

The use of technological systems to explain the development of complex technological innovations

Nardeosingh Rambhujun, Jean François Trinquécoste

I.A.E. Bordeaux4 University

Technology is considered as the hallmark of progress in developing and advanced economies. Research at the macro and micro economic levels shows the importance of R&D in world competition. Advanced countries have instituted supporting bodies to help private firms in their innovative activities as there is a common belief that R&D cannot be considered as an isolated activity. The cooperation among firms belonging to the same or different industrial fields on the one hand and on the other hand among firms and public laboratories enhances scientific, technical and financial support necessary for innovation. This is the picture that the active world reflects when we observe all those firms whose activities are located in the technology sectors.

Research on technological innovations, shows that there are many ways of studying the impact of technological development. Schumpeter was among the first to theorize the innovation process when he explained how a product can be made obsolete by a better one and describes this as the dynamic phenomenon of “creative destruction”. What is different with regards to Schumpeter’s theory is the speed with which technological innovation occurs and the intensity of knowledge incurred in innovations which, as a result, convey a high level of technological asymmetry between sellers and buyers. This means that potential users of technology are not in a position, because of its complexity, to say if the innovations can bring value to their businesses. The greater the complexity of a technology, the more difficult it is for an innovating firm to reach the market and the risk is high. In such a situation how a complex technological innovation is connected to the market seems to be a relevant question. The first seminal researches on high technology, in the seventies and the eighties focused attention on the success and failure factors of products and services. The very basis of these researches was of predictive nature. The development of knowledge-based theories considered technology as a very specific asset generated by a firm. Much research has been done concerning technology generation and the absorption capacity of a firm. Most of those researches considered the firm as the unit of analysis. Among them some focused attention on discontinuous innovations and it was widely recognised that complex technology cannot be considered as “a work-alone” asset. It needs to consider complementary technologies, as well as economic, social and political components. This led some researchers to adopt a network approach. Henceforth our questioning concerns the approach adopted to connect complex technological innovation to the market and what is the appropriate unit of analysis. .

The first section of this paper starts by a brief literature review of the market integration approach in the high technology sector. The second section presents a case study concerning the development of a complex technological innovation and the third tries to draw some conclusions from the case study and define some specific marketing considerations.

A review of literature

Marketing concept is considered to be a theory based on the identification of customer needs and on the decisions to be taken to satisfy these needs better than competitors. Market research is the tool that will help to define market segments and the needs. In this approach the identification of needs is the starting point of the marketing strategy and the unit of analysis is the firm. According to the cost-transaction theory we would say that marketing contributes to minimize on the one hand the coordination costs between buyers and sellers (Williamson, 1985) and on other hand the hierarchy R&D costs by designing products that will fit customer needs. Among these researches those interested by technology used this market approach. For them the identification of market opportunities is closely related to the detection of customer needs which starts with the market-oriented strategic planning where a firm has to identify the changing market opportunities and adapt its resources to fit them. Rochford (1991) believes that strategic planning determines the innovation need “(...) by situation analysis and often market research (.....). Determination of innovation need provides the basis for establishing the firm’s new product objectives and the resources to be committed to the new product development”.

In this category of researches the origin of innovations is explained by opportunities on the market (Rosenberg and Mowery 1978 Von Hippel 1975, Lauglaug 1993, Doudherty 1990, Thomas 1985). Some seminal research papers based on high-tech products studied the causes of success and failure of products (Myers and Marquis 1969, Freeman 1979 Cooper 1979, Modesto and Zirger 1984, Rosenberg and Mowery 1978). The

aim is to identify the causes of success and failure so as to define strategies to avoid failure. The starting point of innovation is the recognition of market needs. For Schmookler (1966) inventions occur because human beings try to solve economic problems or exploit economic opportunities. Whereas Von Hippel (1978), referring to the medical instrumentation sector, shows to what extent users are at the origin of ideas. He coined the “customer active” paradigm. We can say this category of researches pertains to a control environment, that is, they are predictive, using the product as the unit of analysis. Lauglaug (1993) explains how market oriented firms are encouraging customers to join them in the innovation process. This author used the term “Technical market research” to design this collaboration.

Parallel to this school of thought a new trend based on the fact that, in the high-tech sector, the supply side(technology-push) initiative is of vital importance (Moriarty et al (1989). This, by no means undermines the importance of the market. It puts emphasis on the specificity of the high technology sector and the necessity to define a radically different approach to reach the market. Lynn et al (1996), Dosi (1988) show to what extent market cannot be a driver of discontinuous innovations. In this stream of thought Farley et al (1993), Schoonhoven, Eisenhardt, and Lyman (1990) have put emphasis on such variables as size, resources and organisation. These authors seem to value the firm as the driver of innovations. Shanklin (1984) believes that because of an increased level of uncertainty related to expected technical and scientific performance of products and to the difficulty to understand customer needs we need to design and practise supply-side marketing. For Gronroos (1994) there is a paradigmatic change in the sense that the four Ps which characterize traditional marketing must be readapted to fit high-tech situations. This author discusses “the nature and consequences of the dominating marketing paradigm of today, marketing mix management of the managerial school and how evolving trends in business and modern research into, for example, industrial marketing, services marketing and customer relationship economics demand a relationship-oriented approach to marketing”.

