Product architecture and platforms: a conceptual framework

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Abstract: The search for continuous improvement in product development forces companies to look for new competitive capabilities based on a redesign of their product strategies. In particular the role of product architectures, product platforms and modularisation, becomes important in shaping the development and operations strategies.

The paper offers a general framework explaining the relevant product structure concepts that could be used to improve product strategies and the management of the development process. The main relationships between these concepts are analysed, highlighting major constraints and opportunities.

Keywords: New product development; product architectures; platforms vehicles.

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1 Introduction

Increasing worldwide competition between companies has focused attention on the management of processes that enhance the value of the product for the customer. For companies this implies renewing and refining their innovation capabilities. In particular, the product development process has to ensure productivity while at the same time guaranteeing that products meet customer expectations in terms of technical performance, innovation and time of delivery.

To achieve this, companies must make decisions regarding product variety, standardisation and customisation. For this reason companies need to assess their product strategy in order to evaluate the importance of the definition of product architecture, platforms, modularisation and standardisation.

A redefinition of product strategies, based on different product structures has an impact on product development performance, development phasing and organisation, relationship with suppliers, globalisation of R&D and operations. As far as product development performance is concerned, the product structure influences time, cost, product quality and variety [1-7].

Time is the first relevant issue. The case of the computer industry shows how sales of personal computers have grown consistently in recent years thanks to the modularisation of their architectures. This allowed personal computers to be developed much more quickly yet reaching mainframe performances standards, that were instead developed with ad hoc designed hard disks, RAM, mother boards and even operative system software [5].

Regarding costs, they are mostly tied to the economies of scale that companies set and exploit. Redefining product structures heavily affects this aspect because it enables the sharing of more components among different products so achieving bigger production volumes for each of them. Furthermore products built up on flexible structures can be more flexibly managed and produced, for instance externalising some phases of production.

Quality is another aspect of performance. A variation in product architecture influences first of all the perception of products by the customers. Furthermore other aspects of quality, like component reliability, depend upon choices on product structures, because standardisation can be more or less implemented according to architecture setting.

Nonetheless the actual market needs mean that companies have to offer an increasing level of variety (or external variety [8]). Consequently a wide ranging combination of product parts and components must be developed, from which thousands of variants can be obtained [9].

The relationship with partners and suppliers also depends on decisions about product architecture and platforms. The modification of task partitioning in new product development [10] and variations in the number of standard parts in a product involve suppliers' role in the innovation process. As far as the globalisation of R&D and operations are concerned, the influence of product structures can be seen in the allocation of development and/or manufacturing/assembly tasks on a global basis.

The second relevant issue in this paper will be the adoption of platforms in the NPD process. Several authors [1,2,6,9-17] have already looked at topic showing how platforms heavily influence the product development performances. In particular the innovation pace and development lead-time are the first to benefit from a platform strategy adoption.

One of the issues still being discussed in literature is how to provide a definition of platforms good enough to be applied in different industrial contexts. Indeed in literature it is possible to find out, on the one hand, definitions sounding extremely technical and seldom product/industry-specific (narrow definitions; e.g. [15,18,19]). On the other hand, some definitions aim at encompassing different industries and innovation processes, but result in highly generic and abstract (broad definitions; e.g. [16,20-22]).

For our purposes, it is enough to choose a definition generic enough, in order to encompass most of the important elements a product platform adoption arises. At the same time the definition should be flexible and also able to be understood by practitioners. Consequently, basically consisting of Meyer's definition [6,20], 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 Theoretical background

The relationship between product structure and product development strategy must be seen in the context of several related concepts such as: product functions, product architecture, modules, platforms and product families. It is also very important to take into account the opportunities and constraints of the manufacturing and assembly process. Various authors have discussed these concepts in the literature and some of these basic definitions are referred to.

The functions in a product are defined as "what the product does as opposed to what the physical characteristics of the product are" [4]. In this sense, it is possible to extend the application of the definition to subsystems and components of the product itself. The definition of function is a prerequisite for defining a module.

The latter is a part or a subassembly forming a closed function unit, with well defined and often standardised interfaces (geometry, function) which can be developed, manufactured and assembled independently of the rest of the product [3-5,19,23,24].

