



Pergamon

Technovation 20 (2000) 617–630

technovation

www.elsevier.com/locate/technovation

Developing product platforms: analysis of the development process

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Received 6 September 1999; accepted 8 December 1999

Abstract

Several authors have highlighted the importance of companies enhancing their new product development process through a multi-product strategy. This means planning the development of a product family upon a platform, which allows shorter lead times in developing new derivative models. The platform itself has proven to be more flexible when given a modular architecture, so this shifts attention onto evaluating product platform architecture. This paper analyses three industrial cases in order to draw conclusions on the implementation of platforms and modularisation, and in particular on how they deal with this issue. First of all, an interpretation framework is proposed which defines the element taking into account managing with platforms. Secondly, the achieved results in terms of platform flexibility are studied. The paper measures them through analysing the way in which the trade-off between distinctiveness and commonality is dealt with. Finally, since the ability of firms to develop robust product platforms resides in NPD process management and organisation, organisational settings and process flows are examined. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: New product development (NPD); Product platform; Modularity; Case studies; Multiple industry

1. Introduction

Competing with a multi-product strategy, based on product families sharing a common platform, has proved to be a successful approach for many industries (e.g.: electronics, software, automobile, domestic appliances) (Meyer, 1997). In particular, the following advantages in the new product development (NPD) process have been underlined: increased speed in product development, reduction of product development costs, increased product reliability, increased variety and reduced managerial complexity, increased business strategy flexibility.

The first advantage recognised is an *increased speed in product development*. Wheelwright and Clark (1992) described the importance of a long term planning for product development based on the identification of robust platforms allowing fast product upgrades and enhancements. In this way firms can succeed in bridging

the technological gap with competitors or building up long term leadership. Black and Decker, during the seventies, introduced a platform approach to their new product lines development. Their achievement was an average of one new product introduction per week, which lasted for several years (Meyer, 1997).

Another big achievement is the *reduction of product development costs*. For example, the automotive industry is introducing so-called “world cars”, authentic worldwide commercialised models, with regional market customisation, all sharing a unique product platform. It is widely recognised that this policy is essentially meant for saving product development and production costs.

Thirdly, *product reliability is increased* after the platform’s adoption. Sony’s Walkman, through communising the great majority of its mechanisms in successive generations of the product, achieved a quality rise along the platform life (Sanderson and Uzumeri, 1995). Reliability thus became one of the core performances determining a great success of this specific product family on the market place.

The same example of Sony shows how platforms allow *increasing external (on-the-market) variety and*

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contemporarily reducing internal variety. In the personal stereo segment, in 1989–1990, Sony was offering 24 different lines in the US and 18 different lines in Japan, highly outperforming every other competitor. The same models had been originated by a single product family and shared a common technology (Sanderson and Uzumeri, 1995).

Platforms *increase business flexibility through platform scaling up and down.* Indeed the platform approach allows aggressive market strategies, thanks to reduced costs and times in developing new derivative products. The case of Compaq (Meyer, 1997) represents an outstanding case in which the company succeeded in leveraging one basic platform through different market segments. In particular the company extended its “beachhead” platform in both segments of customers and tiers of performance level.

However, a platform approach to product development is not always viable. Sometimes there could be heavy constraints on platform definition, given by a product’s architecture. This is what emerges from the research of Muffatto and Roveda (1998), who inquired how architectural characteristics are related to platform applicability. This particular area of interest found roots in the existence of a research stream stressing the importance of product architectures in determining NPD process performances. For instance, Ulrich and Tung (1991) defined the basic concepts of modularity. Baldwin and Clark (1997) underscored the importance of modularity in the case of IBM personal computers. Again Muffatto (1997) discussed the advantages and drawbacks of modularity in the automotive industry. Erixon (1998) provided a method for the design of modularity.

2. Definitions and literature review

2.1. The platform concept

The concept of a product platform has been receiving increased attention in product development and operations management. Several authors have recently been concerned with it (Meyer, 1997; Wheelwright and Clark, 1992; Nobeoka, 1993; Meyer and Utterback, 1993; Sundgren 1995, 1998; Robertson and Ulrich, 1998). Reviewing the definitions of the platform concept which are provided in the literature, a substantial difference is immediately evident in the approach which researchers adopt. A possible way for clustering them is considering the degree of generality of the platform definition researchers provide. If we follow a similar strategy, on the one hand we will find definitions sounding extremely technical and seldom product/industry-specific (narrow definitions: e.g., Meyer and Utterback, 1993; MacDuffie et al., 1996; Wilhelm, 1997). On the other hand, we will discover definitions aimed at encompassing different

industries and innovation processes, and as a result being highly generic and abstract (broad definitions: e.g., Meyer, 1997; Robertson and Ulrich, 1998; Corso et al., 1996; Calabrese, 1997a).

Narrow definitions of product platforms were first used in the research. To begin with, almost all of these were centred on the automotive industry, where a platform, beyond being a fundamental part of the structural frame of a car, is the part of a product that is shared between different models of a unique family. Hence, narrow definitions of a platform usually refer to some physical elements, sometimes extremely well identified. Some examples are:

- “...encompasses the design and components shared by a set of products.” (Meyer and Utterback, 1993)
- “...[a car’s] underbody and floor pan, serving as the foundation design for multiple needs,...” (MacDuffie et al., 1996)
- floor group, drive unit, part of the cockpit, axles and suspension, fuel tank (Wilhelm, 1997)

It is possible to notice that some of these definitions are quite industry- if not product-specific. A similar approach inevitably leads to considering only some aspects of the problem. Stressing physical commonality indeed means paying attention to the exploitation of the manufacturing and assembly processes within a given product family. This is one of the reasons leading to the search for adoption of the platform strategy (leading to cost and investment cuts). On the contrary, this approach does not explain other significant advantages of a platform, like reduction of development lead-time. On this foreword basis, we will define this stream of literature “production oriented”.