Srivastava et al. (2001) call for a closer link between marketing and the resource-based theories. They believe that proponents of resource-based theories have downplayed “the processes by which resources are transformed through managerial guidance into something that is of value to customers”(p.778). Marketing for high-tech products face what Mohr and Shooshtari (2003), call “double jeopardy environment”, related on the one hand to the engineering oriented nature of firms in which high-tech innovations occur and on the other hand to the marketing insight which is much more important than in other industries. The nature of this double challenge calls for a cooperative behaviour recognizing the fact that technological knowledge is co-constructed and that it may include market factors. Dosi (1982) when studying technological change stated that it occurs through a combination of technologies and non-technological factors. Metcalfe and Boden(1992) state that “accumulation of technological capability is not random, but structured by technological and non-technological factors”. This produced a drastic change from the firm as a unit of analysis to a network of firms. Grandori & Soda(1995) in a review and analysis of literature distinguish two adversarial trends: one in which networks are considered to be an intermediary or hybrid form of organization between firms and markets while in the other they are a third type of organizations. Networks have their own properties: complementarities of resources, governance of interdependence, coordination, asymmetry of resources and flexibility. Ekbja & Kling (2005), applying the network approach to the Enron case, come to the conclusion that existing analytical models cannot analyze the complex interrelations. In a network organization some specific features should be considered: the heterogeneity of players (internal divisions, private firms...) autonomy and asymmetry (various goals, resources and strategies), nuance and multivalence (relationship between two actors might be multiple, variegated and stable), dynamism (part or the whole of a network may undergo changes), nondeterminism (the right balance in an era of information overload) and contingency (new challenges that must be constantly met). A series of articles published in “management Science” in 2007 definitely initiated a new direction in network research. If networks are undoubtedly recognized as appropriate units of analysis for complex systems, the integration and the management of heterogeneous components have a long way to go. According to Amaral and Uzzi (2007) “Complex systems arise whenever there are populations of interacting agents (persons, organizations, or communities) that act on their limited and local information. That is, agents and larger system in which they are embedded operate by trading their resources without the aid of a central control mechanism or even a clear understanding of how actions of (possibly distant) agents can affect them”.

The integration of technological and non-technological factors has been studied in the eighties by sociologists (Callon 1986, 1992, Hughes ,1987). Callon applied the “actor-network” concept to the development of the electric car, in the seventies, in France which was intended to be a major innovation. The author describes the complex social, economic and political interplay between actors and how these actors use non-human factors to serve their purpose. In fact the project failed mainly for “political” reasons as Renault, the automobile firm, was relegated to a position of producer of base-frame of electric car. Renault used its powerful lobbying relations to compel EDF to stop the project. However Callon specifies that what he is questioning “is the claim that it is possible to distinguish during the process of innovation phases or activities that are distinctly technical or

scientific from others that are guided by an economic or commercial logic". Researchers are becoming more and more aware of the fact this approach can be useful to explain the impact of technological development. Gao (2005) used the actor-network theory to analyze strategy formulation process in the telecommunications market. Hughes (1987) studied the birth and development of electricity as a technological system. He describes the path followed to bring electricity from an invention to a wide scale use. This happens within a technological system. The starting point of which is the invention of electricity. But to make electricity available turbogenerators, transformers and transmission lines had to be invented supported by financial organizations. Potential users of electricity were invented to be the first users of electricity.

Some economists applied this system approach to marketing. For example Jolly (1997) listed the market constituents of a new technology. He identified the upstream and the downstream constituents that can favour a technology's entry on the market (Advocates and arbitrators, Incumbent and Competing Technologies and Partners in delivery). He explains how GM Hughes, a direct TV satellite service company, chose to work with RCA-Thomson because of its 11 000-dealer retail network. In this literature the unit of analysis is a technological system and it is created progressively to fulfill the requirements of a technological project. It seems to be more in line with the effectuation theory (Read S., Dew N., Saras D. Sarasvathy S., D., , Song M., & Wiltbank R., 2009). For these authors "Effectuation inverts the fundamental principles, solution process, and overall logic of predictive rationality (...), specifies three types of intangible resources with which the effectuator cocreates new ends (i.e., new firms, products/services, and markets) through an iterative and interactive process of stakeholder acquisition".

In view of the different units of analysis used it was decided to choose the case study of a complex technological innovation that has known success in order to track the path it followed from the laboratory to the market. What is a complex technological innovation? Complex innovations are defined as "radical", "breakthrough", "technology-intensive" or discontinuous innovations. "Radical innovations are "so different that they cannot be compared to any existing practices or perceptions. They employ new technologies to create new markets."(Mohr, Sengupta and Slatter, 2001 p.18). John et al. (1999) define intensive technology as "scientific knowledge applied to useful purposes (...), this definition captures the scientific knowledge embodied in a product's functionality, as well as manufacturing and sales knowledge." P79. Discontinuous innovation is driven by a new technology motivated by the emergence of new markets (Birkinshaw et al., 2007). Tidd et al. use two factors (novelty of markets and novelty of technology) to categorise innovations and complex innovations are concerned by new markets and new technology. There is consensus in the literature to consider, at least, these two aspects to qualify as complex innovations.

