INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN
ICED 03 STOCKHOLM, AUGUST 19-21, 2003

UNUSED POTENTIAL FOR BUILDING PLATFORM BASED PRODUCT FAMILIES

Adrian P. Hofer

Abstract

This paper analyzes the use of the platform concept in practice. It investigates how and where platform potential can be identified and what trade-offs have to be considered. It looks at how different companies use commonality across products within a product family, and where further (unused) potential could be found. The paper uses a framework to compare and to generalize the findings, and finally draws conclusions for the management of platform based product families.

Keywords: Product families, product platforms, layout design

1 Introduction

In a global, intense, and dynamic competitive environment, the development of new products and processes has become a focal point of attention for many companies. Shrinking product lifecycles, increasing international competition, rapidly changing technologies, and customers demanding high variety options are some of the forces that drive new development processes [5], [8], [13], [14]. To increase their level of competitiveness, many companies have switched their focus from single products to product families, in order to increase the potential for reusing elements from product to product. A growing body of literature advocates the building of platform based product families to increase efficiency and flexibility in new product development and in order processing [6], [11], [12].

As defined by Robertson & Ulrich [9], a platform is the collection of assets that are shared by a set of products (i.e. a product family). Meyer & Lehnerd [6] define a platform in a similar way as a combination of subsystems and interfaces, from which a range of derivative products can be efficiently developed and produced. Criteria for platform elements are their high commonality potential (e.g. stability of market demand over time, robustness, similarity) while differentiation needs (e.g. flexibility, high impact of changing market demand) have to be served by non-platform elements. This is necessary to reach a high degree of individualization with robust and standardized product architecture elements. According to Sanderson & Uzumeri [11], a product platform offers a stable frame for the variation and evolution of a product family. Flexibility lowers the cost of necessary modifications and therefore is a way to encounter the demands of a dynamic competitive environment through innovation with smaller expenditure and risk. Cost and time efficiencies, technological leverage and market power can be achieved when companies redirect their thinking and resources from single products to families of products built upon robust platforms. Implementing the platform concept can significantly increase the speed of a new product launch.

The concept of building product families based on platforms has been widely accepted in literature as an option to create variety economically. The reasons (or expected benefits) of the concept are mainly greater flexibility in product design, efficiency in product development and manufacturing, and effectiveness in market positioning. The application of the platform principles leads to different platform types according to the kind of assets that can be used as a common basis. Literature also mentions the substantial risks and trade-offs that have to be made in developing and managing platform based product families [6], [7], [10], [11].

Studies have recently started to draw attention upon the significant costs and trade-offs associated with product platform development [2], [4]. The development and management of platform based product families is generally accepted to demand extensive resources and impose substantial risk in the development and realization of product families. The finding that companies often limit their solution space for platform potential to a low hierarchical level of the product architecture (component level), resulting in physical *product* platforms, lets assume that unused potential in the development and management of platform based product families exists [1]. There is gap in literature concerning the application of the platform concept for complex products, where a complete de-coupling of subsystems is rarely feasible, and the variety of subsystem combination can cause high system integration efforts.

This leads to the question whether the platform concept can lower overall system complexity through the use of commonality on a hierarchically higher level of the product architecture (i.e. on the level of subsystem arrangement or layout). Although no bargain solutions are expected, the search for platform potential in new areas is a necessary completion to our knowledge about the platform concept.

2 Research methodology

2.1 Research design

The objective of our research was to investigate the application of the platform concept in different companies, and to compare how platform and product family concepts are realized in practice. We studied three technology-driven companies. These firms represent a variety of product and market contexts and provide examples of a range of platform and product family concepts and implementations.

The data collection and analysis was carried out in four phases. The first two steps were conducted as exploratory projects with the goal of analyzing the status of product family management, and of identifying unused potential. These projects had a duration of three to four months each and were conducted with a team of experienced people from sales, engineering, research & development, and manufacturing. In the first step, the initial situation of product family management was analyzed, covering the market positioning, market structure, product architecture (and variety), and value chain processes. In a second step, further platform potential was identified, a concept for the realization was developed, and the effects were estimated. In a third step, a framework for structuring the information gathered during the company specific projects was developed. This framework consists of a common description of the product architecture and of the platform effects. It allows to compare case-specific data and to generalize its results for drawing conclusions to answer the research questions. In the last step, the case-specific data was represented within the framework, and a content analysis was performed to compare and to generalize the research results across the cases and to draw conclusions.

