CONNECTION OF THE BALANCED SCORECARD AND THE BULLWHIP EFFECT

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Abstract

Bullwhip effect has strong academic and business interest due to the potential malfunctions that can be generated in the supply chain if it occurs. There are several reasons behind and numerous consequences. There is still no ready to use solution to eliminate the impacts. Balanced Scorecard is a widely used well known performance measurement framework. Due to the flexible setup adaptability of the tool is quite good in the different industries. Even if the measures used are not the same the frame can be successfully applied. In the literature the combined research of the bullwhip effect and the Balanced Scorecard is not common. However, the scope of the perspectives and the bullwhip effect reasons are quite similar.

This paper focus on the analyzation of the connections of the researchers of the Balanced Scorecard and bullwhip effect common literature. The reasons of the phenomenon and the Balanced Scorecard perspectives fits well with each other. The aim is harmonization and synchronization of the two to take advantage of the similarities. Balanced Scorecard is a good framework to group the metrics that shows the presence of the bullwhip effect. Using the measurement system is potentially support the detection of the phenomenon. Applying the mentioned methodology, the KPIs in use are supporting analysation and indication of the bullwhip effect. As a result, the level of control on the phenomenon can be increased. The extension of the common research of the two areas can lead to improvement from the practical aspect.

Key words: bullwhip effect, Balanced Scorecard, performance measurement

1. INTRODUCTION

Bullwhip effect is a widely researched phenomenon. It has both academic and business importance. The phenomenon has been scope of research in the past 40 years but there is still no ready to use solution to prevent it. From business perspective it is mainly in focus due to the cost related impact that is generated as the consequence.

Beside the financial impacts the effective operation is also damaged those results in further costs and requires additional attention. Balanced Scorecard is a performance measurement framework frequently used in practice regardless of industry. The tool is aiming to cover all the relevant measurement areas to support the performance improvement. It is not only focusing on the financial impact but also the other relevant areas. In the literature the Balanced Scorecard and bullwhip effect is typically not scope of research together. Investigation is more likely to be initiated separately.

This article is analyzing the potential connection between the bullwhip effect phenomenon and the Balanced Scorecard perspectives. The reasons behind the bullwhip effect are touching the operational performance from multiple perspective. As BWE can be caused by factors of different areas, investigation should also cover several angles. Balanced Scorecard enables the analysis of the phenomenon from different perspectives. It keeps in focus the comprehensive picture, but at the same time enables deep analysis from multiple aspects.

Considering the impact of the COVID-19 on the logistics and supply chain processes it became more crucial to improve performance on chain level. Finding out operational malfunctions can support to get over extraordinary situation much easier. The uncertain market circumstances make the probability of bullwhip effect even higher. Tracking and analyzation of the phenomenon became even more important.

Usage of BSC framework for analysis of the bullwhip effect is a good opportunity to see multiple reasons behind the phenomenon. It supports the elimination of the reasons and improvement of the processes to achieve better performance. The matching is created based on the common characteristics and scope.

The hypothesis stated is as follows: bullwhip effect reasons can be matched with the Balanced Scorecard structure. This enables the proper categorization of measures. That potentially leads to better control on bullwhip effect phenomenon.

2. THEORETICAL BACKGROUND

2.1. Bullwhip effect

Bullwhip effect (BWE) has strong academic and business interest due to the potential malfunctions that can be generated in the supply chain if it occurs. The main understanding of the phenomenon is common but still among different research groups interpretation differ highly. The phenomenon was researched first by Forester, it is also known as the forester effect. The bullwhip effect term was defined in a 1997 study by Lee, Padmanabhan and Wang. In practice it was recognized by Procter and Gamble through the analysis of the diaper orders. Customer demand fluctuation was not explaining the level of variability. The phenomenon was also present at other sectors and companies. The authors describe bullwhip effect as below: “the phenomenon where orders to the supplier tend to have larger variance than sales to the buyer (i.e., demand distortion), and the distortion propagates upstream in an amplified form (i.e., variance amplification) (Lee et al., 1997, p546).” It can be also described pointing out the huge difference between customer demand and the produced quantities. “The effect by which slow moving consumer demand creates

large swings in production for the suppliers at the other end of the supply chain." From financial perspective bullwhip effect becomes crucial once the fluctuation of production leads to higher cost than the inventory holding (Wang & Disney, 2016). The competitive environment and the structure of the supply chain are also influencing the occurrence of the phenomenon (Xuluo, 2021).