Modules differ from generic components which are "any distinct region of the product, including also a software subroutine" [4]. Modules can be easily interchanged with one another, for instance, to customise products or to make them perform different functions.

Product architecture is "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" [4]. A typology for product architecture may be given as follows: architecture can be integral or modular, but in the latter situation a further division is possible between slot, bus or sectional modular architecture. Ulrich also discusses the relationship between product architecture and managerial problems related to product strategy. In particular he addresses problems related to product changes, product variety, component standardisation, product performances and product development management.

Anyway we see a limitation in using the term integrity as architectural concept opposed to modularity. Indeed it refers both to the perception that customers get of the product [11] and to a concept characterising the architecture of products [3,4]. What is somewhat misleading is that 'external' integrity (the concept expressed by Clark and Fujimoto [9]) should be sought for also in typically modular products. This generates an apparent contradiction with the definition of integrity as an architectural concept (i.e. complex mapping between functions and components, coupling of interfaces). So we think it is more useful to talk about architectural complexity.

The concept of the platform has been receiving increased attention in product development and operations management. Several authors have recently been concerned with the platform concept [2,6,15,22,25]. One broad definition of the platform is "a relatively large set of product components, physically connected as a stable sub-assembly and common to different final models" [6]. From a broader perspective the platform can be considered as a collection of assets shared by a set of products. By using a platform approach a company can develop a set of differentiated products or derivatives [2]. The definition of the product platform provided by Meyer and Utterback [15], is even broader and related not only to a product's technological features or to its physical structure, but also takes into consideration the contributions which other functions of the firm make such as marketing, distribution, service and manufacturing. Sharing processes or distribution channels or marketing efforts, is a broader viewpoint in which to consider a platform. Meyer [22] extends the platform definition to include possible commonality in processes, for instance production. Indeed the definition is focused on the efficiency of the development and production of derivative products, so that a platform can exist not only when products share physical components but processes as well. In particular from the production and assembly perspectives a platform implies a focus on commonality of production tools, machines and assembly lines. As a consequence, some companies in the automobile industry have considered it more interesting to define a platform more on a manufacturing-assembly basis rather than on a product development basis to better exploit commonality among models in the production process [19,26]. Modular concepts, applied to the assembly process, can revolutionise industries traditionally based on integral products [23]. A clear example regarding the automobile industry is described in Kinutani [27].

The platform can also be seen as an organisational structure. From an organisational viewpoint, a platform offers a means of developing a cross-functional team within product development for the integration of product components [17,20]. The benefits and constraints of the platform concept must also be seen from a multi-product perspective [12]. In fact, the product platform must assure product integrity while also exploiting some of the advantages of modularisation and standardisation. For these reasons products must be seen as part of a family. In some industries the 'family feeling' of products is one of the most important characteristics for market success [11]. The multi-product perspective consists in the strategy of defining product features to offer a range of alternatives, which defines the product family boundaries. This definition is compatible to that of the product family given by Meyer and Utterback [15]. A product family typically addresses a market segment, while specific products or groups of products, within the family, target niches in that segment.

Finally, several contributions already focused on the analysis of platform development in the automobile industry [9,25,28]. In particular, Cusumano and Nobeoka [25] elaborated a model that classifies different types of platforms according to the variation of two indexes based on the commonality of dimensional parameters (track and wheel distance) and of technical features (suspension types). Wilhelm [19] reports the successful case of implementation of the platform strategy in the automotive industry taking into account the main influence of this kind of strategy both on the production process and the producer-supplier relationship.

3 Research aim and methodology

The primary aim of this paper is that of contributing to the growth of existing terminology in this field and easing consensus upon the meaning of concepts. The conditions which make it possible to employ architectural concepts in product development will then be examined on the basis of a broad literature review. Concepts are then connected to one another through literature evidence and some examples drawn from specific research carried out by the authors, in order to discover mutual relationships between concepts themselves. In particular, the connection between architectures and platforms will be examined, because of the scarcity of works analysing this particular matter. The final goal is given by the creation of a theoretical framework, in which concepts are related to one another, which should represent the basis for a future collection of empirical research findings to support the schematic. Since the majority of examples concern industries where products structures are based on a robust mechanical frame (e.g. vehicles), the validity of this theoretical analysis is limited essentially to those industries.

