FROM PLANNING TO EMERGENCE:
INNOVATIONS IN PRODUCT INNOVATION MODELS

MIGUEL PINA E CUNHA
Faculdade de Economia
Universidade Nova de Lisboa
Rua Marquês de Fronteira, 20
1099-038 Lisboa
Portugal
(mpec@fe. unl. pt)

July 20, 1999

I gratefully acknowledge the financial support provided by ENIC/PRAXIS XXI for funding the research where this work originated. Several of the ideas developed here, were improved by discussions with many colleagues. Theo M Verhulst, Ken Kamuche, Rita Campos e Cunha, José Manuel Pinto e João Vieira da Cunha deserve special mention. All errors remain my own.
MIGUEL PINA E CUNHA is an assistant professor at the Faculdade de Economia, Universidade Nova de Lisboa. He received his PhD from Tilburg University, The Netherlands. His research interests include organizational innovation and renewal, organizational improvisation and the effects of minimal structures on managing and organizing.
FROM PLANNING TO EMERGENCE:
INNOVATIONS IN PRODUCT INNOVATION MODELS

Abstract
This article argues that the conceptual development of product innovation models is accompanying the more general field of organization science. Remarkable similarities on the change of organizational paradigms and product innovation models can be noticed. To illustrate these changes, the sequential, compression, flexible and improvisational models of product innovation are presented. The evolution of product innovation management shows a move from planned and production-oriented, to emergent and knowledge-based models. Such a reorientation poses many theoretical and practical problems and challenges to product innovation scholars and practitioners. The article discusses them.
1. Perspectives on organizing

Organizations are complex social systems that can be approached from a variety of perspectives [58]. The intrinsic diversity of organizations allows researchers to develop correspondingly diverse views of the several phenomena taking place inside them. Product innovation is no exception: it can be approached from sharply distinct departing assumptions, and proceed towards diverse descriptions and prescriptions.

In this section, this contention is illustrated by showing that distinct perspectives of organizations and organizing coexist in the literature. The perspectives that follow provide contrasting examples of a "rationalistic" perspective and a "complexity" perspective. These perspectives are expected to illustrate how the general evolution of organization science is deeply penetrating theory-building in the field of product innovation models. This may be a pertinent discussion considering that, as claimed by several authors [8, 48], product innovation is frequently (but erroneously) considered as a technical, single-theoretical subject. As it takes place inside organizations, it is this article's assumption that theorizing about product innovation is necessarily close to the conceptual frameworks available in organization science. Two major and contrasting perspectives on organizing will be considered: organizing as planned stability, and organizing as accommodating instability.

1.1. Organizing as planned stability

Organizations are often presented as open systems, and therefore as vulnerable to the uncertainty originating in markets and technologies. Despite the inevitable impact of environmental factors, classical organization theory tried to find ways of protecting the core organizational processes from environmental interference [81].

According to rationalistic approaches, organizations should simultaneously buffer themselves from external influences while maintaining a certain degree of porosity to the environment. These contradictory requirements could be achieved by regulating/controlling the external flows of information and resources. Stability was viewed by this approach as the essence of organizing.
A stable state of homeostasis was expected to be achieved through the introduction of slight, incremental innovations, developed in order to adapt the organization to environmental changes. The top management team was presumed to act as the driver of innovation and renewal, and to base its strategic decision-making processes on the premises of rationality. Organizations were expected to change mainly voluntarily and consciously, in order to keep a state of fit with the external environment [41]. The organizations' landscape was mainly described as composed by cycles of negative feedback, and perspectives on organizing based upon sounding and comforting concepts, like stability, regularity, and predictability [76].

In competitive fields like those, cause-effect relations could be known, organizations were supposed to be designing their futures, and adaptiveness was taken as an outcome of managerial competence. Under a rationalistic framework, the organization pursues clear and shared goals, set by managers able to transform divergent information into convergent solutions.

The essence of classic approaches to management and organization consisted in the maintenance of order and control as paths to organizational equilibrium and stability. To achieve such goals, companies sought to rationalise work processes and to introduce operating routines. The rationalistic perspective, epitomized by the bureaucratic form, follows an organizational archetype based on control and rationality, from where chaos has been removed [52, 62].

1.2. Organizing as accommodating instability
By influence of non-traditional theoretical lenses, like the science of complexity [68, 77] and knowledge-based theories of management [65], an alternative approach to organizing has gained recognition. According to this perspective, organizations are not reducible to formal constructions of top management teams: they are complex webs of interactions that include formal and informal elements, planned and emergent components [40, 54]. Organizations should then be represented as systems of interrelated, complex and not fully predictable behaviors. It may then be impossible to make accurate plans and forecasts of organizational processes and outcomes, including innovation. Organizations, understood as social fields, are crossed by planned and
controlled elements, but also by ambiguous information, contradictory interests, and loosely coupled processes [54] that lead the organization to unexpected new knowledge and outcomes.