2.2 Analysis framework

Our framework for the description and comparison of the effects of platform based product families consists of the following three categories: the flexibility of the product family design (responsiveness), the efficiency of the resources used within the product family realization, and the effectiveness of the product family positioning (differentiation). These elements and criteria form the research framework that was applied to the case studies.

Product family design consists of the definition and the development of the product range offered in the market. In a situation with a broad product range (high variety), and increasing adaptation time and costs, the value of flexibility in the use of resources becomes increasingly important [10].

Elements of *product family realization* are the order neutral (advance) platform development and the order specific processing within the value chain (order handling, product specification, engineering, and manufacturing) [5]. The time- and cost efficient organization of its business processes is a key competitive factor of a company.

Product family positioning covers the communication of the product range to the market and within the company and in its value chain. Its task is the realization of the chosen competitive strategy and the (segment specific) effective differentiation of the product range.

3 Case studies

In the following, the three companies contributing to the case studies are characterized. The first company, a provider of Post Print Management systems, is a global player in a specialized market with 850 employees. The second company is one of the world's largest providers of railway vehicles and employs 20'000 people with a sales volume of 3.5 billion EUR. The third company produces wires and cables for Energy and Signal Transmission with 1'000 employees and sales of 150 million EUR.

3.1 Initial situation

Post Print Management comprises the transport and storage of rotary press output, the inserting of supplements, and the packaging and addressing of finished products (i.e. newspapers with inserts). The company was initially focused exclusively on the upper end market with high demands on system performance. Many efforts to enter a low price segment with the existing systems approach proved unsuccessful due to difficulties to realizing concept or system reuse potential. The lack of a common platform for different market applications led to high individual engineering efforts and intensified the danger of getting pushed into an increasingly narrow market niche. The systems are built of different assemblies (with functional options) which are arranged in a system layout. The layers of the product architecture consist of (1) functionally decoupled assemblies, (2) functional options (add-ons), (3) the layout (arrangement and connection of the assemblies) and (4) the system integration. Each layer of product variety (assemblies, options, layout, and system integration) leads to increased complexity in controls and operations design and to high cost of commissioning and testing. The analysis of the product architecture showed high levels of variety with comparably low segment-specific differentiation effects resulting in high process complexity in all market segments. Although the modular product architecture on the assembly level resulted in a high degree of *component* reuse, reuse on the system level could not be consistently realized from project to project.

The market for *Electro Locomotives* is exposed to strong structural changes. It is characterized by excess capacities which lead to decreasing unit prices. Engines are traditionally specified and built to order while the lack of a common basis prevents an effective reuse of components and modules. The high order specific efforts result in a poor cost position, in particular in the case of small lot sizes. Reaching the profitability targets with medium and small lot sizes can only be achieved through the reduction of engineering and order processing efforts and through the reuse of existing solution elements. The product architecture of electric locomotives consists of different layers: (1) the functionally decoupled assemblies, (2) the functional options of the individual assemblies, (3) the arrangement of the assemblies in the engine room and (4) the integration in the overall system (locomotive). The virtually unrestricted variety on the assembly level leads to high integration complexity and risk, and consequently to a critical cost position for realizing small to medium lot sizes (too high engineering costs per locomotive). The building of assemblies based on physical platform components has some effects of scale on the assembly level but cannot lower complexity in system integration.

The company providing wires and cables for *Energy and Signal Transmission* is positioned in the high end market through the development competence for specific customer needs, e.g. in the automobile manufacturing. While in this segment a high level of development effort for specific products is accepted and paid for by the customers, the ability for rapid and low-cost reaction (flexibility) in a lower market segment (mass customizing) becomes increasingly important. In a market environment characterized by time and cost pressure, high response times for offer creation and order processing represent a competitive disadvantage. Cables are built of single wires which are twisted into a conductor and then coated (extruded) with insulating material of specified thickness and color. Cables consist of a combination of leads which are coated again. Elements (layers) of the product architecture are (1) the components for leads (wires, coating materials), (2) functional options (wall-thickness and color), (3) the lead construction, and (3) the cable construction. These layers also reflect the production processes. The low degree of interaction between the components leads to almost unlimited variety, because few (technical) restrictions exist. As a result, orders for customized solutions have to be checked for feasibility and the processing becomes extremely complex and slow. In the initial situation, the different market segments could not be provided with segment-specific solutions, and as a result, the cost position in the basic market was too high.

