FRAMEWORK FOR DIAGNOSING STANDARDIZATION POTENTIAL IN CURRENT PRODUCT RANGE

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Abstract

Standardization and innovation are two contradictory but essential requirements of modern design. Standardization improves operational efficiency and innovation which essentially results in differentiation of a product improves the marketability. The challenge to share the parts across a range of products without compromising the distinctiveness needs to be resolved by the designer at many levels- at the top level design while defining the architecture of the product and at level of detailing. This becomes more difficult in a situation where a range of products already exist without a clear definition of platforms. This paper successfully attempts to develop a basis for identifying platforms and formulate a tool to identify the focus areas for standardization both from microscopic and macroscopic perspectives accounting for financial considerations. At the macro level, the paper is able to identify the areas with substantial standardization potential by scanning an automobile industry for example.

Keywords: Innovation, Platform strategies, Product architecture

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1 INTRODUCTION

Standardization and innovation are two contradictory but essential requirements of modern design. Standardization improves operational efficiency and innovation resulting in differentiation of a product and thus improving the marketability. The challenge to share the products across a range of platforms without compromising the differentiation needs to be resolved by the designer at many levels- at the top level design while defining the architecture of the product and at the grass-root level of detailing the nuts and bolts. The illustration in Figure1 explains the conflict of co-existence between these two aspects.

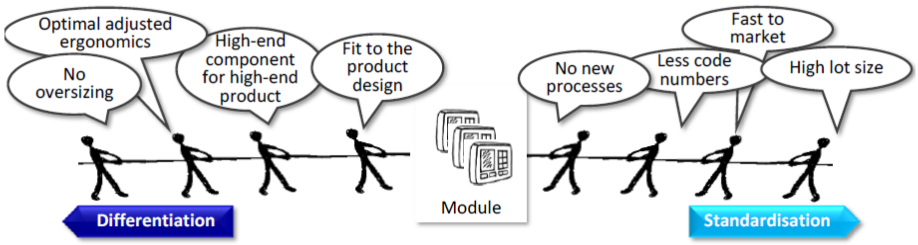

Figure 1. Balancing Design Objectives

Robertson (1998) describes the three ideas underlying the platform planning process- (1) customers' preference for distinctiveness (2) the trade-off between distinctiveness and commonality and (3) the product architecture dictating the nature of trade-off. The different architectural possibilities for this trade-off have been shown in Figure 2, where scenario D on the curve architecture-3 represents a relatively high level of commonality without sacrificing much on distinctiveness.

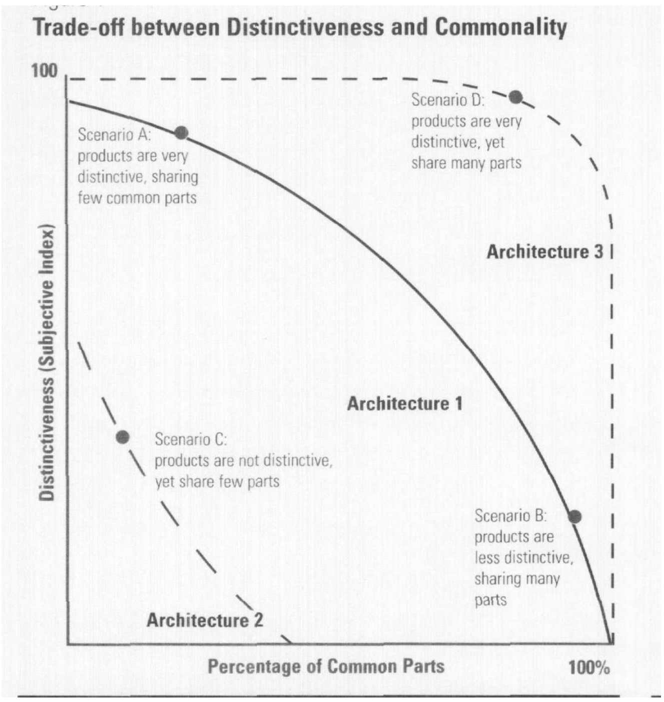

Figure 2. Trade-off Scenarios between Distinctiveness and Standardization

This process of platforming can work well where the process is yet to take off and the designers can plan the platforms accordingly. But in most of the cases, we are presented with a situation where an industry is already manufacturing a host of models and the need for this strategic platforming and standardization is felt in midst of such a scenario. The design planners in such a situation face two difficulties:

a. The models being produced cannot be straight-jacketed in platforms as the products have not been planned with platforms in mind.
b. The parts have not been designed with architecture 3 in view. In such a situation components are different without offering distinctiveness. To create an optimal design with the desired architecture becomes difficult.