Management, by consequence, is not only logic and analysis but also synthesis, intuition, and analogy. In the context of this "chaotic" or "realistic" view of managing and organizing [53], processes like change and innovation involve not only a sequence of planned activities, but also a parcel of emergence and improvisation, as will be discussed later.

Table 1 presents and contrasts the main characteristics of traditional and emergent perspectives on organizing. These perspectives are not, of course, the only possible frameworks for understanding organizing, and should instead be viewed as two extremes of a continuum of multiple possibilities.

This paper's assumption is that the general changes taking place in the field of organization science are generating product innovation models. In fact, remarkably similar changes are occurring in the field of product innovation: after clear-structured, uncertainty avoidance models, some organizations are now engaging in the use of minimally-structured, uncertainty-accommodating models. These models make use of concepts like teamworking, real-time decision making, improvisation and collaboration. After having accepted the premises of the traditional paradigm, organizations are now trying to implement more nimble and faster processes. New organizational architectures are becoming more "ethereal" and less fixed, as captured by labels such as "modular", "virtual" or "barrier-free" [21]. Product innovation models seem to be evolving in the same direction: modular, virtual, barrier-free, are all labels that can be applied to recent developments in the management of product innovation [3]. Section 2 provides a chronologically-based description of product
innovation models, starting with a sequential, machine-like model and moving in the direction of more emergent and "organic" models.

2. Models for developing new product innovations

New product development is a necessary condition for organizational adaption and renewal. The dynamic nature of markets and organizations [19], can be viewed as a compulsory stimulus for product innovation. Product innovation is a prominent strategy for renewal: by launching new products, firms may keep closer to customers [72], counterbalance the organizational tendency towards inertia [31], out-innovate competitors [55], and influence the characteristics of their environments [85]. In other words, product innovation is a powerful mechanism for organizational adaptiveness.

Most organizations, however, develop incomplete or inadequate product innovation processes [14]. These deficient processes may be partly responsible for the high levels of new product failures reported in many industries, which are calling for a re-examination of how companies plan and implement their product innovation processes [85]. Empirical evidence shows that successful and unsuccessful new products frequently follow different paths of development, with failures being the result of incomplete, inadequate or deficient innovation processes [16, 24].

Despite the existence of empirical data showing that innovative (and customer-oriented) firms tend to perform best [20], product innovation is still an uncertain and risky activity, that must be rigorously managed for organizations to increase their chances of success. In the remainder of this section, four product innovation models will be presented, illustrating four different conceptions of what rigorous means and four ways of operationalizing it. This presentation will make clear that the first condition for the success of product innovation may not consist in the proper implementation of a universal model, but in the choice of an appropriate model for the particular environmental or project contingencies the company is facing. Assuming the inexistence of one best model, product innovation managers are warned to build knowledge on the characteristics of different product innovation models, the situations in which each model seems to be best suited, and how it should be implemented, in terms, for example, of the time and the resources needed for implementation.
The models fall in a continuum ranging from planned to emergent approaches, and can be classified according to the types of learning they rely upon: models 1 and 2 (sequential and compression) try to develop increasingly efficient and reliable routines, while models 3 and 4 (flexible and improvisational) look for an increment of resilience and agility. These two forms of learning have been identified in the organizational literature [74] and seem to be helpful for uncovering and interpreting the assumptions underlying each model.

2.1. The sequential model

The sequential, step-by-step approach to product innovation [14], constitutes the dominant perspective (or the paradigm) on the management of product innovation (see Table 2). Step-by-step models are presented as blueprints for a safe and efficient new product development (NPD). These models are rational tools intended to guide the decisions of product managers all along the product innovation journey. They are expected to reduce the uncertainty inherent to innovation [27], by suggesting a sequence of rational steps to be made one after another (e.g. idea, preliminary assessment, concept, development, testing, trial and launch). Between phases, there are decision gates or points for reflecting about whether the process should continue (i.e. "go") or be interrupted (or "killed", according to the model's jargon)

