Innovation in chains and networks

S.W.F. (Onno) Omta
Wageningen University, The Netherlands

Abstract

In this editorial contribution I will sketch a theoretical framework for research on innovation in chains and networks. Interested research groups around the world can use this information to determine whether it is of interest for them to participate in cooperative research with our group in Wageningen. For it is our ambition to build a worldwide virtual knowledge centre on innovation in chains and networks.

1. Introduction

A central theme in our research programme is the search for critical success factors for steering the innovative processes in the rapidly developing international chains and networks. We draw from various scientific fields, namely social network theory, chain science, and industrial organisation theory; and we combine these insight with the theories related to the management of innovation. Up to now, the management of innovation literature has focused only limited attention at the chain and network level. The main focus has been on the individual company and its interaction with the external environment. The question is whether such a limited view is still tenable. For all the companies hold that they are part of networks of actors that influence each other. One could argue, for example, that most of the fundamental and applied research in the pharmaceutical industry takes place within a network that includes biotechnological companies and research institutions. Similarly, in other business sectors it would be wrong to assume that innovation takes place within one firm. A successful innovation entails not only a new product, but the satisfaction of new demands on quality, quantity, transparency with regard to the origin of natural resources (the suppliers), timeliness (logistics and distribution) and the availability of the product (e.g. at the supermarket). Readers interested in knowing what can go wrong if the cohesion of chain partners in the innovation process is not optimal are encouraged to read the example in the Harvard Business Review of May 2002 (Butman 2002). Therefore, innovation management at the chain and network level is becoming increasingly important.

The article starts with a short introduction of innovation, and innovative success, thereafter the framework for innovation at the company level will be presented. After defining the concepts of chains and networks, the given framework will be applied at the chain and network level.

We then focus on the context, the chain and network structure within which innovation has to take place, and the market and technological developments that create the opportunities for and the obstacles to innovation. Finally, we will link these topics to our research programme.

2. Definition of innovation

First of all, what do we mean by innovation? In our research programme we use the broad definition forwarded by the well-known economist Schumpeter ([1912] 1934), who, early in the 20th century, succinctly described innovation as the creation of new combinations. These new combinations can be a new product, a new technology for an existing application, a new application of a technology, the development or opening of new markets, or the introduction of new organisational forms or strategies to improve results. This means that an innovation can be not only a new product, but a new production process, a far-reaching re-organisation of production and distribution, or even an improved way to achieve innovations, for example by means of venture capitalism. That an important innovation need not always be the result of a spectacular new technology is demonstrated by the fact that it was a distribution innovation, namely the introduction of the container (Rosenberg 2001), that led to the greatest cost-reduction in the transport sector. Innovation processes that go beyond the individual company are also called institutional or system innovations. The distinguishing characteristic of system innovations is that they are complex, because they involve many actors such as the business sector, the government, non-governmental organisations, and of course consumers, and they often require the balancing of ecological, physical, spatial and socio-economic values. This complexity makes it difficult to realise system changes and makes it imperative that system innovations in particular be managed with a system dynamic network approach.

3. Success of innovations

When can we call an innovation a success? On the surface, this would seem quite simple. If the product is not a commercial success, it has failed. However, in practice the answer is more complex. A product may fail in financial terms, but its development may have given a company enough technical experience to make a subsequent introduction very successful. For example, Viagra was discovered when a number of the healthy male volunteers in a clinical test complained about the side-effect of a medicine they had been given for chest pain. As a medicine for chest pain, Viagra failed; but as a medicine for the treatment of erectile dysfunction it has become a great success. This example also demonstrates another element of innovation: the surprise discovery or serendipity, which is so often important. Focusing on the agri-food sector, we can see that here too there is a lack of clarity about what constitutes success or failure. Approximately 700 to 750 new agri-food products are introduced annually in the Netherlands, which means that each product is new in at least one aspect, and that it is being introduced on a relatively large market. Research results provided by Eilander (1997) show that more than 80% of these product introductions fail; while Stijnen et al. (2002) cite recent research indicating that two-thirds of new products are still on the shelves one year later, of which one-half can be considered a (possibly great) success. For a meta-analysis of the concepts success and failure and the success scores of innovations in various studies, I refer to Hollander (2002). Our own research is based on a multi-dimensional understanding of the concept success, which includes financial as well as non-financial parameters.