A case study: The development of Cold Plasma Technology:

Our purpose is to track how a complex technological innovation is brought to the market, i.e., to answer "how" questions" which are more explanatory and likely to lead to the use of case studies, histories, and experiments as preferred research strategies. This is because such questions deal with operational links needing to be tracked over time, rather than mere frequencies or incidence"(Yin 1994 p.6). "Case study is preferred in examining contemporary events"(p.8). The author emphasizes that case study method is used to test a theory in order to confirm recognized principles, to refute accepted facts or to complete what is known. In fact this method is also adapted to situations that cannot be explained when using traditional methods.

The case of Cold Plasma technology has been chosen because it was considered to be a complex technological innovation. The technology for this very specific application came out of a research laboratory and as a result the market did not exist at that time. Interviews were conducted with R&D engineers, the marketing director responsible for this project and technicians who had been working directly on this project. The historical development of this technology has been reconstructed using minutes of proceeding, reports produced by the members of the project and interviews.

From the idea to the prototype

Pens is a company specialised in new materials, its competence is based on applied chemistry and is working for different industrial sectors (space, automobile, aeronautics and military). It is also known for its competence in the plasma technology. The idea stemmed out of a problem that the firm was facing, that is, the internal part of engines sold to industrial customers was sometimes covered by a coating due to oxidation and could be responsible for breakdowns.

In the early 90's the engineers developed an interest for Cold Plasma (low pressure) Technology with the hope of applying it for processing of internal coating of engines as existing methods were not totally satisfactory. In 1993 the various in-house research and tests led to the installation of a prototype machine in the

firm's laboratory. Various experimentations were conducted by the firm's engineers and led to the conclusion that the technology was sufficiently advanced to be developed for industrial purposes. The feasibility studies not only showed that the machine would require heavy investments but it would also be in excess capacity with regards to internal use. For the system to be viable, industrial applications for new customers should be developed in order to increase return on investment. At the same time the investment should be shared by external partners otherwise the project would come to a standstill.

From the prototype to industrial applications

To pursue the project one issue was to subcontract R&D studies for regional universities and SMEs. With this idea in mind the C.E.O contacted the Regional Committee for Research and Technology who agreed to fund part of the project provided the existence of a bipartite agreement between PENS and a public organisation and this company chose a local university. This agreement would enable the parties to receive an allowance of 50% of the investment and the local university would be co-owner of the equipment. This solution solved the problem concerning the starting investment and there remained the use of the excess capacity. The C.E.O established contacts with regional SMEs explaining to what extent this new technology could enhance their competitiveness. Seven SMEs were very interested in the project and saw in it a means of solving their production problems. During the meeting with the Regional committee, Pens expressed its desire to work with a public organisation involved in technology transfer. In fact the technological knowledge to be transferred was time and money-consuming. The committee on their side contacted a local organization LECTNOVE, funded partly by Europe, specialised in the transfer of new technologies to industrial sectors.

In the meantime several meetings were held to identify the best opportunities for the technology and the various industrial applications and this in collaboration with the SMEs. It appeared that complementary competence would be necessary in the preparation of surfaces before “sticking” as well as knowledge in the treatment of Polymer, etc. At this stage, a small firm specialized in the preparation of surfaces was invited to join the group. One among the many criteria which lead to the choice of this firm was the fact that this small firm would be used as a gateway as it has established clientele on a national basis. Several public and private laboratories working on Polymer or new materials were invited to form part of the system (Figure 1).

