Societal Embedding and Product Creation Management

J. JASPER DEUTEN, ARIE RIP & JAAP JELSMA

ABSTRACT *Societal embedding of new products—that is, their integration in relevant industries and markets, their admissibility with regard to regulation and standards, and their acceptance by the public—is a challenge. A management approach is developed based on our case studies in the biotechnology sector and on recent innovation literature. Tools are presented to map internal and external alignments. Learning processes, in interaction with societal actors, overcome the dilemmas or at least make them manageable.*

Introduction

The recent theme issue of *Technology Analysis & Strategic Management* on critical perspectives on technology management makes an important point: "The broader social and environmental implications (of technological innovation) have been largely ignored in the technology management literature".[1] On the other hand, firms and other technology actors are increasingly confronted by issues of ecological soundness, public acceptability and other aspects of 'societal quality'. They have to 'manage' these issues, one way or another, and they do so, by trial-and-error.

In this article, we present a management approach that allows managers within a firm to include what we will call 'societal embedding' in the management of product creation processes (PCP). To do so, managers need to have a broader and deeper notion of success, one that includes 'integration' in relevant industries and markets, 'admissibility' according to regulation, and 'acceptance' by the public. While we take the perspective of the firm introducing new technologies and products, the approach does allow outsiders' perspectives to be taken into account.

Our approach is simple in principle: one need not fatalistically await whatever societal embedding of one's product will result, but can anticipate and actively work towards desirable societal embedding. Thus, in addition to, and integrated with, PCP, one can think and act in terms of processes that create societal embedding, i.e. 'societal embedding creation processes' (SECP). In sectors like biotechnology, where integration in business chains and public acceptability are major issues, firms have taken up the challenge of such an integrated management approach (PCP + SECP), even if in a partial and not always successful way. By combining an assessment of their experiences with an analysis based on recent understanding of innovation processes and introduction

J. Jasper Deuten, Arie Rip and Jaap Jelsma are at the School of Philosophy and Social Sciences, University of Twente, PO Box 217, NL-7500 AE Enschede, The Netherlands. E-mail: j.j.deuten(a.rip/j.jelsma)@wmw.utwente.nb.

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of new technology in society, we are able to offer a better approach, as well as some relevant management tools.[2] If we say 'better', this is a theoretical claim: our integrated approach and the new tools have not yet been applied. On the other hand, the learning by trial-and-error that has occurred in the biotechnology sector points in the same direction as our integrated approach, and parts of it can be recognized in recent interface management practices. Internal interfaces between functions in a firm as well as external interfaces between firms and their environments are important.[3] For the external interfaces, staff departments like regulatory affairs and public affairs have emerged in larger firms in some sectors.

In the next section, we shall identify three key issues in innovation and product creation processes, which also occur, and with a vengeance, in the management of PCP + SECP, with its increased complexities. The integrated management approach we propose in the subsequent sections addresses and to some extent resolves these combined issues. We are careful in our phrasing here, because it is in the nature of PCP and SECP that there are no definitive and generally applicable methods to resolve these problems. Often, one cannot go further than identifying and articulating the questions and choices, and take an informed decision. But this is already much better than current practices, in which issues of societal embedding are bracketed until a late stage in the process. As Thomas, in his article in the theme issue, emphasizes and the editors approvingly quote, it is important to "produce organizational participants who are able to reflect on their experiences and avoid the potentially damaging consequences of innovation, for themselves, their organizations and the world beyond".[4]

Management of PCP and SECP

The concept of 'societal embedding' needs some clarification. Why is it necessary to broaden and deepen the notion of market success? On the one hand, the abstract concept of 'market' is not very useful in a world in which insertion in business chains, linkages with various users and adaptation to present and expected regulation and standardization are more important success factors than marketing in the traditional narrow sense.[5] Further, while immediate customers and users determine sales and thus the success of the product, their adoption decisions depend on other than market factors, including public acceptability. The reluctant uptake in the food sector of products based on transgene technology is an example of fear of negative public reactions.

Thus, it is necessary to introduce a concept like 'societal embedding,' which captures this broader notion of success. Three dimensions characterize this notion:

- *Integration:* New products have to be integrated in relevant industries and markets. Embedding in existing practices and cultural repertoires of users is required. Suppliers and customers have to adjust themselves to new products, in the sense that it affects their production processes, and/or allows them new combinations.
- *Admissibility:* New products have to be admissible according to the rules and standards set by government agencies or the sector. A complicating factor is that in many cases appropriate regulation for new products based on new technologies is not available.
- *Acceptance:* New products have to be accepted by the public. Public resistance can cause the failure of a new product. A product is accepted, we propose, when three conditions are fulfilled: societal concern is not overly large, there has been sufficient articulation of the pros and cons so that choices can be made consciously and the new product is actually used.

Note that 'public acceptance' is only one dimension of embedding technology in society. It can be linked to the other dimensions—for example, when admission by regulatory agencies creates public acceptance—but, as the case of biotechnology shows, there is no guarantee.

The broader notion of success refers to the societal quality of the product, and this cannot be realized within the traditional boundaries of the firm. One cannot, therefore, assume that traditional management structures will be adequate; we referred already to new departments of regulatory affairs and public affairs. On the other hand, better management of external interfaces will not help if product development has not anticipated on issues of societal quality. The primary challenge for management of SECP lies at the level of new product and process development. Thus, our discussion of the new management approach will focus on the project team or project network, which is responsible for the product development. In practice, external relations, and sometimes firm strategy, which are the responsibility of central management (chief executive officer, board of directors), are important—for example, in high-level consultations with government regulatory officials and ministers. Not to burden our text with provisos to this extent, we include central management in the project team temporarily, when it takes such action.

If management of PCP + SECP can never completely control the process of creation of societal embedding, the implication is that it will depend on strategies of external actors. Thus interactions and alignments with these actors are important.[6] For technological interdependence, Rosenberg noted: "Many of the numerous instances of entrepreneurial failure can be attributed to the fact that a would-be entrepreneur failed to consider the relevant conditions of interdependence between the component with which he happened to be preoccupied and the rest of the larger system".[7] More generally, it is a question of interacting with environments, but this is beset with difficulties.

We shall briefly discuss three types of difficulties. Our discussion is based on recent literature on innovation management and on case-study material from the biotechnology sector.[8] The same sources provide the frame for our subsequent presentation of the broader management approach.