The main causes behind have been stated by Lee et al as below (Lee et al., 1997):

- Demand signal processing: focus is on the retailer supplier point of the supply chain but applicable on the full chain. Supplier cannot track properly the retailer's signals; the true demand pattern is not getting through the chain. All the forecast related malfunctions can be listed here: inaccurate forecast, misunderstanding of the market information or the applied forecasting strategy. There are also related topics. Handling of stock out situation from the planning perspective is also impacting the forecasting. Common problem of the former mentioned issues can be lack of learning also.
- Rationing game: products with limited supply order can exceed the real needs to secure availability. The issue typically starts from the manufacturer, but it can occur in all levels of the chain. This group is relevant on chain level. Impacting factors are the number of supply chain echelons, lack of transparency, synchronization, and control. Application of local approaches ignoring the global view is also under this category. Fear of shortage also mostly observable on echelon level but it can impact the full chain in a multiplicative way.
- Order batching: can be caused by periodic review processes and the cost of the orders. Rules and strategies can differ in the chain that can drive to bullwhip effect. Mostly the technical characteristics are under order batching. The applied lot size of orders and the used ordering timelines can drive to unrealistic numbers. That can be even aggravated by the lack of harmonization (mentioned earlier) of replenishment strategies in the chain. Limitations of the available capacity can also lead to defective solutions (Potter & Disney, 2006).
- Price variation: promotional plans are not in line with the supply capabilities. It can be even worse with free return policy. Promotional activities, sales deals can also have impact on the supply chain performance and the bullwhip effect. Fluctuation of material or finished good prices can trigger the oscillation. Planned and mainly unplanned promotions can drive to insufficient operation and can also result in fear of shortage. Further causes have been identified later. Lead time is of the most significant. As in today's supply chains long geographical distances are typical lead time cannot be 0. Forecasting methodology and replenishment policy need to be identified considering also the time related information (Geary et al. 2006). Also some different approaches are present in regards of bullwhip effect. Information sharing is connected more to the global supply chain concept. Effects are realised on echelon level but partner connections between the members of the supply chain are driving these processes (Bhattacharya and Bandyopadhyay, 2010).

The mentioned main areas have been completed by the lead time parameter (Geary et al, 2006). The phenomenon can drive to different outcomes. Overstock and stock out can also be the result. Both cases drive indirectly or directly to financial impact. It can be for example because of the lost sales opportunities or the increased warehousing cost. The financial impact can increase through the chain due to the

multiplication effect. Beside the cost impact information distortion is also significant due to the BWE (Szegedi, 2012). The phenomenon results in uncertainty in planning. The expenses also appear due to production and transportation capacity utilization (Warburton & Disney, 2007).

As today's supply chains are rather networks than chains the co-operations is harder. An idealized chain is characterised by information transparency, coordinated processes and common strategy. Considering these circumstances bullwhip effect is less likely to happen. However, these idealized characteristics are not likely to happen in the real-life circumstances. For better forecasting processes and accuracy information sharing is needed. It is not solving the problem by itself, but the highest peaks can be avoided. Lead time should also be checked. The critical points need to be identified and controlled. This helps in the reduction of the uncertainty; processes are more manageable. Third point is the synchronization of ordered batch sizes and/or quantities. In addition, process related differences should also be checked and harmonized, or compatible methods should be used (Towill et al, 2007).

2.2. Balanced Scorecard

The Balanced Scorecard (BSC) is a frequently used measurement system which is not limited for measuring financial results. The idea was developed by Robert S. Kaplan and David P. Norton in 1992. The tool is mainly supporting the work if the strategical goal is clear and the number of metrics we would like to measure is limited. For structuring the result Balanced Scorecard use four perspectives (Kaplan & Norton, 1992):

1. Financial perspective
2. Customer perspective
3. Internal business perspective
4. Innovation and growth perspective.

This model can measure operative processes, but the aim is supporting strategy and long-term changes. The main point in Balanced Scorecard is staying flexible, adaptable with keeping the ability to handle the complexity of measures. The main groups of indicators stated in the model are important in all enterprises and the breakdown of the measurement enables the customization of the system even on enterprise level. Besides the company can also decide regarding the weight of the perspectives based on unique preferences. With regards of the perspectives, it is also important to find a way to connect them and point out the parts where they can influence each other (Chytas et al. 2011).

