Planning Nervousness in Product Segmentation: Empirical Analysis of Decision Parameters

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Abstract. Previous research presents a theoretical relation between planning nervousness and product segmentation and indicates that the concept should be subject to further research. This paper seeks to empirically confirm this relation, by developing hypotheses and testing these on a specific case. Three hypotheses related to historical planning data, planning frequency, and demand variability are developed and tested using data from three-echelons in a case company. A key finding is a confirmation of the relationship, providing operational tools that can assist organizations in battling planning nervousness.

Keywords: Planning, Nervousness, Product Segmentation

1 Introduction

In response to increased need for variety in products, supply chains need diverse operating strategies that can provide these responsively and cost-efficiently [1]. The variety of products is controlled through differentiated planning, where items are planned and controlled according to their characteristics. The segmentation of items is the core in differentiated planning, and thus the foundation for securing stable and effective planning processes. The objective of this paper is to investigate planning nervousness in relation to item segmentation, which is treated only to a limited extent in current research [2]. Existing research on planning nervousness relate to specific planning contexts, primarily MRP and inventory systems, where nervousness is evaluated in connection to determining planning policy [3]. However, as nervousness is a property of planning systems in general, this paper seeks to quantify a relationship between segmentation parameters and nervousness. This constitutes an improved foundation for decision-making, rather than merely relying on subjective intuition when handling nervousness problems in companies.

2 Planning Nervousness in Product Segmentation

Planning nervousness was introduced in the late 70's in order to describe instability and rescheduling of MRP plans in terms of quantity and timing [4] [5]. Later, the discussion of nervousness has broadened to cover multiple planning levels and enti-

ties, highlighting that nervousness propagates horizontally within supply chains and vertically within planning systems [6] [7] [8]. As a result, nervousness can be defined as the counterpart to planning stability, which is defined as the situation where plans do not change and equal the actual requirements imposed on the planning system [9]. A trade-off between responsiveness and nervousness exists, where frequent re-planning results in more updated parameters and ability to respond to changing customer needs, while nervousness increases in relation to the transition from the original plan to the updated plan [10].

As nervousness propagates throughout planning levels, it is important to assess how product segmentation affects planning stability and provides a solid foundation for differentiated planning. In recent research, a tentative relationship between the two areas is proposed, based on the nervousness-responsiveness trade-off, where nervousness is defined as shifts in the assigned groups for specific products between two successive versions of the segmentation [2]. In contrary, responsiveness relates to immediately and continuously updating segmentations based on changes in segmentation criteria e.g. demand variability or demand volume. The aim of this paper is to further investigate this relation and develop an assessable connection between three key segmentation criteria and nervousness. More specifically, historical planning data, planning frequency, and demand variability in relation to threshold values in the segmentation will be tested, as all three parameters were recognized as main influencers of nervousness in previous research [2].

3 Hypotheses

Three hypotheses are developed to test the relationship between nervousness and segmentation. In all hypotheses, nervousness is defined in the context of segmentation, referring to the number of shifts in the assigned segments.

The first hypothesis is built on planning horizons, which is recognized as a key influencer on nervousness [9]. However, as existing research focuses on MRP, MPS, and inventory contexts, planning horizon refers to the number of future time periods determined in the plan. The key notion is that when the planning horizon is prolonged, nervousness is mitigated [5]. In a segmentation context, this concept of planning horizon do not apply, as it is merely a foundation for planning rather than an actual time-phased plan. Nevertheless, the planning horizon has a direct link with the length of historical data periods included, as longer planning horizons require more historical data as the planning foundation [11]. This means that if the objective is to forecast or plan only on a short horizon, less data should be included than for longer horizons [12]. In a segmentation context, planning horizon can thus be compared to the number of periods in the segmentation data foundation. Therefore, the first hypothesis focuses specifically on the data foundation and its relationship to nervousness. The data foundation can be selected based on various reasons, but a relationship where the planning period constitutes a larger period when rolling the plan forward is expected to be more vulnerable to nervousness. This means that the more data that is

included, the more nervousness is mitigated. This notion is encapsulated in the first hypothesis.