2 OBJECTIVE

To create an optimal trade-off between differentiation and standardization in an industry where various models already exist without a consideration of platform-planning becomes a challenge for design planners. The challenge becomes even more pronounced when designers have to customize the designs for low sales volumes. The first problem that they face is to categorize the products in platforms. Now, platform has been defined by Ulrich (1995) as a collection of assets shared by set of products. This definition, when translated into practice creates difficulties. For example, in a motorcycle industry, there are many variants of frame, engines, suspensions brakes etc. Many frames are almost same except for some stays and brackets. Should we categorize the platforms on the basis of frame or engine? Should engine size be the consideration or the engine architecture? This paper attempts to:

a. Define a fundamental approach to platform in context to motorcycle industry, where many models already exist and there is a need to identify the focus area for standardization.
b. Establish a method to diagnose the standardization potential to find the optimal solution.

3 LITERATURE REVIEW

Ulrich mentions function sharing and geometric nesting as means of cost efficient designs. These options can be used only at concept and system level design which is not available here. Importantly Ulrich also offers modular architecture as a way to achieve standardization. Eilmus et al (2013) also compare the various approaches for product re-use as shown in Figure 3.

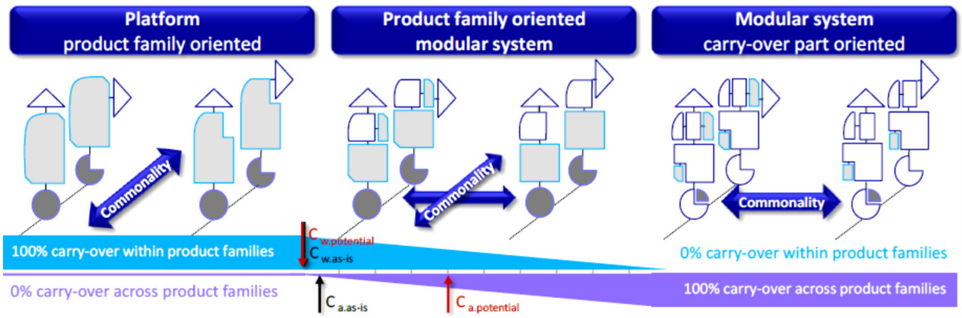

Figure 3. Commonality Approaches to Platform and

Based on definitions of Jiao (200)), and Andreasen (2004), a comprehensive definition of commonality was derived by Eilmus and Crause (2012): '*Product commonality is the relative property of being designed in a way that the variety of product variants to each other leads to possibly low complexity in a specific company. This may be achieved by re-use of components and modules, solutions, product structures or interfaces*'. Eilmus et al (2013) also offer various ways of achieving standardization with differentiation by modularization as illustrated by an example for wiring harness in Figure 4. Studies have been conducted to scan through all design methods for platforms and product families and devise a matrix for selection of the appropriate method based on type, focus, output, boundaries, time and subjective noise. (Nogamuchi et al, 2012). At the same a method has been suggested to design for variety across generations based on Generational Variety Index (GVI) and Coupling Index (CI) (Martin and Ishii, 2002).

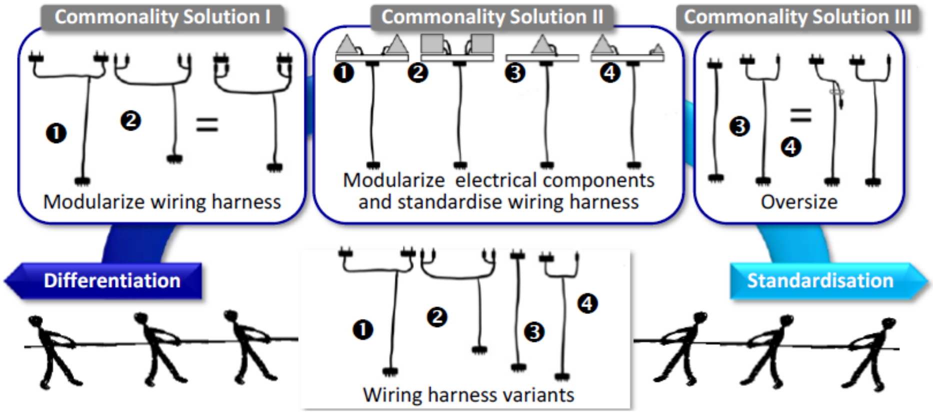

Figure 4. An Example of Approaches to Modularization

Moreover, Crause and Ripperda (2013) have compared the various approaches to compare various approaches to develop modular product families. Jiao et al (2001), while discussing the architecture of product family, describes its three elements-common base, differentiation enabler and configuration mechanism. Here, the identification of the first two elements is critical to our objective. The novelty of this paper lies in using the common base and differentiation enabler concepts to identify focus area for standardization in an already running industry, where plat-forming concepts have not been applied till now.

