had been built, and was geared towards producing simple semiconductors. As noted, RCA had developed the first CMOS integrated circuits, but CMOS was at the time not a widespread technology. RCA was actually about to withdraw from the semiconductor industry and the licensing deal with ITRI was an opportunity to squeeze some last income from a mature technology. The 7.0 micron CMOS was mature, and far behind the worlds leading LSI 2.0 micron circuit designs, nonetheless for ERSO this was a way of gaining access to the world of semiconductors. In retrospect, the licensing of CMOS technology proved to be a wise choice. First of all ITRI did not have to directly compete with established producers on a global market. Second the

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[13] CMOS technology was developed at Fairchild Semiconductor in 1963. In 1968 the first CMOS based ICs were developed at RCA. At the time it was a low power but slow alternative to the standard NMOS (another technology which ITRI wanted to license but proved to be too expensive) and TTL technologies.

market share of CMOS was relatively small at the end of the 1970s, but started to expand rapidly afterwards to become the most used technology in IC design today.[14] After RCA withdrew from the semiconductor industry in the early 1980s, ITRI also inherited the intellectual property portfolio from RCA that had been related to CMOS technology (Mathews and Cho, 2000).

ERSO's semiconductor fabrication plant had been built under the guidance of RCA. After being able to produce integrated circuits in 1977, used in electronic watches, ERSO soon also started to produce experimental semiconductors by using its own designs. By 1979 ERSO were getting better yields from these integrated circuits than what the licensed technology had given. In the early 1980s ERSO could provide CMOS of 4.5 micron and in the mid 1980s of 1.0 micron (Chang et al, 1994). In 1979 ERSO also established a customer relationship with a Honk Kong electronic watch producer that bought integrated circuits from the pilot plant. The order of 10000 integrated circuits was small and the owner of the Hong Kong firm was a former college classmate of the person responsible for running the pilot plant, Shih Ching Tay. This deal provided ERSO with an opportunity to interact with a user. (Tu et al., 2006) The total amount of capital invested from 1975 to 1979 was 410 million NTD dollars (roughly 12 million USD)[15]. After the introduction of CMOS technology the government's commitment also increased. Between 1979 and 1983, 670 million NTD was to be invested. The goal that had been set up by ITRI was to upgrade the technology from 7.0 to 3.0 micron (Chang et al., 1994).

In 1979 the Taiwanese semiconductor sector still only consisted of ERSO's plant and a handful of foreign assembly plants. Local companies were not interested in semiconductors, as it was considered a risky and unproven business. The technology which ERSO had acquired and continued to develop was still far behind the global standards, which were getting to below 2.0 micron bandwidth. In addition, there was no real infrastructure to support high-tech development in Taiwan and the investments required to resolve this issue would have to be quite large (Chang & Tsai, 2000).

5. Hsinchu Science Park and the first ITRI spinoff - UMC

The ambition of creating high-tech industries in Taiwan had strong support in policy circles. A person who came to play an important role for the high-tech development was former Minister of Economic Affairs, Li Kwoh Ting. He had taken an initiative for the creation of a permanent advisory body to the government in science and technology issues. The group that was established in 1978, headed by Li, was named the Science and Technology Advisory Group[16] (STAG) consisted mainly of overseas Chinese with technical backgrounds. Many of the advisers in STAG had worked in the US and experienced the growth of high-tech regions such as Route 128 and Silicon Valley. Based upon their experiences, STAG suggested that Taiwan needed a specialist infrastructure to support advanced industries such as semiconductors (Saxenian & Hsu, 2001; Yu, 2007). The ambition to set up a specialized infrastructure gained adherence in the Executive Yuan, and under the sponsorship of the National Science Council (NSC) a science park was to be established. The decision was however not well received in all political camps. The efforts to set up a science park were met with considerable opposition and scepticism in the

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[14] Originally a low-power but slow alternative to TTL, CMOS found early adopters in the watch industry and in other fields where battery life was more important than speed. Some twenty-five years later, CMOS has become the predominant technology in digital integrated circuits. This is essentially because area occupation, operating speed, energy efficiency and manufacturing costs have benefited and continue to benefit from the geometric downsizing that comes with every new generation of semiconductor manufacturing processes.

15 It was a substantial sum to be invested by the Taiwanese government in a single technology, but compared to the research budgets of large semiconductor companies it was not a considerably large R&D budget.

[16] STAG remains the main science and technology advisory group to the government up to the present. Since 1979, together with the NSC it has also served as the main organ for science and technology policy.

Taiwanese Cabinet. The NSC was nevertheless successful in securing land near Hsinchu, where both the ITRI campus and National Chiao Tung University were located. In 1978 210 hectares of land had been expropriated by the Hsinchu county government to create the new park and in 1980 the Hsinchu Science Park Administration was established (Mathews & Cho, 2000).

The establishment of Hsinchu Science Park was to facilitate the creation of a high-tech industry, but there where no local companies that could locate in the park. What existed were a few foreign subsidiaries that were involved in the downstream stage of packaging and testing semiconductor products. There was also ERSO which had set up a pilot plant manufacturing semiconductors, but other than that there were no local companies specifically involved in semiconductor development and production. Since no private Taiwanese companies were involved in Large Scale Integration (LSI) and semiconductor related R&D activities, the ERSO management decided to create a company (Chang & Hsu 1998; Mathews 2000). It was believed by ERSO that the prospects of a Taiwanese semiconductor industry would be threatened if foreign companies would first establish subsidiaries (Liu et al., 2005). Hence, the pilot plant at ERSO was to be spun off, and form the foundation of a new company named United Microelectronics Company (hereafter UMC). The spin-off would mark an important milestone in the development of a semiconductor industry. ERSO was now ready to exploit commercial opportunities with the technology that had been acquired 3 years earlier (Chen & Sewell, 1996). The idea of a spin-off from ITRI was however novel, and there were difficulties with raising capital for a project advisers at STAG believed that although ERSO was successful in introducing and assimilating the CMOS technology, Taiwan was still far behind the advanced semiconductor nations, and some argued that the gap was actually increasing. The STAG advisers strongly advised that Taiwan should set its target at achieving VLSI capacity of 1.0 micron standard or higher. This would bring the technology competence in Taiwan on par with the top companies in the world. ERSO strongly objected to STAG's advice and argued that Taiwan should be patient in its efforts to develop an industry, and not take on that much risk by directly try to challenge the large semiconductor companies. This could quickly jeopardize what had already been built up. Officials at the state departments such as the *Ministry of Finance* and the *Economic Council for Planning and Development* were also opposing the suggestion from STAG. These departments were more concerned with issues related to macro-economic stability and were not interested in promoting a single technology. STAG's suggestion to achieve VLSI capability was however supported by some high government officials, such as the president and the premier. Hence, in 1983 it was decided that the government would invest 2.9 billion NTD (roughly 85 million USD) to pursue the plan to achieve 1.0 micron VLSI capability by 1988 (Chang & Tsai, 2000; Mathews & Cho, 2000).