A second big typology of product platform definitions is more general and sometimes abstract than the former one. For example:

- Calabrese (1997b), reporting the definition Fiat gives to the platform, writes (our translation): “...Beginning from it, a specific organisational structure [called platform as well] is configured, with the task to withstand the development of all the models belonging to that specific product set”.
- Corso et al. (1996) define the platform as a set of norms and standards to integrate subsystems that evolve over time, within some given constraints, forming a sort of technological trajectory.
- “A product platform is a set of subsystems and interfaces developed to form a common structure from which a stream of derivative products can be efficiently developed and produced” (Meyer, 1997; Meyer and Lehnerd, 1997).
- “A platform as a collection of assets that are shared by a set of products.” (Robertson and Ulrich, 1998).

Later on, the authors specify that the shared assets are: components, processes, knowledge, people and relationships. Only if taken together, do these four elements constitute a platform.

This second stream of literature, and particularly the last definition we reported, suggests that a product platform is a multifaceted concept affecting:

- Production and logistic processes (costs, investments, operations complexity, etc.);
- Development process (development lead time, standardisation, quality and reliability of design);
- Project organisational structure (teamwork, design task partitioning, relationships with suppliers);
- Knowledge (know how transfer among projects, influence on and by technology, etc.).

De facto, there are streams of research concentrated on each one of the previous aspects. For our purposes, it is sufficient to choose a definition which is generic enough to encompass most of the important elements that arise from adoption of a product platform definition. At the same time the definition should be flexible and also understandable for practitioners.

Hence, although the definition Robertson and Ulrich (1998) adopted is pervasive, it is a bit too strict when imposing the presence of all the constituting elements together. Consequently, basically in accordance with Meyer's definition, in the following paragraphs we will assume: *a product platform is a set of subsystems and interfaces intentionally planned and developed to form a common structure from which a stream of derivative products can be efficiently developed and produced.*

2.2. Product architecture

A second concept covered in this paper is that of product architecture. This concept was first introduced by Abernathy and Utterback in 1975 and successively adopted and developed by lots of other researchers (Wheelwright and Clark, 1992; Baldwin and Clark, 1997; Erixon, 1998; Henderson and Clark, 1990; Ulrich, 1995; Sanchez, 1995; Ulrich and Eppinger, 1994). Consistent with Ulrich (1995), product architecture is defined as “the scheme by which the function of the product is allocated to physical components” or “the arrangement of functional elements; the mapping from functional elements to physical components; the specification of interfaces among interactive physical components”.

Usually product architecture may show two extreme configurations: modularity or integrity. The former predicates a simple mapping between functions and components (one-to-one mapping) and standardised/decoupled interfaces between modules. Integrity is conversely the situation when a complex mapping of func-

tions—components is shown and interfaces between components are coupled and not standardised. To measure the level of complexity of a given architecture, an index of architectural complexity has been suggested (Muffatto and Roveda, 1999), taking into account both product architectural complexity (system integrity) and components architectural complexity (component integrity). The product architectural typology also seems to influence the possibility of applying, or not, a platform approach in product development. Muffatto and Roveda (1998) highlighted how product architecture constrains the platform adoption along the product development process. In particular a high level of architectural complexity prevents the communisation of a platform across a family of products. Additionally, an increasing level of modularity is proved to be beneficial in managing the trade-off between distinctiveness and commonality in a product set (Robertson and Ulrich, 1998).

3. Research design

3.1. Aims

This paper is part of a research project about the influence of architectures and platforms on the new product development process. In particular, as underscored in the literature review (Section 2), platforms affect several elements of the NPD process: development strategy, development and operations performance, knowledge retention and transfer, organisation of project teams. The main focus of this paper will be a comparison between different product development organisations in order to individuate which of their characteristics are essential when developing products with a platform strategy. To achieve this, a reference framework will be derived explaining which are the main elements to take into account. Additionally, a quick analysis of existing products is made, with reference to three cases of firms building up electromechanical products (from vehicles to domestic appliances). On this basis the paper attempts to critically discuss some organisational issues relative to platform development and implementation.

3.2. Methodology

The research is based on three case studies of companies operating in the automotive, earthmoving machinery and domestic appliances industries. Data were collected by structured interviews aimed at describing the development process of platform innovations and of derivative/enhancement models. In particular, the organisational settings have been highlighted out and related to the kind of projects they are applied to.

As a preliminary step, data regarding range of products, number of models per family, technical com-

monality between models and others like these, have been collected for understanding the effectiveness of organisational settings on the deliverables that companies produced. A check of interviews with follow-up sessions has been performed and, in two cases, emerging data have been confronted with similar research already performed in the same realities. The research is intended as a discussion of some organisational elements of industrial R&D departments. Given the overall research design, in part exploratory, the results cannot be generalised. In any case, considering the nature of the firms analysed, the validity of the results is more likely to concern companies operating in the mechanical and electro-mechanical industries, developing rather complex products.

4. The cases

All considerations presented in the following sections are based upon the analysis of three case studies. They are first summarised and then thoroughly described with particular attention to their innovation process and platform development organisation.

4.1. Case A: Carmake

4.1.1. Case summary

Carmake is an automobile producer, operating in an international environment. The company is more precisely a division of a wider multinational company producing almost all vehicle categories and competing in a broad set of other markets (services, information, etc.). The new product development process in Carmake introduced platforms during the 80s. Accordingly, since the beginning of the 90s, the NPD process organisation was changed by introducing platform teams.