Using the perspectives all relevant areas are covered but at the same time the number of measures used are limited. This minimizes the potential informational overload that can take the focus away. Having the four perspective not only enables the user to put proper focus on different fields but also support in avoiding the sub-optimal approaches. Using the frame, the comprehensive picture is clearer (Wu, Chang, 2012).

Using BSC, the two main pillars: financial and non-financial aspect can go hand in hand. The cost pressure can be reflected in the financial perspective, but also the customer satisfaction is taken into consideration. In the model what is more than the

already mentioned points are that we can connect these disciplines to internal business processes, and we can see how the development of the internal processes can help with the other factors. In addition, innovation and growth/adaptability can be also integrated into the complex evaluation of the operation, strategy. Basically, the model tries to answer the question 'How does the company succeed?' with the non-financial indicators to support the financial goals and targets (Kurien, Qureshi, 2011). From a different angle BSC perspectives can separate the indicators based on the scope or focus of the measures. Financial related measures are concentrating on the occurred events, focusing on the outcomes in the past. Non-financial factors are considered more forward thinking (Whang, Chen, 2019).

We can differentiate between the perspectives based on the observed period also. Financial perspective shows the financial results of the company, the decisions are made, and the changes occurs due to them. In contrast the other segments mainly focus on the future. What are the areas which can impact future result? How can their improvement help from financial point of view? The limited number of measures also concentrate the focus of decision makers on the focus areas and information does not need to be selected, searched out from huge datasets (Kurien, Qureshi, 2011).

2.3. Scientific landscape of Balanced Scorecard and Bullwhip effect

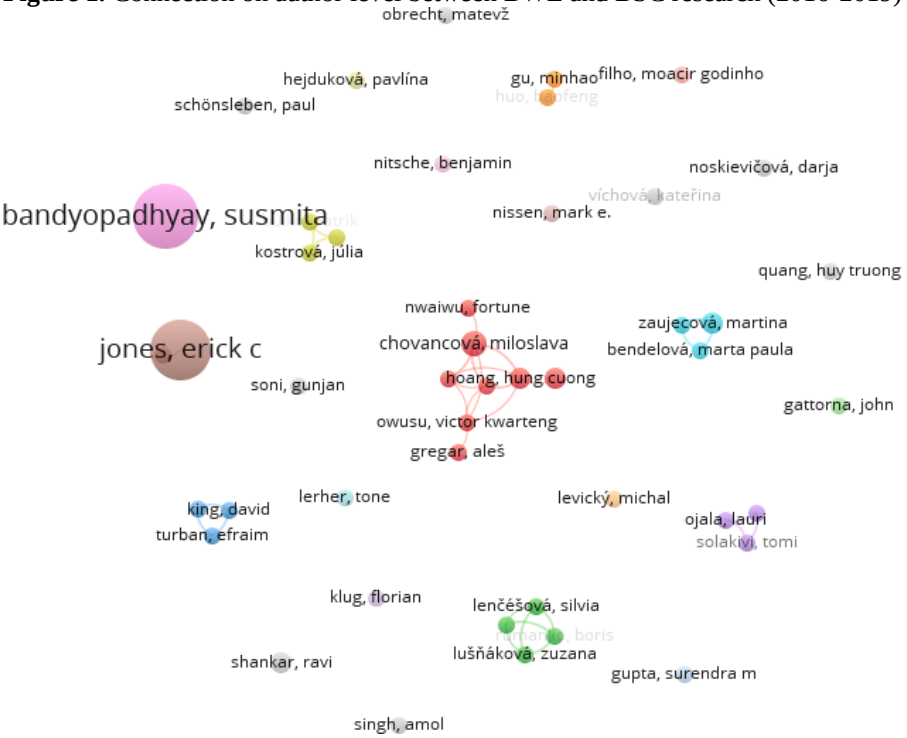
Scientific mapping has been used to check the overlapping research on bullwhip effect phenomenon and Balanced Scorecard framework. There are several possibilities to find and extract information on published articles. Multiple databases are available. In this research the Dimensions.ai database has been used to collect the meta data. For visual display there are also multiple available tools. VOSviewer is a supporting tool for visualization of bibliometric data. The landscape in the tool can be generated based on citation, bibliographic coupling, co-citation, or co-authorship relations. With this tool co-authorship, citation based, and occurrence networks can be created (www.vosviewer.com). The investigation is focusing on 2016-2019 period. 2020 is excluded due to the impact of COVID-19. Bullwhip effect is scope of COVID-19 related research due to the impact on supply chain performance. From the perspective of this research, it is not relevant to consider this outstanding circumstances.