Hypothesis 1: As the number of historical data periods included in the segmentation is increased, nervousness is decreased.

The second hypothesis relates to the frequency of continuous segmentations. How often the segmentation is run, is expected to have a direct effect on nervousness in terms of segmentation changes. The notion of planning frequency impacting planning nervousness is already established and acknowledged in research on nervousness [13] [14], but as in the former hypothesis, not in relation to segmentation. In this context, planning frequency refers to how often products are segmented and planning parameters re-calculated. A relationship is expected, as the possibility of excessive re-scheduling is anticipated to increase with planning frequency.

Hypothesis 2: As the time between re-planning is increased, planning nervousness decreases.

The third hypothesis focuses on demand variability, often measured by the coefficient of variance. This is one of the most commonly used segmentation criteria and is expected to have an effect on nervousness in relation to the selected threshold values set through the segmentation. These values are the limits that separate segments from one another. Demand variability have been frequently mentioned in relation to nervousness [4], but not considered in relation to the chosen threshold values. However, a relationship with low nervousness for both low and high values of demand variation and high for medium values is expected. This is based on the reasoning that low values of demand variability are stable enough to produce stable planning results with few shifts. Likewise, unstable products will also have few shifts, as they will always be treated as make-to-order.

Hypothesis 3: Nervousness peaks if demand variability corresponds to the threshold values selected in the segmentation method.

4 Methodology

In order to test the hypotheses, demand data from a case company is applied. The case company is a Danish utility company with global reach that serves a variety of market segments ranging from domestic use to industrial application. Currently, the case company is introducing new supply chain planning processes, including a new process for item segmentation and assignment of control methods. The aim of this process is to balance inventories and secure product availability in response to pressure of reducing cost and increasing customer service.

The segmentation process at the case company consists of a classification of products to three different groups, two make-to-stock groups and one make-to-order

group. More specifically, the three groups are denoted plan-based (P), consumption-based (C), and order-based (O) and are named in accordance with their planning method. The segmentation is based on the number of order lines and the monthly demand coefficient of variance (CoV) of products, where P products have a CoV less than 0.3, C products have a CoV between 0.3 and 0.6, and O products have a CoV above 0.6. For simplicity, only the CoV's as a determinant for the segmentation is considered here.

In order to be able to empirically test the hypothesis, a specific supply chain at the case company is selected as the unit of analysis. This supply chain consists of three echelons: two supplying factories producing parts and assembly-ready-components, and one assembly site. All of the echelons are internally owned companies, but are separated in terms of management and planning activities.

In each of the three sites, 3-years of historic sales data is extracted for three part numbers belonging to different part types. The selection of part numbers is based on a combination of their initial segmentation and ranking on share of total sales volume. For instance, in the collection of a specific component type, the part number representing the median of the sorted sales volume data in both the P, C, and O group is selected, in order to increase how representative the tested part numbers are. For the finished products, part numbers are selected based solely on sales volume being high, medium, or low, due to lack of data foundation in regards to segmentation of finished products, but medians were likewise chosen. Median sampling is chosen to increase the generalizability of the results despite a relative small number of data points. In total, 24 part numbers representing different levels and types of sales is selected for the quantitative testing.

In order to test the three hypotheses, different assumptions are made. First of all, in all hypotheses nervousness needs to be quantified. As mentioned, nervousness is in this context defined as the number of shifts in overall segmentation, that is when a products shifts from being a plan-based (P) product to consumption-based (C) and order-based (O) product and vice versa.

In order to determine the category of each product, the CoV's are calculated on monthly buckets, with a specific number of months of historic sales included in the calculation and a varying planning frequency. Initially, hypothesis 1 and 2 regarding historical data periods and planning frequency are tested, as they represent a foundation for testing hypothesis 3. In each hypothesis, all part numbers are tested individually, but only the average results are presented and discussed in the following.