Development lead-time (time to market) is about 36 months and is in the process of being reduced. Products are developed in “platform teams” which are cross-functional teams surviving to the launch of products (so called “cradle to grave” teams). Their duty is to develop and guarantee assistance to a whole product family. Product families usually share a common platform, but the technical features and commonality are not always the distinctive driver of choices when allocating projects to teams. A similar organisational setting allows the company to pursue component standardisation between products of a family. There are in any case some components to be standardised across families. In this case a particular platform, the components development team, works to diffuse common solutions throughout the whole range.

4.1.2. Product development process

Before examining the new product development process, comment should be made on the analysis of possible innovation sources. It is possible to track down possible sources of product innovation in basically four mechanisms:

- PRP (product range plan; concept planning for every product to be developed; principles that drive decisions follow market opportunity considerations and product portfolio considerations)
- PDP (product development process)
- CDP (components development plan)
- Advanced R&D (innovation is fostered through “concept cars” and advanced technology components).

Fig. 1 clearly explains the most usual innovation process, where a concept is developed during the PRP phase and then developed in 36 to 38 months’ time. In the concept development phase (PRP), beginning about 10 years before a product’s launch, not only the concept is chosen according to market and portfolio considerations, but also components which need more than 36 months to be developed, produced and delivered (component lead time) are selected. Other components (also called “model/platform specific”) are developed within the product development phase.

Aside the model/platform specific components, the planning and development of cross platform standardised components (chunks like engines, chairs, etc. or parts like springs, screws, nuts, etc.) are made by permanent component teams. Using the definitions we provided in this paper, component teams plan and develop only “non model specific” modules.

Another viable way to introduce innovation is the technological one. This is the case of advanced R&D innovation. Whenever a new product/process technology is developed, an application is attempted in a “concept car” that may eventually be engineered and launched on the market.

4.1.3. Product development organisation

4.1.3.1. Platform teams The main element of Carmake’s product development organisation is the platform team. This structure was introduced in 1991 and since then it has undergone continuous evolution. The main impetus for similar structure was an attempt to communalise the innovation efforts for all brands the company owns. To give a reference, in 1991, the company was selling 14 models based on 8 different platforms, while nowadays the number of models has increased to 22, while contemporarily the number of platforms has reduced to 7.

Basically the platform team is a permanent cross-functional project team, lead by a platform manager, that

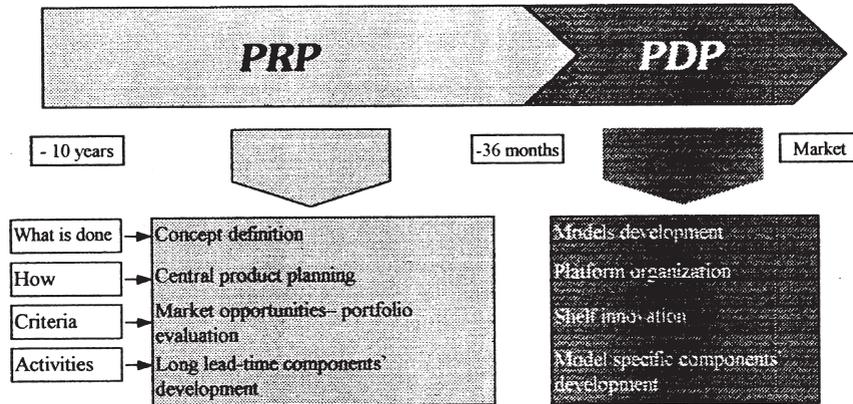


Fig. 1. NPD process in Carmake.

develops a family of models usually sharing a so-called technical platform with one another. The team survives until the launch of the models onto the marketplace (permanency) and is also in charge for the lifelong development (quality assurance, exercise costs, warranties, etc.) and the ordinary model's improvement. Team members are shared with R&D functions, according to an organisational matrix pattern always struggling with the balance of powers between functions and project structures (Fig. 2).

The platform team develops all the products belonging to the same product platform, usually defined as the sum of suspensions, platform, axles, and power train. Anyway, this definition is not so narrow. Indeed, while some platforms are effectively determined by technical reasons (in these cases there is strong similarity between models), in other cases organisational motivations overcome technical considerations (for instance a product can be assigned to a particular platform team on the basis of pure resources availability).

The criteria assigning the development of a model to a particular platform team are:

- Technical commonality of car structure (frame, platform, suspensions, engine, power train)
- Available resources evaluation (resources balance)
- Affinity between the concept to develop and the platform leader character.
- Communitation of the same production (in particular welding) and assembly processes

Recently a further modification has been introduced. A platform team's direction has been created, directly underneath CEO, thus assuring the development of this organisational form throughout the years to come.

4.1.3.2. Co-location From an organisational perspective, platform teams are co-located for 80% of their time, meaning that platform teams work in a unique room, with suppliers, production members, etc., while, for the remaining 20% of their worktime, members are supposed to be in their own functions. This datum is confirmed by the company's incentives system, since 70% of the incentives' weight is assigned on the basis of platform team performance, whereas the other 30% is

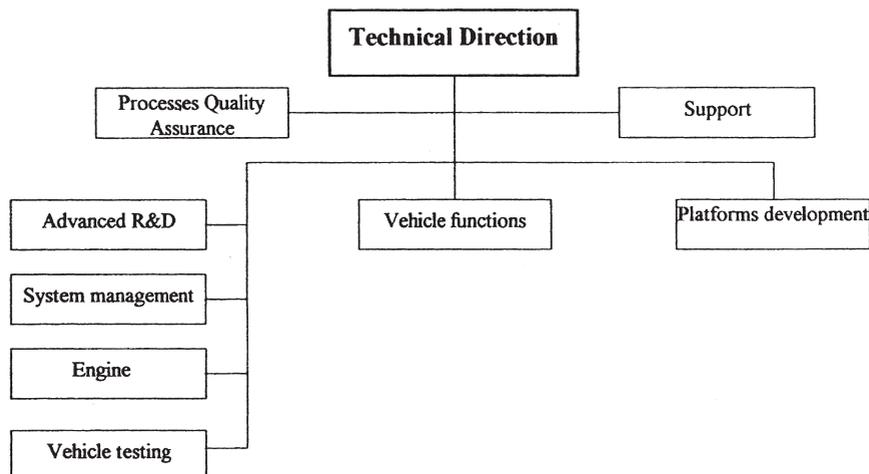


Fig. 2. Innovation and product development structure.

determined by personal skills and dedication to teamwork. Definitely, this is the way the company has adopted to foster teamwork and collaboration among team mates.