4 METHODOLOGY

The approach was to:

1. Scan a motorcycle industry to formulate an appropriate basis for platforming.
2. Scan all parts across various platforms for commonalty and differentiation,
3. Find a mathematical formula to establish the scope of standardization without touching differentiation

Definitions:

Platform: Ulrich defines it as a group of products with a good amount of standardization. In context of motorcycle industry, it amounts to either an almost common engine or almost common frame. Four wheeler industry generally refers to common frame or chassis as the basis of platform but the two wheeler industry selected for this study considered engine capacity as the basis. Here it is important to differentiate common architecture or product family from platform. An engine having exactly the same architecture but different cubic capacity will be considered different platform as parts will not be common. Product family, on the other hand is a marketing construct, where products bundled together for a particular customer segment. A single platform can have several families and a family can consist of products across platforms.

Commonality: It is the ability of a part to be used across the models. Absolute commonality is the ability to be used without a single change. In other words, they will have the same part number. Modular commonality is the case where a major chunk remains common and the change can be affected by replacing a small replaceable component.

Variation Factor (VF): Variation factor for a part within a platform is the ratio of number of varieties of design (x) and the total number of models within the platform (n).

$$VF_w = x/n \tag{1}$$

Similarly the variation factor across the platform is the ratio of the total number of varieties of design of the part (X) and the total number of models across the platforms.

$$VF_a = X/N \tag{2}$$

Differentiation Factor : Differentiators are the parts for a model which are perceived by the customer as the differentiating aspects of the model. We will discuss the characteristics of such parts in next section. The Differentiating Factor for a part within a model is the ratio of number of differentiating parts required within a platform (y) to the number of models in the platform.

$$DF_w = y/n \tag{3}$$

Similarly the differentiation factor across the platform is the ratio total number of differentiators (Y) and the total number of models across the platforms.

$$DF_a = Y/N \tag{4}$$

Standardization Potential: If a part is non-standard or not common to other model despite not being a differentiator, the reasons for non-standardization need to be investigated. In most of the cases, these reasons are relating to their fitment with mating parts. The standardization Potential indicates the scope available for standardization and can be calculated by subtracting Differentiating Factor from Variation Factor. Therefore, Standardization Potential of a part within a platform is

$$SP_w = VF_w - DF_w = (x/n)-(y/n) \tag{5}$$

And, Standardization Potential of a part across platforms is

$$SP_a = VF_a - DF_a = (X/N)-(Y/N) \tag{6}$$

Overall Standardization Potential (OSP): We need this indicator as a diagnostic tool to assess the standardization potential within a platform and across all platforms. The ideal value is zero and a relatively higher value indicates a good potential for standardization without compromising on differentiation. OSP for a platform (OSP_p) and OSP across platforms (OSP_a) can be calculated as:

$$OSP_p = (\sum SP_{w}/p)*100 \tag{7}$$

$$OSP_a = (\sum SP_{a}/p)*100 \tag{8}$$

Where p= no of parts in the class

Standardization Benefit Potential(SBP): The benefit accruing to the organization due to this standardization depends on many factors like costs saved on machines, tools and fixtures, transportation arrangements due to part differentiation, separate storage cost and other costs. Standard Benefit Potential within a platform (SBP_w) and across the platform (SBP_w) can be calculated as

$$SBP_w = SP_{w.}\ x = [(x/n)-(y/n)].x \tag{9}$$

$$SBP_a = SP_{a.}\ x = [(X/N)-(Y/N)].x \tag{10}$$

Where x= Average cost saved on one unit of part on account of standardization

Overall Standardization Benefit Potential (OSBP): This indicator indicates the need for standardization based on monitory consideration. We will observe later that this indicator gives different results than OSP because OSP does not account for the value of standardization. OSBP for a platform can be calculated by:

$$OSBP_p = \sum SBP_{w-}/ p \tag{11}$$

And OSBP across the platforms is

$$OSBP_a = \sum SBP_a/ p \tag{12}$$

Criterions for Differentiators:

Parts become different for many reasons. The question that needs to be answered is that whether it was intended to be different. Considering a motorcycle as the final product, we consider the possible criterions for differentiators.

a. Styling parts: These are the parts which start to be designed in studio for esthetic considerations and provide an identity to the product. In case of a motorcycle, fuel tank, lights and body parts are some examples of this category of differentiators.

b. Differentiated performance parts: Each model is defined and identified by its performance and functionality. There are parts essentially designed to provide this differentiated performance. Suspensions and wheels are some examples of this category. Here it may be noted that some parts like lights can fall in both categories.

Here, it is essential to discuss the category of parts which will not fall in this category. The parts which are made different due to fitment with mating parts and durability considerations cannot be considered differentiators because the user does not consider these aspects to be differentiator for a model.

5 RESULTS

The industry, where this study was conducted is a motorcycle and scooter manufacturer. All designs were divided in five classes of parts (which actually coincided with the actual structure of design function in the company) - frame, chassis, engine, electrical and plastics. The company manufactured 33 models of motorcycles and scooters which are divided over 6 platforms (scooter constituting one) considering the definition by Ulrich. By and large this categorization in platforms is based on engine size though 100cc and 110cc engines are categorized as one platform due to commonality of parts. Similarly, scooters of various engine sizes are classified as one platform. All parts belonging to a class were listed and their designs were studied for commonality. The results were tabulated as shown in Table 1. Here we observe that if the same design is used in many models, it is designated by same digit. At the same time, if there is only a minor modular difference between two parts (modular difference indicates basic part being same with only small module constituting difference) resulting in avoidance of new investment in tools, it is indicated in tabulation as a variant of a digit (e.g. modular variants of model 2 are indicated as 2A, 2B etc).

Table 1. Scanning Part Design for Frame Parts

	FRAME PARTS																			
Platform	**100/ 110 CC**													**125CC**						
Model	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**	**A13**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**
Frame	1	2	2	2A	2A	2B	2B	2C	2C	3	4A	4B	5	6	6A	7	7A	8	9	10
Fuel Tank	1	2	2	3	3	4	5	6	6	1	7	8	9	10	11	12	10A	13	14	15
Rear carrier	1	2	NA	3	NA	NA	NA	NA	NA	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Main stand	1	2	2	1	1	2	2	3	3	1	1	1	4	5	5	5	5	5	5	6
Side stand	1	2	2	1	1	2	2	1	1	1	1	1	3	1	1	1	1	1	1	NA
Saree guard	1	2	2	3	NA	4	4	5	5	1	6	6	7	8	9	8	8	10	11	12
Handle bar	1	2	2	3	4	5	5	5	6	1	3	3	7	8	9	8	8	8	9	10
Rear grip	NA	NA	1	NA	NA	2	2	3	3	NA	4	4	5	6	7	6	6	8	7	9
Engine guard	1	1	1	1	1	2	2	3	3	1	4	4	5	6	7	6	6	8	7	9

	FRAME PARTS														
Platform	**SCOOTER**					**150 CC**					**225 CC**		**250 CC**		
Model	**C1**	**C2**	**C3**	**C4**	**C5**	**D1**	**D2**	**D3**	**D4**	**D5**	**E1**	**E2**	**F1**	**F3**	**F4**
Frame	11A	11B	12A	12B	13	14	15	16A	16B	17	18	18A	19	21	22
Fuel Tank	16	17	18	19	20	21	22	23	24	25	26	26A	27	29	30
Rear carrier	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Main stand	7	8	9	9	10	11	11A	11A	11A	NA	10	11	NA	NA	NA
Side stand	4	5	4	4	6	7	8	8	8	9	10	10	11	11	11
Saree guard	13	14	15	16	17	18	19	20	20	21	22	22	23	25	23
Handle bar	11	12	13	14	15	16	17	18	19	20	21	21	22	22	22
Rear grip	10	11	12	13	14	15	16	17	18	19	20	20	21	23	24
Engine guard	NA	NA	NA	NA	NA	10	11	11	11	12	NA	NA	NA	NA	NA

Similar tables are created for chassis (the parts which are dynamic with respect to the rigid frame), electrical, plastic and engine parts.
Once this first level tabulation is completed, this data was studied for differentiators. For this purpose variants were not considered differentiators. Thus a table indicating variation factor, differentiation factor and standardization potential (as calculated by equations 1 to 6) was created as shown in Table 2.