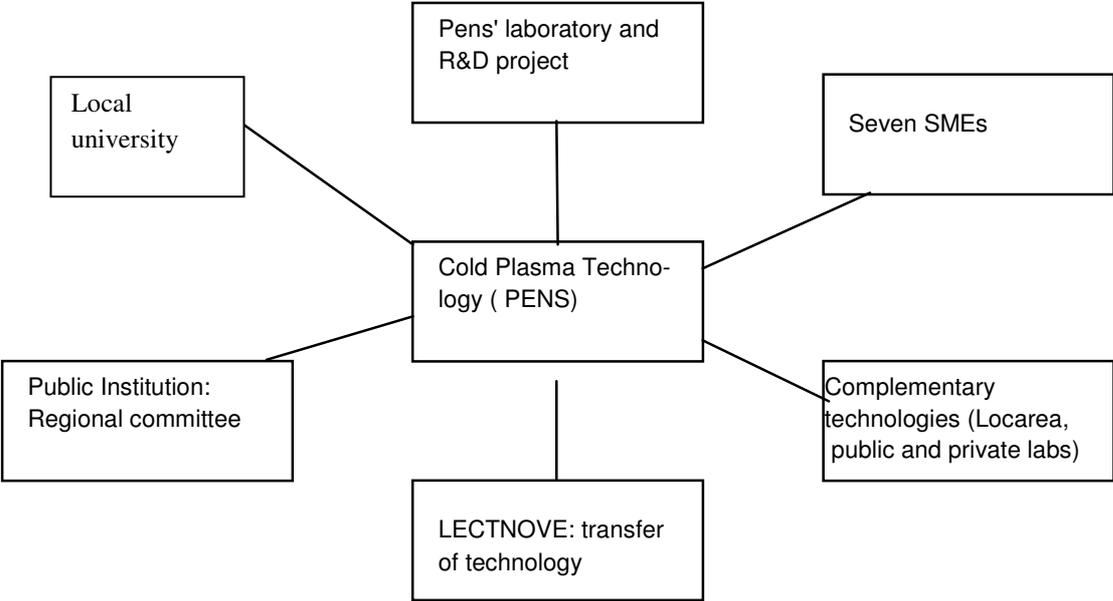


Figure 1

Hence we notice that the primary goal of the firm was to develop a new technology to improve competitiveness but progressively the project took an unexpected form by sharing investment and extending its service to external customers. Sharing technology because of the firm's inability to raise capital was not the only reason that motivated PENS to look for new partners. It was also interested in getting access to critical research capabilities or to very specialized knowledge since time to market was of utmost importance and huge sums of money had already been invested in R&D. PENS could not afford to leave that technology unexploited. It could have licensed the invention to other companies but the C.E.O was against this idea as it would have meant eroding part of the competitive advantage of the firm and at the same time losing control of the technology. This decision to develop the project gave birth to a completely different view, that is, a network of several firms. So from this financial motivation and the desire of controlling the technology the system grew out to be a coherent one which can be analyzed through the three stages described by Forrest (1992) namely pre-alliance, agreement and implementation.

Pre-alliance

PENS had conducted the R&D project till the development of the Cold Plasma Technology. The knowledge generation in this phase pertains to PENS who is the sole owner of the intellectual property rights. The core of the system concerns the use of the excess capacity generated by the equipment installed to exploit this technology.

One can imagine that in such a situation all partnership starts by what is described as a secrecy agreement as the technology will be disclosed. So the starting point of the system was to identify the partners. As it has already been stated the local university is the co-builder of the system, together they had to choose the laboratories that were best suited to work on the project.

A long foregoing tradition of partnership exists between PENS and that university. This large firm was in a position to identify the various university laboratories that could be of interest for the project. As some of the engineers had already worked with university researchers, there already existed some personal interaction between them. It all started by various informal meetings explaining the purpose of the project and the competences that would be required. The two main partners started a canvassing campaign in order to find adequate actors capable of supporting the system. Then during a formal meeting it was decided to start the agreement phase by the signature of the secrecy "act".

Agreement

In this phase it was important to describe the role of each partner. It was clearly stipulated that the excess capacity would be subcontracted for industrial applications. The equipment would be installed in the building of PENS. All demands coming from the customers would be received by the chief technicians of PENS who will be in charge of the necessary measures for "optimization" and the following up of the surface treatments. In case of very specific R&D contracts the different laboratories would undertake supplementary characterization studies. Whenever more knowledge in "sticking" technology would be necessary Locarea would be contacted. The first customers would be the seven SMES who had accepted to take part in the system. The group would help these SMEs to seek allowances from adequate public bodies. It was agreed that Locarea would contribute to do market research as it had full knowledge of the targeted market. When the alliances among the parties were concluded, the system was ready for the implementation phase (Figure 2).

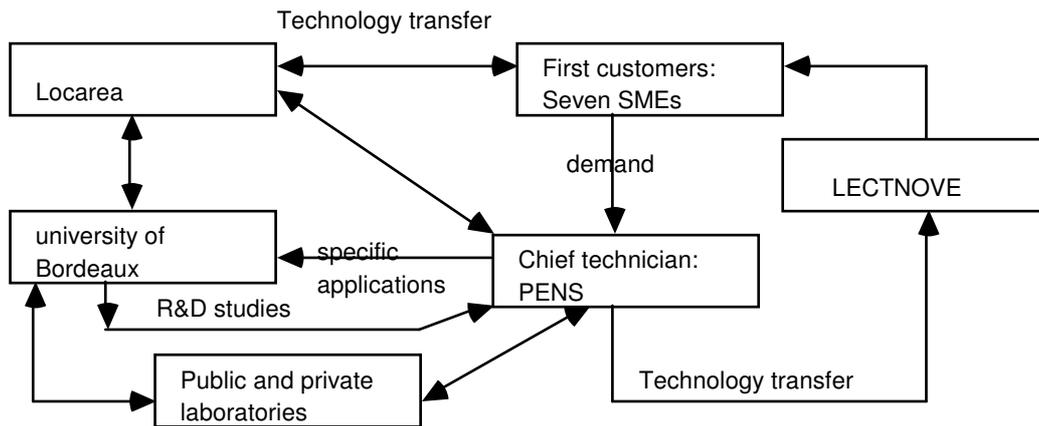


Figure 2

A “technological system is bounded by the limits of control exercised by artifactual and human operators” (Hughes p52). In the case of Cold Plasma Technology the locus of power was defined by the amount of excess capacity that could be subcontracted. This span of power was under the control of PENS and the local university acted as a co-owner. But in fact Pens had full control of the system as all demands were addressed to it and the dispatching was done by a chief technician of PENS . So we can say that the system was managed by PENS. However all the stakeholders in the system had accepted to work on a cooperative basis.