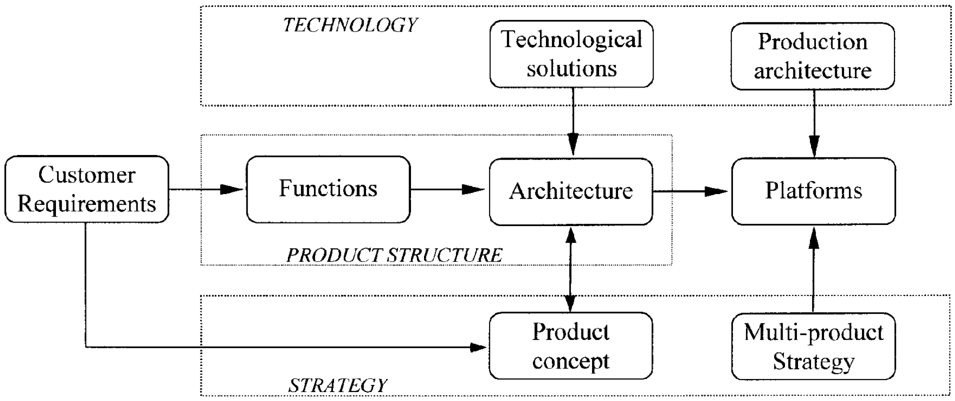
4 The frame of reference

One of the aims of the research presented here is to highlight the relationship that affects the concepts previously defined. Not much can be found in literature regarding this. Furthermore past works haven't analysed how applying a platform approach to the new product development process can be influenced by product architecture. Product development strategies, product and production technology and the organisation of the product development process have an impact on platform development. The model relates the concepts of product requirements, product functions, architecture, modules, and platforms to one another.

The model presented in Figure 1 is a first attempt to correlate concepts concerning technology, product structure and strategy. A detailed explanation of the relationships between the concepts is presented in this section. Then examples will be given with reference to various products. Subsequently, this model will be used to analyse some products from the vehicle industries. It's worth noting that the scheme starts with customer requirements (thus from a market perspective).

The choices regarding architecture and platform are influenced not only by product structure, but also by technological constraints and product strategies. This analysis has been limited to the technical and strategic aspects of product development. Organisational issues are beyond the scope of this research project.

Figure 1 The frame of reference



4.1 Requirements-functions

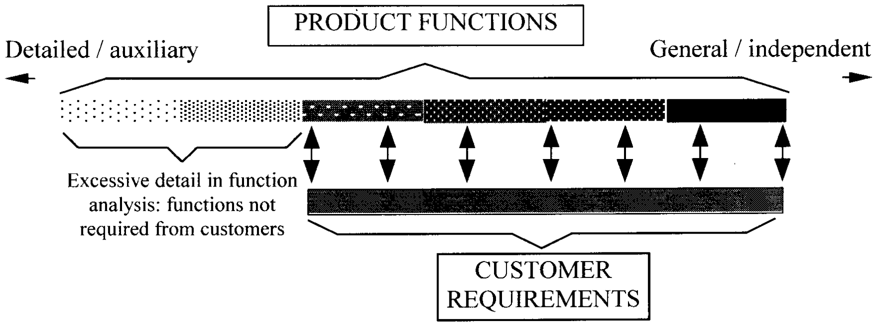
Defining the functions performed by a product is not as straightforward as it appears at first glance. The analysis could be carried out at really different levels, with different results.

Let's consider for example a car. Its basic functions, in a final user perspective, could be those of assuring motion, transporting people and goods/luggage on roads, with an accepted degree of quiet, driving position comfort and climate control and spaciousness. Each of these items can be split down into a set of sub-items. For instance, assuring motion can be subdivided into generating mechanical energy and transmitting power to propel the car along the road. To do so, you quickly realise that power needs to be transmitted from a power unit to the wheels through a power train, with controllable characteristics of power and torque. This, by the way, means thinking of a system to fix the car's wheels to the rest of the car, that is another additional function. The purpose of this example is to show that, when deepening a functional analysis to a product's subassemblies or components or even to its single parts a lot of functions will be discovered. Some of them are truly necessary to the customer, while others must be performed simply to provide a technical solution to enable another function to work. We will define the first ones as 'functions' while the second ones are only 'sub-functions'.