This was a very ambitious goal considering the then current state of the Taiwanese semiconductor sector and the small involvement of the private sector. As earlier, the government entrusted the VLSI project to ERSO. UMC had also tried to convince the government that it was capable of handling the task, but it was considered too risky to hand over such a mission to a newly started company. Thus the plan was that a VLSI plant would be set up at ERSO. But where would the VLSI technology come from? Instead of turning to another large company as before, ERSO signed an agreement with two Silicon Valley start-ups, Mosel and Vitelic, to develop VLSI semiconductor chips. Already by 1985 a bandwidth of 1.25 micron had been achieved at ERSO for the CMOS technology, and in 1986 CMOS memory chips of 1.0 micron were available. Taiwan now had the capability of designing 1.0 micron chips. There were however no fabrication facilities in the country to produce these semiconductor chips (Mathews, 1997; Mathews & Cho, 2000).

6. The growth of design capabilities and the emergence of TSMC

The results of the VLSI project were advanced design capabilities and "state of the art" technology in one of ERSO's special laboratories. Where was Taiwan heading from here, should the designs be licensed to third parties for fabrication? The problem with lack of fabrication capacity became more obvious with the growing number of semiconductor design companies in Taiwan. As mentioned earlier ITRI had started to transfer the capabilities and resources which had been built up, the first one being UMC. In 1982 ERSO had also spun off the first two independent Taiwanese semiconductor design houses, first *Syntek* and shortly thereafter *Holtek*. But if no private sector companies would willingly get involved in the semiconductor industry, ITRI would have to create an industry through spin-off companies (Mathews & Cho, 2000).

In addition to the VLSI laboratory, ERSO had in 1985 set up a Common Design Center for chip design companies to develop application products, which was mainly aimed at start-up companies (Liu et al., 2005). This encouraged several overseas Taiwanese from Silicon Valley to return to Taiwan and start their own companies or expand their business with the support of the Common Design Center (Chiang & Hsu, 1998; Mathews & Cho, 2000; Liu et al., 2005). The semiconductor design industry in Taiwan did not really take off, however, even though the technological levels had been raised and were approaching those of the advanced companies. A reason was not only that there were no customers, but also a lack of fabrication capabilities in Taiwan contributed to the situation (Chen & Sewell, 1996). UMC was the only semiconductor company in Taiwan with a fabrication plant prior to 1987 (An, 2001). ERSO also had some fabrication capacity since it had retained a part of the plant for continued research after the UMC spin-off. Nevertheless, none of these plants were intended for VLSI manufacturing, and as noted earlier the development was moving towards VLSI technology. This capability was believed to be necessary in order to catch up with the advanced semiconductor nations. So how would the products developed with VLSI technology be manufactured?

In 1985 Morris Chang had become the new president of ITRI. Chang, an overseas Chinese with a Ph.D. from Stanford University in engineering, had three decades of working experience in the semiconductor industry and prior to joining ITRI was head of the global operations department at Texas Instruments. In Chang's first week at ITRI he proposed a new spin-off from ERSO. He suggested that this spin-off should be focusing strictly on manufacturing chips, i.e. *semiconductor foundry*, for local and international customers based on VLSI technology. The rationale for this was mainly based on two reasons. First, most of the top 20 semiconductor companies in the world did not have financial capital to quickly upgrade their fabrication facilities to VLSI-standard. Second, the growing Taiwanese semiconductor design sector needed fabrication plants to meet their production needs (Liu et al., 2005).

The idea was quite novel, since up to now the semiconductor companies had been vertically integrated, involved in both design and manufacturing. Although these two activities are separable, the companies with fabrication capabilities were also designing their own semiconductors in order to reduce the risk of having semiconductor designs copied. The new spin-off from ITRI would be the first company focusing strictly of foundry. The proposal to create a pure foundry company was accepted by the government, but it was not to be fully funded by the state; instead it was to have both public and industry support. This would be a way to push the private sector to participate in the semiconductor industry. The government gave ITRI the task to find a multinational company as a sponsor. The ambitions for the new company was to become a global semiconductor company, and in order to receive credibility, technology and a cross licensing portfolio it was believed that a venture with a leading semiconductor company would be best (Chang & Hsu, 1998; Mathews & Cho, 2000).