The university would be requested to deal with specific applications if PENS did not possess the required competence. At the same time the university might need the collaboration of other public laboratories or that of Locarea. In fact any member might use any other stakeholders' competence. Besides specific applications the university or public laboratories would carry out R&D studies on the equipment installed in PENS buildings and in that case they, too, would have to address their demand to the chief technician of PENS. Once the demand, especially those of the seven SMEs had been addressed LECTNOVE might intervene to help in the transfer of technology by financing the necessary training needed to receive the technology, given the fact that any member of the system might assume this responsibility. When all aspects were precisely defined, the system was ready for the implementation phase. Figure 2 gives an idea of the state of relations that existed between the different partners.

Implementation

By 1998 the project was fully financed and in September the machine was installed and became operational in December of the same year. The collaboration with the SMEs was very promising and the various projects submitted by them started in the early 1999. Part of the projects was handled directly by PENS while those which needed specific competence were handled by the relevant laboratories. The test period showed that the system was working as planned and could be developed on a commercial basis by the end of 1999.

It was then decided to identify market opportunities for a wide scale industrial application. Three categories of competing surface treatment techniques were identified (mechanical, chemical and physico-chemical). Cold Plasma Technology belonged to the last category and it was again important to distinguish among the various possibilities offered by physico-chemical technologies (hot, thermic and cold Plasma). With reference to the different applications developed in the SMEs and other identified opportunities the advantages and inconveniences of cold plasma were compared to competing technologies. At the same time different sectors where this technology could be applied had been analyzed so as to choose those firms which could benefit from that technology and could appreciate its market value. Another dimension that had been discussed was the evolution of law and ecological considerations. At that time, the legal bodies were more exacting as a recent European decision were about to set norms and standards to be respected as far as treatment and coating of surfaces were concerned. Those norms and standards were viewed as a source of competitive advantage for the Cold Plasma Technology as it did not cause pollution.

In the implementation phase, the competitive market conditions were also evaluated so as to prepare the entry of the system on the market (Figure 3).

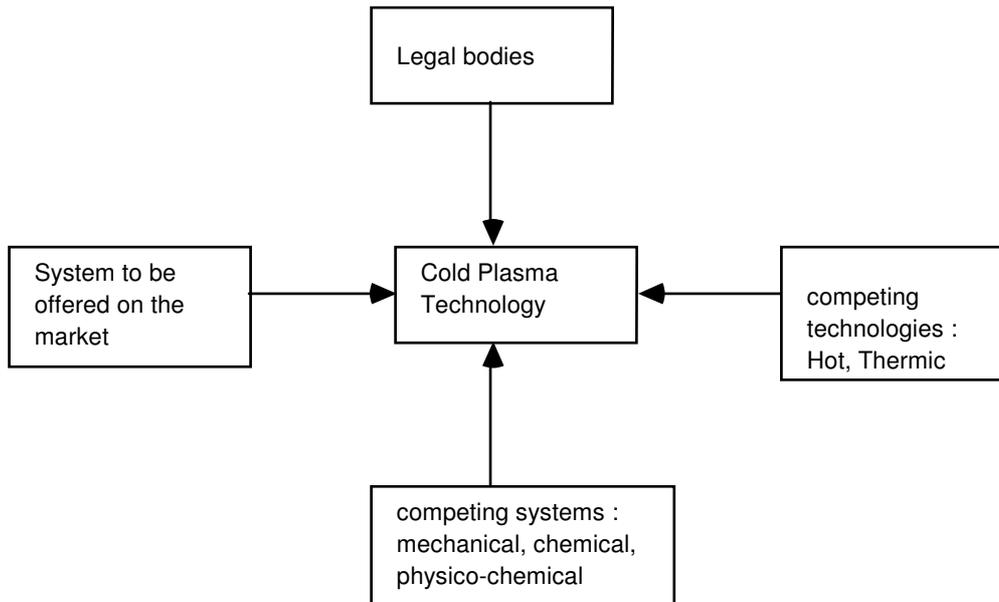


Figure 3

The system that is marketed is composed of various elements: R&D projects, industrial applications, treatment of small lots of parts, training and consultancy. In fact it means that PENS and its partners decided to practise system-selling (Figure 4)

