Proposal of an SKU Classification Framework
A Multicriteria Approach

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Abstract: Changes to an organization's internal and external environment may cause an increase in the number of Stock Keeping Units (SKU) in inventory. Therefore an SKU classification and corresponding grouping become highly important for improving the inventory management process. In this paper we propose a framework for SKU classification in an industrial context using a multicriteria approach considering three criteria: value of usage; criticality and demand variability. This approach emphasizes the importance of SKUs that despite their small value are of vital importance for the operations/production of the organization.

1 INTRODUCTION

Companies cannot ignore the reality of managing a large number of SKUs. As such, classifying SKUs can bring significant benefits (van Kampen et al., 2012).

The biggest challenge for inventory management that companies face is controllling a large number of items. This is a very complex task to when using individual SKUs (Soylu and Akyol, 2014). Grouping items together makes it easier for managers since the decisions are taken for a group of SKUs. When classifying SKUs companies need to have a clear understanding of the context, and of the aim of the company inventory management policy.

Bacchetti et al. (2013) mention that the gaps between theory and practice show that empirical studies have not been properly validated. As a result, inventory management solutions that are adequate for some cases may not be suitable for others. For that reason, some researchers have suggested that additonal studies are needed looking at ways of achieving more integrated solutions.

Questions of how to operationalize an SKU classification, or the determination of the ideal number of classes are popular topics in the literature; moreover, the context of the company is decisive for the choice of which method to apply (D'Alessandro and Baveja, 2000; Soylu and Akyol, 2014; van Kampen et al., 2012).

Another issue that increases the complexity of inventory management is the fact that reality is dynamic. This results not only from market changes, but also internal changes in the organization, with a consequent impact on stock size which increases the cost of inventory control activities (Soylu and Akyol, 2014). Therefore, it is very important that organizations realize that an efficient SKU classification could represent an important source of competitive advantage.

This paper proposes a framework for classifying SKUs, that can serve as a useful tool in the decision making process of inventory management. The next section of the paper presents the framework, while the final section presents the conclusions and recommendations for future research.

2 FRAMEWORK/ PROPOSED APPROACH

In the management of an organization, not every SKU has the same level of importance. The stock-out of some SKUs may jeopardize the organization's normal production activities; other SKUs, due to their high value of usage and high demand, require additional attention by managers.

It is not wise to apply the same inventory management policy to every SKU; however, it is also true that managing SKUs individually is a very complex task (Soylu and Akyol, 2014). As a result,

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several researchers proposed different frameworks to help managers classify SKUs into groups and apply an adequate inventory management policy to each group (Bošnjaković, 2010; Cavalieri et al., 2008; Duchessi et al., 1988; van Kampen et al., 2012).

2.1 Methodology

The main aim of this paper was to develop a framework for classifying SKUs. The framework was developed in the context of a company in the car industry, with the purpose of helping managers to improve the inventory management process in the spare parts and consumables warehouse.

In this study we applied the concepts of action research (Figure 1). This is a method of collaborative research which may be used to establish a link between companies and researchers. Sexton and Lu (2009) define action research as a "phenomenon-change" (or action) and critical learning that lead to a change and produce new knowledge (research) in a social scenario where researchers and practitioners intervene. By intervening in the context, the aim is to modify the scenario by actively participating in the research. Furthermore the authors say that action research generates a mutual development of know-that and know-how.

This choice of method was made as reflection and co-working were important for assessing the phenomenon and it was not necessary to control environmental elements. In any case, the focus of the research is to introduce changes in reality (Baker, 2012). Or, we might say that action research matches theory and practice through a change in a problematic situation.

Susman and Evered (1978) propose five steps for leading an action research project, which in the present case study we define as: 1) Diagnosis, 2) Criteria definition, 3) SKU classification, 4) Framework validation, 5) Defining inventory management policies.

2.2 Diagnosis

The diagnosis is an assessment phase, where the main goal is to identify the context in which researchers will intervene, which problems are relevant and how they could affect the rest of the organization. This step was carried out over several meetings with the personnel of the warehouse, purchasing, maintenance and other groups of interest.

The researchers concluded that the main problem for the warehouse is related to the lack of physical space. Besides that, (unplanned) corrective maintenance activities raise serious problems for the supply of spare parts and several stock-outs have been reported as a consequence.