The possibility of creating a large scale VLSI semiconductor business through financial support from the government and combined with engagement from an international semiconductor user, appeared an attractive solution. Interest was shown from four multinational companies: Texas Instruments, Intel, Philips, and Matsushita (Mathews & Cho, 2000). All of these companies, with the exception of Intel, already had prior production activities in Taiwan. Philips was the pioneer, starting production in Taiwan when the company established its production of TV sets, audio equipment and related components in 1961. In 1962 Matsushita established a production facility in Taiwan, to be followed by among others RCA and Texas Instruments. After the Taiwanese government had negotiated with all four companies, Philips proved to be the only serious candidate. In 1986 it was announced that the Taiwanese government and Philips would be the largest shareholders of the new company, Taiwan Semiconductor Manufacturing Company (TSMC)[17], and the company was established the year after (Chen & Sewell, 1996). ITRI provided the technical personnel, around 150 persons, of which most had been involved in the VLSI project. ERSO also spun off its 6 inch VLSI manufacturing plant that became TSMC's first fabrication facility. With this TSMC became the first dedicated foundry in the world, and pioneered a concept which became a central element of the semiconductor supply chain. Since Philips

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[17] According to Saghafi & Davidson (1989) 10 billion NTD was raised. Philips became the largest private shareholder with 27.5 percent of the equity. The largest shareholder was the Taiwanese government, with 48.3 percent of the equity.

production activities in Taiwan already included semiconductor assembly operations, the step to an engagement in semiconductor foundry was already locally established (Saghafi & Davidson, 1989).

Through Philips' engagement, TSMC not only received a financier but also a large, skilled and demanding customer. In the technology area, Philips agreed to transfer 2.0 and 1.5 micron process technology to produce VLSI devices. For more advanced technologies Philips, would be paid royalty fees. The condition for the deal was that the new company would not become a competitor to Philips own products in Taiwan. The initial technology inputs supplied by Philips accounted for 80 percent of TSMC's original capability. Philips transferred its portfolio of cross licenses to TSMC to avoid the company being accused of infringing intellectual property rights of other semiconductor companies, something which had happened to several upcoming Korean semiconductor companies. In addition, Philips also supported TSMC with product and process know-how, but more importantly what was gained was legitimacy for the new company. As a result of the extensive support, TSMC experienced strong growth and was successful in upgrading its technology to world standards in a short period of time. Until the end of the 1980s TSMC had to rely on the support from Philips in order to be able to produce advanced integrated circuits. However, at the end of the 1980s both the customer base and the knowledge of making advanced semiconductors had grown so much that TSMC was able to design 0.8 micron semiconductors without any technical support from Philips. In the early 1990s, a decade after the operation started, TSMC's annual sales surpassed 1 billion USD, and the production activities included design and manufacturing of semiconductor chips (Mathews & Cho, 2000).

7. A growing semiconductor industry

As discussed earlier, by the time the government decided to promote semiconductors many foreign electronics companies had a steady presence in Taiwan. Philips had already been involved in Taiwan since the early 1960s when the company had set up a transistor and television tube factory, which today is the largest of its kind in the world and the main supplier of tubes to the Philips group. The company's commitment came to grow stronger over the years. Hence, when the Taiwanese government searched for a partner to form TSMC, Philips was a potential sponsor. The reasons that Philips turned out to be the only serious candidate was not only because the company had the financial and technical resources but equally important was its long term dedication to Taiwan. It must be taken into consideration that TSMC was an unproven business idea and the burden of proof was on ITRI. The other companies, Texas Instruments and Intel were just not convinced of TSMC's potential, but for Philips the incentive to invest was the opportunity to gain a stronger foothold in the emerging Taiwanese market (Chang & Tsai, 2000; Mathews & Cho, 2000).

The development of TSMC functioned as a catalyst for the continued start-up of new semiconductor companies[18] in the Hsinchu region. Around TSMC and its interaction with customers such as Intel and Texas Instruments, a structure of related companies started to emerge. ITRI had also continued to run its R&D operations, and fuelled by its proven spin-off strategy, projects became companies as soon as technologies were considered ready for commercialization. The research institute maintained a liberal view on employees' ambitions to create new companies, direct as well as indirectly[19], and this benefited the enlargement of the semiconductor industry. With the growing opportunities, Taiwanese private capital was starting to flow into the semiconductor industry in larger amounts (Chang & Hsu, 1998).

UMC, the only other company in Taiwan at the end of the

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[18] E.g. Destiny Technology Corp., Realtek, Weltrend, Sunplus, ICSI, Eltron et cetera.

[19] This high mobility of labour was also a major contribution to the successful development, according to Saxenian (2001).

1980s with fabrication capabilities, had already been listed on the Taiwan Stock Exchange in 1985. But although the company was profitable it was lagging behind TSMC in technological sophistication. For example, in 1987 when TSMC's technological capabilities were almost similar to the world leading producers, i.e. close to 1.0 micron, UMC only had 3.5 micron process technology. Furthermore, while TSMC was attracting large multinational companies as customers, UMC was serving mostly "small" customers (Chang & Hsu, 1998). However this did not mean that UMC was unsuccessful, the CMOS technology which the company inherited from ITRI was also becoming a standard technology used in producing integrated circuits. Initially ITRI had chosen to license a mature CMOS technology from RCA because the more advanced technological solution could not be afforded. Although CMOS based integrated circuits were a somewhat slower alternative to some more advanced solutions, it was also less power consuming. This meant that CMOS became an attractive solution for products where low power consumption was of greater importance than speed, for example in the watch industry. Since the CMOS technology was considered by the dominating US and Japanese semiconductor companies as obsolescent, it became a niche product which UMC later became one of the few to supply. About two decades after ERSO started the development and production of CMOS technology it had emerged to become one of the predominant standards in integrated circuits[20] (Mathews & Cho, 2000). TSMC and UMC had proven to be triumphant cases which encouraged private sector and non-public investors to participate in an industry which had earlier been dominated by government organizations. The development progressed quickly, and by the early 1990s Taiwanese companies had similar technology levels to those of the advanced global semiconductor manufacturers (Chang & Hsu, 1998; Hsu & Cheng, 2002).

Today the semiconductor industry is considered an icon of success in Taiwan. At the end of 2005, Taiwan Semiconductor Industry Association (TSIA) estimated that 60 percent of worldwide semiconductor foundry, package and testing revenues were generated by Taiwanese semiconductor companies, with a majority of them located in Hsinchu. For worldwide revenue in semiconductor design as well as dynamic random access memory, Taiwanese companies held around 25 percent. The total economic value generated by Taiwan's semiconductor industry totalled 1118 billion NTD (roughly 33 billion USD) at the end of 2005 (TSIA, 2006).