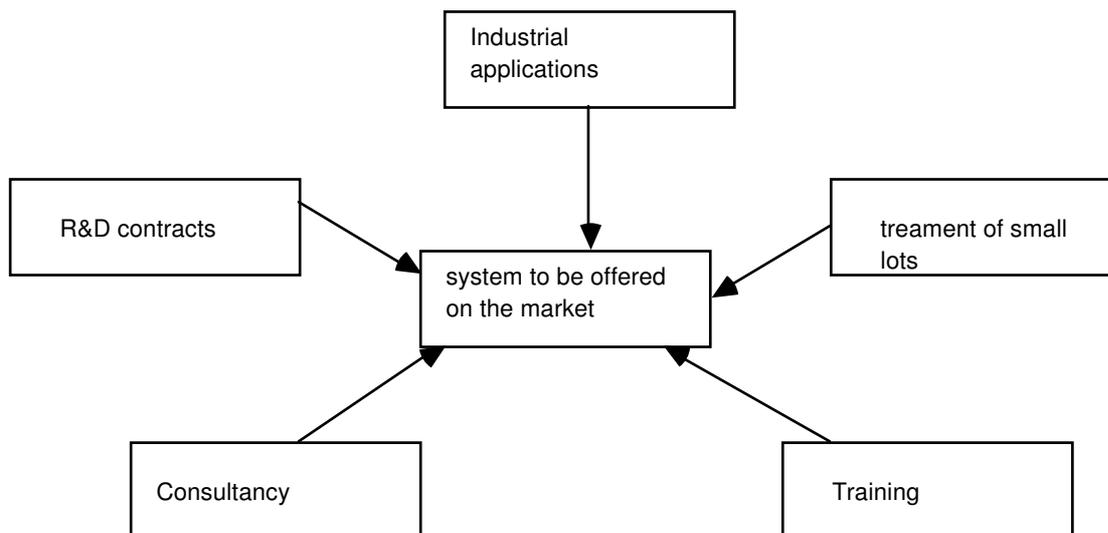


Figure 4

A customer might buy the whole system or part of it. Behind each component of the system offered on the market there existed specific competence. For example the R&D contracts were executed by PENS or the local university, while treatment of surfaces required the expertise of Locarea. Lectnove, for example, financed a small firm for the training module which was delivered by a laboratory and a member of the network. So we can say that the collaboration between the stakeholders did not stop when the technological innovation came to the market. Success depended on the long term cooperation between them.

What is important to bring to light here is the fact that when it was decided to launch the system on an industrial basis, the players were in a position to answer to almost all the tenders from potential customers. In fact many firms fail at this stage because they do not have a clear idea of the difficulty that very specific projects may represent and of the competence required to fulfil their needs.

Discussing the case study and Marketing implications

The idea generation process starts by a problem-solving situation. PENS found that existing technologies could not give a satisfactory answer to its engine internal coating problem. Based on cold Plasma competence it initiated a R&D project. The excess capacity changed the trajectory of the project, to become an integrated system being managed by the owner of a key technology. The seven SMEs which joined the network experienced a high level of technological asymmetry with regards to PENS. LECTNOVE was in charge of technology transfer in order to reduce that technological asymmetry. When developing high tech products and testing them by in-house laboratories, very often it is difficult to have a full view of their functionalities and drawbacks in real world. The seven SMEs can be seen as an extension of PENS laboratory. The birth of the market can be located in the network when the finalised products satisfied the technological needs of these SMEs. It is a situation of co-evolution of technology and market.

As a result systems can be considered to be an appropriate unit of analysis when radical innovation is concerned. The Cold Plasma system was created and was in competition with three categories of surface treatment techniques, themselves represented by technological systems. This means that competition takes place between systems. Marketing should be enriched to deal with competition between systems.

The success of the system depends on the choice of partners, the level of collaboration and coordination.

The choice of partners:

A long standing collaboration existed between the local university and PENS which was beneficial for this firm during the technological feasibility phase of the project. The research competence of the university offered a certain level of guaranty. The deliberate choice made was to remain R&D specific and to commercialise specific products. The technology and process developed would produce semi-finished products that these SMEs would use in their particular own processes. It was tailor-made products which required a wide scope of competences. Some actors (Locarea and Lectnove) were invited to participate in the system because of their market connexion. This is in line with the GM Hughes case (Jolly (1997) where in the inception phase of a project upstream market strategies are defined. On the whole each partner was competence-specific, and was chosen for its contribution to the success of the system,

The level of cooperation and coordination

Pens was the holder of the key competence and as such decided to take over the management of the whole system. That key technology was protected through a patent and all the partners were invited to sign a secrecy agreement. The agreement was necessary because some partners, suffering from a certain level of technological asymmetry, benefited from a competence transfer process. The organization was clear for every partner. It had clearly been stated that all demands should to be addressed to Pens' technicians who dispatched them with regards to the competence needed. The communication mechanisms were based on the function of each party and it created a stable social coordination.

Based on the case study our point is that whenever a technological innovation requires specific and highly sophisticated knowledge that one single firm cannot afford, there will be a tendency to form integrated networks. As most high-tech systems are complex and multi-technologies, the need to collaborate is unavoidable. As a result a system will be created for breakthrough technologies. However a technological system is a dynamic ensemble. With time the key technology at the basis of the system will be eroded and will lose its specificity. In other words it will reach the maturity phase and in that case the system will be broken-up or may be replaced by another one. We can here just mention how the analogical photography system has been replaced by the digital one. As from the years 2000, all those shops selling argentic films, for example, were closing their doors while the digital technology was opening new market opportunities for technological devices.