Table 2. Calculating Standardization Potential for Frame

Platform	100/ 110 CC			125CC			150 CC			225 CC			SCOOTER			250 CC			ACROSS PLATFORMS		
	VF	DF	CP	VF	DF	CP	VF	DF	CP	VF	DF	CP	VF	DF	CP	VF	DF	CP	VF	DF	CP
Frame	0.38	0.08	0.31	0.71	0.14	0.57	0.80	0.20	0.60	0.50	0.50	0.00	0.60	0.40	0.20	1.00	0.75	0.25	0.61	0.10	0.52
Fuel Tank	0.69	0.69	0.00	0.86	0.86	0.00	1.00	1.00	0.00	0.50	0.50	0.00	1.00	0.40	0.60	1.00	1.00	0.00	0.81	0.81	0.00
Rear carrier	0.75	0.08	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.25	0.50
Main stand	0.31	0.08	0.23	0.29	0.14	0.14	0.25	0.20	0.05	1.00	0.50	0.50	0.80	0.20	0.60	0.00	0.00	0.00	0.35	0.04	0.31
Side stand	0.23	0.08	0.15	0.17	0.14	0.02	0.75	0.20	0.55	0.50	0.50	0.00	0.60	0.20	0.40	0.25	0.25	0.00	0.29	0.03	0.26
Saree guard	0.58	0.58	0.00	0.71	0.71	0.00	0.80	0.80	0.00	0.50	0.50	0.00	1.00	1.00	0.00	0.75	0.75	0.00	0.67	0.67	0.00
Handle bar	0.54	0.23	0.31	0.43	0.29	0.14	1.00	0.40	0.60	0.50	0.50	0.00	1.00	0.20	0.80	0.25	0.25	0.00	0.55	0.10	0.45
Footrest (Rider)	0.00		0.00	0.57	0.29	0.29	0.00	0.20	-0.20	0.50	0.50	0.00	1.00	0.20	0.80	0.75	0.25	0.50	0.55	0.25	0.30
Rear grip	0.63	0.63	0.00	0.57	0.57	0.00	1.00	1.00	0.00	0.50	0.50	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.73	0.73	0.00
Engine guard	0.38	0.08	0.31	0.57	0.14	0.43	0.60	0.20	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.04	0.44
Overall Standardization . Potential	19.81			15.97			20.00			5.00			34.00			7.50			27.73		

The standardization potential, thus calculated for all platforms and all classes of parts are tabulated in Table 3.

Table 3. Overall Standardization Potential for all Parts at a Glance

	100/110 cc	125cc	150cc	225cc	Scooter	250cc	Across Platforms
Frame	19.81	15.97	20	5	34	7.5	27.73
Chassis	12.89	9.76	17.13	9.72	13.8	15.28	27.26
Electrical	9.05	13.45	5.88	2.94	13.24	23.43	14.82
Plastic	0.53	0.93	1.39	0	2.41	0	3.97
Engine	7.18	7.43	5	5	8.1	0	2.43

Average standardization benefit for a part was calculated by using the relationship:

$$x = \frac{\sum \frac{t}{v}}{n} + y \qquad (13)$$

Where x= average standardization benefit for a part,
t= cost of tooling and facility for a model, v= number of parts produced by one set of tools
n= number of models considered for calculation, y= Average cost of separate storage

Table 4. Calculating Overall Standardization Benefit Potential for

Platform	100/ 110 CC		125CC		150 CC		225 CC		SCOOTER		250 CC		ACROSS PLATFORMS		
	SP	SB	SP	SB	SP	SB	SP	SB	SP	SB	SP	SB	SP	SB	Average Benefit (x)
Frame	0.31	20	0.57	38.51	0.60	39	0.00	0	0.20	13	0.25	16.25	0.52	33.55	67.4
Fuel Tank	0.00	0	0.00	0	0.00	0	0.00	0	0.60	15	0.00	0	0.00	0	26
Rear carrier	0.67	4.038	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.50	3	6.3
Main stand	0.23	0.808	0.14	0.529	0.05	0.175	0.50	1.75	0.60	2.1	0.00	0	0.31	1.077	3.7
Side stand	0.15	0.308	0.02	0.05	0.55	1.1	0.00	0	0.40	0.8	0.00	0	0.26	0.516	2.08
Saree guard	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	6.3
Handle bar	0.31	0.923	0.14	0.454	0.60	1.8	0.00	0	0.80	2.4	0.00	0	0.45	1.355	3.18
Rear grip	0.00	0	0.00	0.006	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.003	4.45
Engine guard	0.31	1.231	0.43	1.791	0.40	1.6	0.00	0	0.00	0	0.00	0	0.44	1.76	4.18
Overall Standardization Benefit. Potential	3.03		4.59		4.85		0.19		3.70		1.81		4.58		