The sub-function of a component is therefore a function that doesn't give the product any new capacity and whose aim is only to guarantee that the primary functions are technically realisable. So it has been shown how difficult it is to distinguish between 'real' functions and 'sub-functions' when carrying out functional analyses together. A mistake in this phase would prejudice subsequent architectural considerations. Figure 2 summarises the contents of the discussion reported in the lines above, suggesting a method of selecting the right level in a functional analysis. The right level is providing all a customer's requirements in a product.

There is a second aim behind the decision as to the level of detail in the functional analysis, more concerned with the research methodology. If the basic architecture different products are to be compared, an even level of analysis has to be sought. Indeed, some products could be extremely modular if broadly analysed (at the level of major chunks) while integral or complex in their components.

Figure 2 Level of detail in function specifications vs. customer requirements



As far as this analysis is concerned, we estimate that the right level of detail is that of product main subassemblies (level of chunks in the definition of [4]). Indeed a similar procedure can be performed repeatedly up to the level of simple parts (the iota level in a product). Accordingly, first of all, the overall architecture of the product is so determined and then, particularly with rather complex products, the single architectures of each subsystem, in the respect of a hierarchical structure. This type of approach is also suggested in other studies (e.g. [7]).

4.2 Functions – architecture

The second relationship to be highlighted in the frame of reference is the product functions – architecture link. The existing literature [3,4,29] usually subdivides architecture into two possible extreme configurations: modular vs. integral (or open vs. closed). Consisting with Ulrich [4], a modular architecture is defined using two criteria:

- a one-to-one mapping from functional elements to the physical components of the product;
- presence of de-coupled, or non-specific, interfaces between components.

Modular architecture can be split into three sub-cases, or modularity patterns, according to the way in which modules are interconnected with one another: slot, bus or sectional [4]. While they are all modular patterns, and thus have one-to-one mapping or de-coupled interfaces, the differences lie in the degree of standardisation of the interfaces. Slot modular architecture has different interfaces for each component. In bus modular architecture, there's a common bus joining the components via the same interface typology. Finally, sectional modular architecture presents the same standard interface for all the components of the products.

Based on these patterns, we have developed a method to evaluate architectural complexity.

First of all, the mapping from functional elements to the components of a product must be analysed. The mapping can be one-to-one (one function is allocated perfectly into one chunk), many-to-one (many functions to only one chunk) or one-to-many (one function is performed by many chunks). The first situation is typical of modular architecture

(Figure 3A). The others define three patterns of increasing architectural complexity: function driven complexity, component complexity, combined complexity (integrity).

Function driven complexity (Figure 3B) is where one function is performed by more than one chunk. A good example of this is car air conditioning. Its function is to cool the inside of the car. This happens when a group of components, e.g. the compressor, the radiator, fans, etc., work together even if they are located in different parts of the car and are constrained by interfaces with other components.

Component driven complexity is where a component performs many functions. The overall architecture could still be modular, but in this case modifying one component function would imply re-designing the whole component, as the functions are interdependent (Figure 3C). For example, the body of a car performs the product's structural function, as well as the aesthetic, aerodynamic and weight distribution functions. It is therefore difficult to change one of these aspects without a major re-design of the body.

Combined complexity is the case shown in Figure 3D. An example of this comes out by simply combining the previous two. The parts - body, chassis, engine - on the one hand, and the functions - aesthetics, power, air-conditioning, structural strength, weight distribution- on the other, are mutually interdependent. This is how Ulrich defined architectural integrity. Mapping the key concepts of the discussion above on a three dimensional graph, it is possible to build a picture to evaluate the level of complexity of a product architecture, at least as far as concerns the functions – chunks mapping (Figure 4).