The three cases represent different markets, products, and applications. However, common to all three companies is a market structure with different market segments. The analysis found a similar structure of product architecture layers across all cases, where existing platform concepts were in use to increase commonality on a hierarchically low (component or assembly) level. These product platforms have no substantial limiting effect on system complexity, as they do not restrict subsystem interactions and lead to high system integration efforts. This complexity prohibits entering lower market segments.

3.2 New product family concept

Starting from a situation where the use of commonality is limited to a low hierarchical level in the product architecture, the question arises whether new platform potential can be found in other layers of the product architecture. The traditional platform approach focuses on the component level, and affects mainly direct material and labor cost through improved economies of scale. These effects are not always sufficient to support a product range for multiple market segments, as complexity along the value chain is not substantially reduced by this platform approach.

In the case study projects, the search for new platform potential was thus extended to other layers of the product architecture. As a first step, these layers were identified and then they were separately characterized by their differentiation needs and commonality potential. The overall goal was to realize a segment specific product range based on a common basis, and supporting distinct processes and process cost. The basic idea of using the platform concept was to search for commonality potential across all market segments with the goal to increase the reusability of concepts especially in the low end market. The focus in all cases was on using the system layout (arrangement of components or assemblies) as a conceptual platform.

Post Print Management: The analysis showed, that two layers of the product architecture with a high commonality potential could be identified. The new concept is based on the commonality potential on the assembly and on the layout level, while segment specific functional options and system integration allows for differentiation. The platforms of the product family are (1) the standardized assemblies (product platform) and (2) the standard arrangement of these assemblies (layout platform).

The *layout platform* describes the basic arrangement of assemblies. It is highly de-coupled from functional options and from system integration by coping with a standardized input and providing a standardized output of material and information flow. The layout platform serves as a robust basis for system design and engineering in different market segments. It facilitates the efficient variation without increasing complexity, and at the same time enables the company to design a high tech (and high cost) system for the higher market segment while employing economies of substitution.

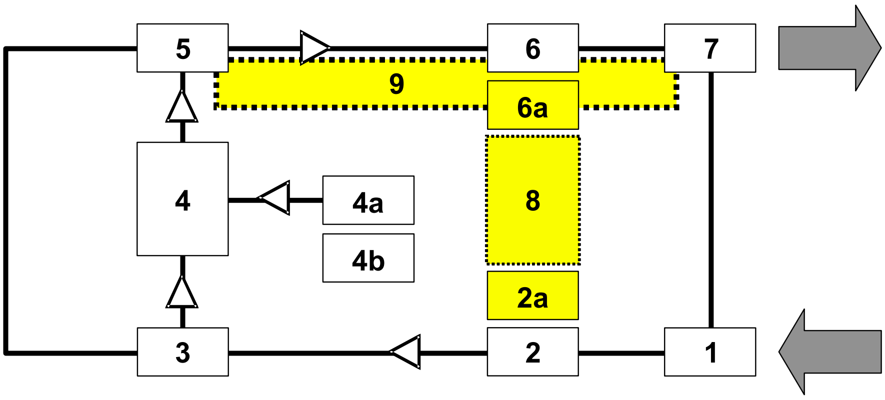

Figure 1: Standardized subsystem arrangement as layout platform

Electro Locomotives: The analysis of the product architecture showed, that two of the four layers offered substantial commonality potential. The new product family concept was based on (1) an existing product platform on the assembly level, and (2) the standardization of the arrangement of these assemblies in the engine room (layout platform).

The *layout* of the engine room is used as a common basis for the whole product family of electric locomotives. This platform defines the arrangement of all assemblies in the machine room, as well as their interfaces and enforces the realization of different product variants within an identical layout. The assemblies are always positioned in the same place; cabling and piping between the assemblies runs in the same guide rails. It is possible to install one, two and multi-frequency systems in locomotives with the same engine room measurements. Thanks to small power converters, additional train control systems can be included without having to enlarge a four-axle locomotive for the multi system variant.