However, according to the actual platform team manager's opinion, a similar conception of power balance in the matrix organisation (functions vs platform teams) is supposed to evolve towards a much heavier importance of functions (not more than 10–20% of time in co-location). Leaving designers and engineers working within their functions for a longer time, guarantees a stronger development of specialist competencies, with a lesser communisation of technical solutions as a counterpart. To reduce this risk, some protocols for managing human resource mobility across teams ought to be defined.

4.1.3.3. Component teams A particular platform team is constituted by the components' development. This is defined as a platform because it is a project group surviving to the release of new components, as platform teams do. Possible outputs of this team can be: development of autonomous components (modules) to insert in a platform, support current platform teams for developing model specific components, warranting for the coherence of technical solutions across platforms (standardisation).

4.2. Case B: Scrapers Co.

4.2.1. Case summary

Scrapers Company was established in 1963 as a local earth moving machine maker. In the early nineties, a Japanese competitor entered into its shares pack, until it became a major shareholder in 1995. Now Scrapers Company is one of the three European divisions of a world-wide multinational company. The division actually employs about 650 people, whereas its yearly total revenues are around 175 million Euro.

The company operates in five different market niches that could be clustered and defined "utility machines" market. Otherwise a traditional digger–scraper market, a similar company's policy means targeting a broad range of different customers, behaviours and needs. In this case, product families are constituted by an entire market niche, while models of a family differ from one another for the overall machine weight and work capability. Models may be customised through changes in their basic functionality, which is given by opportune chunks or add-on components.

A new product platform introduction requires from about 18 to 24 months (time-to-market). During a platform's life a "minor change" is usually made (derivative product) requiring 8–12 months development time. Typical modifications are those attaining cost reductions, added functionality and improved manufacturability. The company does not utilise platform teams, although

the engineering department is subdivided in two sub-groups according to the product lines they develop.

The use of common product planning and supervision implements standardisation throughout the product lines. This is possible, thanks to the small dimensions of the engineering function. Component teams are on the contrary occasional.

4.2.2. Market strategy and general data

Within the earth moving machinery market, Scrapers Company competes on five different product segments (or lines): "mini" diggers (licensed by an external company), "midi" diggers, backhoe loaders, articulated backhoe loaders, skid steer loaders. All these products are defined "utility machines", because they are targeted on extremely specific customer requirements more than on plain production capability. Accordingly, the range of possible users and customers to take into account becomes much wider than in the traditional digger market.

To get an idea of the dimensions of the industry in which Scrapers Company competes, the backhoe segment (both normal and articulated steering) is estimated to be 60,000 units/year worldwide. For mini diggers, 45,000 units are yearly sold in Japan, and 20,000 in Europe. All in all, the worldwide utility machines market is estimated to be about half a million units per year.

Primarily, market segments are determined by: machine typology (basic functionality and work type applications, overall machine shape), machine weight, digging force, lifting capacity, maximum digging depth (all of these are performance traceable back to specific components, so "local"). Now some general performance issues (involving machine integrity) are becoming more important: fuel consumption, noise, active and passive safety. These require higher product integrity.

4.2.3. Product development process

Innovation generally emanates from the engineering department, since the firm has not got a proper R&D office. Suppliers are therefore often those who suggest innovative solutions. The new product development process (NPD) flow shows a typical "tollgates" pattern, made up of 4 phases: market searches and concept development, prototype development and test of target performance achievement, prototype enhancement, production ramp-up (Fig. 3).

4.2.3.1. Phase 1 The *start up* phase is a consequence either of a market search or of a specific request of a customer. The input data for the design phase are expressed in the form of performance values (e.g.: machine power, loading power, hoe volume, digging depth, work radius, etc.). After that, project teams are constituted, technical feasibility hefted and one product proposal is fostered. The phase ends up with a meeting

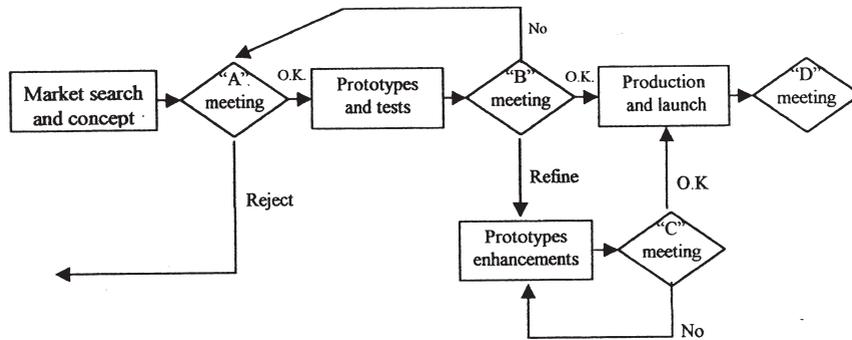


Fig. 3. The NPD process in Scrapers Company.

called an “A” evaluation meeting, in which all functions are involved (general direction, engineering, manufacturing, commercial, marketing, finance), and whose aim is the complete evaluation of the product proposal.