Behaviour of Firms Towards the Environment

The nature of the environment in which a new product has to survive is essential for its getting embedded. The relevant environment of product innovations can be divided in three parts (see Figure 1), functionally defined as follows:

- *Business environment:* Actors in the business environment have input–output relations with PCPs (for example, suppliers, customers and research institutes).
- *Regulation environment:* Actors are local, regional, national and international governments and other regulatory bodies (including standard setting bodies).
- *Wider society:* Actors are consumer organizations, environmental groups, animal protection organizations and also public opinion leaders, media and independent scientists.

Looking from within the firm, i.e. the traditional perspective of PCP managers, the environment is almost necessarily seen as concentric layers around the PCP (Figure 2). The first layer is the business environment, the second layer is the regulation environment and the third layer is wider society.[9]

The business environment is the most familiar one for management of PCP, while the wider society is unfamiliar, and remote from PCP. Alignments with all three parts of the environment have to be made eventually. In practice, our case studies and experience

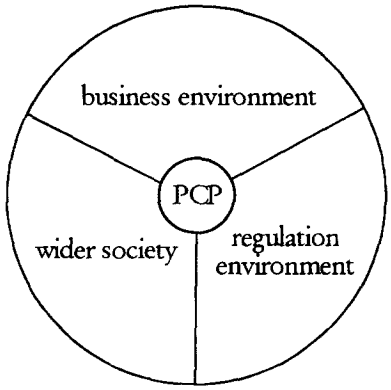

Figure 1. The relevant environment of PCP.

show that the environments are not addressed simultaneously, but sequentially. The web of alignments in which the new product is to be embedded is gradually filled in. In many cases management of PCP wants to clarify the functional and technical aspects of the new product before it makes alignments with other parts of the environment. Therefore, in the early stages, alignments with the business environment are seen as the most relevant. Only after the product concept is more definite do links with the regulation environment become important. Alignments with the wider society are only put on the agenda in later stages of the PCP, in particular if resistance of the public is expected, or becomes manifest.

Thus PCP managers will often have a sequential approach to the environment. This may well be unavoidable.[10] When management is forced, as in biotechnology, to deal with alignments with the wider society, this is still taken up only in later stages of PCP, or not at all. Learning by error, as happens when products fail, can lead to reassessment, and a willingness to be more anticipatory.

PCP and Contingencies

Managing PCPs is a complicated business. New products are developed by a heterogeneous team in a complex and dynamic environment, and embedding also depends on the position and strategy of other actors. In other words, PCPs are shot through with

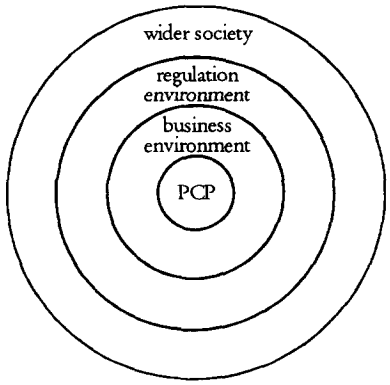

Figure 2. The environment of PCP as concentric layers around PCP.

Table 1. A comparison of the conventional wisdom and our observations

	Literature implicitly assumes:	**But we see**
Ideas	One invention, operationalized	Reinvention, proliferation, reimplementation, discarding and termination
People	An entrepeneur with fixed set of full-time people over time	Many entrepeneurs, distracted, fluidly engaging and disengaging over time in a variety of organizational roles
Transactions	Fixed network of people/firms working out details of an idea	Expanding and contracting network of partisan stakeholders diverging and converging on ideas
Context	Environment provides opportunities and constraints on innovation process	Innovation process constrained by and creates multiple enacted environments
Outcomes	Final result orientation; a stable new order comes into being	Final result may be indeterminate; multiple in-process assessments and spin-offs; integration of new orders with old
Process	Simple, cumulative sequence of stages or phases	From single to multiple progressions of divergent, parallel and convergent paths, some of which are related and cumulative, others not

contingencies. Gradually a new product is created, without anyone really knowing beforehand what the product will look like in detail eventually. The stereotypical image of PCP, however—also in a large part of the literature—is that PCP is a purposive, rational process. People involved in PCP will often tell such a linear story, in retrospect. One of us has traced this in more detail for the development of the enzyme fytase.[11]

Van de Ven *et al.*, in their extensive, real-time study of innovation projects, contrast the stereotypical image with their own findings (Table 1).[12] Managing PCP is not like following a plan, but is more like managing uncertainties and contingencies. "An innovation is, almost by definition, a leap into the unknown. It may be necessary, in order that the innovation have a chance to succeed, to relax traditional notions of managerial control."[13] PCPs should be seen as innovation journeys with several set backs along the road. "Innovation success might be more usefully viewed as 'byproducts along the journey' than as end results."[14] When one wants to deal with contingencies during a journey, retrospective attributions of success to certain approaches or persons is risky. "Such attributions reinforce the myth that managing innovation is fundamentally a control problem. Rather it should be seen as one of orchestrating a highly complex, uncertain and probabilistic process of collective action."[15] When the management of PCP also wants to manage the societal embedding creation process, the notion of control is even more deceptive. "[M]anagement cannot control innovation success, only its odds."[16] This implies that the management of PCP should direct itself to the creation of circumstances and conditions which enhance the chances of success. Good preparation and anticipation of possible problems during the innovation journey increase the chance of success.[17] Including SECP as management task will introduce more contingency, and fewer possibilities to 'control the odds'.

Problems of Anticipation

Everyone will agree that it is important to act prudently. But anticipation is not always a simple matter, not only because short-term issues get priority over long-term consider-

ations,[18] but also because new product development is not a linear process. PCPs hardly ever follow the ideal path starting with a new idea, followed by the distinct stages of invention, development and innovation, and ending with introduction, adoption and diffusion. During the PCP many cases of iteration and feedback occur, and as a consequence there is no definite starting point—the concept of the product-to-be—from which one can anticipate.

Clark and Wheelwright note that managers often anticipate too late. They emphasize that "managers often seem to respond to problems as their importance becomes apparent", and argue that as a consequence actions are undertaken at moments when only little flexibility is left.[19] Anticipating is most effective at an early stage of PCP, when room for change still exists. In our case studies of product innovations in Dutch biotechnology firms it appeared that in some cases firms only paid attention to wider society by the time the new product was near market introduction. Signals of public concern and resistance reached management of PCP too late to be incorporated in the product concept and consequently the success of the innovation was at risk.

