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Product Family의 부품공통성 평가방법의 비교연구

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A Comparison Study on the Evaluating Methods of Component Commonality in a Product Family

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고객의 요구에 대한 빠른 대응과 유연하고 효율적으로 새로운 제품을 적기에 개발하기 위해서는 제품 플랫폼에 기초한 대량 맞춤이 절실히 요구된다. 이러한 목적을 달성하기 위하여 기업들은 상대적으로 생산비용을 낮게 유지하면서 대량생산의 이점을 유지하고 동시에 고객의 요구사항을 만족시키기 위해, product family를 도입하고 가능하면 작은 변화를 통하여 제품의 다양성을 유지하고자 한다. Product family를 설계할 때 중요한 이슈는 제품의 공통성과 차별성간의 절충점을 어떻게 찾아낼 것인가인데, 이를 위하여 개발된 것이 product family내에서 부품의 공통성을 평가하는 방법이다. 본 연구에서는 product family의 공통성을 평가하기 위해 개발된 대표적인 7가지의 공통성 평가방법을 여러가지 측면에서 비교분석한다. 이를 위하여 두 개 회사의 컴퓨터 마우스 제품군을 대상으로 공통성 평가를 위한 비교연구를 수행하였다. 추가적으로 본 연구에서는 product family를 설계하거나 재설계할 때 공통성 평가지수의 효과적이고 효율적인 사용방안을 위한 전략도 제시하였다.

Keywords : Commonality, Diversity, Commonality Indices, Product Family Design

1. Introduction

To survive in global competition, companies need to develop a wide range of products to fit several market segments with different quality levels. At the same time, a new methodology for product variety is required to optimize the product development efforts across product families and generation. Companies are faced with the challenge of providing as much variety as possible for the market with as little variety as possible between products. In order to achieve this, product families have been developed, allowing the development of a sufficient variety of products to meet the customers' demands while keeping costs relatively low [1].

A product family is defined as a group of related products that share common features, components, and subsystems to satisfy a variety of market niches. A product platform is the set of features, components or subsystems that remain constant from product to product, within a given product family. The challenge when designing a family of products is in resolving the tradeoff between product commonality and distinctiveness. Toward this end, some commonality indices to evaluate component commonality in a product family have been developed by design researchers and these indices are to measure the amount of commonality within a product family. This study compares and contrasts several of the commonality indices from the literature based on their accuracy,

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repeatability, and simplicity. In this study, we analyze computer mice families of two companies. The commonality of each product family is then computed using seen commonality indices. The results are then analyzed, and recommendations are given on their use and utility for product family design.

2. Commonality Indices to Evalyuate Product Family

Commonality is the possession of common features or attributes in either the product or the manufacturing process for a set of products. The core functionality remains essentially unchanged across the product families, while new functions, features, and technologies are incorporated into new products.

To assess the degree of commonality within a product family, several commonality indices have been developed based on different parameters such as the number of common components, their connections, their costs, and so on. A brief overview of several component based commonality indices is summarized in <Table 1>[2-8], and each index is briefly described next.

The Degree of Commonality Index (DCI) is the most traditional measure of component standardization. It uses information contained in the company's bills of materials to assess commonality for a product line. It can be interpreted as the ratio between the number of common components in a product family and the total number of components. The Total Constant Commonality Index (TCCI), introduced by Wacker and Trelevan, is a modified version of the DCI with absolute boundaries ranging from 0 to 1 that facilitates comparisons between families (benchmarking) and between competing designs. Martin and Ishii also introduced a commonality index similar to Collier's-namely, the Commonality Index (CI)-along with indices for measuring set-up costs and the point of product differentiation, which correlate with many of the indirect costs of providing variety. Jiao and Tseng extend Collier's DCI to create indices for component commonality and process commonality, including the Component Part Commonality Index CI (C), which takes into account production volume, quantity per operation, and component costs. Another index found in the literature is the Product Line Commonality Index (PCI) developed by Kota et al. The PCI does not penalize the components that are unique given the product mix. It is based on size and shape, materials and manufacturing processes, and assembly and fastening schemes. Siddique et al. propose using separate indices for measuring component commonality, connection commonality, and assembly commonality, applying them to automotive underbodies, which are predominantly integral architectures. Each of these indices results in a percentage of commonality, which can be combined to determine an overall measurement of commonality by weighting each index to create the Percent Commonality (%C). Thevenot most recently recently developed the Comprehensive Metric for Commonality (CMC). The CMC extends the PCI to assess the impact of each component on the overall level of commonality and variety in the product family and assesses the design of a product family based on the ratio of the current component commonality and variety and the level of commonality and variety that is desired [2].