How marketing can use a system is the next challenge? It is a widely accepted fact that in the high-tech sector firms have to watch the technological trajectory (Nelson and Winter, 1977) which is "the path of progress established by the choice of a core technical concept on the outset" (Utterback, 1996). As seen in the case study a breakthrough technology will create a system and if a firm would like to enter the system it has to connect the specificity of its competence to a technological system. For example if a firm is specialised in high density calculators and would like to join the electronic car system (car of the future: see figure 5), it has to adapt research projects

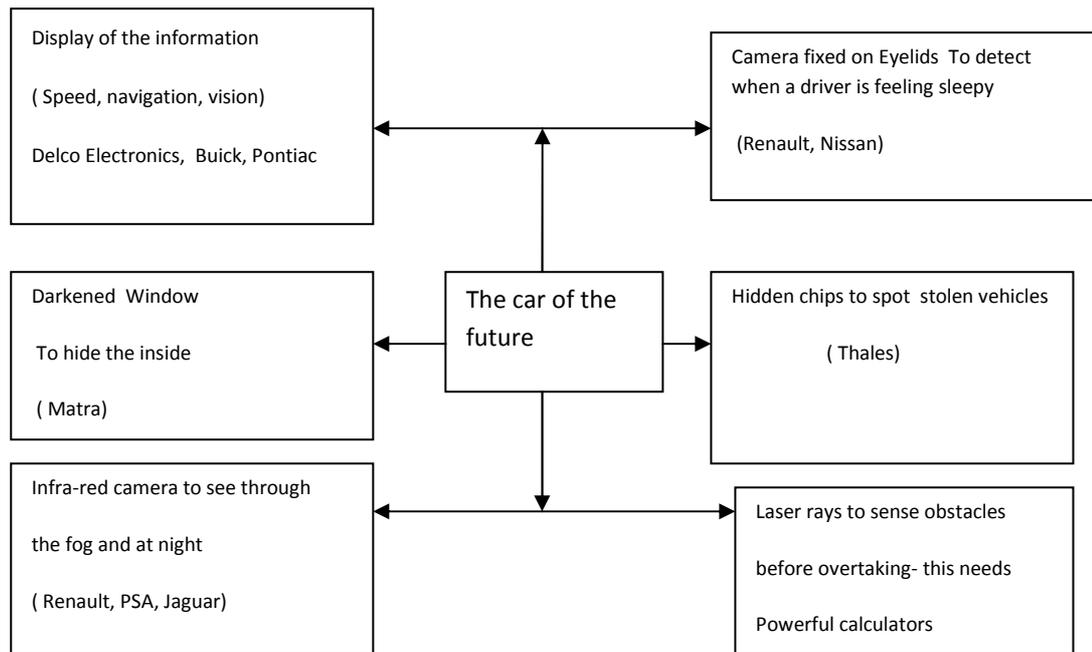


Figure 5

to fit electronic cars. So the starting point is the identification of a system that is marketed. Next it has to identify a related component of the system that hinders performance or can bring superior value to the system. In this particular case our firm will track the technological path of high density calculators. By bringing more value, the chance to be a member of the system will be high. It has to identify who makes the rules and behaviours in the system and will try to develop upstream strategies (alliances) with the “behaviour makers”. Another way of entering a system is to create new value by the provision of new functionalities and this will enlarge the frontiers of the system. However a partner who wants to keep its status in the system must innovate to better its performance.

The European and U.S prototypes of the electronic car exist already. If marketed they may be in competition. Our point here is that competition may exist between systems and market share will depend on the value for users of this type of cars. At the same time one particular member can participate in both systems to share risks.

We believe that the use of the concept of technological systems can help marketers involved in discontinuous innovations to identify and follow technological trajectories, to detect technological opportunities, to define upstream marketing strategies, to choose partners that can upgrade their technological knowledge base as the product complexity demands the integration of a broad variety of specialized skills or favour market entry. The main drawback of this concept is that it had been applied to socio-technical systems and several authors have questioned its usefulness. It has also been used to explain the development of industrial sectors and as such it lies beyond the sphere of micro-level interest of marketing. Today there is a growing literature insisting on the use of technological systems as a third form of organisation between the market and the firm. These systems can take different forms and there is a strong need to do more case studies in order to understand the complex set of relations implied when developing a discontinuous technology.

References

- Amaral N. A.L., Uzzi B.,(2007), Complex Systems- A New Paradigm for the Integrative Study of Management, Physical, Technological Systems, *Management Science* Vol 53, N°. 7, July, pp 1033-1035.
- Birkinshaw J., Bessant J., Delbridge R., (2007), Finding, Forming, and Performing: creating Networks for Discontinuous Innovation, *California Management Review* Vol. 49. N°. 3 Spring.
- Cooper R.G.,(1979) “ The Dimensions of Industrial New Product Success and Failure” *Journal of Marketing* 43, pp.93-103
- Callon M.,(1986) *Society in the making: The study of Technology as a Tool for Sociological Analysis*, in Bijker W E., , Hughes H P., and Pinch T., (eds) (1987), *The social construction of technological Systems: New Directions in the Sociology and History of Technology* Mass Press, Cambridge,MA p. 83- 106.
- Callon M.,(1992) The dynamics of techno-economic networks, in *Technological Change and Company Strategies* (Coombs, Saviotti, Walsh(Eds.)) Academic Press Limited p. 49-71
- Carlsson, B. (Ed) (1995) *Technological Systems and Economic Performance: the Case of Factory Automation* (Dordrecht, Kluwer).
- Carlsson, B. & Stankiewicz, R. (1991) On the nature, functions and composition of technological systems, *Journal of Evolutionary Economics*, 1, pp. 93- 118.
- Dosi,G (1982), Technological paradigms and technological trajectories: asuggested interpretation of the determinants and direction of technical change, *Research Policy*, vol.2, n°. 3, pp 147-162.
- Dosi G, (1988)“ The nature of the Innovative Process” in *Technical Change and Economic Theory*, Pinter Publishers, pp.221-235
- Dougherty D, (1990) “ Understanding New Markets for New Products” *Strategic Management Journal* Vol 11 pp 59- 78 1990
- Ekbia H., R., Kling R., (2005), Network Organizations: Symmetric Cooperation or Multivalent Negotiation? *The Information Society*, 21: pp. 155-168.
- Forrest, J.E. (1992) “Management Aspects of Strategic Planning” . *Journal of General Management* 17 , pp 25-40.
- Freeman C.,(1979), “*The Economic of Industrial Innovation*” Penguin Modern Economics Texts, 409p.
- Grandori A., Soda G., (1995) Inter-firm Networks: Antecedents, Mechanisms and Forms, *Organization Studies*, 16/2 pp. 183-214.
- Gao P., (2005) Using actor-network theory to analyse strategy formulation, *Information Systems Journal* 15,pp. 255-275.
- Gonroos Christian .(1994) From Marketing Mix to Relationship marketing, *Management Decision*, Vol 32. N° 2, pp 4-20.
- Hughes P. H.,(1987), “The Evolution of Large Technological Systems” in *The social construction of technological Systems: New Directions in the Sociology and History of Technology* Mass Press, Cambridge,MA
- Lauglaug S.A(1993) “ Technical-Market Research- Get Customer to Collaborate in Developing Products” *Long Range Planning*, Vol 26 N° 2 pp 78-82
- Jolly K.V., “ Getting from the mind to the Market” Harvard Business Press 1997, 410p.