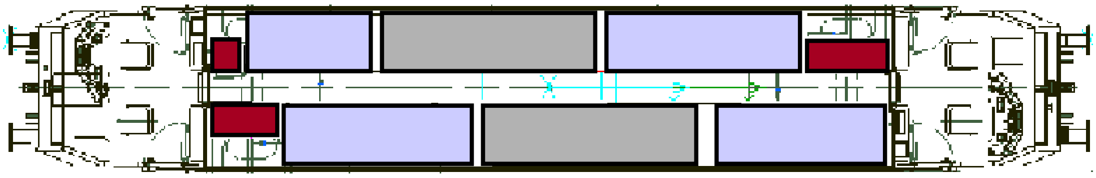

Figure 2: Standardized engine room as a layout platform

Energy and Signal Transmission: The product architecture analysis resulted in two different layers with high commonality potential. All products within a product family are based on (1) a range of standardized components, and (2) a common lead construction, which defines the arrangement of wires (layout platform). This leaves the coating material, thickness and the color as variable differentiation elements. A component system further supports the selection of wires and coating materials, and segment specific selection rules were defined for the variety of coating material, wall-thickness, and color.

The *layout platform* defines the arrangement of wires to leads and decouples the leads from other layers of the product architecture. This lowers complexity in the product range which is needed for easy variation of the end-product within tight limits. The so defined leads can be produced in a standardized process and kept on stock, before being processed to customized cables.

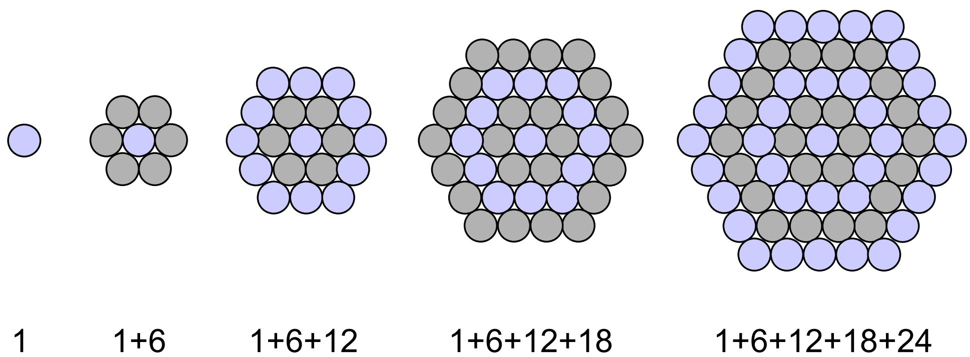

Figure 3: Standard lead construction as layout platform

4 Discussion

4.1 Potential of layout platforms

In all three cases it was possible to identify platform potential on a hierarchically higher level of the product architecture. Commonality on a low level (components, assemblies) was already used by all companies. The decisive difference between traditional product platforms and the (new) layout platforms is the degree of influence they have on system and process complexity. The definition of the different layers of the product architecture resulted in much clearer structured product ranges. The identified commonality potential on multiple layers of the product architecture (product and layout platform) is a basis for segment-specific product differentiation. In this section, the effects of the layout platform found in the three case studies are described. This description is done within the framework presented earlier.

Product Family Design: The product family design is *limited* by the layout platform. The standardized layout forms a stable basis for the development and realization of the entire product family and defines the design options of the product family to a large extent. The platform limits the innovation capability, and the challenge is to define these restrictions in order to have as little influence as possible on the rest of the product architecture. The most important requirement for the definition of a layout platform is the possibility for its decoupling within the product architecture to achieve independence from changes within the product family (robustness). This is done by limiting the variety of subsystem arrangements to facilitate the integration of elements with differentiating attributes.

The layout platform is a prerequisite for building systems on existing elements (reusability) while lowering overall system complexity. This results in greater flexibility in a *narrower* defined field. By building a product family on a common (stable) layout, the remaining elements can be rapidly adapted to variable needs. Within the boundaries of the standardized layout and the product family, the potential for efficient variation increases. The structuring of product architecture limitations and options can be used as a framework for the distinction of existing (predefined) and new solutions, and for directing future development efforts.

Product Family Realization: Products based on a layout platform can profit from a more rapid and less risky development. The platform concept allows the efficient product specification and order processing through the advance investment of platform development. The development of the platform as advance investment for the design of the product range can be high, but as a consequence, the derivative products can be developed and produced more efficiently (in shorter time and to smaller costs). The platform has a high leverage effect, as is allows the variation and derivation of products to incremental costs and time, compared with the development of the platform itself [7]. Through the reuse of platforms, companies can substantially lower the time and the risk for the development of derived products [12].