4. Critical success factors of innovation at company level

In global research on the critical success factors of innovation, I compared the best pharmaceutical companies with those that are more average (Omta 1995). Based on this comparison, I developed a framework of critical factors for successful innovation, which cover the areas of strategy, culture and innovation systems.

First, the *innovation strategy*. Miles & Snow (1978) distinguish the *prospector and analyser strategies* as the most important offensive innovation strategies. Prospectors react immediately to market opportunities and are often among the first to introduce innovations on the market. Yet it is not necessarily the prospectors who will become the market leaders. Particularly with completely new products, the advantages of being the 'first-mover' often turn out to be

illusory. After all, the prospector has to deal with higher development and marketing costs, while other firms can just copy the product and optimise it based on market experiences. For completely new products, the firms that are second or third to enter the market often become the market leader (Hultink 1998 in Stijnen et al. 2002). It is thus not unusual to see analyser firms develop the necessary technology and then wait with it in order to react quickly when a competitor introduces the new product. This means that *timing-to-market* is of great strategic importance.

Second, a *business culture* directed towards innovation is extremely important. While certainly capable of conducting thorough and highly technical research, the somewhat bureaucratic R&D departments of large concerns often lack the flexibility and entrepreneurial drive that are so characteristic of small companies. In my research I observed that the more successful pharmaceutical concerns attempted to recreate the entrepreneurial culture of small companies within or as an extension of the larger concern. Greater autonomy and responsibility were given to the project leader and the R&D project team. In addition, there was an active start-up and spinning-out policy. Many research employees ended up in, often very successful, biotechnology companies that were set up by or in cooperation with these large pharmaceutical companies. A parallel development in other industries was observed by my wife and me in a global benchmarking study conducted in part in the US, where more fundamental R&D is still kept at 'arm's length'. A comparable development can be seen in the Netherlands, exemplified by the recent transfer of KPN Telecom Research to the Dutch knowledge institution, TNO.

The third critical factor is the *innovation system*. The more successful pharmaceutical companies appeared to have a stronger external orientation. They worked together closely with biotechnology firms and knowledge centres, and their employees spent a considerable amount of time attending conferences, writing for publications and maintaining contacts with external actors. In this way, firms run the risk that employees will divulge company-sensitive information during their presentations or in their informal discussions with colleagues. The reality of this risk was demonstrated by Glaxo workers, who were able to develop Zantec, Glaxo's highly successful medicine for the treatment of stomach ulcers, based on information divulged during a presentation at the Technical College of Hatfield by Professor Black, an employee of SmithKline & French, Glaxo's competitor at the time (Omta 1995). It can be considered a consolation that the two firms have merged since then to become GlaxoSmithKline. In the interviews it became apparent that the average firms have concentrated more on secrecy and the

risk of allowing vital information to leak out; while the better firms are apparently less worried about the negative consequences, and place more emphasis on the advantages of external contacts, namely exposure to new ideas and prevention of the 'Not invented here' syndrome. In recent years, the external orientation has increasingly become the subject of research. Among other factors, this has resulted in a plea for integration of consumer values at an early stage in the development process, i.e. the *consumer orientation*. Von Hippel (1988) emphasises in this regard the importance of selecting the right consumers to serve as the 'lead users'. Using a random selection of consumers can at best lead nowhere and at worst push the innovation process in the wrong direction. The better firms also focused more attention on *cross-functional integration*. More departments were involved at crucial steps in the development process, which offered the added advantage of making it possible to discuss problems that could be expected later-on in an early stage of development, e.g. concerning up-scaling and production. More attention was also given to *ICT communication*. Du Pont, for example, has created approximately 240 technology-related and 180 management-related ICT information networks (Omta and Van Engelen 1998). Finally, the *human resource development* systems were directed more towards collective learning rather than emphasising the success of individual projects. Staff exchanges between departments and countries were encouraged on the basis of special competency databases. Diverse career opportunities

were offered, in addition, and as an alternative, to the dominant career path that leads to top management, *'If you want to get on, get out of research'.*