5 Results

5.1 Hypothesis 1

In order to test the relationship between the number of historical data periods and nervousness, varying amounts of historical data periods are tested with a constant re-planning frequency of 1 month. In Figure 1, the average result for all part numbers is depicted. The expected relationship is a decreased number of shifts with an increased amount historical data periods.

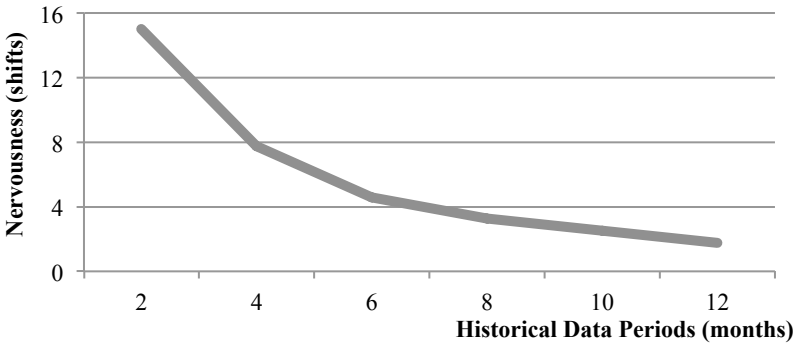

Fig. 1. Test Results For Historical Data Periods

As seen in Fig. 1., this hypothesis has strong empirical support. Moreover, there are indications that the relationship is exponentially decreasing, which mean that the benefits from increasing the amount of included historical data periods are considerable in the beginning and then decreases as more periods are included.

5.2 Hypothesis 2

In order to test the relationship between planning frequency and nervousness, varying planning frequencies are tested with a constant number of 6 months historical data points. In Figure 2, the average result of the testing is depicted. Again, there is empirical support for the hypothesis concerning a decrease in nervousness when planning frequency decreases. It may seem that planning frequency do not impact nervousness as strongly as the included historical data. However, the absolute number of planning shifts would have been considerably higher, if less than 6 months of historical data was applied. In other words, the absolute number of shifts is not as interesting as the relationship between the two tested parameters, which indicates an approximate decreasing exponential relation.

5.3 Hypothesis 3

In order to test the impact of the chosen threshold values in the segmentation, all the tested part numbers and their respective number of shifts and monthly CoV's are

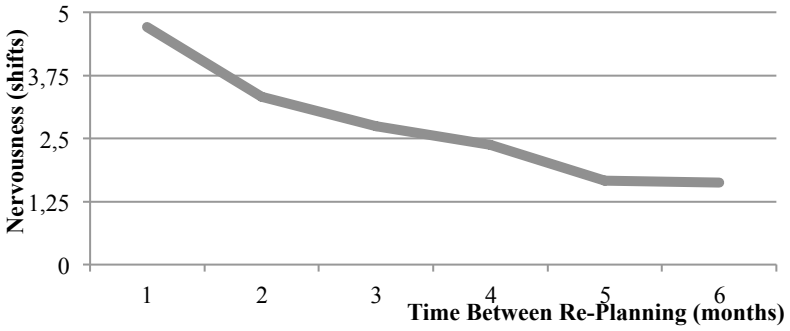

Fig. 2. Test Results For Planning Frequency

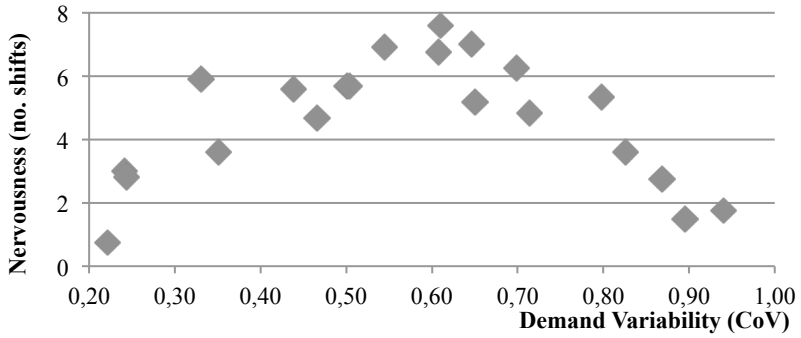

Fig. 3. Test Results for Threshold Values

plotted in Fig. 3. The shifts are computed, as the average results for each part number that were used in Fig. 1 and Fig. 2.