Figure 3 Types of integrity, based on functions-components mappings

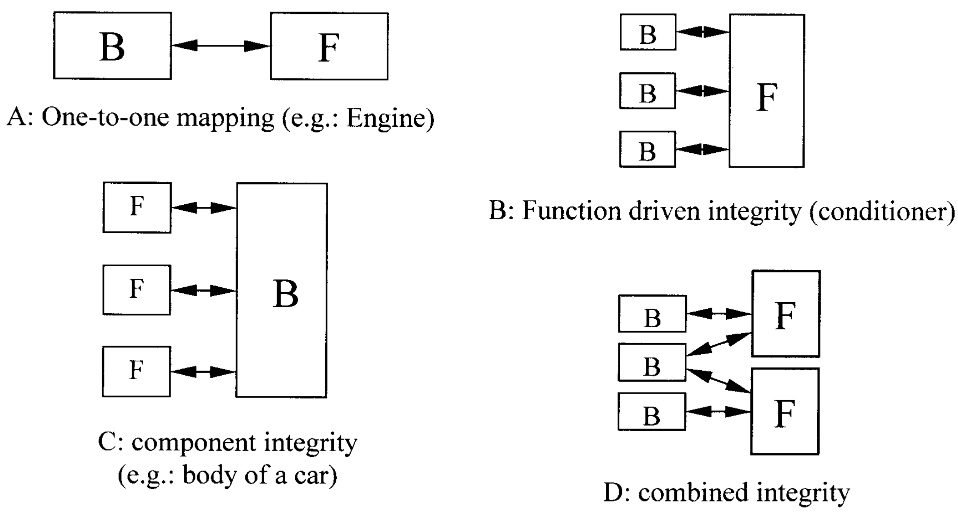
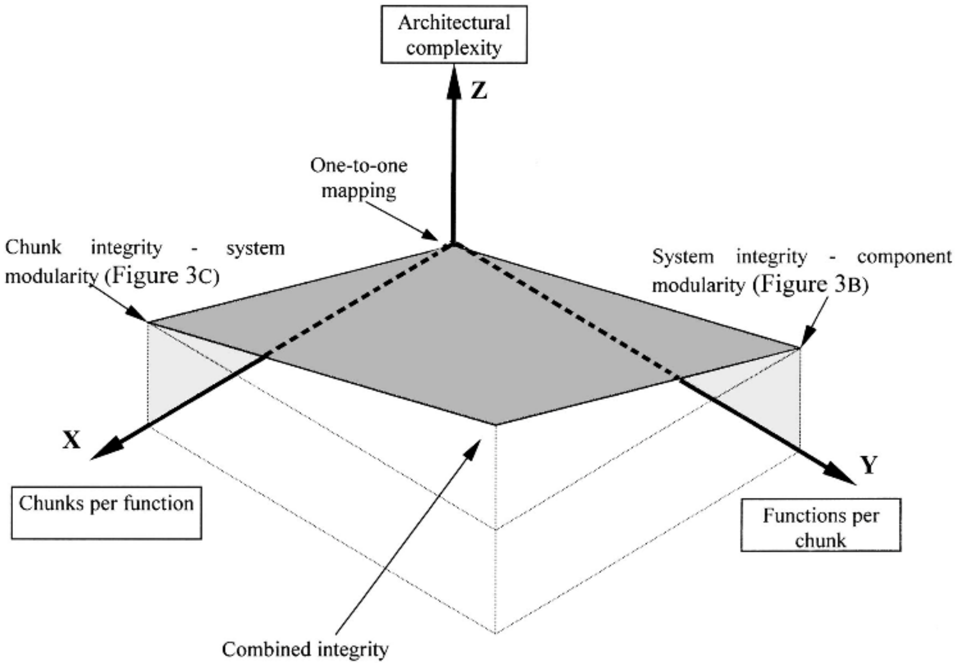


Figure 4 Architectural complexity determined by functions-chunks mapping



The vertical axis (Z) measures the architectural complexity of a product. The X-axis represents the mean number of chunks performing the same function in a product. The Y-axis represents the mean number of functions a single chunk performs. Products generally show a range of architectural solutions that, if reported on the previous graph, draw a surface in which four extreme possibilities have to be pointed out – see previous cases in Figure 3.