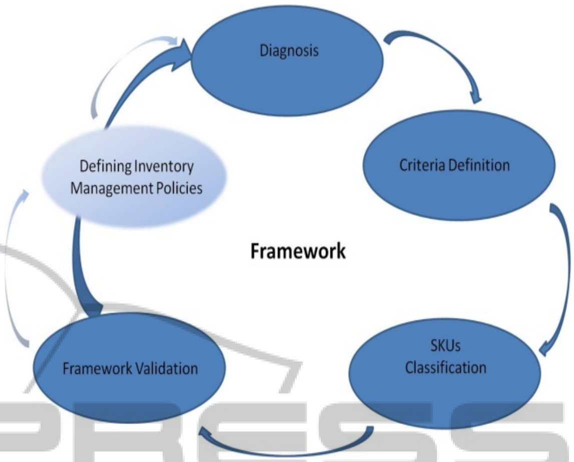

Figure 1: Framework - action research proposal.

The clients of the warehouse are mostly from the maintenance area. For this reason, maintenance personnel are relevant stakeholders in this project.

After several meetings an SKU classification was suggested. It was observed that a large number of items are spare parts and it is in the best interest of the company to define which SKUs should be more strictly controlled.

2.3 Criteria Definition

The major departments of the company should participate in the criteria definition step (Sexton and Lu, 2009) and the classification aim should be clearly defined (van Kampen et al., 2012). This is a critical step, and it is not possible to move forward without collecting all the relevant data from the company's activity.

The framework to be presented is built and shaped for a specific industrial context. However, it is possible that, with the right modifications (mainly at the criteria level), this framework could be applied to another context.

Choosing which criteria to apply is something that must be discussed and adapted to the classification context and objectives. Several studies show that multicriteria approaches are the more efficient way to assess spare parts and consumables problems. Bacchetti et al. (2013) proposed a classification method with six dimensions (life cycle, lead time, number of orders, demand frequency, criticality and value). Bošnjaković (2010) presented a multicriteria framework with value, demand frequency and criticality. Childerhouse et al. (2002) built a classification based on life cycle, lead time window, volume and variability, which is named DWW[3]. Flores and Whybark (1986) and Flores et al. (1992) presented frameworks which included criticality, lead time and value in the multicriteria ABC Analysis and proved that such analysis is a very important tool for improving the efficiency of inventory management. Ramanathan (2006) remarks that multicriteria ABC Analysis is a very effective approach for classifying SKUs, presenting a framework of linear optimization for solving the multicriteria problem.

This paper proposes a multicriteria approach with three criteria, following the recommendations of Flores et al. (1992). The process ends with the presentation of a multicriteria ABC Analysis. This is a very widespread technique which is easily understood and implemented in organizations.

Managers use this analysis to help understand which SKUs are more frequently used in the warehouse and thus need closer monitoring.

However, just looking at the number of spare parts used makes this analysis very narrow, as many such items are only used in very specific time periods. It is thus very important to include other criteria. As several studies have shown, one of the most important criteria to consider when analyzing spares is criticality (Cavalieri et al., 2008; Huiskonen, 2001; Jouni et al., 2011; Molenaers et al., 2012), but, because these items are characterized by an erratic consumption, it is important to verify demand variability (Heinecke et al., 2013).

Also, while the value of usage and demand variability are quantitative, the criticality analysis requires data (such as managers' tacit knowledge) which implies a qualitative analysis.

The Framework should then incorporate three criteria:

- value of usage, with the corresponding ABC Analysis;
- criticality, with the corresponding VED Classification;
- demand variability, which will be associated with the classification HLW (High, Low, Without Variability).

2.4 SKU Classification

2.4.1 Ranking Demand Value – ABC Analysis

ABC Analysis shows – with a very high level of accuracy – which SKUs have most impact on the company in terms of value.

Cavalieri et al. (2008) says that this analysis is very important from different perspectives. Financially it provides data on which investments should be taken into account depending on whether they relate to durables or consumables. Logistically it provides information about whether stock should be kept for an item or not, or even if the consumption should be linked to the demand. From a maintenance perspective it gives the basis for a balance between the availability of spares and consumables and the company maintenance policies, coordinating with purchasing the decisions of maintenance policies to minimize the effects of failures.

Bacchetti et al. (2012) state that an SKU has an important role in the total amount of inventory held. Bošnjaković (2010) remarks that any SKU has an associated value and when it is taken from the warehouse it becomes a cost. So value-usage of an item is defined as the product of the cost of an SKU with the annual demand.