5. Definition of chains and networks

Now that we have shed some light on the critical success factors of innovation at firm level, we will introduce the chain and network perspective from which we study innovations. Within the framework of our research programme, we define a network as follows:

All of the actors within one industrial sector, or between related industrial sectors, which can (potentially) cooperate to add value for the consumer.

We define actors at micro and meso level, for example the individual farmer or consumer, or a company, research institute or governmental department. Within this broadly defined framework, a supply chain can be seen as a special network, namely one in which the partners cooperate vertically.

Figure 1 shows a company as the focal point in a value chain of suppliers and customers, which starts with the initial producer, moves through a number of tiers of suppliers to the focal company, and then proceeds through a number of tiers of customers until it eventually reaches the end-
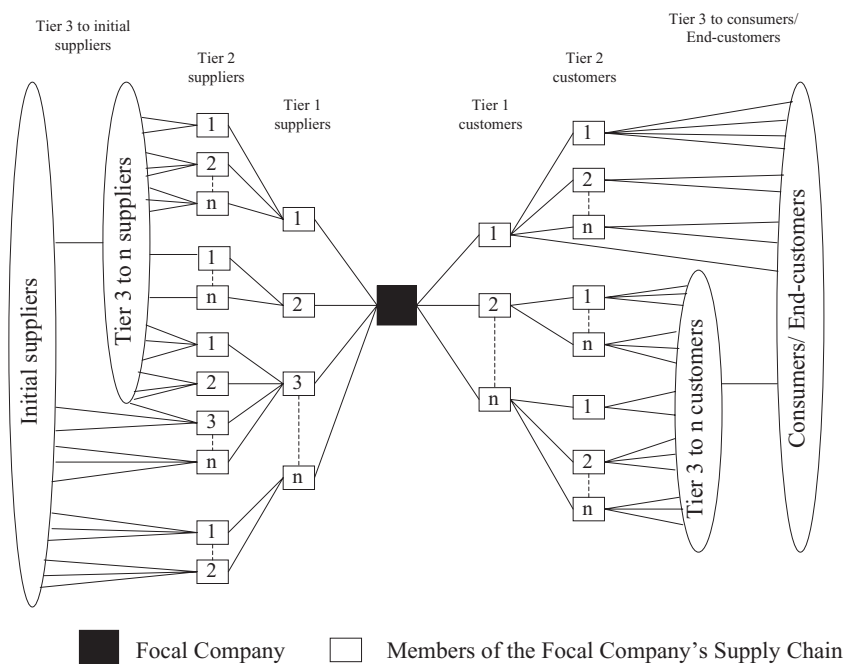

Figure 1. Supply chain structure, source: Lambert and Cooper, 2000.

customer. Supply networks can vary in length and width. The length of a network indicates the number of steps involved between the initial producer and the end-customer, while its width reflects the number of suppliers involved per step. In recent years, the width of supply networks has generally declined due to the movement towards a limited number of 'preferred suppliers' (Van der Vorst 2000). The fact that being a 'preferred supplier' is actually a mixed blessing was demonstrated by the economising operation recently announced by Opel (called 'Olympia') in which expenditures to suppliers will be cut by 400 million euro.