Now we want to progress a bit further in the evaluation by introducing an index of architectural complexity. Its evaluation makes it possible to compare different product architectures. The index considers both the functions-chunks mapping scheme, the level of interface interdependence among components and the number of chunks coupled together. In this way, architectural complexity may be defined as follows:

$$AC = f\,(M,C,N)$$

Where: AC= Architectural Complexity

M= Mapping from functions to blocks or chunks

C= Coupling of interfaces

N= N° of coupled blocks

As far as interface coupling is concerned, a measurement of architectural complexity must examine the level of interface complexity. The interfaces can be:

- completely independent (all the same, as with Lego, i.e. sectional modular architecture);
- uncoupled, but different (more than one kind of interface in the various chunks of the product, but not coupled, e.g. slot or bus modular);
- coupled.

4.3 Requirements – architecture

Ulrich [4] presents a guide to help make decisions about product architecture, starting from the product/process performances that should be obtained. A first element to consider when choosing product architecture is the need for changes. In particular, all components likely wear or need add-ons to give configuration flexibility during product life should be kept independent (modular architecture). The same goes for elements likely to be upgraded in future models or remaining identical in different models.

Product variety is the second issue to evaluate. Greater variety is more easily obtained with modularity, thanks to a higher number of possible combinations.

Product performance constitutes a third issue, which has a twofold influence on architectural choices. When key performances depend upon one or two components, modular architecture makes it easier to improve them. On the other hand, integral architecture can bring about improvements in 'global' product performance, like weight optimisation, aesthetics, synergies between elements and so on. Other typical requirements such as price (tightly constrained by manufacturing costs) and product quality are encompassed in the issue of 'product performance'.

In his analysis, Ulrich also considered two other elements i.e. the influence of architecture in components standardisation and in the management of the design process. Since these two elements (standardisation and process management) can't be exactly defined as 'requirements', we'll leave them out of this paragraph.

As a concluding remark of this section, it is useful to emphasise that variety, beyond being a customer requirement influencing product architecture, constitutes also the main concern in platform planning. As a consequence, it represents one of the key issues upon which to analyse the relation between platform-architecture.

4.4 Technological solutions – architecture

The technology of a product has a significant influence on its architecture. Anderson and Tushman [30] have defined a paradigm for the technological life cycle within a particular industry. Technology develops through a set of cycles which take place one after another. In each of these cycles any period in which breakthrough innovations emerge is followed by a period of technological stability, characterised by a dominant technology and incremental change. In the same period the stability of product architecture is often verified, while the emergence of a different technical solution may be the driver for architectural changes.

A second great influence on the technology of architecture is given by the rate of change of component technology and product technology. If component technology evolves faster than product technology, then a modular architecture is more convenient, as it is easier to implement rapid upgrades which concern only part of the product's chunks. A clear example is the personal computer industry, in which the key performance can be associated with specific components (microprocessor, HD drive, peripherals, etc.).

4.5 Product concept-architecture

Product concept is the output of the process that defines the target market niche, customers, product characteristics and so forth. As a consequence, the development process objectives must take product concept into account. The required product performance must guide the choice of architectural types. For example, the fact that a truck should be flexible in order to be used for different types of loads makes modular architecture preferable to integral architecture.

Another example could be derived again from trucks. Among the factors a truck should take into account the ‘earning factor’ (an index that takes into account average commercial speed, payload and fuel consumption, considering the product like an investment) is more essential than, for instance, good aesthetics. So, the prevalence of economic criteria in the product concept definition of this product guides the development process toward adopting all techniques useful in reducing product costs while maintaining the same functions. In this case, modularity is a good solution.

4.6 Architecture – platform

It is the writers’ opinion that product platform, though not an architectural concept, is strongly correlated to product architecture. Indeed a platform strategy is not always viable because of product architecture. In general terms, it is possible to say that product architecture influences the development of a platform since, the more integrated the product architecture is the more model-specific its interfaces are and it is more difficult for its subsystems to be shared with other models of a family. This relationship will be examined throughout the paper when analysing the various vehicles.