An ABC Analysis reveals that only a small number of items is responsible for the most of the value. Likewise SKUs are usually classified into 3 groups – group A includes 5% of the items that represent 75% of value-usage, group C includes 75% of items representing only 5% of value-usage, the rest of items will be placed in group B, with 20% of items representing 20% of value-usage.

Nevertheless, this analysis is proven to be unsuitable when inventory is not homogenous –, mainly when the major differences are not related to the value of the SKUs. In this case it is important to introduce other criteria, but these criteria must represent factors which are significant to the company (Flores and Whybark, 1986; Molenaers et al., 2012; Ramanathan, 2006).

2.4.2 Ranking Criticality – VED Analysis

Criticality is the most important attribute when classifying spare parts and components (Huiskonen, 2001). This analysis is very subjective. Considering the industry and the organization context, the criteria could potentially be very well defined. It is important that all parties concerned (purchasing, maintenance) should share ideas and reach agreements. However, maintenance has more influence in this case (because maintenance managers know better than anyone else which SKUs could compromise the normal running of the company).

Several authors (Cavalieri et al., 2008; Molenaers et al., 2012) have conducted a criticality analysis, and used a VED Classification which divides SKUs into 3 groups: Vital (Group V), Essential (Group E) and Desirable (Group D). Although other techniques could be applied, most studies consulted use this technique. A VED Analysis allows SKUs to be easily understood and ranked according to their criticality, allowing the most critical items to be quickly identified.

Defining criticality is not an easy task, although this concept could be linked to the type of activity for which the SKU is used (Bošnjaković, 2010). This author assesses criticality through four attributes: criticality for plant production, criticality for safety, criticality for supply and criticality for inventory. Duchessi et al. (1988) claims that criticality is a function of the level of criticality of the equipment where the SKUs is installed.

After close observation in the case study, it was found that the company did already distinguish between SKUs based on criticality. The company uses two attributes to measure criticality; one assessing the consequences for production and the other related to the safety of operators. This is an idea shared in the literature, where criticality is measured as a function of the failure of a piece of equipment (Duchessi et al, 1988; Huiskonen, 2001; Molenaers et al., 2012).

Therefore, following the recommendations of maintenance managers to build the framework and proceeding as Flores and Whybark (1987) reccommend, the main concern of management should not be the cost of keeping of an item, but the consequences of not keeping it.

Assessing criticality is very hard because it is mainly based on subjective judgments and opinions of managers (Botter and Fortuin, 2000). To achieve a more systematic measure of criticality we decided to use an Analytic Hierarchy Process (AHP).

The AHP sets pairwise comparisons for the different criteria using a predefined scale (Saaty, 1980). This is a procedure used in Cavalieri et al. (2008), Flores et al. (1992) and Moleanaers (2012) with the purpose of establishing a ranking of criticality.

2.4.3 Ranking Demand Variability

Bošnjaković (2010) claims that the frequency of demand is a very important criteria when selecting the inventory model. But as frequency of demand may differ widely among SKUs, management should be adjusted to reflect the pattern seen in the frequency of demand. SKUs with the same pattern of demand should then be grouped together. Nevertheless the frequency of demand does not account for erratic demand, as annual average consumption does not reveal peaks of consumption over time (Heinecke et al., 2013; Syntetos and Boylan, 2005).

Calculating of the coefficient of variation (CV – a measure that establishes a ratio between standard deviation and average demand) reveals the variability that exists between SKUs, showing how they differ in volume and distribution of consumption. Although the CV does not have an intrinsic meaning, D'Alessandro and Baveja (2000) present an example which illustrates what we should see when this measure is used for analyzing demand. If an SKU has a CV of 0.25 it varies little, so its demand is more predictable than an SKU with a CV of 0.75.

The boundary between high and low variability SKUs is determined by using the procedure of D'Alessandro and Baveja (2000). Here, a Pareto Principle is applied, using an 80/20 rule to assess the cut-off between SKUs. This same principle is applied in ABC Analysis.

Potentially, many SKUs may not vary at all over time. This may occur if the SKUs are not being consumed or if the pattern of consumption is so regular that the variability is almost zero.

2.4.4 Associating Criteria

More criteria could be considered, but Flores et al. (1992) remark that the main purpose of SKU classification is to simplify the stock and inventory management. These authors argue that although it is possible to include more than three criteria, the analysis would be very complex (Flores et al., 1992). The framework should only include those criteria that are really important to management, and each group of SKUs should have a matching inventory management policy.