6. Explanatory model for cooperation in chains and networks

We see increasingly that firms no longer just set out on a course towards innovation, but that they prefer to do so in cooperation with others. Examples include co-innovation of suppliers and customers, joint ventures and majority or minority holdings of small start-up companies, particularly in cooperation with knowledge centres. How do we apply our framework for innovation, i.e. *strategy, culture and innovation systems*, to these cooperative relationships at chain and network level? For the top management it all starts with the *strategic choice* between cooperation and integration, by means of a merger or takeover. For example, if the management of a pharmaceutical company decides to cooperate with a biotechnology company in an early stage of product development, then this decision was preceded by the following strategic deliberation. If it were to take over the biotechnology company, it would be buying a share of the company knowing that the chance of receiving a very positive return (that would not have to be shared with others) is relatively small, while the chance is much greater that the takeover would not be profitable at all. The 'New Chemical Entity' may not progress beyond pre-clinical or clinical research, or the present technology may not be sufficient. However, if the pharmaceutical company waits until there is more certainty, and, for example, the biotechnology company has completed the most important clinical research, with positive results, then the costs of a takeover will have increased astronomically, or the revenue will have to be shared with other firms. By entering into cooperative relationships at an early stage with a number of biotechnology companies, the management of the pharmaceutical company reduces its uncertainty by increasing its *strategic flexibility* (Volberda 1992). The management thus buys a package of options, including some that can be expected to fail and others that should eventually perform well enough to greatly outweigh the losses. The number of these options can be very high; on average the largest 15 pharmaceutical companies participate in 50 R&D alliances with biotechnology companies. It is interesting to note that the size of these networks can vary greatly from around 10 to more than 70 R&D alliances per firm. A closer look reveals that these variations stem from completely different strategic concepts held by the top management of the pharmaceutical companies. Interesting questions addressed in our research projects are: What are these differences in strategy based on? And what can this teach us about strategy development in innovation networks?

If we concentrate on the *cultural aspect*, then we see that *trust* plays an important role. A comparable culture, at country or company level, contributes to a relationship based at the outset on mutual trust between the partners. Research conducted by Omta and Van Rossum (1999) on the 'dark side of cooperation' revealed that it is these types of cultural differences that often play an important role in the failure of alliances. A good *reputation* in the network is cited in the management literature as an essential ingredient for initial trust and for the eventual success of a alliance. However, research has shown that these types of assumptions are in fact quite context-related. Bailey et al. (1996) concluded on the basis of their research among 70 alliances that it is not advisable to make a judgment based on previous positive experience with a partner, because a new innovative trajectory will often require different competencies and know-how. Based on their research findings, they even believe that selecting partners based on their good reputation within a network only will doom the project to fail.

Omta and Van Rossum (1999) also concluded that in the innovation management literature too little attention is paid to the contractual aspect of cooperation. In a alliance directed toward innovation, the uncertainty inherent in cooperation is amplified. The advantages of *opportunistic behaviour* can be relatively great, because unexpected, and commercially very attractive, results might be achieved. This is particularly true if a company does not know its partner very well at the outset, which is generally the case in cooperation between industrial sectors and in international alliances. Finally, good *innovation systems* are possibly even more important at chain and network level than for innovation at the company level. For example, without effective monitoring and a clear commitment from top management, daily activities in one's own laboratory will quickly become more important than the interests of the alliance. The research by Omta and Van Rossum also revealed that research conducted in consortiums was more likely to exceed deadlines, with the accompanying risk of losing focus and incurring high additional costs.

7. The context: characteristics of the market, technology, and chains and networks

Now that I have given an overview of the characteristics of cooperation, I would like to focus on the context: the characteristics of the market and technology that provide opportunities for and obstacles to innovation, and the characteristics of chains and networks within which innovation has to take shape. The characteristics of the market and technology refer to turbulence, degree of complexity, dynamics and unpredictability, which are all influenced by the characteristics of the industry as identified by Porter (1985), such as the level of entrance restrictions, substitution opportunities and the level of competition. According to Porter's model, the most important factor at chain level is the balance of power between suppliers and buyers. Depending on the type of market and chain, innovation can offer either the suppliers or the buyers greater advantages. Based on research among 114 suppliers in the auto industry, Kamath and Liker (1990) underlined the importance of this dependence relationship. The most dependent suppliers were prepared to invest (sometimes large sums) in innovation if they knew that this investment was desired by the customer, even if it was not profitable for them from a purely economical perspective.