4.2.3.2. Phase 2 Phase 2 is attended by the engineering department (drawings and prototype realisation), commercial department (supports engineering in making make-or-buy choices) and manufacturing (helps determining costs through manufacturing cycle costing). After phase 2, the project undergoes another “yes-or-no” tollgate, namely a “B” evaluation meeting (all functions involved as in meeting “A”). The aim of this meeting is to evaluate whether the physical prototype respects the performance targets, set in the previous phase. Three kinds of answers are admitted: the project is rejected, the product is partially accepted and will undergo a refinement phase, the prototype is fully satisfactory and the production ramp-up authorised.

4.2.3.3. Phase 3 This is basically an optional phase the project will go through if the target requirements, evaluated in the “B” meeting, were only partially satisfied. As a consequence, the functions attended to in the phase are the same as in phase 2, with the only difference being that only some parts of the product have to be redesigned. The phase ends with a “C” evaluation meeting identical to the “B” meeting.

4.2.3.4. Phase 4 Whenever production has been authorised either in phase 2 or 3, phase 4 is supposed to begin. The product is thus manufactured and sold to the market place. During the production phase, no broad meetings, involving several functions, are scheduled. Contingent problems are hefted in a “D” evaluation meeting, that is a post audit which happens 6 months after the product’s launch. Both technical aspects and market expectation fulfilment are evaluated.

4.2.4. Product development organisation

The organisation of NPD is basically a weak matrix with relatively strong functions’ weight. One lightweight

Project Manager co-ordinates the development process, guaranteeing that projects step forward. The engineering department constitutes 25 people, working in two main substructures that develop different product families. Whenever the firm plans the launch of a new product, a project leader is appointed and resources assigned to the project team. These teams are disbanded when projects end, and engineers assigned to other projects within the substructure they belong to. In this way some knowledge retention is sought for.

4.2.5. Product strategy

4.2.5.1. Platforms The definition of the product platform is tightly linked to that of the product family, or product line. Different models of a family are plainly obtained through scaling up and down (in the physical sense of a dimensional scale) of a basic model. The latter is usually the first product of the family to be developed and launched onto the marketplace. The remainder of the product family quickly follows. Though no platform teams operate inside the engineering department, models are developed as plain variations of the reference models, knowledge transfer being assured by common family development planning, eased by small dimensions of teams (everything is developed under single person supervision). Developing a brand new product line requires from 18 to 24 months, while its market life lasts from about 5 years for small machines to 10 years for bigger ones. During this period, usually a “minor change” is made (derivative product), lasting for about 2–3 years on the market and requiring 8–12 months to be developed. Typical modifications are those attaining cost reductions, improved manufacturability and added functionality.

4.2.5.2. Component development and modularisation

Within the platform, product shows a large set of common components. Nevertheless there is a discrete commonality between products belonging to different families, obtained through implementation of module sharing and parts standardisation. These regard:

- Some visible components in machines of similar weight (e.g.: cockpit);
- Under-body components (engines, servomechanisms, hydraulic and pneumatic components);
- Subassemblies of some machines (e.g.: entire cockpit and hoe in backhoe and articulated backhoe loaders) despite their completely different frame structure.
- A lot of common parts (codes) like pipes, screws, and so forth, are then standardised across families.

Model specific components (those adding functionality to the reference product) are usually bought as “black boxes” from specialised suppliers. The interfaces that suppliers define become compelling for successive development phases.

4.3. Case C: Whitegoods

4.3.1. Case summary

Whitegoods is part of an industrial group operating in the appliances market. In particular our unit of analysis is one of the group’s three divisions, producing domestic refrigerators and employing about 1600 people. Production is subdivided into three plants sited in different countries of Europe, whereas the R&D function is centralised. The other group’s divisions produce washing machines and cooking appliances. The group’s turnover was about 2 billion Euro in 1997, one of the five biggest European firms in the domestic appliances market.

The new product development process presents a typical “weak matrix” as an organisational structure. Besides stable and long lasting functions, temporary multifunctional project teams are created, which aim to implement *Concurrent Engineering* principles. Moreover, within the temporary project teams, some component sub-teams are created, charged with the development of a single component whose design does not depend upon other activities. Co-location is not implemented. The organisational matrix is unbalanced toward a heavy functional weight. Organisational settings and team management is centrally decided, planned and implemented. The objective is that of obtaining cross-family standardisation through central planning.

A new platform development process lasts on average from 14 to 17 months. For attaining derivative models and minor product adaptations, the process of design and development is shorter, but with consistent variability in duration. The company introduced platform planning and development many years ago. The current number of product families within the whole portfolio is 6, whereas 68 different models are offered. The definition of the platform is usually based on the definition of well identified technical elements like crossbar width and choice of aesthetic parameters.

4.3.2. Market characteristics

Whitegoods competes within the domestic refrigerators and freezers market, where product performances determining market segments are as follows:

- Product functionality (e.g., temperature control, 2nd compressor, super-freezing,...);
- Energy consumption;
- Quality of external and cells design.

What does not determine any kind of market segmentation is the external dimension of the appliance, because every product typology is offered in a complete set of different dimensions. Dimensional standardisation is anyway a positive element to attain.

Critical success factors, intended as those elements determining success or failure of a particular product in the marketplace, can be tracked back to aesthetics, simplicity of use, impression of space (in other terms, effectiveness of the cell design). Lately, the ever-increasing importance of environmental factors is shifting customers’ attention towards performance issues like electrical consumption and choice of refrigerator fluids. Long duration, reliability, low noise, and volume capacity, no longer constitute “order-winning” performances. Rather, they are something that producers must ensure.

Products are sold with different brand names, often sharing common product platforms. Hence the number of different models originated by a shared platform (product family) can be about 100 units (different product codes). Sometimes only some irrelevant particulars like product plates or labels differentiate models from one another.