Table 2 about here

Sequential models rely heavily on planning, anticipation and control. Their rationality, however, do not seem to fit the way most organizations actually work: as reported by Cooper [12], less than 1 per cent of the firms inquired in his study, used a complete sequential or stage-gate approach. The question then is: why do companies resist a procedure that claims to be so beneficial?
To answer this question, it should be remembered that step-by-step models are "tools to manage, direct, and control (...) product innovation efforts" [13, p.44]. Or, to phrase it differently, they are tools for rationalizing and controlling product innovation. They are not learning or creativity-oriented tools, but means of control through standardization [70]. This characteristic may make them more appropriate for managing routine, incremental innovations, than for radical innovations (i.e. those innovations that deviate the company from current courses of action) and to innovation processes that are not much pressed by time requirements. As the argument of time will be discussed below, we will now discuss the inadequacy of these models for managing radical innovations. The definition of tight steps to follow while developing new products, inhibits the development of innovations that require unexpected and unplanned movements, i.e. radical or framebreaking innovations. These, in fact, can not be expected to be accomplished "by a simple application of programmed switching rules" [50, p.175]. One of the dangers inherent to these models is the creation of habits of mind [45] or automatic ways of dealing with problems that may require learning and flexibility. The physical and social separation of activities implied by sequential models also seems to work against learning because social interaction - facilitated by physical proximity and intense crossfunctional communication - is a fundamental means for knowledge creation and diffusion [64, 84].

Some organizations may also decide not to follow the complete set of instructions provided by step-by-step approaches, because the model may not be adequate to the kind of products they are developing: in the case of new service development, for example, the technical development phase may be greatly reduced or even absent, while in the case of manufacturing this is the most time-consuming and costly phase of the whole new product development process [51].

Despite the potential pitfalls previously mentioned, step-by-step models may have many advantages. Above all, they can be powerful instruments for developing systematic, standardized and comprehensive product innovation practices [14]. As such, they provide a clear-cut, easy to learn and to routinize set of guidelines for developing new products [12]. This road map, however, does not seem to be a
universal solution. Some goals, namely exploration of novel opportunities and high speed of response, may require different means for managing product innovation. This latter necessity led to the development of the compression model.

2.2. The compression model

The compression model may be thought of as a version of the step-by-step approach adjusted to high-velocity environments (see Table 3). As in the previous model, a sequence of steps forms the basis for developing new products under a compression model. However, due to market pressures, collapsing product life cycles, and the competitive importance of time [39, 78], these steps need sometimes to be accelerated or compressed. There are several ways of achieving compression: improving planning, simplifying the process, eliminating unnecessary steps, involving suppliers, shortening the completion time of each step, overlapping steps, and rewarding people for speed of development [28]. The crucial phase of a compression approach is predevelopment planning; if predevelopment planning is accurate, the entire process may be rationalized, delays eliminated and mistakes uncovered earlier. Careful planning, is presented as a determinant of quick development. Deficient planning, on the other hand, can be at the origin of numerous product deficiencies (e.g. stop gaps, unwanted reorientations [9]) as well as hidden costs (e.g. low profit/highly trivial innovations, unexpected inefficiencies [17]). Other practices that facilitate speed of development include knowledgeable leadership, the use of cross-functional teams, and an organization-wide support for the project [46].

Table 3 about here

The compression model operationalizes Cooper's [15] suggestion for parallel processing of the activities involved in product development. With parallelizing, organizations try to integrate the advantages of sequential models with the demands for a faster process. Thus, the logic is that some development tasks can start simultaneously, instead of following a rigid sequence of development steps. This perspective intends to keep the uncertainty-reduction aspect of sequential models.
while recognising the need to save time. Therefore, it stands for the need to invest in planning in order to harvest in speed. Unnecessary tasks can then be removed, time spent on each task reduced to the minimum, interactions and responsibilities within teams regulated, and some tasks delegated, namely to suppliers.

The compression model assumes, like the traditional one that: (1) development activities can be known in advance, and (2) product innovation models are expected to reduce uncertainty as much as possible. By recognising the need to speed up processes, it tries to shorten the development phases as much as possible, compressing some activities, overlapping others, and obliterating those that are not strictly necessary.

Similarities between the sequential and compression models exist because they both rely on the assumptions of planning and certainty. The compression model can be adequate for developing products that demand the use of familiar technology and are directed towards well understood but high-speed markets [28]. Or, in other words, to high speed routines.