Management should anticipate in time to avoid problems in later stages. But anticipating is most difficult when the product concept is still flexible, as it is in an early stage of the PCP. Without a definite product concept, it is difficult to make detailed forecasts or to interact with external actors. Already within the firm, interaction with other functions is difficult. For example, one characteristic reaction in case studies in Dutch biotechnology firms was: "It is highly dangerous to link up with marketing at a stage when you, as R&D, do not yet know exactly what you can do with this new possibility".[20]

So an anticipation dilemma exists: anticipating in an early stage is necessary, but inevitably diffuse and uncertain. Anticipating at a later stage can be more precise, but is less effective (because costs of changing the product increase in the course of PCPs). As the need for fast product development has increased in the last decade, this dilemma has become more pressing.

Managing the Extended Innovation Journey

The first step in the management approach of PCP + SECP is to confront the increased complexity head on: that is, not shirk away from the new challenge to create societal embedding, but include it from the beginning.

A principal, even if difficult, way to manage the innovation journey is to use an extended version of concurrent engineering. Concurrent engineering implies intensive interaction between upstream and downstream functions, and upstream and downstream are regarded as parallel, rather than sequential, processes. Furthermore, concurrent engineering implies integration of functions. Cross-functional teams are used to stimulate integration.[21] Concurrent engineering is a reaction to changes in the business environment (increasing international competition, decreasing product life cycles, growing demands of customers and consumers, etc.). Managing for societal quality implies that pressures in the regulation environment and wider society have to be taken into account as well. So extended concurrent engineering approaches, if necessary somewhat redefined, provide tools and suggestions to manage PCP + SECP.

To begin with, management should have a clear picture of the different activities in the PCP that are being done, not necessarily distributed accordingly to an official division of labour in departments and units. In PCPs, people do not work completely independently of each other, but work in teams and build on the work of others. R&D, for example, is often a self-contained activity, but there may be situations where part of

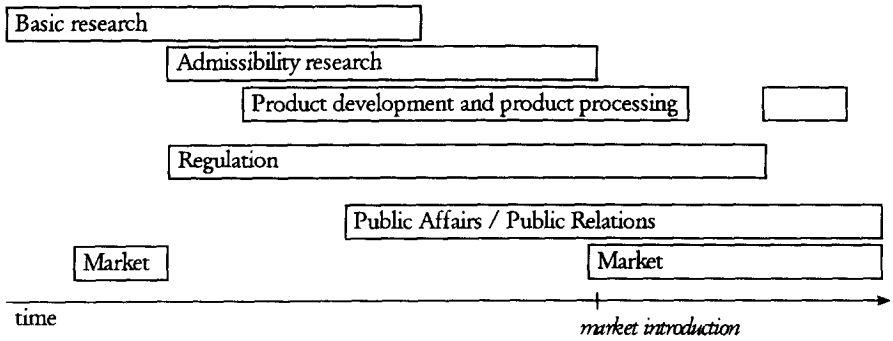

Figure 3. Development lines in a product creation process.

design is done in close interaction with production, and/or with a lead user. Concurrent engineering in the real world has to coordinate on-going dynamics—which is difficult, but if successful, makes a difference—rather than just organize meetings between official functional units. In practice, project team leaders and some active team members often do a lot of informal coordination and repair work.

What we propose here is to recognize the importance of actual on-going dynamics, and map them in terms of different 'development lines'. A development line is defined as a series of activities with internal connection and cumulation, and with its own dynamics, up to the forming of a 'world' of its own.[22] R&D, production and marketing can be examples of development lines with their own 'worlds', cumulation and dynamics, but development lines may well cross organizational or functional divisions in a firm. PCPs can be mapped in terms of development lines, even if the organizational structure is different, and management of PCP can use this as a tool to make assessments about the desired degree of parallelism of the different development lines and the necessary coordination between them. Moreover, these maps help to create a shared understanding about the direction of the PCP.[23] Mapping should be seen as a process rather than a one-time exercise, and thus be a line, rather than a staff, responsibility.

Figure 3 visualizes development lines in a PCP. The R&D line consists of basic research, admissibility research and product development and application research. After market introduction, additional product development and application research are often needed. The regulation line includes patent directed research, patent applications and negotiations. The third development line is aimed at the environment and often consists of public affairs/public relationships and marketing.[24]

The key step in extended concurrent engineering is the introduction of an additional development 'line' dedicated to embedding in society. Management of PCP + SECP also has to orchestrate activities necessary to create alignments with the wider society. Although these activities partly take place outside the firm, they should be seen as a part of the internal business process that needs to be managed, and get timely and structural attention.

Cross-functional teams should be extended to include someone who is responsible for the alignments with the wider society to ensure that societal embedding issues are integrated in decision-making at the level of product innovation. In this way, societal quality can be put on the agenda of the PCP.[25]

The concept of different development lines enables management to make decisions about the coordination of these lines. Alignment between the lines is necessary to find integrated solutions. Timing and sequence of the internal alignments is an important

aspect of the management of PCP + SECP, because activities and results in one line of development have consequences for the flexibility in the other lines. For example, once registration tests have been done in the 'regulation line', R&D cannot develop a new prototype without extra costs because that would mean new, expensive and time-consuming tests.

Within development lines, decision occasions occur. Decisions to involve another function—another development line—are crucial. For example, at what stage should marketing get involved in the PCP? In the R&D line it is quite common to wait with involvement of other lines until there is more clarity about the technical and functional characteristics of the new product. Because of the need for fast product development, this is not advisable.

In the societal embedding line, anticipating embedding should be seen as an on-going process, not an activity that should be done once to check if public resistance can be expected.[26] If anticipating is seen as a process, it offers a way out of the anticipation dilemma. Activities in the societal embedding line should start with the formulation of 'scenarios for embedding'. These scenarios articulate how a new product can get embedded in its environments.[27] They are an important input for 'routeing' the innovation journey. When management makes decisions about the product definition and positioning in the market, it also has to select a scenario for embedding. Along the road of the innovation journey the selected scenario for embedding should gradually become more fleshed out. This is important because in practice one often sees that such scenarios, if used at all, are only used in the early stages of development and are not updated or monitored during the PCP.[28] By continuing to use scenarios, PCPs can profit both from early, broad anticipation and later, more concrete anticipation.