4.7 Multi-product strategy and platforms

The multi-product perspective influences the concept of product platform. Effectively, as will be seen later on, the product platform is a means to give architectural complexity to products while contemporarily exploiting some advantages of modularisation and standardisation. To do so, products have to be seen as part of a family rather than as isolated models. In order to effectively use resources and improve development performance, knowledge of various projects must be transferred and shared during the development stage. This is possible only within a multi-product strategy.

The use of platform teams, from an organisational point of view, is another example of the importance of multi-product strategies. In fact, by co-locating platform teams, companies try to achieve commonality of technical solutions among development projects.

4.8 Production/assembly architecture – product platform

The platform strategy has significant consequences at both the production level and for the assembly process. According to the production perspective, adopting platforms means basically defining a standard core in at least one product family. Furthermore this common core, shared alongside the product family, mustn't necessarily embody standard interfaces in order to be adapted to different model/product specific features, nor need it be defined as a functionally independent unit. The product platform should be a sort of big subassembly to produce and assemble separately from the remainder of the product. The reasons why the production and assembly architectures should be affected by the adoption of a similarly defined platform are almost straightforward. Indeed, since production volumes become much higher for the platform than for the product specific components, primarily, different production technologies (e.g. automatic machines, robots) might be hypothesised in platform manufacturing. Secondly, even the assembly process can be reshaped. A common layout solution encompasses a platform assembly line and, if applicable any secondary lines to sub-assemble the product specific components.

It is rather evident that the production and assembly processes seek physical commonality between models of a family in order to achieve economies of scale. Accordingly the platform could be defined as a common subassembly in the product family. This perspective of platforms is different from the broader one used in product development, where it is important to look not only for physical commonality, but also for interface standardisation and interchangeability of components. In fact it is possible to save time on development work only if a new derivative model can be designed and tested without interacting with the existing platform (e.g. testing only the new specific components rather than the product as a whole). Thus, this occurs only if the platform is functionally independent from what is to be developed. Moreover, a similar definition of the platform achieves also the aforementioned advantages in the production and assembly processes, because a 'module' is tautologically a separate subassembly.

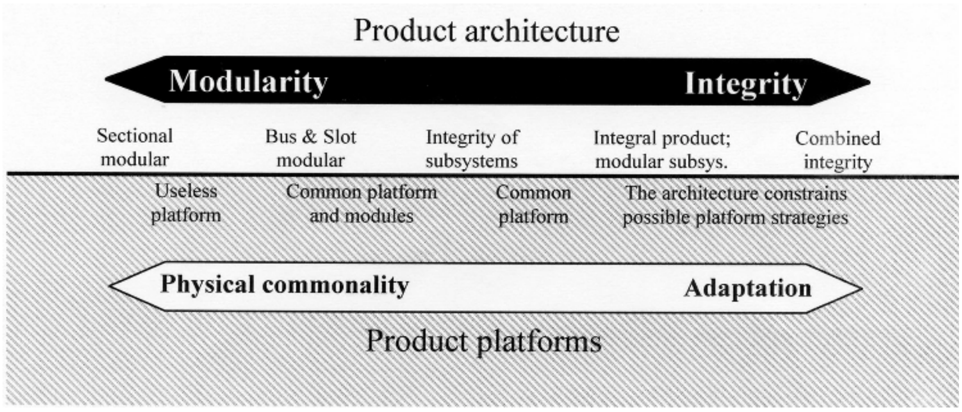
5 Architecture-platform relationship in vehicles

In this section the feasibility of introducing a platform approach will be evaluated, with reference to the market sectors defined above. Along with the empirical evidence, a platform's applicability is influenced by a set of factors, product architecture being the first. Therefore, this section examines how architecture is related to the possibility of defining a platform approach to product development. Some hypotheses, about the reasons why platforms have only been applied in some of the analysed cases, are then drawn.

Product architecture is a fundamental part of the product concept. Consequently, where product concepts embody high integrity characteristics, they lead to a highly integrated architecture. This makes it difficult to adopt a platform concept in product planning, at least according to the idea that a platform is the common object of a family of products.

Figure 5 shows the relationship between product architecture and product platforms. It can be explained making reference to the vehicle products that have already been analysed in other works [25,31]. When there is a high degree of modularity, a product platform becomes rather meaningless. During the past few years, there has been an increase in more integrated technical solutions for bicycle production. Nonetheless, given the modular nature of bicycles, it makes more sense to develop new products on the basis of modular innovation rather than plan a common basis, like a platform, for a set of products.