Authors, like Burt (1992) and Uzzi (1997), formulate the general mechanism by which relationships between firms and the changes in networks can be explained. The explanatory foundation upon which these theories are based uses as a starting point two different aspects of networks, namely the positioning of the firms in the structure of the network and the nature of the mutual relationships. The relevant aspects of the social embeddedness were already noted above in relation to the characteristics of cooperative relationships. The relevant point for our explanatory problem is the degree to which the company has opportunities within the structure of the network. Burt formulates this as the positioning of the actors in a network that enables them to span 'structural holes'. For example, one party can be in a strategic position for the implementation of innovations if it is a partner in more than one tightly-knit cluster of relationships such that it can serve as a bridge by introducing innovations from one network into the other. This leads to the paradoxical situation in which the chance of achieving completely new innovations (the so-called radical innovations) decreases as more and more companies in the network establish mutual contractual arrangements, which is particularly relevant in the formation of chains. Links with other companies in the chain can be so strong that they prevent a company from successfully implementing an innovation, even if it is in a strategic position to do so. Burt calls this over-embeddedness. Burt (1992) also stresses the importance of the network's heterogeneity. Particularly in complex or turbulent markets and technologies, it is important that the network is sufficiently heterogeneous. As, according to Ashby's (1956) famous adage: '*Only variety can destroy variety*'. This aspect of reducing insecurity by increasing heterogeneity was demonstrated above by the 'option strategy' of cooperation between the pharmaceutical and biotechnology companies.

Figure 2 presents the three related elements of the model, namely the context and cooperation characteristics and the critical success factors for innovation at company level. This model makes it possible to make predictions on the potential success of innovations implemented in chains and networks. The combination of the three elements implies that our model is an extension of Burt's model. It predicts the behaviour of individual companies, given their context, structural position and social imbeddedness in the network.

In our research programme we study the consequences of a given network approach, focusing on the analysis of factors that create opportunities for or obstacles to inter-company cooperation directed toward innovation. Our research is designed around three related research themes: innovation benchmarking and system dynamic analysis, agri-pharma innovation and the consequences of internationalisation for innovation in the diverse chains and networks. The research theme innovation benchmarking and system dynamic analysis is designed to obtain a clear understanding of innovation in the various chains and networks. The two other research themes focus specifically on situations in which both the advantages of cooperation and the possible problems that can occur are magnified, namely innovation in agri-pharma alliances, in which the competencies of the two industries have to be integrated, and innovation in international cooperations.