2.3. The flexible model

The mix of high-speed and uncertainty of a growing number of industries led to the appearance of another model for developing new products: the flexible (or agile) model. The flexible model, currently under development at the Harvard Business School with major contributions from Marco Iansiti and Stephen Thordarson, introduces an organic approach to the development of new products [74, 80]. Flexibility, or 'the ability to make design changes in response to a changing environment with little or no penalty' [75], becomes an important feature of product innovation models when turbulence increases. Where flexibility is low, the economic cost of modifying the product is high. And also high is the need to do things right at the first time, a tough achievement when the environment is permanently changing. A possibility to bridge the gap between planning (and the anticipated reality) and execution (or "real" reality), is to trade a mechanistic approach by an organic one, where the succession of changes is no longer part of the game. The flexible model, then, substitutes the machine-like process of previous models, by a focus on adaptiveness through diversity seeking.
Flexibility is influenced by the product development's expense, unit cost, performance, and development schedule, and can be increased via the adoption of flexible technologies, the modification of management processes (e.g. locking requirements progressively, instead of in advance) or of design architectures (e.g. using modular product structures and reducing the coupling between modules).

The speed of change and the high levels of environmental turbulence invite organizations to see innovation not as an organizational disruption to keep under control (like in the traditional, mechanistic models) but as an engine of renewal in light of changing circumstances. This need for agile product innovation led to the flexible model (see Table 4), a model whose necessity was firstly felt in industries where even “the ground is in motion” [29, p.26]. In these industries, an organic approach, based on keeping the concept development stage open as long as possible, may increase development agility through diversity and fast integration [35]. This also reduced the negative impact of forecasting errors. Rejecting the idea of product innovation as a rigid and mechanistic sequence of phases, the flexible model proposes the agile utilization of “rapid and flexible iterations through system specification, detailed component design, and system testing” [34, p.2].

Frequent iteration and testing can work in turbulent environments because they favour the creation of more opportunities and probabilities for variety to occur [28] and offer frequent feedback, which has two advantages: errors are uncovered earlier and team members may have a perception of progress that will act as a powerful motivator [28].

Table 4 about here

In the flexible model, the idea that sequencing (with or without overlapping) is the most appropriate way of handling new product innovation, is abandoned. And a more dynamic perspective is adopted, based on learning-while-doing and on the emergent character of the innovation journey under turbulent conditions. Considering that only
less than 5% of the developing products are completely specified before beginning product design [80], the flexible model may take advantage of its realistic premises.

This model is best suited to business environments that are unpredictable, rapid and populated by aggressive competitors (e.g. computers and software, multimedia, and the fashion industry). Here, companies with a flexible approach may incorporate market information in the new product concept until a later timing, neutralizing competitor moves or taking advantage of surprise.

A flexible approach to NPD is also an action-biased one: instead of investing in careful pre-specification of design details, the model rests on the creation of alternative and non-defensive (i.e. reversible) designs. The use of prototypes, for example, may generate early knowledge of real product attributes and immediate customer feedback.

A distinguishing feature of the model is that the generation of diversity should be accompanied by the faster possible integration when a satisfying solution is achieved.

The flexible model is not immune to criticism. The major one is possibly the "night as well" syndrome, or the propensity to keep on waiting for information to come, which can lead to delays due to late concept freezing.

2.4. The improvisational model

Improvisation refers to the temporal convergence of planning and execution, which means that an action is improvised when it constitutes a deliberate, real-time response to a problem or opportunity, and is executed with the available resources [57].

The improvisational approach to NPD (Table 5) tries to facilitate innovation under relentlessly shifting and fluid conditions. It is thus, like the flexible approach, indicated to disturbed or turbulent environments. The use of the improvisational model is most appropriate under those circumstances that lead to the failure of models based on the notion of predictability, while not recommending too much flexibility (due, for example, to the need to preserve a reasonable amount of efficiency). A state of limited flexibility is allowed by the improvisational model, an organic-mechanistic approach to new product development.
This model may be viewed as combining elements of the flexible model - with which it shares some features like the responsiveness and the search of exploratory learning - with elements of traditional approaches including the need to use development models as control devices. However, the use it makes of minimal structures, introduces several significant differences, including a "mechaistic flavour".

Table 5 about here

Clear roles, no-exceptions milestones, experimentation and gradual convergence, are on the basis of the use of the improvisational model, an approach that balances structure and ad hocery and that, consequently, synthesizes structured and flexible approaches (see Figure 1 for a general illustration of the four models). Development improvisational teams are allowed to work autonomously inside the limits prescribed by a small set of "big" rules (i.e. within a minimal structure). If the balance between autonomy and control constitutes a major challenge for product innovation in today's firms [11], the improvisational model suggests a pragmatic way of putting this balance in practice, namely through the utilization of the so-called minimal structures or semi-structures. Minimal structures basically consist of a simple and well-defined set of rules, where some features are formalized but others are not [9, 26]. In the case of product innovation, minimal structures may consist of clear roles and responsibilities (for product definition and financial performance, project schedules, portfolio priorities, and time intervals between projects [9]), action-based communication, and freedom to act inside existing limits. Minimal structures collapse the traditional notion of structure, substituting a serial, step-following process, by the freedom to act and to build a unique process, contained within a set of technical and social rules that must be well known and taken for granted by people working in an improvisational mode (for a discussion of the [minimal] infrastructure underlying the minimal structure described here, see section 3.7). The case of the Honda City provides a good illustration of the utilization of NPD with minimal structuring. Honda's top management provided the team with only two instructions: (1) to come up with a product concept fundamentally
different from any previous concept developed at Honda; (2) to make an inexpensive but not cheap car [63].