<Table 1> Summary of commonality indices

Name		Developed by	Commonality measure for :	Zero Commonality	Complete Commonality
DCI	Degree of Commonality Index	Collier[1981]	The whole family	1	$\beta=\sum_{j=i+1}^{i+d}\Phi_j$
TCCI	Total Constant Commonality Index	Wacker and Trelevan[1986]	The whole family	0	1
PCI	Product Line Commonality Index	Kota, Sethuraman and Miller[2000]	The whole family	0	100
%C	Percent Commonality Index	Siddique, Rosen and Wang[1998]	Individual products	0	100
CI	Commonality Index	Martin and Ishii[1997]	The whole family	0	1
$CI^{(C)}$	Component Part Commonality	Jiao and Tseng[2000]	The whole family	1	$\alpha=\sum_{j=1}^{d}\sum_{i=1}^{m}\Phi_{ij}$
CMC	Comprehensive Metric for Commonality	Theve not and Simpson[2007]	The whole family	0	1

3. Experiments and Analysis of Commonality Indices

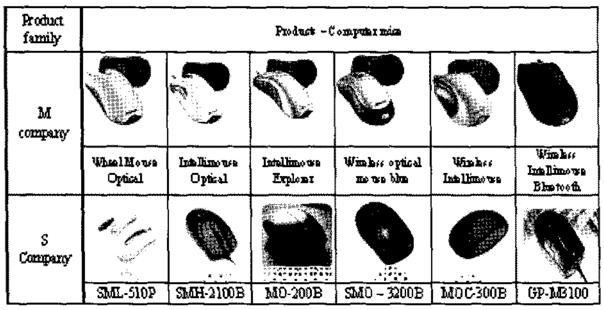
3.1 Description of the experiments

In this section, we investigate the relationships between the product design and the resulting degree of commonality within a product family using the seven commonality indices. First, two different product families such as computer mice of M and S companies are selected and dissected. The second step is the collection of data related to the dissection. The third step uses these data to compute, compare and contrast the commonality indices. Two experimental measures are studied: ease of data collection and repeatability. Finally, we propose the methodology to use the commonality indices during product family redesign.

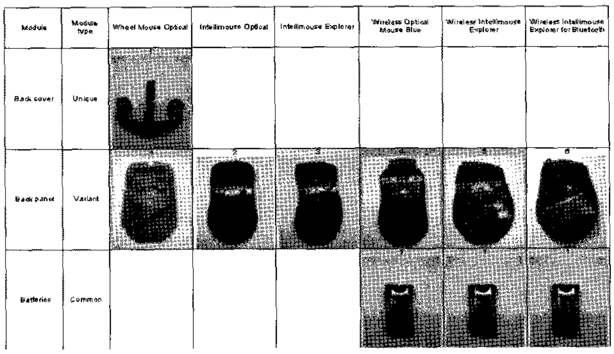
(1) Dissection and data collection

As mentioned earlier, we chosen two different families of products such as computer mice as shown in <Figure 1>, are dissected and analysed for this study. Product families cover a wide range of manufacturing processes, including plastic injection moulding, metal casting, metal stamping, and electronics assembly. For each family of products, the same dissection methodology was applied. In order to keep the results homogeneous, the same level of dissection is applied to all the products. When possible, the products are dissected to the lowest level, i.e., the parts cannot be divided into further subassemblies. Each product within each family is dissected to the lowest level. However, some assemblies were difficult, if not impossible, to dissect to that extent, such as the electronic printed circuit boards, taken as a single part for analysis.

After disassembly, each part is photographed and weighed. The data (e.g. part, mass, type of commonality, manufacturing process, cost, etc.) are then stored into a product family database as shown in <Figure 2>.



<Figure 1> Computer mice in product family



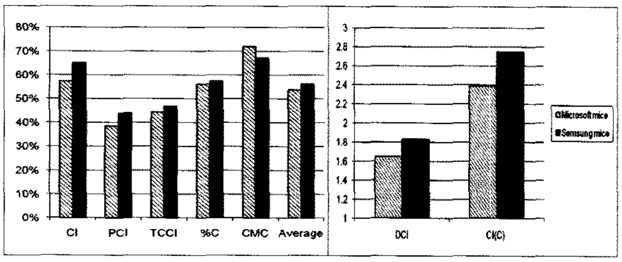
<Figure 2> Storage of product family data

(2) Computation of commonality indices

The first focus in this study is the comparison of the seven indices applied on each product family. For each index, the computation is performed using an Excel spreadsheet program in order to minimize errors and maximize the repeatability from one family to another. The computation results are shown in <Table 2> and <Figure 3>. The average value of five commonality indices such as CI, PCI, TCCI, %C and CMC is 2.43% greater for S family than for the M family; From these indices, the S family can be considered to have a better design with more common components while the M family still have too many variant components. DCI is 0.18 and CI (C) is 0.36 greater for S family than for the M family. This main difference also affects the CI (C), where the S family achieves lower costs. From these indices, a conclusion can be drawn: the S family has a better design than the M family : more components are common and fewer components are unique.