8. Innovation benchmarking and system dynamic analysis

The first part of this research theme involves innovation benchmarking, that is, systematically identifying and comparing the differences in the innovative capacity of various chains in the agri-food sector, with the objective of discovering the underlying causes of these differences. We compare innovations implemented by one chain partner with innovations that involved numerous chain partners, based on their degrees of success and the underlying critical success factors. Galizzi and Venturini (in Alfranca et al. 2002) indicate that much of the innovative strength of the
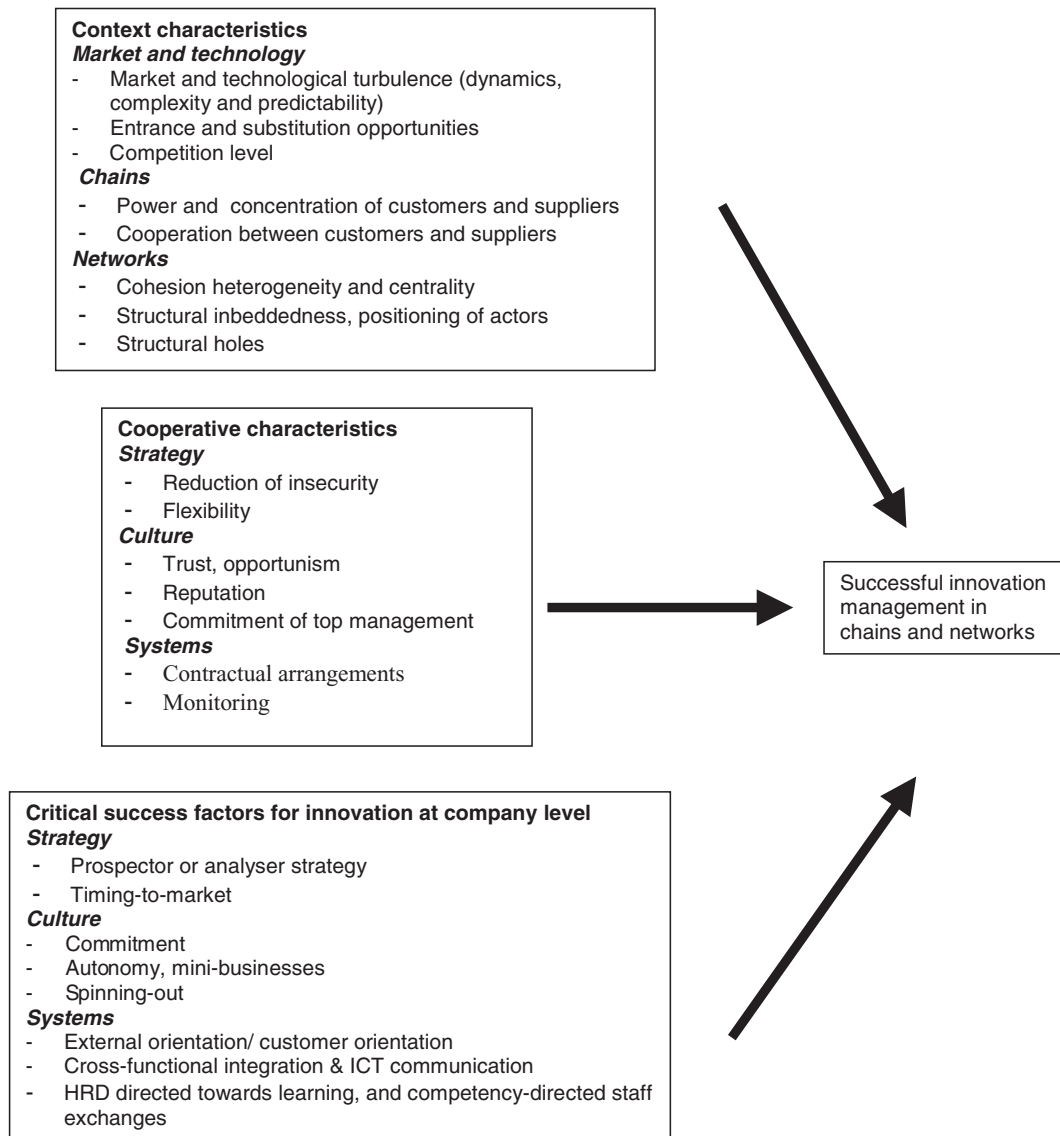
Context characteristics
Market and technology
- Market and technological turbulence (dynamics, complexity and predictability)
- Entrance and substitution opportunities
- Competition level

Chains
- Power and concentration of customers and suppliers
- Cooperation between customers and suppliers

Networks
- Cohesion heterogeneity and centrality
- Structural inbeddedness, positioning of actors
- Structural holes

Cooperative characteristics
Strategy
- Reduction of insecurity
- Flexibility

Culture
- Trust, opportunism
- Reputation
- Commitment of top management

Systems
- Contractual arrangements
- Monitoring

Successful innovation management in chains and networks

Critical success factors for innovation at company level
Strategy
- Prospector or analyser strategy
- Timing-to-market

Culture
- Commitment
- Autonomy, mini-businesses
- Spinning-out

Systems
- External orientation/ customer orientation
- Cross-functional integration & ICT communication
- HRD directed towards learning, and competency-directed staff exchanges

Figure 2. Conceptual framework for the research of innovation in chains and networks.

agri-food sector can be found in the co-innovation of packaging. We investigate which actors have taken the 'lead' in this type of innovation: Is it the 'channel captain' (Venkatraman 1997) or have other firms taken over the role of 'innovation captain'? And what do these co-innovations learn us about the innovative strength of the chains involved? The benchmarking research is a longitudinal study conducted at 4-year intervals, which will make it possible to study cause and effect relationships.