Minimal cognitive structures—like the one proposed to the Honda City developers—should coexist with minimal development structures. New product development in an improvisational mode may proceed through gradual convergence or the progressive narrowing of an initially larger range of acceptable solutions. Gradual convergence means that each group involved in the development of a new product works autonomously, but has to meet regularly with the other groups to coordinate efforts and eliminate flawed solutions. The search for variation is then limited, from the very beginning of the project, by the (semi)structural constraints introduced by the improvisational modus operandi. Due to the improvisational model’s search for flexibility and efficiency [1], it seems to be especially suited to organizations competing in industries where high levels of efficiency can be considered critical, and for which the purely organic functioning of the flexible model, is not suitable (e.g. the automobile industry).

Figure 1: about here

The improvisational model balances planned and emergent features:

Planning: Like the more traditional models, the improvisational approach implies the existence of structure, in this case a minimal structure able to provide the team with the possibility of “escaping from freedom” [38]. The absence of structure while dealing with novelty may produce confusion and low-quality outputs.

Emergence: The new product concept is achieved gradually, while action unfolds. As pointed out by Stobek and his colleagues [75], gradual convergence provides the group with the possibility of collective learning based on real-time information, and does not force the choice of early and potentially misleading convergence points.

Innovating in an improvised mode entails some risks, including high levels of stress and ambiguity, and the possibility of strategic drift. These risks are augmented if
3. Management trends underpinning new product innovation models

To conclude, and elaborating on the above discussion, a general picture of trends in product innovation models is presented in this section (see Table 6 for an overview and Figure 5 for a graphical illustration).

Table 6 about here

3.1. From universal to contingent

Recent research suggests that there are no universal models for developing new products. Eisenhardt and Tabrizi [28] and Olson, Walker and Ruekert [67] have shown that the models that should be used and the structural coordination mechanisms they require, depend on the types of innovation being pursued, as well as on the characteristics of the environment where it takes place. The development of highly innovative new products may require more improvisational development modes and participative and non-obtrusive coordination mechanisms (e.g. minimal structures). Sequential or compressed models may be appropriate for routine projects, like those involving line extensions or product improvements, where high levels of efficiency are a relevant goal. The different structural and procedural requirements of products with differing degrees of newness (e.g. product variations and product reorientations) have been noticed as early as 1976, by Normann [66]. Apparently, however, the implications of this finding have not deeply penetrated the dominant and universalistic view of product innovation that, for a long time, pursued the "one best" model. From a resource-based interpretation [86], proficiency in the use of the sequential model may preclude the use of other types of models even when recommended, thus turning a capability into a rigidity [42].

3.2. From invariant to flexible
Recent product innovation models are replacing static by dynamic views, and control by adaptiveness [71]. This may be due to the fact that universal models do not seem to be adequate to the specificities of many projects, which demand more "loose" and tailored processes.

The validity of traditional models in face of emerging business conditions, is being questioned and paving the way for new modes of thinking and managing new product innovation. The flexibility they grant facilitates a degree of accommodation between the process and the situation that may be beneficial in those cases where it is not possible to plan the whole process in advance, and where the creation of new knowledge is required. Traditional models, then, are closer to an information-processing (or exploitation) perspective, while recent models are closer to knowledge-creation (or exploration [49]), a finding that again parallels the evolution of management thought [63].

3.3. From avoiding risks to taking advantage of opportunities

Global changes in business environments stimulated organizations to adopt qualitatively different ways of developing new products. Traditional linear models appeared as appropriate to relatively stable and predictable markets but not to turbulent and complex ones. Sequential approaches may be appropriate to products that rely on routine and predictability, and to placid but not to unpredictable or turbulent environments, where the risk is competing against time and coping with surprise. Using the terminology of Dickson and Gigleriano [22], sequential approaches limit the risk of missing the boat while increasing the risk of missing it. Latter models try to achieve a balance between these two tensions.