After selecting the classification criteria, SKUs will be brought together to create groups of homogeneous items. The outcome should result in a scheme of classification that associates all three criteria. This results in 27 different possible combinations. Visually the outcome is a tridimensional scheme as displayed in Figure 2.

Nevertheless, one of the purposes of this work is to present a multicriteria classification, so in this step each SKU will be ranked using a multicriteria ABC Analysis. The main purpose of this step is to decide which SKUs deserve closer attention by management, also allowing inventory managers to easily identify and quickly implement the framework.

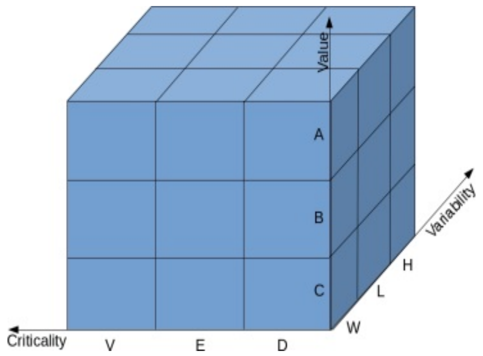

Figure 2: Criteria association scheme.

Therefore, weights were given to the three criteria presented – value, criticality and demand variability. The extra importance placed on criticality meant this criteria had the highest rank in terms of classification. Criticality is more important for spare parts or components, but value is more significant for consumables. In view of this, a 40% weight is assigned to each of these criteria. The demand variability, which is an indicator of consumption patterns, received the remaining 20% weighting. This multicriteria approach and ranking of SKUs was also conducted by Flores et al. (1992) and Ramanathan (2006).

It's important to note that the outcome of criteria weights reflects the concerns of all parties involved in the project. These weights were arrived at using the AHP technique that was explained earlier.

As mentioned before, the criteria were chosen taking into account the industry, organization and sector specificity.

2.5 Framework Validation

Once the SKUs have been classified it is necessary to perform the validation processes. This can be considered to be one of the most important steps in the framework. A meeting is held with researchers, purchasing, warehouse, financial and maintenance personnel where the results are presented. This meeting assesses if the framework is an important tool for the decision-making process and if adjustments are necessary.

2.6 Defining Inventory Management Policies

The purpose of the framework was to identify SKUs that share the same inventory management policies and group them together. These policies may determine that there is either "no need to stock", or there is a need to maintain a "safety stock", or that the traditional models of periodic/continuous review policies should be applied.

SKUs with a zero stock policy should only be purchased when the demand arises. This policy means that a minimum amount of financial resources are invested. The decision of "no need to stock" can only apply to those SKUs that, if unavailable, do not affect the normal operation of the company (Braglia et al, 2004), or to SKUs with low criticality where the inventory holding cost is higher than the "stock out" cost (Bošnjaković, 2010). Nevertheless, these policies should match with very reliable suppliers.

Following a "safety stock" policy means that orders are made when a reorder point is reached. This should be applied to SKUs with medium value and medium demand variability; or SKUs with low value, low demand variability and low criticality; or for SKUs with high/medium criticality and with low value and low demand variability; or lastly for SKUs with medium criticality and medium demand variability.

All the other cases should be managed using a policy that defines a fixed reorder point, with continuous reviews; however, it should be remembered that high demand variability is a criterion of high uncertainty. In these cases, management should try to manage quantity discounts for items of high and medium value and diversify suppliers, while maintaining a tight control on continuous reviews, especially in high and medium criticality SKUs.

3 CONCLUSIONS

This paper proposes a framework for classifying SKUs, which is designed to be an effective tool to support decision making process for inventory management.

The multicriteria classification has proven to be a good solution for a warehouse storing a high number of SKUs. Furthermore, the framework benefited from co-working with personnel of different departments of the company.

The multicriteria ABC analysis has proven that a classification of SKUs using only one criterion is not adequate as it ignores other criteria of vital importance to the organization. This is particularly relevant when the criteria of criticality and demand variability are considered together. In this case some SKUs, which previously were placed in groups of low importance, emerge as critical SKUs. Where

SKUs are vital for companies operations there should be a separate inventory management policy.

Future research should validate the framework and include any necessary adjustments. It is also important to establish the periodicity for revising the framework. It could also be of interest to apply the same framework to other types of organizations and contexts.

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