7.1 Key interfaces in the semiconductor business network

The story of the emergence of the Taiwanese semiconductor business network is both an interesting and impressive example of industrial development. Some of the major actors that contributed to the development were policy actors, foreign manufacturers, public research institutes and local industry. Figure 2 below is a network map of some of the key resources in the emergence of the semiconductor business network. The following analysis will take a closer look at Taiwanese policy's interfaces to: 1) ITRI & TAC; 2) RCA and the CMOS technology; 3) Foreign electronics producers; 4) Spin-off companies and; 5) Advanced semiconductor users. These interfaces will illustrate the role of policy in the emergence of the Taiwanese semiconductor business network.

1. Interface with ITRI & TAC

In 1973 the public research institute ITRI was established and commissioned by the Taiwanese government to develop semiconductor technology. Accordingly this was the formal start of a policy created Taiwanese semiconductor business network. The

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[20] It was a combination of CMOS features, for example the geometric downsizing, the development of operating speed together with energy efficiency, and the low manufacturing costs that made CMOS a dominant standard in semiconductors.

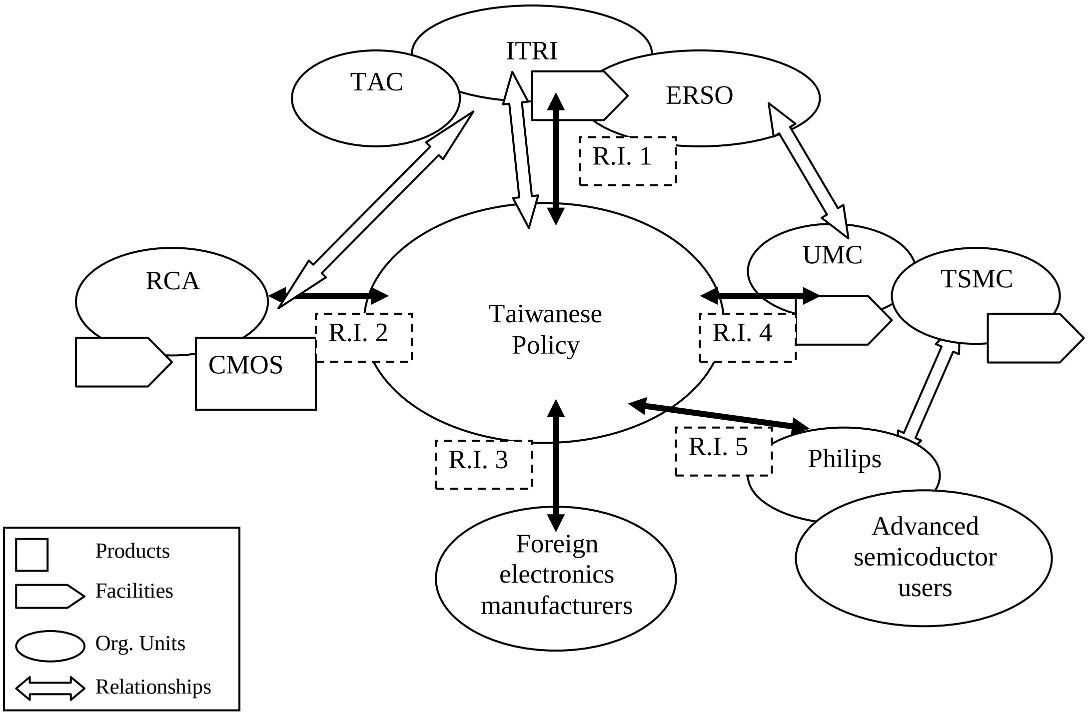

Figure 2
Network map of key resources involved in the semiconductor case

capabilities and knowledge within ITRI emerged over an extended period of time.

For example national Chiao Tung University had already established Taiwan's first semiconductor laboratory in the early 1960s and played a significant role in training and educating personnel at ITRI. Another important factor in the establishment of the local research institutes was existing sources of semiconductor knowledge outside of Taiwan. Much of the knowledge of semiconductors stemmed from Taiwanese professionals working within existing companies and research environments. Almost all the experts engaged in the expert committees that the Taiwanese government created, were US-based Chinese and Taiwanese engineers involved in semiconductor research or business.

Members of the *Technology Advisory Committee* (TAC) were especially influential in establishing a local structure. It was these experienced semiconductor experts who helped set up ITRI, and ERSO in 1974. Hence, already from the start of attempting to develop a domestic base of semiconductor technology, Taiwanese policymakers and engineers were interacting with individuals working in world leading semiconductor companies and research units. This created a large number of organizational interfaces not only to other developing structures but also to existing producing and using structures mainly in the US. It was through these interfaces which ITRI were able to access technologies and knowledge.

2. Interface with CMOS technology and RCA

A local structure was built up through using experienced semiconductor professionals and organizational units outside of ITRI. In addition to the creation of such organizational interfaces, through policy support, there were also important physical interfaces that shaped ITRI and the Taiwanese semiconductor business network. One important physical interface was the mature CMOS technology that ITRI licensed from RCA in 1976. Although the government provided the funding to develop semiconductor technology it was not going to be developed instantaneously. ITRI needed first an existing technology to experiment on and learn from. However no advanced producers were interested in licensing any cutting edge technology to Taiwan. The only viable option was to license mature and less advanced technologies. The decision to license an “obsolete” technology from US producer RCA served as a way to educate ITRI and its personnel on how to manufacture semiconductors. The fact that it was mature had several advantages; one was that the cost of the technology was within the proposed budget. Another advantage was that it was already thoroughly tested in existing producing and using structures. In other words the technology already had established user and producer interfaces. Although the technology lacked novelty, which was considered as a weakness by the multinational companies, it made it possible for ITRI to work on solutions suitable for both production and use already in the 1970s. Consequently it was not only the new institutions that policymakers created that had an imprint on the emergence of a business network. ITRI’s ability to take advantage of already embedded resources, such as a mature technology was decisive.