The move from risk avoidance to the balance between avoiding risk and exploiting opportunities, illustrates the importance of time for the new product development game [79]. This transition is changing the role of planning in product innovation models: traditional planning may be complemented with real-time action (i.e. improvisation), with planning being understood, in more recent models, as a flexible, learning-oriented process, instead of a rigid, control-oriented mechanism.
The growing importance of time is the reason why so much attention has been paid to the analysis of how the new product development process could be shortened and flexibilized [30, 44], and to the pitfalls of time-reduction techniques [87]. Despite the dangers potentially involved in accelerated product development [17], competitive conditions do not present alternatives to new product managers: launching products in the right time, although risky, may be crucial for the success of product innovation [60]. Successful product innovating firms, then, will be those able to reduce development time, while keeping the process rigorous and accurate.

3.4. From structure to emergence

Tables 6 illustrates how conceptual thinking in the field of product innovation is evolving from intentional to emergent perspectives, thereby incorporating recent advances in organization science [7, 76]. The emergent nature of organizational innovation is attracting a growing body of research [5, 56], which in turn stimulated the burst of new approaches to the study of the topic. Product innovation in an emergent manner is viewed as an open process, permeable to outside information, dependent on social and organizational learning, and porous to real time information in order to preserve product competitiveness. Plans, forecasts and a technical orientation, should be complemented by emergent learning, improvisation, and a socio-technical orientation. Recent models, thus, trade forecasting accuracy by development flexibility [80] and structure by minimal structure in order to achieve that goal.

3.5. From exclusive teams to inclusive networks

Product innovation is a collective effort consisting both (1) members from outside the strict development team, and (2) people from outside the company. The transfer of knowledge among new product development projects may be a source of learning, especially if linkages between projects are managed with that purpose [61]. Additionally, the involvement of suppliers is expected to fine-tune the work of the development team by making available potentially relevant information and suggestions [11]. The involvement of customers can be useful because they will potentially provide information on how the product is actually used, catch potential gaps between expected and observed utilization, and provide inputs for improving the product. Then, instead of relying in closed teams with restricted (and function-based) membership,
product innovation is evolving towards an inclusive network of enlarged membership, with non-core members entering and leaving the stage according to necessity.

3.6. From stability to complexity
From a complexity perspective, when organizations strive to be innovative, they need to operate at the edge of chaos [10]. Recent models of new product innovation are aware of this proposition and suggest several ways for overcoming the rigidity of traditional models without risking to be pulled towards disintegration or strategic drift. It is interesting to note that the first formal approach to new product development (NASA’s Phased Project Planning, developed in the 1960s) has been implemented in order to “bring discipline to an otherwise chaotic, ad hoc activity” [15, p.5]. Today, the field seems to be moving in the opposite direction, trying to bring some “chaos” and ad hocery to an “over-engineered” and mechanical process. There is a significant difference, however, between the 1960s and the 1990s: the difference between a porous, semi or minimally structured, agile system, and the inexistence of a systematic approach.

3.7. From “full” structures to minimal structures
The success of classical (sequential and compression) models was due to an heavy emphasis on the idea of structure: structure provided rationality, order and clarity to a potentially messy process. The evolution of organizational environments, however, stimulated the appearance of different product development approaches. Structure became more loose with the flexible model, and minimal with the improvisational model. The concept of minimal structure marks a significant departure from a command-and-control perspective on new product innovation. It provides neither a mechanistic nor a organic (and, to a certain extent, chaotic [9]) approach to product innovation, but a form of organic-mechanicism, or the possibility of creating exploratory knowledge within clear but not constraining limits. Minimal structures, however, are not inherently superior to traditional ones: they are different and potentially useful under diverse contingencies.

The adoption of a minimally-structured approach to the product innovation process, may not be an easy task; it requires a minimal infrastructure based on social and
technical components. The social infrastructure refers to the existence of shared codes of communication, interpersonal trust, and a genuine interest for teamworking and collective knowledge creation [47]. The technical side refers to equivalent and high skills amongst team members (e.g. the case of Toyota’s engineers, described by Sobek et al. [75]), and a deep knowledge of task requirements, task characteristics and existing resources. If this set of infrastructural requirements is not deeply embodied by participants, the advantages of improvisation may be offset by some severe shortcomings, including high levels of anxiety, added uncertainty, and strategy-less (or the exhibition of no pattern in new product decision making or development [36]).

Under a minimally structured product innovation process, the functions of leadership do also change. The functions of chief engineers at Toyota [75] provide an example of what “minimal” leadership is all about: “controlling the narrowing process of product concept, insisting on broader exploration, resolving any disagreements across functions and, when needed, making decisions on competing alternatives based on an analysis of trade-offs” (p. 73).