This innovation benchmarking research in various chains provides the database we use for the system dynamic analysis. We study how companies can best approach innovation in their specific chains and networks. We begin

with an analysis of the innovative structure, the institutions, networks and actors. All relevant stakeholders are identified, i.e. the chain partners, competitors, consumers, non-governmental organisations, knowledge centres and governmental institutions; and the formal and informal relationships between them are examined. Subsequently, a so-called 'values and interests map' is created that indicates which (potentially conflicting) values and interests play a role. A system dynamic analysis is then carried out that incorporates in the model the often non-linear relations, feed forward and feedback loops, and (by means of 'gaming') the subjective human assessments. Based on a sensitivity analysis, a hierarchy of expected bottlenecks is drawn. Unexpected consequences of the innovations are thereby

often revealed, and the chain and network conditions under which these consequences occur can then be identified. This eventually leads to the design of those system conditions under which the innovation has the most chance of succeeding, together with an estimation of the risks, costs and benefits and the necessary competencies, means and best alliance partners.

9. Agri-pharma innovation

Burt's assumption that innovation is most likely to occur where 'structural holes' are bridged implies that there is a good chance that innovations will occur where the domains of various industries overlap. In our second research theme we concentrate on the exciting new area that involves both the agri-food and the pharmaceutical sectors, namely the 'functional foods' segment. A whole assortment of 'functional food' products is now being developed in the spectrum between 'food' and 'medicine'. That the two industries meet in this new terrain was demonstrated by the fact that both the Finnish firm Raico, a subsidiary of the large pharmaceutical firm Johnson & Johnson, and the food multinational Unilever introduced a new margarine onto the market, under the brand names Benecol and Becel ProActive, claiming that it reduces the level of LDL cholesterol in the blood. We currently have three projects that are studying the biotechnological developments, particularly genomics and proteonomics (Baltimore 2001), of 'functional foods'.

10. Internationalisation

That the internationalisation of business activities is not a simple task was shown in recent research by Rugman (2001), which indicates that the globalisation of multinational enterprises has progressed only marginally. Most of these multinational companies appear to concentrate mainly on their own regions, which Rugman broadly defines as the EU, NAFTA and Japan. Interestingly, it is the companies within the life sciences industries that form the exception to this rule. Food processing companies such as Unilever and Nestlé and pharmaceutical companies such as Bayer, GlaxoSmithKline and Novartis operate literally around the globe. Of course it is not so surprising that food companies operate globally. It is now possible to ship fresh food products around the world and sell them fresh throughout the year for a reasonable price. The large agri-food companies are participating more and more in international networks, which enable them to make optimum use of the opportunities that various regions can offer. However, most multinational companies have not been very good at managing their international activities. Profit margins

outside of their own regions are considerably lower, and they are not capable of anticipating changes in local conditions. Ahold, for example, has pulled out of China and reduced its activities in the rest of Asia, not to mention its predicament caused by the recent crisis in Argentina. Many other examples could also be cited, such as the problems experienced by Numico, with its recent takeovers in the USA of GNC and Rexall Sundown. Surely Numico must have underestimated the American mentality and readiness to 'sue the bastards'. As noted earlier, international alliances often fail, in part due to overwhelming cultural differences. One of our research projects is aimed at structurally identifying these cultural differences in order to offer the business community an instrument with which they can gauge their plans for international cooperation.