About two decades after ITRI started to engage in the CMOS technology it had emerged to become a dominant standard in integrated circuits. From a using perspective the features of the mature technology (for example, low power consumption) were much more important than novelty and untried solutions. The CMOS technology later became a niche product which ITRI’s spin-off UMC was one of the few manufacturers to supply. Of course this could not have been known by Taiwanese policymakers at the time of the technology transfer. However, an important aspect to point out is that it was enabled due to the fact that it could increase the value of the users’ existing resource structures, and thus providing opportunities for Taiwanese companies to become suppliers of semiconductors. Furthermore, an important reason for ITRI choosing RCA was the extensive support program the company offered. RCA provided a complete production technology and training for 37 Taiwanese engineers at RCA’s US laboratories for a year. Since the technology transfer also entailed extensive personnel training, ITRI had a large number of trained engineers by the mid-1970s. In addition RCA helped ITRI set up a fully operational semiconductor production facility. RCA was willing to help ITRI set up a production facility since the technology was considered obsolete and the company was about to withdraw from the semiconductor field. The production facility that was established was fully functional within a year after the signing of the contract with RCA. As the technology transfer was accompanied by interaction related to other complementary resources, capabilities and knowledge of semiconductor development could be built up. However, as mentioned in the case, this did not lead to any major achievements commercially. But the explicit goal of ITRI was not primarily to make economic returns on the investments made, at least not at that stage. The main aim was to learn how to develop and produce semiconductors. Until the 1980s the capabilities and technologies of the local structure had already been built up through a large number of resource combinations with existing developing and producer-user structures, where the interface with RCA was quite substantial and important.

3. Interface with established producers

Besides RCA, other foreign semiconductor companies were not actively collaborating with the emerging Taiwanese semiconductor network, although relationships to multinational electronics companies had already existed since the 1960s. The view of Taiwanese policymakers was that the business units of the foreign companies had positive effects on Taiwan’s economic growth but had added little value to the emergence of a home-grown industry. It was not until the mid-1980s that they were considered to have an important role by the Taiwanese government. Nonetheless, it is difficult to separate and neglect the role the foreign companies played before the Taiwanese industry started to grow rapidly in the late 1980s. Although the presence of the foreign companies in Taiwan in the 1960s had no immediate impact on the development of advanced semiconductor technology in Taiwan, it served as an important platform whereby important relationships and commitments came to be established. By the time Taiwanese policy decided to start promote the semiconductor field, foreign electronics companies had been present in Taiwan for over a decade. The relationships which were established between Taiwanese and foreign companies provided knowledge to Taiwanese employees, gave rise to new companies, and set the foundation for the electronics industry (which later became a source of users of Taiwanese semiconductors). Furthermore, established Taiwanese companies also received a share of technologies and business as they were seen as important business partners to the foreign companies. Thus an intricate network of interfaces to producer-user settings had emerged. In this period the local structure had already had extensive interaction with established business structures, which was also inherited by the spin-offs.

What the case indicates is that the organizational interfaces that were created were often not consciously part of an ambition to build up a semiconductor industry. For instance the relationships, developed between foreign electronic companies and the Taiwanese government were built up over decades, starting with the establishment of a foreign-owned electronics industry in Taiwan in the 1960s. The activities to develop semiconductor technology as well as business in the 1970–1980s were thus undertaken in an environment where major global suppliers of semiconductors were already active in the Taiwanese economy, as producers of electronic appliances. As relationships between Taiwanese companies, policymakers and the foreign companies were established there was continuity in their interaction. However, it was after many years of infrastructure build-up and commitment from the Taiwanese government that the foreign companies present in Taiwan eventually became interested in the Taiwanese semiconductor industry.

4. Interface with UMC and TSMC

Following the establishment of ITRI the local resource structure became incrementally more advanced and was on par with world standards in the mid-1990s. This was in part due to the structure of local companies emerging in the 1980s. ERSO had improved the CMOS technology in the production facilities created with the help of RCA. Eventually a part of ERSO’s production facility was spun off into a new company, UMC. Later ERSO’s VLSI production facility was spun off laying the foundation to TSMC. Not only were these two spin-off companies the first two Taiwanese producers of semiconductor technologies, today they are also the two largest semiconductor foundry companies in the world. When UMC was spun off from ITRI it inherited both a production facility and its first customer. The first Taiwanese semiconductor company became a producer of reliable but non-advanced semiconductors, catering mainly for small South-east Asian electronic companies. This business idea changed when Philips became interested in a joint venture with ITRI. The creation of TSMC had a profound effect on the Taiwanese semiconductor industry, and also the global semiconductor business. The birth of the semiconductor foundry and Taiwan’s flagship company TSMC was the result of the interaction between ITRI, Philips and the Taiwanese government. These organizational units had at the time goals which were commensurable. The Taiwanese government wanted to create an industry and ITRI had reached a stage where it could spin-off a part of its facilities. For Philips there were clear business opportunities from outsourcing its production. Hence, Philips transferred technology, know-how, a cross-licensing portfolio, as well as legitimacy to the new start-up (each resource being instrumental to the development of the TSMC). But perhaps more important was the fact that TSMC had one of the largest electronics companies in the world as its customer from the start. This allowed TSMC to upgrade its manufacturing technology and skills in a short amount of time. Becoming a supplier to a large and advanced user not only proved beneficial in upgrading the technology of TSMC but it also drew the attention of other large electronics companies such as Intel and Texas Instruments to mention a few that later also became customers of TSMC.