In the segmentation approach applied in the testing of the hypothesis, the limits for the three different segments are CoV´s of 0.3 and 0.6. In the empirical test, it is seen that nervousness peaks for products that has demand variability similar to these threshold values. In particular, a peak in nervousness is indicated around a CoV of 0.6, which is the limit between consumption-based and order-based segments. In other words, products that have a natural demand variability close to the chosen threshold values is expected to have the highest number of shifts between segments. A natural consequence of this is that in order to reduce nervousness, threshold values that secure that the main part of products stays in between limits and not across and around the limits should be selected. This idea corresponds to the idea of clustering, where maximum between-segments variability and minimum within-segment variability is the goal, in order to make the segmentation as effective as possible [15].

6 Discussion & Managerial Implications

With the data foundation from the case company, it is concluded that the three hypotheses can be accepted for this specific case. However, when considering the sparse data foundation and the fact that only one specific case supply chain is tested, the need for further testing is stressed. For instance, only 24 different part numbers have been tested, which even though they are selected as median representatives, only make up less than a 1 ‰ of the total number of part numbers in the tested supply chain. Therefore, it is suggested that future research should focus on empirically validating these hypotheses on a broader data foundation cutting across both organizations and industries.

Another point that should receive more attention is the criticality of shifts. In this paper, the number of shifts in the segmentation quantifies nervousness, where the criticality of shifts is overlooked. This criticality is perceived to have larger consequences if a product changes directly from being a P product to an O product, without transitioning through the C group. Therefore, it could be argued that some shifts are more intense than others, thereby causing increased nervousness. This should be ad-

dressed in future research, where it is suggested that e.g. inventory limits in relation to segment changes are considered.

Validation of the three hypotheses implies that some degree of planning nervousness can be mitigated through changes in the product segmentation processes. As a result, it is expected that for this specific case, nervousness can be battled through changes in the segmentation setup. However, the objective of reducing nervousness by all means should be questioned, as this may create an inflexible setup with little emphasis on responsiveness. Therefore, nervousness reductions should always be considered in relation to the desired level of operational responsiveness. In this paper, only the mitigation of nervousness is considered, without measurable connections to responsiveness. However, nervousness should not be approached in a vacuum but must be addressed with emphasis both to the desired goals and the environment of the organization.

The confirmation of the hypotheses examined in this paper has led to findings on how the relationship between the amount of historical planning periods and planning frequency affects nervousness, and how it can be accelerated or alleviated through changes in the segmentation process. Additionally, the selection of threshold values poses a direct consequence on nervousness. A negative consequence is experienced if these threshold values are improperly chosen around the values. This outcome is seen as an initial step in operationalizing the measures causing and possibly mitigating planning nervousness within the process of segmentation. Nevertheless, no generalizable conclusions can be derived from this analysis, as the empirical evidence should be broadened, but indications strongly suggest a direct and controllable relationship between segmentation and planning nervousness.

7 Conclusion

The contribution of this paper should be seen as an initial step in the direction of explaining the relationship between nervousness and planning processes on a general level. Three hypotheses concerning key decision parameters within product segmentation have been established and tested for a specific case. The hypotheses are indented to operationalize the concept of nervousness, by allowing for quantitative evaluation of the amount of data periods included in the segmentation, the frequency of the segmentation, and the segmentation limits. In conclusion, it can be stated that for the case tested here, a relation between these segmentation parameters and planning nervousness exists. Evidence suggests that planning nervousness can be minimized through changes in the segmentation process. In other words, the degree of nervousness and planning instability experienced in companies can be controlled and is not solely determined by the incontrollable environmental factors. Though, it should be emphasized that in order to generalize the findings, these hypotheses should be tested on different cases in alternate environments. This paper therefore strengthens the field of knowledge-based production planning by operationalizing the concept of nervousness through establishing a direct relation between nervousness and product segmentation.

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