How much work has to be done in the societal embedding line depends on the anticipated 'seriousness' of the embedding problems. If scenarios are articulated and monitored, unnecessary failures or costly repair work can be avoided.

Orchestrating Alignments with the Environment

Internal alignments are important for success of an innovation, but alignments with the environment are just as important. Extended concurrent engineering highlights the importance of timing, selection and monitoring of alignments with the environment. In order to orchestrate alignments—and not go for a sequential approach immediately—two issues have to be resolved: (a) what is a productive strategy to orchestrate alignments and (b) how to monitor what is happening and what has been achieved, so as to be able to adapt. We start by briefly discussing mapping relevant environments.

In marketing and in strategic analysis, mapping relevant environments is important, and many techniques are available. Recently, stakeholder analysis and other techniques to identify actors that might be encountered in the introduction of a new product have been used.[29] For the question of societal embedding, these techniques can be adopted, but should be broadened. Studies of constructive technology assessment offer relevant insights and heuristical advice.[30] For biotechnology, Jelsma and Rip have sketched four interlinked domains to be mapped (see Figure 4).[31]

In mapping and monitoring the environment, a firm should remember that it is only one among several relevant actors, and so be sensitive to new and unexpected developments. On the other hand, in monitoring its external alignments, PCP remains the 'centre of the world'. Thus, 'concentric maps', based on Figure 2, can be used to map alignments (see Figure 5). It is in assessing these maps that sensitivity to being part of multi-actor processes is required.

(1) *Structure of the sector and the production chain*

Embedding in society is partially determined by other firms (e.g. suppliers, customers and competitors) and branch organizations. If, for instance, customers do not want to use a new product, it will not get *integrated* in the market. When mapping this part of the environment, assessments have to be made about the willingness of firms to make the necessary preparations and adaptations.

Mapping of the production chain —and the developments in it —is also necessary to assess the possibilities and necessity of coordination between the different firms in case of expected problems with embedding in society. If firms have a common interest in the embedding of a new technology, collaboration is a possibility. Branchy organization can play an important role in the coordination of different market introductions of new products, and in the interaction with governments and societal actors.

Other important indicators in mapping the business environment are the intensity of (international) competition and the degree of concentration and vertical integration.

> Dutch biotechnology firms are increasingly aware that consultation with actors in the production chain is important for the societal embedding of new biotechnological products. 'Chain management' is suggested as a means to come to a mutual adjustment of actions of firms upstream and downstream the production chain. The branch organization NIABA already plays an important role in this 'chain management'.

(2) *Regulation*

It is important to have a clear picture of regulation—and the developments in it —on the national, European and international levels, to be able to make assessments about the efforts that are needed to get a new product *admitted*. For example, what is the attitude of the government towards a new technology in general, and products that are produced with it in particular?

Regulation is also an important issue for corporate management, and consequently the mapping of the regulation is typically a staff function. Maps produced by the staff can be used by the management of the PCP.

> In the case of modern biotechnology, implementation of the regulation was new not only for the firms involved, but also for the government. Both parties had to learn to identify the bottlenecks and how to deal with them. If firms are ahead of the development of regulation, *ad hoc* solutions sometimes have to be found. Sometimes bilateral deliberation is started between firms and governmental departments to find ways to deal with this matter.

(3) *Societal actors relevant for product development and embedding*

Societal actors can influence the way a new product gets embedded or not. They can mobilize public awareness, and influence governmental agencies and other firms. It is important for firms to know the field of societal actors and the developments in it. Some firms try to identify key opinion leaders, and use them as 'early indicators' for public acceptance of a new product.

(4) *Culture*

Culture is a determining factor in the way in which a new technology in general, and a new product in particular, gets embedded (or not). Norms, values and opinions in a culture and its evolution should be identified. For example, it is important to know cultural values to position a new product in the market. Do consumers want ecologically 'sound' products or do they want 'high-tech' products? To what extent does the public expect a new product to make a contribution to social welfare?

Figure 4. Mapping the environment: four interlinked domains for biotechnology.

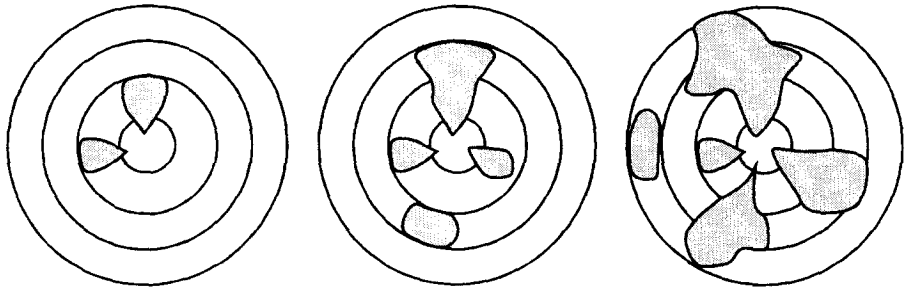

Figure 5. Three schematic subsequent concentric maps during a PCP, showing some path dependency (see the extent of linkage at the top).

Alignments are always specific. It is impossible to make alignments with every relevant actor in an environment. As a consequence, alignments are always partial, and in that sense unbalanced or asymmetric, compared with the eventual web of alignments in which a new product will find its embedding. For example, in one of the case studies in Dutch biotechnology firms, a firm chose to collaborate during the PCP with one lead customer. In a later stage of the PCP it became clear that the production process of this customer was not representative of that of other intended customers. The adaptations that had to be made to the product definition caused extra costs and delays.

This is an example of unbalanced alignments within one layer of the environment. Unbalance can also occur with respect to the total of alignments which are made with different layers of the environment. This is very clearly the case when alignments with environments are treated sequentially. Alignments with the business environment take precedence and create an unbalance with respect to other parts of the environment.

Both types of unbalanced alignment bring along risks (of extra costs, delay or even failure). While some degree of unbalance is inevitable, management must make assessments about the extent and consequences of unbalanced alignments. The issue of unbalanced alignments is a pressing one because a possible unbalance cannot be taken for granted temporarily in the hope to be able to compensate for it later on. Irreversibilities occur because of path dependencies during the gradual forming of the web of alignments with the different parts of the environment. Once an alignment has been made with a specific actor, alignments with other actors can become more difficult. For example, when a firm has decided to collaborate with one specific customer, it cannot collaborate with another customer, without facing tensions. Once a path has been chosen, it is not easy to abandon it.