Regarding the Balanced Scorecard we can find several research in multiple perspectives. Considering the period of 2016-2019 16951 publication is listed in dimension database. When the search is narrowed down to common research of BSC and BWE it is only 391 hits for the given period. We can see from these numbers that usage of BSC in terms of bullwhip effect research is not that likely. Only 2% of the articles in the database are considering both key words. If the period is not limited Dimensions contain 75 thousand BSC related hits and only 1 thousand on the "Balanced Scorecard" AND "Bullwhip effect" combined expression. In percentage this is even less than 2% (Strommer, Földesi, 2020).

For the examined period (2016-2019) Figure 1. landscape shows the connection between the authors. The threshold value for the authors has been set for two due to the small number of articles. So only the authors with at least two articles in the research are visualized. As visible on the figure Bandyopadhyay Susmita and Jones

Erick have the biggest number of articles on the topic. Considering the search requirement ("bullwhip effect" AND "Balanced Scorecard") these two authors are isolated. We can also see a bigger network of eight researchers and some smaller groups (Strommer, Földesi, 2020).

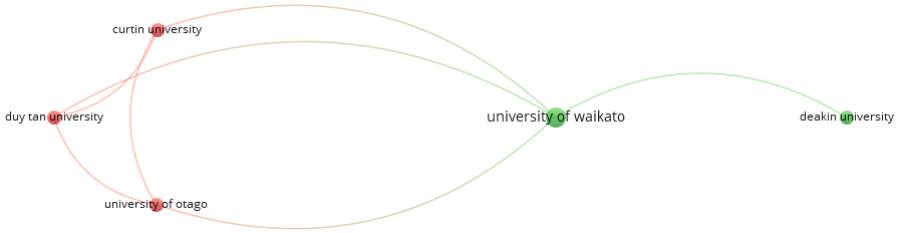
Figure 1. Connection on author level between BWE and BSC research (2016-2019)



Source: Strommer, Földesi, 2020

On institution level even less connection occurs. Even if the threshold value is deleted (set to one) only five connected elements can be presented. Below figure shows these five institutions. Bullwhip effect and Balances Scorecard is not present together in big number of research. Based on the examined period individual research or small research groups are typical. Most of the institutions are also not connected on this topic (Strommer, Földesi, 2020).

Figure 2. Connection on institution level between BWE and BSC research (2016-2019)



Source: Strommer, Földesi, 2020

3. BALANCED SCORECARD AND BULLWHIP EFFECT

As chapter 2.3 shows common research of bullwhip effect and Balanced Scorecard is not typical. Each topic is extensively studied but the joint investigation is not regular. Connection between the two is the operational performance. BSC supports a frame to integrate metrics. BWE influence the operation and this impact needs to be presented and tracked by the measures.

Balanced Scorecard's four main perspectives are: innovation and growth, internal business, financial and customer. Bullwhip effect reasons are also categorized in four main groups: demand signal processing, rationing game, order batching, price variation. The connection of the framework and the phenomenon can be built based on the scope of the BSC perspectives and the characteristics of the reason groups. The pairing is in Table 1.

Table 1. BSC perspectives connected to the BWE reasons

Balanced Scorecard		**Bullwhip effect**	
Innovation and growth	improvement actions long term focus deeper understanding of performance	Rationing game	affecting the whole chain strategical aspect
Internal business	existing processes operational metrics	Order batching	replenishment policy time frame
Financial	costs related measures	Price variation	promotional impact price changes
Customer	customer satisfaction loyalty	Demand signal processing	forecasting uncertainty estimation based planning

Source: own research

Innovation and growth perspective contains the measures that support the process improvement actions with long term focus. These metrics are supporting the better knowledge on the performance of the processes to support learning and development (Lim, Ok, 2021). Bullwhip effect rationing game reason group also contains the chain level reasons like number of echelons, local vs global approaches or lack of control and synchronization. These elements are mostly on strategical level. The KPIs that shows the mentioned reasons of the rationing game group focuses on chain level questions, can be used to support the improvement actions. With this approach rationing game reason group can be connected to the innovation and growth perspective of the Balanced Scorecard.

Internal business perspective places the focus on the metrics related to the existing, operating processes. These are the activities in the background that need to be initiated to support better service for the customer (Lim, Ok, 2021). Regarding BWE order batching contains process related reasons: the applied ordering and replenishment strategy, timelines used. The BWE order batching reasons highly can be connected to the purposes of the internal business perspective of the BSC.