5. Interface Philips and other advanced users

A major reason why advanced semiconductor companies were not initially customers of Taiwanese semiconductor products is quite simple. The Taiwanese companies did not offer any complementary resources which they needed. Most of these advanced companies were fully vertically integrated in terms of design and production, and had no interest in what was being developed at ITRI. The only part of the production which was outsourced was the testing which did not require any advanced capabilities. Thus in the beginning ITRI's production catered to a largely "low-tech" segment of the semiconductor market. ITRI and later UMC was not regarded as a threat by the top semiconductor manufacturers, neither did they produce anything of economic value for them. This changed with the idea of semiconductor foundry and the opportunity to create an external supplier. The established semiconductor companies were not interested in another company that could develop advanced technologies. Instead the solution that was created, and which provided a complementary resource base to these advanced users' existing resource structures, was a Taiwanese company TSMC. The business idea was to supply advanced semiconductors based on users' specifications. This business was not a result of ITRI creating a high-tech production plant and then finding customers. The demand was created through interaction between the ITRI and an established business structure. For example, the business relationship between TSMC and Philips had a long history. Philips had been present in Taiwan since 1961 and over the years the commitment had come to grow stronger. When the Taiwanese government searched for a partner to form TSMC, Philips was a potential candidate. Other companies that were approached were Intel and Texas Instruments, all advanced semiconductor companies, but in the end Philips turned out to be the only serious candidate. The reason was not only because it had the resources, of importance was also the company's long-term dedication to Taiwan. It must be taken into consideration that TSMC was an unproven business idea and the burden of proof was on ITRI. The other companies were just not convinced of TSMC's potential. However, for Philips the incentive to invest was to increase the value of its already made investments abroad and in Taiwan. The company also wanted a supplier for a set of VLSI technologies, the leading standards at the time. The idea was something which quickly became embedded into the existing structure of related producer-user interfaces. Later on TSMC also became a major supplier to other semiconductor companies such as Intel and Texas instruments among others.

8. Discussion and conclusions

In this article the purpose has been to increase the understanding of forced network creation in the context of resource interaction, and in relation to the role of public policy. The understanding reached from this study will be discussed through three propositions which have been identified in earlier studies of resource interaction (Håkansson & Waluszweski, 2002, 2007; Waluszewski et. al., 2009; Shih, 2009 among others). The propositions are as follows: 1) *Resources are combined over multiple spaces and times*; 2) *New resources are always combined with existing resource structures* and; 3) *The economic value of any new resource is closely associated with how it can embedded in a using structure*.

Table 2
Summary of resource interfaces

1	ITRI & TAC	ITRI created from a directive from Taiwanese policy with mandate to establish an industry and undertake research in the field of semiconductors. Established with the help of TAC which consisted of semiconductor professionals from abroad provided ITRI with direction, knowledge and contacts.
2	RCA & Technology	RCA not willing to license an advanced technology but saw a chance to make some revenue by licensing out an obsolete technology. Provided ITRI with knowledge, support, facility, training and a mature technology which already had established user-producer interface. Policy wanted advanced technology, acquiring the mature technology within the realms of the government budget.
3	Electronics producers	Multinational producers already in Taiwan during the 1960s, wanted to take advantage of low cost production. Government policies of import substitution and export promotion provided incentives for these companies to set up shop on Taiwan. Important relationships and commitment from the established producers created, especially with Philips. Also helped establish a local electronics business network, although not a direct goal of Taiwanese government.
4	Spinoffs	Government supported the spinoffs, UMC and TSMC. TSMC was created through the combination of spinning off ITRI's VLSI production facility and the technological know-how from Philips. This resource combination brought forward a new production process, semiconductor foundry, a novel idea which was enabled partly due to the support of the Taiwanese government. It later in turned out to become a money-earning business model for both TSMC and other Taiwanese businesses.
5	Advanced users	Advanced users not interested in Taiwanese semiconductor technology or products. Taiwanese policy not able to control or influence these actors. After a complementary resource was established base (TSMC) the advanced users were willing to cooperate with Taiwanese semiconductor companies.

1) Resources are combined over multiple spaces and times

As has been highlighted in the analysis it is not single events at a certain time or place which triggers the formation of new industries. What this study illustrates is that the emergence of the Taiwanese semiconductor business network was the result of both planned and unplanned combinations of various resources over an extended period of time and in different places. The emergence of a semiconductor business network happened without following a linear path with first R&D, then production and finally use, at consecutive separate stage. Rather use-production-development happened concurrently, where developing structures emerged in relation to already existing using and producing structures. With the assistance of established knowledge sources, it took more than a decade to establish research and development capabilities. A producing structure was built up over an even longer period with close contact to users. These users had an established presence in Taiwan already in the 1960s and, although they were not active at the time, resource synergies were created. The emergence of a Taiwanese semiconductor business network was thus a result of combinatory efforts stretching over at least three decades and shows the importance of the close ties between developing, producing and using structures.

2) **New resources are always combined with existing resource structures**

As discussed above a factor for value creation was the ability of different actors to take advantage of what had already been created in other resource structures both locally and internationally. The Taiwanese government's effort to create space for Taiwanese organizations and companies in an international network, covering development, production and use of semiconductors, was a key factor for the emergence of a business network. In particular the connections to established producer-user settings were imperative in the development. For instance the subsidiaries of the foreign companies provided local employees and suppliers with education, knowledge and technology. Already from the 1960s new local companies were started in the wake of the foreign investments. What was in creation was the emergence of a producer-supplier network which continues until today, where semiconductors became an extended business activity due to already established business relationships. These interfaces brought forward knowledge and also various solutions which could benefit the Taiwanese semiconductor business network. Thus the notion that there is always something to build on is imperative when formulating viable public policies to develop business networks.