<Table 2> Computation results of commonality indices for computer mice

	M mice	S mice
CI	57.3%	65.1%
PCI	38.7%	43.9%
TCCI	44.5%	46.8%
%C	56.2%	57.3%
CMC	71.9%	67.2%
Average	**53.72%**	**56.06%**
DCI	1.65	1.83
CI(C)	2.39	2.75

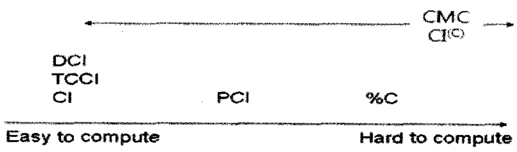


<Figure 3> Comparision results of commonality indices

3.2 Analysis of commonality indices

(1) Ease of computation analysis

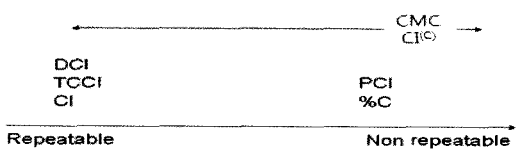
The indices computed do not require the same amount of data, and the ease of computation also differs as illustrated qualitatively in <Figure 4> The easiest indices to compute are the DCI, the TCCI and the CI. They require the same information. These data can be easily obtained from BOMs, and the computation can easily be automated without any human intervention. The PCI and the %C are more difficult to compute: they need 'subjective' information, which can vary from one person to another. Finally, the CMC and CI (C) can be pretty straightforward, but it also can be the hardest to compute.



<Figure 4> Ease of computation of the indices

(2) Repeatability analysis

The data needed for each index also influence the repeatability of their computation. Depending on the data available for the families of products, the indices can be classified into two groups : repeatable and non-repeatable indices. A repeatable index can be computed by two different persons, without any variation. On the other hand, a non repeatable index is subject to variation. The reperatabilty results are shown in <Figure 5>.

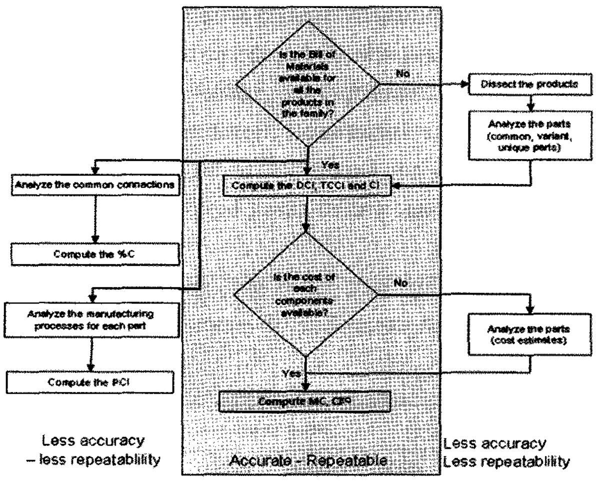


<Figure 5> Repeatability of the indices

3.3 Utility policy of commonality indices

In this section, some recommendations can be drawn from the analysis of these seven indices. For the analysis of a product family, there are two different approaches. The first one consists of getting the most accurate commonality indices based on the information available. In this case, the computation is fast, but it can be very limited if little information is available. The second approach is to define which commonality indices are needed and to find the corresponding information for each family. This method results in more accurate indices, but it can also require much more.

<Figure 6> explains a methodology to compute the seven indices analyzed in this study. The first step is to define what the most important point is when designing a product family. Depending on the strategy of a company, the focus can for example be on the common components, the common connections, their number, their costs, etc. From that, the most relevant commonality indices can be chosen. The commonality indices could be calculated by the characteristics of commonality indices in the second step. The third step is to optimize the designs based on the commonality indices previously computed. An advantage is that the computation can also be done during the optimization so that the proposed policy can be repeated during the optimization stage.



<Figure 6> Proposed methodology for the computation of seven commonality indices

4. Conclusion

In this paper, we proposed the framework for designing or redesigning a product family using commonality indices is proposed. We first compare and contrast seven of the commonality indices based on their ease of data collection and repeatability. Two families of products such as computer mice are dissected, and the commonality of each family is then computed. This study lays a foundation for understanding the relationships between different platform leveraging strategies and the resulting degree of commonality within a product family. From these multiple comparisons, the effective use and utility policy of commonality indices during product family (re) design was proposed.

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