The advantage of layout platforms is that for complex products it is comparably easier to standardize the *arrangement* of its subsystems than to standardize these subsystems. A layout platform is especially suitable for redesigning product architectures of *existing* products by supporting the reuse of developed elements within a clearly structured framework (layout). In the case studies, their effects were considered less on direct (material and labor) cost, but on the whole chain of order processing by reducing process complexity (and indirect cost).

Product Family Positioning: The platform has a strong impact on the competitive positioning of a product family. It allows bridging the gap between two strategic directions, individualization and standardization. The platform represents the standardized part of the product range, while the individualization is being achieved with the remaining elements of the product architecture. This allows to design the product range in a segment specific way. The platform is the *segment-neutral* basis while the remaining elements can be individualized in a *segment specific* way. So, the needs in different market segments can be countered within the same product family at different individualization degrees.

The layout platform is the basis for a structured definition of the product range. Through the consequent reuse of standardized layouts in every product of a product family, external as well as internal communication is focused on relevant and value-adding issues. Consequently, resources for the individualization of the non-platform elements of the product architecture are freed and become accessible for the offer of a broader and more dynamic product range. The layout further supports the effective segment specific offering and provides clear boundaries for a product family.

4.2 Fundamental trade-offs

To value the layout platform concept, the potential benefits must be compared with the negative effects on product family management. In the following, the basic trade-offs of the platform concept are summarized.

The first trade-off concerns the product family design. Through the relatively longer life-cycle of the platform (in comparison with the individual products of the product family) the variation and evolution capabilities of the product range are limited. A compromise must be found between the flexibility to realize a high product *variety*, and the *restriction* of variation through the stability of the platform. In defining a standardized layout it is necessary to choose the optimum level of detail. A layout defined in a too general way will not have the expected effects on product complexity, while a too specifically defined layout will not fit variable market demands and the need for product differentiation in multiple market segments. The extent of layout limitation furthermore determines the degree of innovation capability. The case examples show, that commonality potential can be realized on different layers of the product architecture within a product family. The layout platform has a distinct influence on product variety and complexity, and it defines product design flexibility by restricting innovation to the subsystem level. However, in cases where the layout proves to be an important element for product variation and differentiation, this platform type will not be suitable.

The second trade-off refers to the efficiency of product family realization. Here the decision must be made between the advance investment for platform development and the resulting savings for the development of products based on this platform. The development of a layout platform is useful in cases where the unrestricted combination of subsystems causes different levels of complexity, and the restriction on the layout level clusters solutions with comparable (and lower) complexity. As a result, products based on this layout can be realized with low design and engineering efforts. The layout platform can be developed in an evolutionary way by starting with existing (pre-engineered) solutions and later adding new solutions within the restricted layout. This makes sense for complex products, where the total variety can not be completely described. For products where the different arrangement of subsystems does *not* add complexity (i.e. complete decoupling), however, this restriction is not necessary.

Thirdly, product family positioning is defined by the balance of standardized and individualized layers of the product architecture. Competitive advantage can be achieved by the optimal combination of individualization and standardization. The layouts in the case examples are standardized across all segments, while the differentiation aspects are met by the other layers of the product architecture. This allows a segment specific design of the product range. In cases, where the system layout is necessary for the market positioning, this platform type should not be used.

4.3 Conclusions

The platform effects discussed in the preceding section concerning the product family management can be summarized in the tension field between the demands on variation and on innovation. Sanderson & Uzumeri [11] identify this as an elementary trade-off, in which companies must use their limited resources (development resources, budgets, technology options).

Sanchez & Mahoney [10] describe product design as a kind of controlled innovation in which companies create new products through the application of existing and new knowledge about components and interfaces. In order to make this knowledge reusable, the architecture of the products as well as the functions of the components and their interfaces have to be known. Innovation thus is based on the creation of new information about components and learning about the interfaces and configurability of these components through the possibilities of the product architecture. These differences can be shown in a typology of the innovation by Henderson & Clark [3] where they complement the traditional separation into *radical* and *incremental* innovation and distinguish between modifications of *components* and modifications of the *interfaces* between these components. The platform concept meets these requirements by separating the elements of the platform itself, by not employing them for variation and innovation, and by using the platform elements to offer a stable basis for differentiating elements.

It can be concluded that the stability of a platform can be used to simplify the evolution of a product range (variation) within clear boundaries. The danger of restricting the innovation capability must be considered, however. Fundamentally, the platform concept allows a hybrid strategy by allowing the combination of flexibility and restriction. The concrete realization of this combination is of central importance for the success of the platform definition. The extent of the platform determines the balance of standardized and individualized elements and is a measure for the flexibility (and/or restriction) of the product family. The definition of the platform can be influenced through the criteria for choosing platform elements, through the product architecture, and through the platform type.