Figure 5 Architecture-platform relationship



The central area of the figure is where platforms can be applied. Platforms are possible both with modular and mainly integral architecture. In fact, the application of platforms can be found in the following industries: trucks, earth-moving machinery, scooters and cars. When there is a high degree of modularity, it is possible to share not only a platform but also specific modules among products. Instead, when a product is more integral, sharing a platform, which is also a kind of large module, becomes increasingly difficult. In fact, in the case of a high degree of architectural integrity, e.g. motorcycles, platforms cannot easily be planned and it is the very product architecture that limits the use of platform strategies. For example in the motorcycle industry fashion and customer requirements have a strong importance. Thus, trying to apply a platform strategy is futile, as a product platform would constrain the structure of products for its whole lifecycle, which determines a loss of flexibility. Furthermore, since motorcycles are less complex than cars, the new product development times are significantly shorter, (up to one third). Consequently, from the perspective of lead-time reduction, a platform approach would not be advantageous.

In conclusion, it can be said that platforms as a product planning concept cannot be applied at either extreme of the figure, i.e. when product architecture is either perfectly modular or totally integral. The production and assembly process is another factor to be considered. Flexible production systems are needed when there is low volume per model. If the process is flexible, it is possible to have products with integral architecture that do not allow for much commonality among models. In the case of low volumes per model, the platforms and modules can be used to make the assembly process more efficient. Platforms and modularity allow the production process to be more flexible by making it possible for different products to share the same assembly line without needing significant modifications to the line itself.

It is important then to distinguish between ‘production modularity’ and ‘product development modularity’. The former consists of an attempt to make the assembly more modular with the possibility of assembling sub-systems off the main line. The latter, on the other hand, seeks to design the product with interfaces which are as standardised as possible to allow for a high degree of configuration flexibility [9]. With regards to this latter point of view, modularity and platforms can be advantageous not only in the product development stage but also during the production process, since even if it is not always true that a sub-assembly represents a module, a module often constitutes a subassembly [7]. A further consideration is that product platforms are at the same time a form of modularisation and of standardisation. In fact, a platform is usually a large part of the product that can also be considered a module. The definition of a product platform reduces efforts needed to develop a product since part of it is already designed and developed.

6 Conclusions and further research directions

The paper has presented a general framework explaining the connections between the relevant product structure concepts that could be used to improve product strategies and the management of the development process. The main relationships between these concepts have been thoroughly analysed with reference to existing literature and industrial examples, highlighting major constraints and opportunities when defining product structures. At the end the framework provides a system to understand all the elements influencing the applicability and the definition of a product strategy based upon platform development.

It is worth emphasising that product architecture constrains the product planning process and in particular the definition of a platform. Indeed the product platform is not beneficial for both cases of complete modularity and product and component high complexity. In the former, a platform does not offer advantages during the design and product development process, and so it becomes a mere theoretical job defining its boundaries. In the latter, the product architecture is so compelling that it requires a complete redesign when renewing products, thus jeopardising a platform approach. As a consequence the actual field of platform applicability is in all intermediate cases, where, it has been proved to be extremely useful in reducing NPD lead time and production costs. The validity of this relates mostly to the production of vehicles, which have been used to provide examples explaining the reasons why concepts should be connected to each other.

Therefore, there is still a lot of room for further research. In fact the conceptual framework we have suggested helps in making the correlation between architectural concepts, by providing a reference scheme. Nonetheless the scope of the present paper was mostly theoretical and the analysis still lacks some further examples together with some quantitative measures. Getting a practical guideline to help make decisions constitutes the objective for the near future. This should take into account both implications for product strategy (thus analysing how choices attaining product structures must be considered when defining product strategy) and the role of the NPD departments (analysing the influence of organisations on the management of product structures in terms of constraints and performances).

In this paper, the reference made to some particular products implicitly assumes that to some extent there exists homogeneity within the same industrial sectors. In future analyses, both industry-wide and firm-specific behaviours should be considered.

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