Financial perspective relates to price variation. Price related changes can have huge impact on the forecast, level of inventory. These unplanned price changes (both increases and decreases) leads to inventory related oscillation. This result can be reported in the KPIs and involves financial expenditures. As the financial perspective of the BSC shows the quantified impacts it can be matched with the BWE reasons connected to price variation.

Customer perspective aims to point on customer focus and relationship with the customer. Focus is on satisfaction, retention, and loyalty. These elements can be rather measured by the customer, from the enterprise perspective the service quality can be evaluated (Lim, Ok, 2021). Demand signal processing also touches this topic. It is highly impacted by information sharing and forecasting methodology used by the different echelons. These all are based on the initial information from the customer. These aims to reach the highest possible level of customer satisfaction.

Below table (Table 2) shows KPIs that can be potentially used to show the presence, or the impact of the bullwhip effect categorized according to Balanced Scorecard perspectives. The first table is providing the basis of the categorization:

Table 2. KPIs to detect bullwhip effect in the BSC structure.

Innovation and growth	• number of supply chain echelons • number of harmonized local KPIs • number of occurence of shortages
Internal business	• Safety stock level, • Lot size
Financial	• Bias • Price level fluctuation, • Number of promotions
Customer	• Forecast Accuracy • Service level

Source: own research

The metrics in Table 2 are supporting analysis of the presence of the bullwhip effect. In addition, some of them can be used to reduce the impact by early detection (such as service level). Some other KPIs can also support the indication of the phenomenon. As bias and forecast accuracy compare historical forecast data with real market situation these KPIs can support the indicative approach.

4. CONCLUSION AND DISCUSSION

The literature mapping led to the result that Balanced Scorecard and bullwhip effect is typically not present together in research. Nevertheless, the BSC perspectives and the BWE reasons are showing similarities in regards the scope. Based on the similar logic reason groups and perspectives have been connected. Some example KPIs that can be used as measure of bullwhip effect has been systemized based on the Balanced Scorecard structure.

Balanced Scorecard is a good framework to group the metrics that shows the presence of the bullwhip effect. The reasons of the BWE fits well with the BSC structure. Using the measurement system is potentially support the detection of the phenomenon. This gives opportunity to have better control on it. It can also be basis of process improvement actions that leads to the elimination of the bullwhip effect. Balanced scorecard can be used as indicator framework of the BWE.

As the next step it is worth to check how the mentioned KPIs can be used to indicate bullwhip effect. If the measure is not supporting the indication how it can be used for analytic purposes. It is also important to identify the characteristics of the supply chain that impact the set of measures used.

The mentioned methodology is mainly suggested for companies using BSC already or any compatible system. The data handled by the supply chain can limit the usability. If a given information is not tracked, it may be not worth to introduce new measures. Financial or other sources can also limit the applicability.

Usage of KPIs that are not covering the spectrum of the scorecard can also limit the usability. It is also valid that short supply chains and some product categories are not typically impacted that heavily by the bullwhip effect. The method is mainly aiming to support the chains that are hardly impacted by the bullwhip effect. These cases the phenomenon is the result of the combination of multiple reasons. Using BSC can support in recognition and parallel treatment of the issue.

There are also some other directions of research that can be initiated to cover the scope of this investigation. Below questions should be analysed as first step:

- What are the bottleneck points in practical application?

As a next step it is possible to check how the similarities between BSC and BWE can be used in practice. Based on the result reached it is visible that KPIs that can be used to show the consequences, or the presence of the bullwhip effect can be built in the Balanced Scorecard frame. The question is how the metrics can be categorized to generate a tool that in long term eliminate the negative impact of the phenomenon. Some of the mentioned measures support the process improvement that can reduces the likelihood of occurrence. The others can indicate the presence or the sings of it. It

needs to be checked if tracking bullwhip effect separately from multiple angles can work or not.

- What other frameworks can be used?

It should be checked if there is any other performance measurement framework that can be matched with the bullwhip reasons or consequences. This would make wider choice of tools for the supply chains and better adaptability.

- What are the further logistics KPIs worth to be included?

In Table 2. there are some examples listed that can be integrated to the framework and that is also shows the bullwhip effect. The set of metrics that can be used is not limited to the mention items, further KPIs can be included. It would be worth to check what other measures are used widespread in multiple industries.

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