Path dependencies are inevitable, but some paths will be better than others. This should be an incentive to managers to be aware of evolving path dependencies. Using maps, management of PCP + SECP is able to make assessments about the occurrence and effects of path dependencies. The first alignments are especially important because they determine for a large part the further course of a path. These have to be handled with special care, and should not overly depend on whatever prior alignments happen to be in place.

As with the timing of anticipation, timing of alignments with wider society is not straightforward. Again, there is a dilemma. Early alignments have the advantage that the product definition can profit from insights of societal actors at a moment when flexibility is relatively large. At the same time early alignments can be a risk for the protection of the 'niche' or 'protected space' in which the new product is being created.[32] When the product definition is still unstable and diffuse, reactions of societal actors can be too

general or premature, and damage the protected space. For example, firms often think of involving societal actors as a risk, because these may use (confidential) information and make it public to stop an unwanted product development. But there is another risk: societal actors may not want to be involved at a late stage of PCPs only, when only little room for adjustments is left. If societal actors are expected to play a constructive role, they should be involved at a moment when it is still possible to have some influence on the product concept.

Dutch biotechnology firms followed two types of strategies. Some firms made early alignments with actors in society—for example, with a consumer organization—before they had an extensive web of alignments with actors in the business environment. What other firms might see as the risk of premature negative reactions was interpreted as a valuable input to prevent 'bad' investments. Other firms did not make alignments with societal actors until the new product was near market introduction. They took the risk of bad embedding in society (sometimes without being aware of it) because they wanted to develop their product without societal actors looking over their shoulders.[33]

Both strategies have their pros and cons, and management has to make a well considered decision about which strategy is best in the situation. Again, maps and notions of unbalanced alignment and path dependency are an important input in making this decision. In general, one could say it is impossible to define an embedding strategy that is appropriate to all PCPs, but it is possible to deal with these dilemmas productively by developing and using management tools for better assessments.

Closing the Gap with the Wider Society

Managing for societal quality introduces broader quality considerations than market success, and this implies that society has, or gets, a stake in development and introduction of new products. Consequently, societal actors (consumer organizations, environmental groups, etc.) should, in principle, be seen as stakeholders.

By regarding societal actors as stakeholders, the cultural gap between firms and wider society can be bridged. Reducing this gap is not an easy task. Firms and societal actors often have conflicting interests, different norms and values, and different ways of interpreting the situation. Van Riemsdijk notes that firms often have a low opinion of the strategic significance of societal actors.[34] Although societal actors play an important role in articulation of public opinion, they are usually not involved—directly or indirectly—in decision-making processes inside firms. Firms normally do not have internal departments that probe the desires or demands of actors in the wider society in order to include these in the decision-making process. Relationships between firms and societal actors are difficult because both have their own goals, structure, culture and way of communicating. In short, they function and act in different 'worlds'.[35] Firms often only get interested in the wider society when they are confronted with a crisis that can cause direct harm to their business.

From a societal quality point of view, relations and interaction between firms and societal actors are potentially very valuable. Societal actors can give indications of the degree of public acceptance of new products. They are also important because they can influence public opinion, governments and other firms.

Mapping the wider society, as discussed earlier, provides management of PCP with information about societal actors. When trying to orchestrate alignments with the wider society, management can try to influence societal actors. To be successful in influencing, firms should have a good story about their views on societal embedding, which takes into

account strategies and positions of other actors. Scenarios for embedding are an important tool, now as a resource in articulating the story.

In the case of controversial technologies and products, a good story is not enough. There must be an audience willing to listen. If management wants societal actors to contribute to PCPs, dialogue is an option. In that case firms should show willingness to listen to the views of other actors, and a willingness to change. To create a situation in which dialogue is possible, the firm has to be a trustworthy discussion partner. Mutual trust and respect have to be built. To accomplish that, personal contacts are necessary. Some big companies already employ people who are responsible for communicating with societal actors.[36]

In the present situation, where constructive dialogue is not usual, a firm will encounter difficulties when it tries to define a constructive role for societal actors. Societal actors are not always prepared to get into a relationship with firms, because they fear to becoming 'accomplices'. They have a constituency that needs to be satisfied. Interactions always take place in the context of 'strategic games'. Every actor has its own interests to look after.

To overcome such impasses, firms could try to stimulate the notion of new product development as a collective learning process in which all actors involved play a constructive role in developing new technology/products. Obviously, this is not a simple matter. When the pros and cons of new products are not yet articulated, however, the benefits of such constructive interactions are sufficiently high to make a serious attempt worthwhile.[37]

Managing for PCP + SECP as a Learning Process

Managing for societal embedding means learning new ways of viewing problems and solutions, and new ways of dealing with the environment. Managing PCP + SECPs should be regarded as a continuous learning process.[38]

From our case studies it appeared that biotechnology firms had to learn how to behave in public disputes about the acceptability of their biotechnological products. Often they found themselves in strange and unfamiliar environments, in which values, opinions and political stances were brought up as relevant arguments, and the style of technical-rational decision-making preferred by firms could not sway the debate.[39] Opinions and arguments of societal actors were seen by firms as 'irrational' and 'emotional'. Firms had to learn that their technical/economical rationality was not the only valid rationality in interactions with the wider society.

Even when firms prefer to maintain the dichotomy of rational and emotional, they should recognize that they themselves also behave as political actors. In some cases, this was not only realized, but also fed back into PCP and strategic decisions, e.g. in the switch from herbicide-resistant plants to disease-resistant plants. A number of biotechnology firms started with the development of herbicide-resistant plants from an assessment that this was a good product–market combination. They learned how to develop such varieties, and created new alignments with seed firms and herbicide firms. Gradually, however, it turned out that public acceptability was a problem, so some firms shifted their goals and started to work on the much more complex disease-resistant plants.

What we see occurring here is what Chris Argyris and others have called 'double loop' learning.[40] In 'single loop' learning, experience is used to improve ways and means to achieve one's goals. In 'double loop' learning, experience and reflection lead to reconsideration of one's goals. Such a reconsideration was forced on these biotechnology

ogy firms. In a proactive mode, firms could explore the need for 'double loop' learning of their own accord.[41]

While learning processes and the importance of including 'double loop' learning may well be accepted as a general point, actual learning is hard and time-consuming work, and shifting PCP + SECPs (or product development portfolios) is not without costs. Sunk investments, including the investment in creating and maintaining linkages with other firms (and other relevant actors), have to be given up, while inexperience with the new situation creates risks of moving away from core business. So in a real-world management approach one should consider the need to invest in learning, as well as the room available to explore new interactions and new options.