This table reveals that standardization benefit potential (SBP} may indicate a different focus than indicated standardization potential. For example, for 100/110cc platform, though rear carrier is the component with highest standardization potential, benefit potential is highest for frame because the average benefit potential is highest for frame. Similarly, though the overall standardization potential is highest for scooter platform, the overall benefit potential is highest for 125cc platform.
Finally, the tabulation for standardization benefit potential was done by multiplying the standardization potential to average standardization benefit (x) as show in Table 4.

Table 5. Overall Standardization Benefit Potential for All Parts at a Glance

	100/110 cc	125cc	150cc	225cc	Scooter	250cc	Across Platforms
Frame	3.03	4.59	4.85	0.19	3.7	1.81	4.58
Chassis	0.65	0.55	0.77	0.2	0.36	0.73	1.11
Electrical	0.25	0.49	0.1	0.04	0.89	0.44	0.51
Plastic	0.01	0.01	0.02	0	0.07	0	0.09
Engine	0.05	0.05	0.06	0.07	0.04	0	0.48

6 CONCLUSION

The ways to define a platform in automobile industry vary. In most of the four wheeler industry, platform is defined by basic chassis structure. In two-wheeler industry, there are two popular approaches. Some industries define it by product family. One product family consists of same basic frame and engine capacity varying with same engine architecture. Ducati, Harley Davidson and Bajaj Auto follow this principle. The industry studied for this paper categorized platforms on the basis of engine capacity. Both approaches satisfy the criterion defined by Ulrich as they are able to provide a good amount of standardization and sharing of assets in terms of parts, knowledge and teams. The data generated in this study shows that sharing of parts is maximum in models with same engine capacity and therefore engine capacity forms a good basis. Though this is a circular argument (this study is conducted with engine capacity as the basis and we are trying to prove with this study that engine capacity is a good basis) but it proves the point nevertheless. We also observe here that architecture can form the basis for platforms as exemplified by scooter and 250cc platforms which have different architectures. But architecture is not essentially the only basis as all other platforms have same architecture but without much sharing of parts.

The tool proposed in this paper works well to quickly identifies the areas, where there is a good potential to standardize. Of course, the whole potential is not possible to be realized, because many non-differentiators have to be designed differently in order to match and fit with the differentiators. So, the Standardization Benefit Potential is an indicative figure indicating the total idealistic potential to standardize. But it definitely indicates a comparative potential and the areas with higher potential indicate the area to be attacked first. Moreover this diagnostic tool helps in many ways:

a. The individual standardization potential helps to quickly identify the parts needing maximum attention. For example, table 2 indicated that rear carrier in 100/110 cc platform and frame in 125cc platform are the parts with highest potential for commonality.
b. The standardization benefit potential further fine-tunes the diagnostics through a financial lens. For example table 4 clearly indicates in contrast to table 2 that though rear carrier in 100/110 cc platform has highest standardization potential, standardization benefit potential is highest for frames in 125 cc platform. This is because the high investment needed for new frame development and this aspect is not accounted for while calculating standardization potential.
c. Similarly for overall potential, though OSP detects the focus area with highest standardization potential, it is OSBP which brings out the real focus are with highest benefit. For example in table 3, electrical parts show a considerable potential due to various varieties, the OSBP is negligible as seen in table 5. This is due to relatively low level of investment required for new electrical parts where only programming needs to be changed for a new part.
d. Though the calculation of SBP and OSBP has many simplifications (e.g. it does not account for production volumes or number of tools required for a new model), it still provides a good basis for diagnosing the focus areas. Specifically for low sales volume models, this method proves more accurate due to absence of multi-toolings.
e. This study not only detects the current focus areas, it also helps the designers for designing further models. With this tool, the designers know the number of varieties readily available and work to standardize within those varieties, unless the part is a differentiator.
f. As Ulrich, Jiao and Eilmus have already pointed out; modularization is one of the most effective ways to reduce the number of varieties.

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