3) **The economic value of any new resource is closely associated with how it can embedded in a using structure**

From the empirical account it is also evident that the value of any new resource is strongly related to how it can be embedded in using structures. Although there were interfaces to advanced using structures already before the Taiwanese semiconductor business network emerged, multinational semiconductor companies did not become customers of Taiwanese made semiconductors until the early 1990s. Why the advanced multinational companies eventually became customers of Taiwanese semiconductors products was to a large extent dependent on the possibility to create additional value of their already made investments. What happened in the Taiwanese case were Taiwanese companies becoming part of a global semiconductor supply chain. By concentrating on only a part of the production chain and becoming suppliers of semiconductors to advanced using structures, the Taiwanese companies were not competing with their customers and did not risk eroding the value of their investments. Instead they complemented the resource structures of the advanced using structures.

9. Policy implications

What can the above discussion tell us about forced network creation and what implications are there for policy? What the analysis of the resource interfaces in the Taiwanese semiconductor business network has portrayed is that the emergence of the network came about through interaction between both established and new resources over several decades and geographical borders. The industry was not an instant economic success nor did it just surface in a setting with tabula rasa antecedents. Development of semiconductor technology occurred in close relation to already existing producer-user structures and the closeness functioned as a catalyst to the emergence of a semiconductor business network in Taiwan.

As is evident from the empirical account the different actors in the network that emerged had various goals which often were not compatible. But Taiwanese policy was an important and skilful network actor. For example Taiwanese policymakers assisted in establishing and creating interfaces to various organizational and physical resources, in particular to existing producing-using structures. Policy was also innovative in creating new organizations, empowering professionals with experience to lead the way in development and allowed the policy-supported institutions to take new directions. What seemed to be an essential factor is the flexibility through which policy acted, a trait which does not always seem to go well with pro-active government intervention and guidance. Thus the notion of Taiwanese policy creating and controlling the business network omits several important empirical conditions in the emergence of the network. An important factor seems to be the reliance on an existing network of resources, locally and internationally, within and beyond organizational borders. Taiwanese policy was far away from controlling this larger network, especially

Chichester: John Wiley & Sons..

Easton, G. (1998). Case research as a methodology for industrial networks: A realist apologia. In Naudé, P. & Turnbull, P. (Eds.). *Network Dynamics in International Marketing*. Oxford: Pergamon Press.

Edquist, C. (Ed.). (1997). Systems of innovation; Technologies, Institutions, and Organizations. Pinter.

Eklund, M. (2007). *Adoption of the Innovation System Concept in Sweden.* Doctoral Thesis, Department of Economic History, Uppsala University

Ernst, D. (1997). *What permits David to defeat Goliath? The Taiwanese model in the computer industry*. International Business Economics Research Paper Series

Ford, D., Gadde, L-E., Håkansson, H. & Snehota, S. (2003). *Managing Business Relationships*. Chichester: Wiley & Sons..

Håkansson, H., Ford, D., Gadde, L-E., Snehota, S. & Waluszewski, A. (2009). *Business in Networks.* Chichester: Wiley & Sons.

Gadde, L.E. & Håkansson, H. (2001). *Supply Network Strategies*. London:John Wiley.

Gressetvold, E. (2004). *Product Development – Effects on a Company's Network of Relationships*. Doctoral Thesis. Norwegian University of Science and Technology

Harrison, D. & Waluszewski, A. (2008). The development of a user network as a way to re-launch an unwanted product. *Research Policy*. 37 (1), 115-130.

Hsu, J. Y. & Cheng L. L. (2002). Revisiting Economic Development in Post War Taiwan: The Dynamic Process of Geographical Industrialization. *Regional Studies*. 36 (8), 897-908.

Hughes, T. P. (1987). The evolution of large technical systems. In Bijker, W., Hughes, T. P. & Pinch, T. J. (Eds.). *The Social Construction of Large Technological Systems*. Cambridge, MA: MIT Press.

Hung, S. C. (1999). Policy system in Taiwan's industrial context. *Asia Pacific Journal of Management*, 16 (3), 411-428.

Håkansson, H. & Snehota, I. (1995). *Developing Relationships in Business Networks*, London: Routledge.

Håkansson, H. & Waluszewski, A. (2002). *Managing Technological Development. IKEA, the Environment and Technology*. London: Routledge.

Håkansson, H. & Waluszewski, A. (Eds.). (2007). *Knowledge and Innovation in Business and Industry. The importance of using others*. London: Routledge.

Hägg, I. & Johanson, J. (Eds.). (1982). *Företag i Nätverk*. Studieförbundet Näringsliv och Samhälle. Stockholm.

IMF (2008). *Nominal GDP list of countries*. World Economic Outlook Database. International Monetary Fund.

Jahre, M., Gadde, L-E., Håkansson, H., Harrison, D. & Persson, G. (Eds.). (2006). *Resourcing in Business Logistics – The Art of Systematic Combining*. Sweden: Liber AB.

Lin, M. K. & Trappey C. V. (1997). The development of Taiwan's integrated circuit industry. *IEEE Transactions on Components, Packaging and Manufacturing Technology* - Part C. 20 (4), 235-242.

Lin, Y. (2003). *Industrial Structure, Technical Change, and the Role of the Government in Development of the*

Electronics and Information Industry in Taipei, China. Asian Development Bank. ERD Working paper no. 41.

Liu, C. Y. (1993). Government's role in developing a high tech industry: The case of Taiwan's Semiconductor industry. *Technovation*. 13 (5), 299-309.

Liu, T. H., Chu,Y. Y., Hung, S. C. & Wu S. Y. (2005). Technology Entrepreneurial styles: a comparison of UMC and TSMC. *International Journal of Technology Management*. 29 (1/2), 92-114.

Lo, C. L. & Tung L. R. (1997). Integrated packaging industry in Taiwan. *IEEE Transactions on Components, Packaging and Manufacturing Technology* - Part C. 20 (4), 243-255.

Lundvall, B-Å. (1988). Innovation as an interactive process: from user-producer interaction to the national innovation systems, In Dosi, G., Freeman, C., Nelson, R.R., Silverberg, G. & Soete, L. (Eds.). *Technical Change and Economic Theory*. London: Pinter.