We can use biotechnology as an example again. Using terminology introduced in an earlier report,[42] we can identify two dimensions.

- *Learning pressure* is high when a new technology is essential for the firm, and competitors are actively searching for ways to use it in new product development. Pressure is also relatively high when firms are at the end of a production chain and therefore close to consumers. These firms are very visible compared to firms at the beginning of production chains. Especially when firms are at the end of several production chains, as in the food sector, they cannot control the use of new technology in their products and experience a high pressure to learn.
- *Room for learning* is small when the degree of acceptability in a market sector is low. Firms that are dependent on one or a few products and/or brands (e.g. beer brewing companies) have little room for learning. Small firms pioneering the use of new technology have little room to learn because of few resources and little management experience. At the same time pressure on learning is probably very high for these small 'early starters.' Firms that require fast new product development also have little room to learn compared to firms that can take 10 years or more to develop a new product (as in the seed business).

In a two-dimensional matrix, four situations can be characterized as to their degree of 'difficulty' of managing for good societal embedding creation processes (see Figure 6):

(1) Little risk is involved in trying out a new technology in new product creation. Some firms do, and others do not.
(2) Waiting for uncertainties in societal embedding to diminish is not risky.
(3) Anticipating societal embedding and interaction with wider society are important, and possible.
(4) 'Wicked situation': to wait with using a new technology in new product development is risky, but an early start is also risky.

Especially in 'wicked situations', the management approach for PCP + SECP is important. When learning pressure is low, management may decide to economize on anticipating societal embedding, but when learning pressure is high this would be unwise.

Thus, the extended management approach of PCP + SECP should be seen as a framework of tools and suggestions that are to be mobilized, to a smaller or larger extent, according to the assessment of the situation, e.g. the extent of its 'wickedness'.

Conclusions

In this paper we used societal embedding as a broader notion of success, and argued that managing societal embedding creation processes is an important addition to product

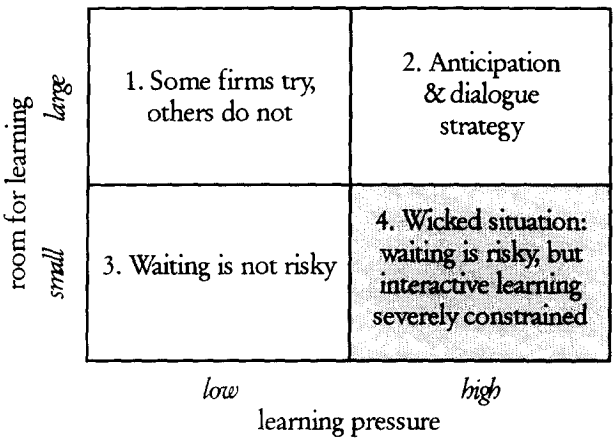

Figure 6. Four situations in management of good societal embedding.

creation processes. No straightforward management approach is available at present to manage this multi-actor process, because of some fundamental difficulties: concentric treatment of environments; PCPs are like innovation journeys with contingencies and setbacks; and the anticipation dilemma. It is exactly these difficulties that the approach we propose concentrates on, not by solving them, but by providing tools, considerations and suggestions to manage the innovation journey to societal embedding. Success can never be guaranteed, but it is possible to reduce risks and mistakes along the road.

Extended concurrent engineering was introduced as a management approach to make sure that societal embedding creation processes are managed as a simultaneous and integral part of PCPs from the start. PCP + SECPs can be mapped in terms of development 'lines', including a separate development 'line' for societal embedding. These maps are a means for management to assess the desired degree of parallelism and coordination of the development lines, and to orchestrate the internal and external alignments.

Articulation of scenarios for embedding is a means to orient action in embedding creation processes. Articulation and monitoring of scenarios for embedding resolve the anticipation dilemma. They allow PCPs to profit from early and necessarily diffuse anticipation and later, more detailed anticipation of societal embedding. Extended concurrent engineering and scenarios for embedding are line responsibility, not staff responsibility. While staff will be involved, the line manager, i.e. the project team leader, will be accountable.

A central issue in managing for societal quality is the way in which the web of alignments with the environment should be filled in. Management should map the relevant environment and the alignments. These maps should be made on a regular basis to assess the balance of the alignments made, and to check if the 'right' path dependencies are created that will lead to desirable societal embedding. Mapping also helps management in identifying relevant societal actors, and weighing the pros and cons of early involvement of societal actors.

Although a cultural gap remains between firms and the wider society, this gap can be reduced by treating societal actors as stakeholders. Of course, there is also a responsibility of societal actors who have to accept this new role. Benefits of reducing the gap can be substantial, because listening to, and interactions with, societal actors provides

Table 2. Elements of the management approach

Has management	Has management paid enough attention to
Distinguished separate development line for societal embedding?	Articulation of scenarios for societal embedding?
Included someone responsible for societal embedding in cross-functional team?	Mapping and monitoring relevant environments including society at large?
Treated societal actors as stakeholders?	Mapping and monitoring alignments using concentric maps?
Showed openness and willingness to listen and change in interactions with societal actors?	Stimulating continuous learning in societal embedding creation processes?

valuable indications of public demands and acceptance. Directly or indirectly, these actors can influence governmental agencies, and they can influence and mobilize public opinion. The role of firms itself also changes when society gets a stake in PCP + SECP. Firms should show a willingness to listen and to change. They have to become a trustworthy discussion partner, while societal actors are expected to play a constructive role.

In interaction with society, firms have to tell 'good' embedding stories, and give societal actors a constructive role. By a 'constructive' role we mean that the actors contribute to the product creation process; this includes contributions which signal difficulties and may lead to shifts in the process, up to decisions to stop altogether. A key feature of managing for societal quality is continuous learning and improvement. Creation of societal embedding is a continuous learning process. Experience with societal embedding creation processes and reflection on it should include reconsideration of one's goals, i.e. 'double loop' learning.

The way in which management of PCP + SECP can use the extended management approach depends on room for learning and learning pressure. Especially in 'wicked situations' characterized by little room for learning and large pressures, the approach is valuable. In principle, the approach is valuable for all PCPs, although not every mapping exercise has to be done in the same degree of detail, depending on the 'wickedness' of the situation.