It is our ambition to become an internationally recognised knowledge centre on innovation in chains and networks. We therefore invite research groups in other countries to join us, so that we can work together towards achieving this goal.

References

Alfranca, O., R. Rama and N. von Tunzelmann 2002, A patent analysis of global food and beverage firms. The persistence of innovation. *Agribusiness*, Vol. 18, No. 3, pp. 349-68.

Ashby, W.R. 1956, *Introduction to Cybernetics*. Chapmann and Hall, London.

Bailey, W.J., R. Masson and R. Raeside 1996, Choosing successful technology development partners: A best practice model. *Proceedings of the 6th International Forum on Technology Management*, pp. 271-83.

Baltimore, D. 2001, Our genome unveiled. *Nature*, Vol. 409, pp. 814-16.

Burt, R.S. 1992, *Structural holes. The social structure of competition*. Harvard University Press, London, Cambridge (Mass.).

Butman, J. 2002, A pain in the (supply) chain. *Harvard Business Review*, May, pp.31-46.

Eilander, G. 1997, Nieuwe producten falen vooral wegens niet waargemaakte belofte, *VMT*, No. 23 pp. 35-7.

Håkansson, H. and I. Snehota (eds) 1995, Developing relationships in business networks. *International Thomson Business Press*, London, Boston.

Hippel, E. von 1988, *The sources of innovation*. Oxford University Press, New York, Oxford

Hollander, J. 2002, *Improving performance in business development. Genesis of a tool for product development teams*, PhD thesis, University of Groningen.

Kamath, R.R. and J.K. Liker 1990, Supplier dependence and innovation: A contingency model of supplier's innovative activities. *Journal of Engineering and Technology Management*. Vol. 7, pp. 111-27.

Lambert M.D. and M.C. Cooper 2000, Issues in supply chain management. *Industrial Marketing Management*, Vol. 29, pp. 65-83.

Miles, R.E. and C.C. Snow 1978, *Organizational strategy, structure, and process*. McGraw-Hill, New York.

Omta S.W.F. 1995, *Critical Success Factors in Biomedical Research and Pharmaceutical Innovation*. Kluwer Academic Publ., Dordrecht, Boston, London, 285 pp.

Omta S.W.F. and J.M.L. van Engelen 1998, Preparing for the 21st century. *Research.Technology Management*, Vol. 41, No. 1 pp 31-44.

Omta, S.W.F. and W. van Rossum 1999, The Management of Social Capital in R&D Collaborations. in *Corporate Social Capital and Liability*, R.Th.A.J. Leenders and S.M. Gabbay (eds), Kluwer Academic Publishers, Boston, Dordrecht, London, pp 356-376.

Porter, M.E. 1985, *Competitive Advantage, Creating and Sustaining Superior Performance*. Free Press, New York.

Rosenberg, N. 2001, Challenges to the social sciences in the new millennium. *Tokyo Social Science and Innovation Workshop*, OECD, pp. 7-27.

Rugman A. (ed.) 2001, *The Oxford handbook of International Business*. Oxford.

Schumpeter, J.A. 1934, *The theory of economic development*. Harvard University Press, Cambridge (Mass.).

Stijnen, D.A.J.M., F.P Scheer, F.M.S. Martins and R.P.M. de Graaf 2002, *Productinnovaties in agriketens*. ATO/LEI Report, The Hague, Netherlands.

Uzzi, B. 1997, Social Structure and Competition in Interfirm Networks: the Paradox of Embeddedness. *Administrative Science Quarterly*, Vol. 42, pp 35-67.

Venkatraman, N. 1997, *The emergence of value networks*. Index Genesis Research report, GSC Index Research and Advisory Services, London.

Volberda, H.W. 1992, *Organizational Flexibility. Change and Preservation*. PhD thesis University of Groningen, Wolters Noordhof, Groningen.

Vorst, van der J.G.A.J. (2000), *Effective food supply chains: generating, modelling and evaluating supply chain scenarios*. PhD thesis, Wageningen University.