4.3.3. Product development process

The overall duration of a typical new platform development process ranges in average from 14 to 17 months. This includes: market analysis and concept proposal (1–2 months), overall design and evaluation of feasibility and investments (3 months), detailed design (2 months), prototype building and testing (6–8 months), pre-series (2 months). Regarding derivative models and minor adaptations of products, design and development is shorter, but with consistent variability in duration.

A product platform lifecycle lasts on the marketplace for about 5–6 years, whereas a major restyling is usually made after 3–4 years.

4.3.4. Product development organisation

The new product development process presents a typical organisational structure classifiable as a “weak matrix”. Besides stable and long lasting functions, temporary multifunctional project teams are appointed whose aim is to implement *Concurrent Engineering* principles. Their task is essentially co-ordination. Moreover,

within the temporary project teams, some component sub-teams are created charged with the development of single components, which do not interact with the remainder of the product.

Co-location is not implemented, since team members are supposed to continue their respective activities within their function, except for referring to the project manager for those activities related to a specific project. Incentives confirm that the organisational structure presents a heavy functional weight. Indeed, not only the functional manager decides personal incentives and career advancements, but there is also a lack of formal criteria to evaluate and reward the team's achievements.

For analogy, platform teams are claimed to exist. They are defined as temporary, de-located and part-time teams differing from normal project teams for the presence of a program manager, as co-ordinator for a bunch of projects. The definition of platform teams sounds, in this case, not punctual, since teams, rather than a single product family, develop different projects. Moreover, team members change between one team and another, with the exception of the program manager. Centralising the R&D direction allows the firm to pursue cross-family standardisation through unique planning. Also organisational settings and team management are decided, planned and implemented centrally.

4.3.5. Product strategy

In the domestic cooker and refrigerator industries, product policies are usually based on a large set of different models, since customers need models to fit into highly customised environments (kitchens). Accordingly, Whitegoods product strategy, as with its main competitors, aims at developing broad product families more than offering single products.

From a technical point of view, identical structural materials (metal sheets) and foams constitute the elements of commonality between products of different families. The assembly process is another element in common between them.

4.3.5.1. Product platforms The company introduced a platform view many years ago, which enabled products to be developed from a common basis, differentiating models from one another only through light adaptations. The current number of product families within the whole portfolio is 6, whereas 68 models are offered. The definition of a platform is usually made upon the definition of cross-bar largeness and the choice of aesthetic parameters (that means curvatures of the metal sheets and choice of internal furnishing). Also, electronic controls are usually shared within a product family. In any case, these elements do not allow the engineers using them as a basis for developing the remainder of the products. Hence, no meaningful advantages are seen in the development time compression. Standardisation of engines

and compressors (supplied black boxes) encompasses instead the whole range of products and is ensured by the central planning of product development.

4.3.5.2. Modularisation and standardisation strategies

Product architecture is a familiar concept inside Whitegoods. Products present a plain one-to-one mapping between functions and chunks. Nonetheless, there is no complete independence between modules according to the perspective assumed. Indeed, from a project viewpoint, there are five modules which are: structure (external furniture and doors), refrigerator circuit (compressor, circuit and refrigerant), electric circuit (engine and cables) and internal fittings. The number of functional units is also five: structural, refrigeration, power, controls, aesthetics and functionality in use (carried out by the internal fittings). A small problem is that the subdivision of chunks used in the design phase is not the same as for the assembly process (e.g., the evaporator, part of the refrigerating circuit, is considered part of the furniture when assembling products).

5. A reference framework

A first examination of the three cases presented suggests a sort of interaction between NPD organisation, process flow and use of product platforms as defined above in this paper. What we try to explain here can be illustrated as shown in Fig. 4.

5.1. NPD organisation and platforms

To define a coherent subsystem of interfaces and components means defining what the boundaries of a product family could be since the planning phase. Information should be disseminated to the project teams to enable technical solutions to be repeated and standardisation objectives to be met. The cases show that a similar achievement is obtained either through a common leadership or through formalised teams. Indeed, in all cases a defined team is in charge for the definition and planning of the whole new product platform. In cases A and B, the same teams then complete the development of that platform, while in case C a program manager coordinates the following tasks of the development process, carried out upon the basis of previous planning and early development activity. After this analysis we can conclude that the choice of organisational setting has a strong influence upon platform development.

5.2. NPD process and platforms

A further organisational effect of platform applications is in the process flow. The same definition of platform we adopted (see Section 2.1) underlines an

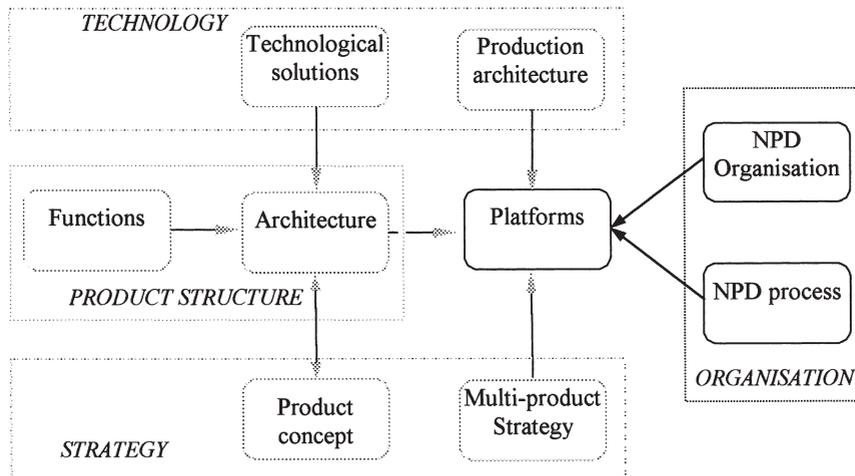


Fig. 4. Relationship between platform, NPD organisation and process flow (adapted from Muffatto and Roveda, 1999).

intrinsic feature of platform development strategy: efficiently deriving streams of incremental innovations. This feature modifies radically the product introduction flow. First of all there is a sharp distinction between platform introduction and light product enhancement. Hence the new product development process is recognised alternatively following two distinct patterns. Secondly, the way in which the process follows preferably one of these two patterns allows the definition of a sort of platform efficiency. The more numerous the streams of derivatives and enhancements, the more efficient the initial definition and planning of the platform.