Table 2 lists the elements of the approach, but it is their mix which is important, and the judicious treatment of the dilemmas and 'balancing acts' inherent in PCP + SECP. The first and necessary step is the awareness of the nature of such problems, plus the attention given to their resolution.

The management approach outlined here has not been tested in full. But elements of it are visible in practice, and the biotechnology firms studied by Jelsma and Rip[42] are 'hard' tests, because their management has felt the pressures and experienced the dilemmas. In addition, our proposal for an approach relates to a body of empirical studies of innovation in context, and by building on it, takes advantage of accumulated experience and insight. So we claim that the approach is robust.

If the approach becomes a regular and recognized feature of the behaviour of firms, further changes will occur. There will be effects at the level of the firm, e.g. on its public image and on the way societal actors interact with this particular firm and with firms like them. There will also be changes in the way societal actors define themselves in relation to PCP + SECP, if the management of such processes accords them a constructive role.

Acknowledgement

Our discussion of the management approach has profited greatly from comments by Petra de Weerd-Nederhof, Maarten van Riemsdijk and Olaf Fisscher, of the School of Business and Management Studies of the University of Twente.

Notes and References

1. K. Green, O. Jones & R. Coombs, 'Critical Perspectives on Technology Management: An Introduction', *Technology Analysis & Strategic Management, 8*, 1996, p. 4.
2. J. Jelsma & A. Rip (with co-operation of J. L. van Os), *Biotechnologie in Bedrijf: Een Bijdrage van Constructief Technology Assessment aan Biotechnologisch Innoveren* (Den Haag, Rathenau Instituut, 1995); J. J. Deuten, *Anticipatie op de Maatschappelijke Inbedding van Nieuwe Produkten als Onderdeel van het Produktieproces* (Master's thesis, Enschede, University of Twente, 1995); J. J. Deuten & A. Rip, *R&D Management for Public Acceptance: An Important Aspect of Total Quality* (paper presented at the R&D Management Conference 'Quality and R&D', Enschede, University of Twente, March 1996).
3. See, for instance, K. B. Clark & S. C. Wheelwright, *Managing New Product and Process Development: Text and Cases* (New York, Free Press, 1993).
4. P. Thomas, 'The Devil Is in the Detail: Revealing the Social and Political Processes of Technology Management', *Technology Analysis & Strategic Management, 8*, 1996, p. 82; Green, *op. cit.*, Ref. 1, p. 6.
5. Marketing is now broader. See, for instance, R. W. Nason, 'The Social Consequences of Marketing: Macromarketing and Public Policy', *Journal of Public Policy and Marketing, 8*, pp. 242–251. Social consequences of market transactions are a central issue in macro-marketing. At p. 242, Nason defines macro-marketing as "a theoretical and analytical bridge between market consequences and public policy design and evaluation". Nason is quoted after G. Fonk, *Een Constructieve Rol van de Consument in Technologie-Ontwikkeling: Constructief Technologisch Aspectenonderzoek vanuit Consumentenoptiek* (dissertation, Den Haag, SWOKA, 1994).
6. S. H. McIntyre stresses the need for horizontal coordination. The success of new products depends on "the development, by other members or organizations in society, of supporting products or services to capitalize on the actual or potential adoption of some original innovation" (S. H. McIntyre, 'Market Adaptation as a Process in the Product Life Cycle of Radical Innovations and High Technology Products', *Journal of Product Innovation Management, 5*, 1988, pp. 140–149, at p. 141). McIntyre illustrates the process with examples from the early days of the automobile and computer. Both the performance of the car and its speed of acceptance in the market were fundamentally affected by complementary assets such as the building of suitable roads, the development of tyre, gas and service stations, and the creation of places to go (including drive-in movies and regional shopping centres), none of which, of course, took place under the direct control of the automobile companies. This relates to a general point about outcomes of such multi-actor processes: "actor strategies do not determine outcomes. It is the interaction, and the indirect effects, that are responsible for how a technology gets embedded or not" (A. Rip, 'Introduction of New Technology: Making Use of Recent Insights from Sociology and Economics of Technology', *Technology Analysis & Strategic Management, 7*, 1995, at p. 16).
7. N. Rosenberg, 'Technological Interdependence in the American Economy', *Technology and Culture*, January 1979, pp. 25–50. Reprinted in: N. Rosenberg, *Inside the Black Box: Technology and Economics* (Cambridge, Cambridge University Press, 1982, pp. 55–80, at p. 59).
8. Jelsma & Rip, *op. cit.*, Ref. 2.
9. This concentric view also appears in the model of Van Riemsdijk. His definition of the layers is somewhat different. M. J. van Riemsdijk, *Actie of Dialoog: Over de Betrekkingen Tussen Maatschappij en Onderneming* (dissertation, Enschede, University of Twente, 1994).
10. This bias is not particular to managers. Rogers has noted a 'pro-innovation bias' in diffusion of innovation, not only with the innovators and with authorities, but also with scholars studying diffusion processes. E. M. Rogers, *Diffusion of Innovations* (New York, Free Press, 1995).
11. J. J. Deuten, *Ironie en produktontwikkeling* (master's thesis, Enschede, University Twente, 1994).