4. Concluding comments

Organizational theories and product innovation models are apparently coevolving in the planning–emergence, universal–contextual directions, and being influenced by the emergence of new business landscapes [6]. New landscapes, as we saw, necessitated new product innovation models.

In this paper, an analysis of the changes in product innovation models did take place. It was not intended to present a normative view of product innovation, but to illustrate that multiple models exist and can be used, depending on the circumstances.

Sequential models were context-free, and presumably adequate to every case of product innovation in any organizational context. This “one size fits all” assumption is no longer tenable. Future research will need to refine a contingency approach to product innovation. Such an approach will need to find types of products, structures, and technologies, that recommend the use of a certain product innovation model.
The evolution of product innovation models is also due to the gap between prescriptive models and actual organizational needs and reality, where things usually have planned but also emergent or unplanned/unplannable features [25]. For a long time, innovation researchers payed attention to the planned side of the process, and treated emergent actions and particularly improvised acts as disfunctional [43]. Recently, however, a growing body of work is placing a significant focus on the emergent side of product innovation which will possibly lead to a higher degree of theoretical sophistication and applied relevance.

Other promising features of product innovation research exist, both on the theoretical and practical sides. Non-traditional views and analogies of the product innovation process have been proposed recently. These include the jazz and rugby metaphors [32, 79, 88] in the theoretical domain, and the study of the principles of set-based concurrent engineering and model changeovers at Toyota [1, 75]. These new approaches may not only stimulate new theory development, but provide richer descriptions of real world-best practices in new product development. A closer and more sensitive look at organizations' actual practices [48], may thus be undergoing.

The existence of alternative product innovation models –like the four "pure types" presented here– is also a critical condition for managing product portfolios: the mix of new products being simultaneously developed by organizations, may require different development processes, which means that the same company can be expected to use more than one model at once for different new products, or sequentially for a single product. This way, organizations will be able to extract competitive advantage not only from the product itself, but also from the development process [2], an assumption that can hardly be made if different models are viewed as competing or a universal way postulated. A contingency perspective on product innovation, supported by the existence of multiple models, will potentially show that companies should use mechanistic models to exploit established designs, and more organic models to explore new designs. And that different practices may produce distinct outcomes in diverse industries [37]. Considering that most firms try to keep up with market changes through incremental change [4], one can expect traditional models to continue to be
viewed as important tools. However, as shown here, they may no longer fulfill all the needs of contemporary organizations.
References