- Lynn S.G, Morone G.J, Paulson S.A (1996) Marketing and Discontinuous Innovation: The probe and Learn Process *California Management Review* Vol. 38, N° 3, Spring pp 8-37
- Metcalf J.S., Boden M., Evolutionary Epistemology and the Nature of Technology Strategy, in Technological Change and Company Strategies (Coombs, Saviotti, Walsh(Eds.)) Academic Press Limited 1992 255p.
- Modesto A.M, Zirger J B, (1984) "A study of Success and Failure in Product Innovations: The case of the U.S Electronics Industry", *IEEE Transactions on Engineering Management* 31(4) pp.192-20.
- Mohr J., Sengupta S., and Slatter S., (2001) "Marketing of high Technology Products and Innovations" Prentice Hall: 451 p.
- Mohr, J., J. and Shooshtari, N., H., (2003), 'Introduction to the special issue: Marketing of High-Technology Products and Innovations', *Journal of Marketing Theory & Practice*, 11:3, 1-12
- Myers S, Marquis D.G (1969), "*Successful Industrial Innovations*" National Science Foundation Washington - NELSON R.R, WINTER S.G (1982), "*An evolutionary theory of economic change* ", Cambridge MA, Harvard University Press
- Nelson R., Winter, S. (1977) In search of a useful theory of innovations, *Research policy*, vol.6n°1, pp.36-77. Moriarty R.T., Kosnik T.J .(1989), High-Tech Marketing : Concepts, Continuity and Change, *Sloan Management Review*, N° 7 Summer
- Rosenberg N, Mowery, "*The Influence of Market Demand upon Innovation*" *Research Policy*, 8, 1978
- Read S., Dew N., Saras D. Sarasvathy S., D., , Song M., & Wiltbank R.,(2009) Marketing Under Uncertainty:The Logic of an Effectual Approach **Journal of Marketing Vol. 73 (May 2009), 1–18**
- Rochford Linda, (1991)Generating and screening new product ideas *Industrial Marketing Management*, 20, 287-296p.
- Shanklin W.L., Ryans J.K.(1984), *Essentials of marketing high technology*, Lexington Mass, Lexington Books,.
- Scott John (1987), *Social network analysis a Handbook* John London, Sage Publications 124p.
- Peter J., Scott J., Wasserman S., eds., *Models and Methods in Social Network Analysis* Cambridge University Press, 2005, 344 pp.
- Schmookler J, (1966) "*Invention and Economic Growth*" Harvard University Press, Cambridge,
- Schoonhoven C.B, Eisenhardt K.M, Lyman K, " Speeding Products to markets: Waiting Time to First Product Introduction in New Firms," *Administrative Science Quarterly* , 35, pp. 177-207.
- Srivastava RK K., Fahey L, Chritensen H.K.,(2001) "The resource-based view and marketing: The role of market-based assets in gaining competitive advantage" *Journal of Management* 27 pp. 777-802.
- Thomas R J,(1995)" Problems in Demand Estimation for a New Technology" *Journal of Product Innovation Management* 3, pp.145-157
- Tidd J, Bessant J, Pavitt K (1998), *Integrating technological, Market and organizational Change*, John Wiley & Sons, 337 p.,.
- Utterback J.,M., (1994), *Mastering the Dynamics of Innovation* Harvard Business School Press 253P.
- Von Hippel E, (1978) " Successful Products From Customer Ideas" *Journal Of Marketing* pp. 39-49
- Williamson, O (1975) *Markets and Hierarchies*. Free Press, New York
- Yin R. (1994), *Case Study Research: Design and Methods* Beverly Hills, CA: Sage Publications, Vol. 5.