6. Managing product platforms

6.1. Commonality–differentiation management

6.1.1. Basic characteristics of product ranges

Table 1 presents some basic characteristics of the product ranges that the firms analysed offer to the market place. First of all it is crucial to understand the relation-

Table 1
Basic characteristics of product ranges

	Case A	Case B	Case C
Number of platforms	7	5	6
Number of models	22	28	68
Average number of models per platform	3.1	5.6	11.3
Number of model variants	98	71	~250
Platform architecture	Small common core and lots of options	Base+ derivatives+ add-ons	Multiple complete subassemblies

ships involving models and families. The higher the number of models spreading out from a unique platform, the heavier is the exploitation of the platform itself and the higher its effectiveness. In the first row of Table 1, the total number of product families is counted. The second row shows the number of models that companies offer so that the third row is simply obtained by dividing the previous two lines. The automotive manufacturer (Case A) produces an average number of models per family which is much lower than the domestic appliances maker (Case C), with an intermediate situation shown in case B.

The number obtained is a first key element to finding out about the trade-off between distinctiveness and commonality. A platform approach to product development is indeed based upon a difficult equilibrium between these two issues (Robertson and Ulrich, 1998). The higher the percentage of parts communised between two different models the lower will be their production costs, but at the same time, products will show lower distinctiveness. Conversely, two products that share no common parts will result in being totally distinct but will not allow economies of scale. In any case, giving flexibility to the platform's architecture could change the relation between distinctiveness and commonality. A way to achieve this is modularity (Fig. 5). Fig. 5 shows that once product architecture is fixed, the distinctiveness–commonality curve is determined, or, at least, the maximum level of distinctiveness two products can achieve for a given level of commonality. A rough system to define which curve the products are moving on, so evaluating the level of flexibility of their platform's architecture, may consist in simply counting the number of different models originating from the same platform. The longitudinal analysis of historical trends suggests that platforms are supporting an increasing variety of products. For instance, even Case A saw a growth of the average number of models per platform from 1.8 to 3.1 between

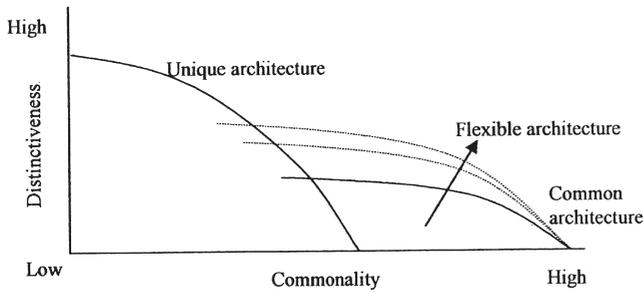


Fig. 5. effects of modularity on distinctiveness–commonality (adapted from Sheriff, 1998).

1991 and the present day. As a result of this analysis, we can anyway underline that everyone tried to cope with the problem above, since in each case a common architecture has been adopted for a set of products (Table 1, line 3).

Further confirmation comes from the analysis of the variant number. More modular products imply more numerous product variants of a basic model. In line 4 of Table 1 variants are reported. All cases confirm the search for modularity in at least some components of the product. Furthermore, although only some basic considerations about product architectures have been made, comparing different products confirms what is a common perception: domestic refrigerators are more easily given a modular architecture than cars.

6.2. Platform development organisation

Once it has been verified through product analysis, that platforms are applied and modularity sought for, we are interested in understanding how firms manage to deal with platforms and architectural flexibility. In other words, we will focus on how they move the curve in Fig. 5. In the following, some basic elements of development teams and process organisations are critically discussed. To ease readers in following the analysis thereafter, a synoptic table is presented of the adopted organisational patterns (Table 2).

6.2.1. Team management

More and more products cannot be considered the results of an individual effort, but the achievement of an entire development team. Since Concurrent Engineering has already been accepted as the only viable way to manage the modern NPD processes, consequently dealing with product development means working with teams. A first consideration arising about platform teams attains knowledge. Knowledge is created within teams and there it must be managed. Generally, embodying the enterprise's know how into physical objects, as in platform development, improves the companies' capability of transferring knowledge among different projects. But there is a significant part of knowledge still residing in people who constitute the team. The emerging issue is: what to do with teams after a product (or platform) has been developed? Using temporary teams often signifies dispersing the knowledge that has been created while carrying out the development phase. Along with this perspective, in "Case A" permanent teams have been defined. The advantage of this approach lies in keeping the competencies developed along with the products and using them to support a lifelong product improvement process. These considerations are amplified when talking about platforms. The experience gathered by solving the ordinary problems of products already in the market provides information on how to improve successive models, balancing the need for standardisation among models and the necessity of making the platform evolve. Conversely, engineers permanently living within platform teams increase the need for resources in the engineering departments. Functions cannot indeed be eliminated not to lose the technical innovation edge. Hence, if platform teams are permanent, added resources must be enrolled to supply productivity for periods in which designers are called back to work in their engineering function. Nonetheless, the permanence of projectised structures amplifies the issue of resources mobility, discussed in the next section.