Lundvall, B-Å. (2007*). National Innovation System: Analytical Focusing Device and Policy Learning Tool*. Working paper R2007:004. ITPS.

Mathews, J. (1997). A Silicon Valley of the east: Creating Taiwan's semiconductor industry*. California Management Review*. 39 (4), 26-54.

Mathews, J. & Cho, D. S. (2000). *Tiger Technology - The creation of a Semiconductor Industry in East Asia*. Cambridge: Cambridge University Press.

MOEA (2003). *Introduction to Investments in the Biotechnology and Pharmaceutical Industries in Taiwan, ROC*. Ministry of Economic Affairs, BPIPO. Taiwan, ROC.

MOEA (2005). *Introduction to Biotechnology and Pharmaceutical Industies in Taiwan, Republic of China*. Ministry of Economic Affairs, BPIPO. Taiwan, ROC.

OECD (1996). *The Knowledge Based Economy*. Organisation for Economic Co-operation and Development. Paris.

OECD (2007). *Innovation and Growth Rationale for an Innovation Strategy*. Organisation for Economic Co-operation and Development. Paris.

Penrose, E. (1959). *The Theory of the Growth of the Firm.* New York: John Wiley.

Peng, B. W., Chen, H. G. & Lin, B. W. (2006). A Taiwan research institute as a technology business incubator – ITRI and its spin-offs. *Comparative Technology Transfer and Society*, 4 (1), 1-18.

Porter, M. E. (1990). *The Competitive Advantage of Nations*. London: Macmillan.

Porter, M. E. (1998). Clusters and the New Economics of Competition. *Harvard Business Review*. 76 (6), 77-90.

Rosenberg, N. (1982). Learning by using, In Rosenberg, N. *Inside the Black Box: Technology and Economics*. Cambridge: Cambridge University Press.

Saghafi, M. M. & Davidson, C. S. (1989). The new age of global competition in the semiconductor industry: enter the dragon. *Columbia Journal of World Business.* 24 (4), 60-70.

Saxenian, A. L. & Hsu J. Y. (2001). The Silicon Valley – Hsinchu connection: Technical communities and industrial upgrading. *Industrial and Corporate Change*. 10 (4), 193-202.

Saxenian, A. L. (2002). *Taiwan Hsinchu region: imitator and partner* *for Silicon Valley*. Unpublished Saxenian.

Sher P. J. & Yang P. Y. (2005). The effects of innovative capabilities and R&D clustering on firm performance: the evidence of Taiwan's semiconductor industry. *Technovation*, 25, 33-43.

Shih, T. (2009). *Scrutinizing a Policy Ambition to Make Business Out of Science – Lessons from Taiwan*. Doctoral Thesis, Department of Business Studies, Uppsala University.

Strömsten, T., & Håkansson, H. (2007). Resources in use: Embedded electricty. In Håkansson, H., & Waluszewski, A. eds. *Knowledge and Innovation in Business and Industry. The importance of using others.* London: Routledge.

Sturgeon, T. J. (2000). How Silicon Valley Came to Be, In: Kenney, M. (Ed.). *Understanding Silicon Valley. The Anatomy of an Entrepreneurial Region*. Standford: Stanford University Press.

Swirbanks, D. & Cyranoski, D. (2000). Taiwan backs experience in quest for biotech success. *Nature.* 407, 417.

Teigland, R., Lindqvist, G., Malmberg, A. & Waxell, A. (2004). *Investigating the Uppsala Biotech Cluster*. Cind Research Paper 2004:1.

The Economist (2007). Special report on innovation: The fading lustre of clusters. October 13, 2007.

TSIA (2007). *Overview on Taiwan semiconductor industry.* Taiwan Semiconductor Industry Association. Taiwan, ROC.

Tidd, J., Bessant, J. & Pavitt, K. (2005). *Managing Innovation*: *Integrating Technological, Market and Organizational Change* (3rd edition). Oxford: John Wiley and Son.

Tu, Y. Y. (2001). The electronics and information technology industries. In Hsueh, L. M., Chen, K. H. & Perkins, D. *Industrialization and the State – The Changing Role of the Taiwan Government in the Economy*. Boston: Harvard University Press.

Van de Ven, A., Polley, D., Garud, R. & Venkataraman, S. (1999). *The Innovation Journey.* New York: Oxford University Press.

Von Hippel, E. (1988). *The Sources of Innovation*. New York: Oxford University Press.

Wade, R. (1990)0 *Governing the Market: Economic Theory and the Role of Government in East Asian Industrialization*. Princeton: Princeton University Press.

Waluszewski, A. (2004a). A Competing or co-operating cluster or seven decades of combinatory resources? What's behind a prospering biotech valley? *Scandinavian Journal of Management.* 20, 125-150.

Waluszewski, A., Baraldi, E., Linné, Å. & Shih, T. (2009). Resource interfaces telling other stories about the commercial use of new technology: The embedding of biotech solutions in US, China and Taiwan. *IMP journal.* 3 (2), 86-123.

Wedin, T. (2001). *Networks and Demand - The Use of Electricty in an Industrial Process*. Doctoral Thesis, Department of Business Studies, Uppsala University.

World Bank. (1993). *The East Asian Miracle: Economic Growth and Public Policy.* Oxford: Oxford University Press.

Yang, W. T. & Lee, W. H. (2000). The cradle of Taiwan high tech development - Hsinchu science park. *Technovation*. 20 (1), 55-59.

Yin, R. (1994). *Case study research: Design and methods* (2nd edition). Beverly Hills, CA: Sage Publishing.

Yu, M. F., Hung, S. C., Lin, B. W. & Shih C. T. (2006). *ITRI in Taiwan's Semiconductors: Fueling New Industry Formation*. Paper presented at IAMOT.

Öberg, C. & Brege, S. (2009). What Happened with the Grandiose Plans? Strategic Plans and Network Realities in B2B Interaction. Paper presented at IMP Conference in Marseille, 2009.