12. A. H. van de Ven *et al.* (Eds), *Research on the Management of Innovation: The Minnesota Studies* (New York, Harper & Row, 1989) at p. 11.
13. *Ibid.*, p. 695.
14. *Ibid.*, p. 679.
15. *Ibid.*, p. 690.
16. *Ibid.*, p. 695.
17. Clark and Wheelright also use the metaphor of a journey: "A central part of [the] preparation [for an expedition into unknown territory] is developing plans for the journey, which includes acquiring all of the information about the terrain ahead as well as likely contingencies that one may encounter" (Clark & Wheelwright, *op. cit.*, Ref. 3, p. 159).
18. See Green *op. cit.*, Ref. 1, p. 5, where the editors discuss Istemi Demirag's paper. According to Demirag there is no conclusive proof that short-termism is the direct result of external financial pressures from the 'City of London'; indeed, there is some evidence of a reverse causation. Short-termism is not limited to accountants and the City. Engineers and R&D managers have their own short-termism.
19. Clark & Wheelwright, *op. cit.*, Ref. 3, p. 87.
20. Jelsma & Rip, *op. cit.*, Ref. 2. Our translation of a quote in Dutch.
21. Biemans, for instance, notes at p. 313: "Probably the most frequently mentioned piece of advice for realizing high product quality and drastically reducing product developing times, is the practice of concurrent engineering (also known as parallel product development, overlapping stages and the rugby approach), combined with the use of cross-functional team". W. Biemans, 'Managing Internal and External Cooperation in Product Development: A Case for Integration', in: P. C. de Weerd-Nederhof, I. C. Kerssens-van Drongelen & R. Verganti (Eds), *Coursebook Managing the R&D Process* (Enschede, University of Twente, School of Management Studies; Enschede, Twente Quality Centre; Milan, Politecnico di Milano, Dipartemento di Economia e Produzione, 1994).
22. This definition is based on earlier studies of academic and industrial research (respectively H. Dits, *Turn to Coal: Mission Orientation of Academic Research* (dissertation, Amsterdam, University of Amsterdam, 1988) and P. J. Vergragt, 'The Social Shaping of Industrial Innovations', *Social Studies of Science, 18*, 1988, pp. 483–513). 'Niches' allow further development in a relatively protected space. External and/or internal 'critical events' are a challenge to ongoing development and require adjustment.
23. See also Clark & Wheelwright, *op. cit.*, Ref. 3, p. 155: "The basic idea [of mapping] is that what matters in laying the foundation for product development is the creation of a shared understanding and a common direction among the functions and the senior management of the company".
24. Jelsma & Rip, *op. cit.*, Ref. 2, pp. 58–59.
25. As we noted before, central management is now often involved. In due course, when alignment with the wider society has become 'domesticated', central management can delegate this responsibility.
26. Even if the result of early anticipation is that no public resistance is to be expected, it is important to check this on a regular basis, because unanticipated changes in the wider society can easily occur.
27. Actor-network studies have shown how actors continually project worlds in which their new technology option can live and be successful. As De Laat and Larédo phrase it: "In [technological development], implicit or explicit anticipation on new future worlds is the rule. Such an idea of scenario can be seen as an extension of Callon's 'socio-technical scenarios' (Callon, 1987) with a stronger emphasis on the trajectories defined by actors, i.e. the conditions under which, according to them, these worlds will be realized". B. de Laat & P. Larédo, *Foresight for Research and Technology Policies: From Innovation Studies to Four Hybrid Fora of Scenario-Confrontation*, paper presented at the third ASEAT conference, Manchester, 6–8 September 1995. The reference is to M. Callon, 'Society in the Making: The Study of Technology as a Tool for Sociological Analysis', in W. E. Bijker, Th. P. Hughes & T. J. Pinch (Eds), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA, MIT Press, 1987).
28. Exploratory studies are often done in the early stages of product innovation projects, to investigate market needs, competition, production opportunities and so forth. These studies are subsequently also used to create a 'niche' for the project. Embedding scenarios can make use of such broad studies. In practice, however, elaboration of scenarios during PCPs is often neglected, as they are

mainly used as a justification in negotiations with higher management. As a consequence there is a very real risk that the story about the markets, the competition etc. is not adequate any more, because the environment and the product concept itself continually change.

29. See, for instance, I. C. Macmillan & P. E. Jones, *Strategy Formulation: Power and Politics* (St Paul, MN, West, 1986). At p. 66 they give five steps involved in stakeholder impact analysis: (1) identify stakeholders; (2) identify their interests and concerns; (3) as a result, identify what claims they are likely to make on the organization; (4) identify the most important stakeholders from the perspective of the organization; (5) identify the resultant strategic challenges.
30. A. Rip, T. J. Misa & J. W. Schot (Eds), *Managing Technology in Society: The Approach of Constructive Technology Assessment* (London, Pinter Publishers, 1995).
31. Jelsma & Rip, *op. cit.*, Ref. 2.
32. For a discussion of 'niches', see Rip, *op. cit.*, Ref. 6. An interesting example (and general analysis) of 'protected space' is given in J. Law & M. Callon, 'The Life and Death of an Aircraft: A Network Analysis of Technical Change', in W. E. Bijker & J. Law (Eds), *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, MA, MIT Press, 1992).
33. Jelsma & Rip, *op. cit.*, Ref. 2.
34. Van Riemsdijk, *op. cit.*, Ref. 9, p. 160.
35. Van Riemsdijk, *op. cit.*, Ref. 9, pp. 167 168. Note that different 'worlds' also exist inside organizations. Rosabeth Moss Kanter's discussion of 'segmentalism' within organizations (and the barriers to innovation this entails) reflects this point. R. M. Kanter, *The Change Masters: Innovation and Entrepreneurship in the American Corporation* (New York, Simon and Schuster, 1983).
36. H. Vermaak, 'Managers leren groen communiceren', *Holland Management Review*, *40*, 1994, pp. 64–71.
37. In fact, Unilever is one firm which has adopted regular consultation about parts of their research and development portfolio with societal stakeholders.
38. When confronted with embedding problems, firms have many learning experiences. Unfortunately it is not always the case that these experiences are maintained in an 'institutional memory'. As soon as a situation stabilizes, learning experiences are often overgrown by business as usual. To prevent a learning organization becoming a forgetting organization, firms should strive for a well organized institutional memory and a continuous learning process. Implications are, for example, that people with learning experiences have to be debriefed before they leave a project, and creation of an accessible and systematic database or archive. Frequent changes of personnel involved in PCP are one of the main causes of loosing valuable information. Van de Ven *et al.*, *op. cit.*, Ref. 12, p. 674, suggest: "Where possible ... it is important to stabilize the core innovation team [to prevent information getting lost]".
39. One should not forget that technical-rational decision making is just one component, also within firms. Cf. C. Cabral-Cardoso, 'The Politics of Technology Management: Influence and Tactics in Project Selection', *Technology Analysis & Strategic Management*, *8*, 1996, pp. 47–58; and Thomas, *op. cit.*, Ref. 3.
40. C. Argyris & D. Schön, *Organizational Learning: A Theory of Action Perspective* (Reading, MA, Addison-Wesley Publishing Co., 1978).
41. This in fact implies that 'deutero learning' should occur: the learning how to switch from single loop learning to double loop learning (see *ibid.*).
42. Jelsma & Rip, *op. cit.*, Ref. 2, Chapter 4.