<table>
<thead>
<tr>
<th>Features</th>
<th>Traditional</th>
<th>Emergent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object</td>
<td>Organization</td>
<td>Organizing</td>
</tr>
<tr>
<td>Essence of organizing</td>
<td>Order, clarity</td>
<td>Disorder, ambiguity</td>
</tr>
<tr>
<td>Role of people</td>
<td>Information processors</td>
<td>Information creators</td>
</tr>
<tr>
<td>Nature of the approach</td>
<td>Static</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Unit of analysis</td>
<td>Decision</td>
<td>Interaction</td>
</tr>
<tr>
<td>Basis for action</td>
<td>Planning</td>
<td>Retrospective sensemaking</td>
</tr>
<tr>
<td>Networks for innovation</td>
<td>Formal</td>
<td>Informal</td>
</tr>
<tr>
<td>Model</td>
<td>Sequential</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>Placid clustered</td>
<td></td>
</tr>
<tr>
<td>Assumptions underlying the model</td>
<td>Buffering the process from unnecessary change and uncertainty</td>
<td></td>
</tr>
<tr>
<td>Process characteristics</td>
<td>Explicit</td>
<td></td>
</tr>
<tr>
<td>Process goals</td>
<td>Efficiency, predictability, incremental change</td>
<td></td>
</tr>
<tr>
<td>Major raw material</td>
<td>Product innovation principles</td>
<td></td>
</tr>
<tr>
<td>Key organizational functions</td>
<td>Introducing discipline and control, evaluating each phase</td>
<td></td>
</tr>
<tr>
<td>Fundamental assumptions about organizing</td>
<td>Certainty, equilibrium, stability, predictability, mechanism</td>
<td></td>
</tr>
<tr>
<td>Current shortcomings</td>
<td>Rigid, early lock in, fitted to long cycle products, vulnerable to crystallization / centrifugal forces, risk of &quot;missing the boat&quot;</td>
<td></td>
</tr>
<tr>
<td>Applications</td>
<td>Routine innovations</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>Compression</td>
<td></td>
</tr>
<tr>
<td>------------------------------------</td>
<td>-------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>Placid cluttered, high speed</td>
<td></td>
</tr>
<tr>
<td>Assumptions underlying the model</td>
<td>Rationalizing the process as a way of adapting</td>
<td></td>
</tr>
<tr>
<td>Process characteristics</td>
<td>Explicit</td>
<td></td>
</tr>
<tr>
<td>Process goal</td>
<td>Increasing speed while keeping low levels of uncertainty, incremental innovations for fast moving markets</td>
<td></td>
</tr>
<tr>
<td>Major raw material</td>
<td>Product innovation principles, time</td>
<td></td>
</tr>
<tr>
<td>Key organizational factors</td>
<td>Rewarding speed, emphasizing planning, using multifunctional teams</td>
<td></td>
</tr>
<tr>
<td>Fundamental assumptions about organizing</td>
<td>Certainty, equilibrium, stability, adaptiveness, mechanical</td>
<td></td>
</tr>
<tr>
<td>Current shortcomings</td>
<td>The traps of acceleration: lack of quality, shortcut, omission of important steps</td>
<td></td>
</tr>
<tr>
<td>Applications</td>
<td>Fast routine innovations</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>Environment</td>
<td>Flexible</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Assumptions underlying the</td>
<td>Disturbed, reactive, turbulent</td>
<td>Embracing change, absorbing uncertainty</td>
</tr>
<tr>
<td>process characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process goals</td>
<td></td>
<td>Flexibility, responsiveness</td>
</tr>
<tr>
<td>Major raw materials</td>
<td></td>
<td>Product innovation principles, list, variety</td>
</tr>
<tr>
<td>Key organizational functions</td>
<td></td>
<td>Organic structures, unclear timings</td>
</tr>
<tr>
<td>Fundamental assumptions about organizing</td>
<td></td>
<td>Uncertainty, unexpectedness, organicism</td>
</tr>
<tr>
<td>Current shortcomings</td>
<td></td>
<td>The &quot;night as well&quot; syndrome can provoke serious delays, due to unrefecting product concept</td>
</tr>
<tr>
<td>Applications</td>
<td></td>
<td>Rapid innovations in high complexity, high competitiveness markets</td>
</tr>
<tr>
<td>Model</td>
<td>Improvisational</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------------------------</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>Disturb-reactive, turbulent</td>
<td></td>
</tr>
<tr>
<td>Assumptions underlying the model</td>
<td>Trading structure, minimal structure</td>
<td></td>
</tr>
<tr>
<td>Process characteristics</td>
<td>Mainly tacit, w/ explicit elements</td>
<td></td>
</tr>
<tr>
<td>Process goals</td>
<td>Coping w/ turbulent environments, adaptiveness</td>
<td></td>
</tr>
<tr>
<td>Major raw material</td>
<td>Product innovation principles, ideas</td>
<td></td>
</tr>
<tr>
<td>Key organizational functions</td>
<td>Minimal structures, learning while doing</td>
<td></td>
</tr>
<tr>
<td>Fundamental assumptions about organizing</td>
<td>Complexity, emergent organization, organic mechanism</td>
<td></td>
</tr>
<tr>
<td>Current shortcomings</td>
<td>Fuzzy, unclear, ambiguous process, vulnerable to disintegration/ environmental forces, risk of “sinking the boat”</td>
<td></td>
</tr>
<tr>
<td>Applications</td>
<td>Innovations in high coordination, high complexity, high competitiveness markets</td>
<td></td>
</tr>
</tbody>
</table>
| From universal to contingent | • There is not a one best model  
• The innovation process should be adapted to the type of product  
• The process should be adapted to the type of environment |
| From invariant to flexible | • Introduce freedom if necessary  
• Consider the possibility of making use of more emergent models |
| From avoiding risks to taking advantage of opportunities | • Product innovation is not only risk avoidance but also building on opportunity  
• Long range plans should be complemented with short-term, real time plans |
| From structured to emergent approaches | • The product innovation process is a technical but also a social one  
• The process should include planning, but infuse it with real time learning (while doing)  
• To prevent errors of forecasting, product flexibility should be high |
| From exclusive teams to inclusive networks | • NPD teams are networks of inclusion, not cells of exclusion  
• Transfer of knowledge between projects should be systematic  
• Customers and suppliers should be included in the team for contribution |
| From structured to emergent approaches | • Over-engineering may be constraining  
• Process focus (control vs innovativeness, principles vs ideas) should be diagnosed |
Figure 1. Product Innovation Models