A *product platform* standardizes a defined part of the physical elements of the product architecture and their interfaces to the non-platform elements. This platform type influences mainly direct (material and labor) costs through improving the reusability of the platform elements. It is suitable when achieving efficiency and scale effects with simultaneously short processing times is the main focus. The definition and development of a product platform requires a high degree of standardized functions and elements as well as the continued stability of the platform.

A *layout platform* standardizes the conceptual arrangement of product architecture elements. This has a strong influence on system complexity as it decouples different layers of the product architecture. It proves specifically suitable for the integration of complex systems (with multiple product architecture layers), and it affects the complexity and resource utilization of order processing. It is a means for the coordination of different functions and can be useful in particular for the realization of systems with small lot sizes and incompletely decoupled subsystems which cause complexity in system integration. The layout platform can lower system complexity and affects (indirect) process efforts and cost along the value chain. It can be complemented by a component system and then be used for product configuration.

The description of the effects of the platform concept on the elements of product family management and on the product range shows, that different compromises about the development of platforms with regard to the flexibility of product family design, the efficiency of product realization and the effectiveness of product positioning have to be taken into account. The building of product families on a common platform is an important instrument for the realization of a product/market strategy. The structuring and the positioning of the product range in the conflict between standardization, individualization, and mass customization can gain substantially by the use of a platform as a common basis. In this context, the standardization of a system layout can offer additional benefits for products with multiple architectural layers. Further research is necessary, though, to support the decision making processes for the definition of suitable platform concepts. With the increase of platform alternatives to choose from, their valuation and comparison becomes decisive for reaching and defending competitive advantages.

References

[1] Halman, J.I.M., Hofer, A.P. and van Vuuren, W., "Platform driven Development of Product Families: Linking Theory with Practice", Journal of Product Innovation Management, Special Issue on Strategic Planning, 2003, forthcoming.

[2] Hauser, J.R., "Metrics thermostat", Journal of Product Innovation Management, Vol. 18(3), 2001, pp.134-153.

[3] Henderson, R. M. and Clark, K. B., "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms", Administrative Science Quarterly, Vol. 35(1), 1990, pp.9-30.

[4] Krishnan, V. and Gupta, S., "Appropriateness and impact of platform-based product development", Management Science, Vol. 47(1), 2001, pp.52-68.

[5] McGrath, M.E., "Product strategy for high-technology companies", Irwin, Homewood IL, 1995.

[6] Meyer, M.H. and Lehnerd, A.P., "The power of product platforms: Building Value and Cost Leadership", Free Press, New York, 1997.

[7] Meyer, M.H., Tertzakian, P. and Utterback, J.M., "Metrics for Managing Research and Development in the Context of the Product Family", Management Science, Vol. 43(1), 1997, pp.88-111.

[8] Pine, J.B. (1993). "Mass Customization: The New Frontier in Business Competition", Harvard Business School Press, Boston, 1993.

[9] Robertson, D. and Ulrich, K.T., "Planning for Product Platforms", Sloan Management Review, Vol. 39(4), 1998, pp.19-31.

[10] Sanchez, R. and Mahoney, J.T., "Modularity, Flexibility, and Knowledge Management in Product and Organization Design", Strategic Management Journal, Vol. 17, 1996, 1996, pp.63-76.

[11] Sanderson, S. and Uzumeri, M., "Managing product families: The case of the Sony Walkman", Research Policy, Vol. 24(5), 1995, pp.761-782.

[12] Sawhney, M.S., "Leveraged high-variety strategies: from portfolio thinking to platform thinking", Journal of the Academy of Management Science, Vol. 26(1), 1998, pp.54-61.

[13] Ulrich, K., "The role of product architecture in the manufacturing firm", Research Policy, Vol. 24(3), 1995, pp.419-440.

[14] Wheelwright, S.C. and Clark, K.B., "Revolutionizing product development: quantum leaps in speed, efficiency, and quality", The Free Press, New York, 1992.

Adrian P. Hofer, Hofer und Partner AG, Untere Roostmatt 8, CH-6300 Zug, Switzerland
Tel +41 878 80 80 01, Fax +41 878 80 80 04, E-mail adrian.hofer@hoferundpaertner.ch
URL: http://www.hoferundpartner.ch