Table 2
Comparative table of organisational issues in observed cases

	Case A	Case B	Case C
Platform architecture	Small common core and lots of options	Base+derivatives+modular additions	Multiple complete subassemblies
Number of people in engineering department	2000	30	~150
Platform teams management	Permanent teams	Permanent teams	Temporary teams
Co-location	Yes	Yes	No
Component teams	Permanent and temporary teams	No component teams	Temporary teams
Solutions transfer mechanisms	Unique concept team and permanent component teams	Unique product development planning and control	Multiple product managers (coordinators)

6.2.2. *Co-location*

Co-location amplifies the typical advantages of cross-functional teams. Firstly, information is much more easily shared between team members, and personal involvement increased. Broadly shared information quickens the problem solving cycles, accelerating the solution of problems and anticipating their likely occurrence at earlier phases of product development. People working shoulder to shoulder consistently improves communication and allows transmission of so-called “tacit knowledge”. In particular, the organisational solution adopted in Case A also involves the main suppliers, thus broadening knowledge sharing.

The main drawbacks of co-location are the loss of technical expertise. It is widely recognised that technical capability only improves by working for long time spans on the same concerns. Accordingly, a functional organisation constitutes the best solution for increasing specialised knowledge inside R&D departments. A big concern especially for large organisations becomes that of balancing powers of functional and platform managers within R&D. This means defining patterns for mobility of human resources between functions and platform teams, stating since the beginning what is expected from it. Case “A” (Carmake) is meaningful again. This company looks for a modification of its actual organisational setting, seeking for a lesser importance of co-location. The way the company moves towards it is by a higher functional importance supported by easier mobility of resources.

6.2.3. *Component teams*

Component teams are a possible solution for matching the need for technical leadership and the necessity of product integration. Indeed they can develop advanced technical solutions, embodied into physical components, that are then integrated into coherent products by multi-functional teams. All cases we described underline the importance of having component teams that could be either internal (in particular Case A) or constituted by specialised suppliers (Cases A, B and C). Conversely, pursuing a similar pattern for innovation is rather difficult. Indeed innovating products by choosing “a la carte” components often creates problems in achieving integration and coherency between elements. Firstly, because of different development times. To achieve a good integrity, development times should be matched; in other words it is quite usual that systems developed by the component team are not ready for the new product to come. If similar situations occur, products are launched with technical solutions which are still “old” or not integrated with one another. We derive also that architectural innovation is a form of innovation that must be planned along with product families.

Another important element of component teams that should be examined is duration. In Case A component

teams are permanent, while in others they are temporary. Teams which do not expire with the end of a particular project (permanent) allow the development of more advanced solutions, since teams go on developing the chunks/components even after that they are selected for production. Temporary teams are usually created for more specific tasks, like an occasional development effort or a model specific component, but do not assure the lifelong innovation of the components they develop.

6.2.4. *Solution transfer mechanisms*

The platform generation must be planned at the beginning of the development of a whole product range. Indeed, if platform development is not intentional, cases show that it is not possible to satisfy the needs of product distinctiveness without excessively constraining new products with non-optimised interfaces between components. As a consequence, the evolution through years of product ranges ought to be carefully planned in order to exploit the advantages of standardisation without being trapped by its intrinsic stiffness.

However, standardisation raises a further problem: transferring technical solutions across ranges. Common planning and control over projects in progress has to be maintained. Firms adopt different mechanisms to achieve this. In Case A, a common planning of products is performed by a specific structure (see: product range planning structure in Fig. 1). It aims at linking the market inputs to the product development process but, to some extent, it determines the possibility of eventual technological transfer when performing product portfolio considerations. The effectiveness of a similar structure is anyway limited in this sense, because it does not control the downstream process. A second structure targeting the cross transfer of technological solutions is the component platform, which develops solutions to be inserted in whichever model or platform when needed. We have already discussed its characteristics in a previous section.

In two cases (B and C) a unique supervision and control over the platform development process is intended to seek knowledge/information transfer. In particular, in case B the engineering department direction overviews all the development activities and supervises that similar problems are solved with identical solutions. In the absence of a common team for developing one specific product family, in case C information is transferred through functional support. Indeed, there is a unique multi-product manager, with more coordinating tasks than technical leadership over a bunch of projects. Technical commonality is then pursued through functional leadership involvement, fostering engineers to apply standardisation principles.

7. Conclusions and further research

In this article we have analysed three industrial cases of platform development processes. In each case, products have a similar overall structure, being essentially based on a mechanical core (iron frame), a power supply, an electrical circuit and electronic controls.

A first achievement is the proposal of a new definition of a platform. Our literature review suggested that existing definitions could be complemented through underlining the need for intentional planning of the platform development on a long-term basis.

Secondly, our analysis worked towards the creation of a conceptual schematic, basically referring to a previous work of ours, but enriched by some organisational insights. Its usefulness consists essentially in clarifying all the elements influencing and being influenced by platforms. This reference framework will create the basis for the successive development of a tool for decision making during product development strategy setting.

Finally we analysed three cases to discuss how platform development can be managed in practice. All cases belong to the electro-mechanical industry, develop and make rather complex products (in terms of number of parts and dimensions) embodying a multiple technology, and produce them in relatively large batches. Within these constraints the analysis is limited and, thus, more easily generalised. In addition, this is a field for further research. Our discussion led us to consider the importance of four issues: platform teams management, co-location, component teams management, structures for supporting standardisation.

An element of certain interest is represented by the theme of organisational flexibility. If the literature has already underlined the role of architecture in giving products the necessary configuration flexibility, on the organisational side the present work suggests another element that is affecting companies' decisions: resources mobility. From the present research we have shown that firms are always looking to find the right organisational setting. Human resource mobility can represent a condition to achieve all the advantages of different organisational typologies without the major drawbacks typical of the same structures.

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