PERFORMANCE INSTABILITY OF LOGISTICS PROCESSES AND THEIR IMPACT ON MANUFACTURING COMPANIES

Ivo FORMÁNEK, Iveta VOZŇÁKOVÁ

VŠPP, a.s., Prague, Czech Republic, EU, ivo.formanek@vspp.cz, iveta.voznakova@vspp.cz

Abstract

Logistics has not been considered as an "extra" important part of business processes in the past. Often, it was underestimated and most often dealt as a last part of value added chains. There were several reasons. One of the main reasons was that in the past companies could afford to keep a relatively large amount of stocks in external warehouses or their in-house storage areas. More than sufficient inventory levels did not require logistics processes to work efficiently and effectively. However, unlike in the past, the situation today is quite different. The global markets and the involvement of business processes in global value chains put pressure on companies to optimize all business processes and their productivity. Thanks to these facts, the importance of all logistics processes and their management is growing. The main task of today's managers in logistics is thus about having the right inventory at the right time, in the right place, at the right quantity and quality and all these at the minimum cost. The managers should therefore apply all available means to meet the requirements above. The first step that should be carried out always at the beginning of the optimization, is processes stabilization. The reason is simple. Optimization of non-stable processes is extremely difficult, if not impossible. The contribution presents some practical experience gained during stabilization of logistic processes in several manufacturing companies in the Czech Republic. The paper also includes results of simulation experiments, which explain some frequent phenomena in logistics.

Keywords: Process, Stabilization, Optimization, Management, Six Sigma

1. INTRODUCTION

Logistics is currently a very dynamic industrial sector that uses the most advanced technologies such as information and communication technologies (ICT), the Internet of Things (IoT), robotics, automation, artificial intelligence, etc. In contrast to the past, logistics offers also quite new and unexpected possibilities for the future. Especially if we realize the possibilities of unmanned aircrafts and drones, driverless cars and lorries, etc. All these possibilities must result in completely new logistics systems.

It is not too long ago, when logistics has not been considered as an "extra" important part of business processes. Often, logistics was underestimated and most often dealt as a last part of Value Added Chains (VACs). There were several reasons. One of the main reasons was that in the past companies could afford to keep a relatively large amount of stocks in external warehouses or their in-house storage areas. More than sufficient inventory levels did not require logistics processes to work particularly efficiently and effectively. There was enough time for everything. However, unlike in the past, the situation is quite different today. The global markets and the involvement of business processes in Global Value Chains (GVCs) put extreme pressure on manufacturing companies to optimize all business processes and their productivity. Thanks to these facts, the importance of all logistics processes and their management is dramatically growing. The main task of today's managers in logistics is thus about having the right inventory at the right time, in the right place, at the right quantity and quality and all these at the minimum cost. The managers should therefore apply all available means to comply with the above requirements. One of the most important steps that should be carried out always at the beginning of the process optimization, is processes stabilization. The reason is simple. Optimization of non-stable processes is extremely difficult, if not impossible [1].

The contribution presents some practical experience we gained during stabilization of logistic processes in several manufacturing companies in the Czech Republic. To support the truth of our claims, the paper also includes results of simple simulation experiments. The reader can thus easily verify why stability is so important for any process optimization. The contribution also briefly introduces methodology that we commonly use in process optimization.

2. METHODOLOGY

As already mentioned above, the contribution is mainly about process optimization. To optimize processes, there are various methods and methodologies we can apply [2], [3], [4]. From our perspective, the best methodology for process optimization is (Lean) Six Sigma [5]. We achieved the best results every time when we followed this methodology. The (Lean) Six Sigma methodology is characterized by a fixed structure called as DMAIC. The DMAIC expression represents an acronym for the names of the five steps: Define, Measure, Analyse, Improve, and Control [5].

1st step - Define opportunities. The main aim of the phase is to define the purpose and scope of the project. In this phase we define the project objectives, build up the project team, define the products and services provided, create process maps and diagrams (e.g. Flow and SIPOC diagrams), define metrics for measuring the quantity and quality etc. [6]. The outcome of the Define phase is basic information about processes and their customers.

2nd step - Measure performance. In this phase the process customers and their key requirements and expectations are identified. We also evaluate, what and how processes are currently performed. It is necessary to determine the process current status [7], [8].

3rd phase - Analyse the chances and opportunities. The main goal of the phase is identification of opportunities and threads. We analyse and identify main process problems and their root causes.

4th step - Improve performance of processes or activities. The final goal of the phase is the process improvement. We define a process and construct its maps, gain necessary information, analyse causes of defaults, plan modifications and specific project solution and define an improved process and construct its maps [7], [8].

5th step - Control performance. We build up a monitoring system of the new and improved process, gain the necessary information, analyse the causes of major defects, control and improve the new and improved process again; update its maps.

The Six Sigma methodology was applied also to the processes stabilization we are discussing about in this contribution.

3. PROCESS STABILITY AND IMPACT ON STOCK

Imagine five processes *Pi*, *i = 1,2,3,4,5,* which are in series. Then assume interim stocks *STi*, *i = 1,2,3,4,5* placed between processes. The combination of individual processes and interim stocks is then as follows: *P1, ST1, P2, ST2, P3, ST3, P4, ST4, P5, ST5.* See also **Figure 1d** or **Figure 2d**.

Let us further assume a situation where the performance of respective processes *Pi, i = 1,2,3,4,5* can be any (i.e. random) integer value in the range of values *1* to *6* (including *1* and *6*). It means that applies:

$$N = \{1, 2, 3, 4, 5, 6\}, \quad Pi \in N\ , \quad i = 1, 2, 3, 4, 5 \tag{1}$$

where:

N - the set of natural numbers
P_i - process i
i - process index

This situation corresponds to the results of a simple simulation experiment in the **Figure 1**.

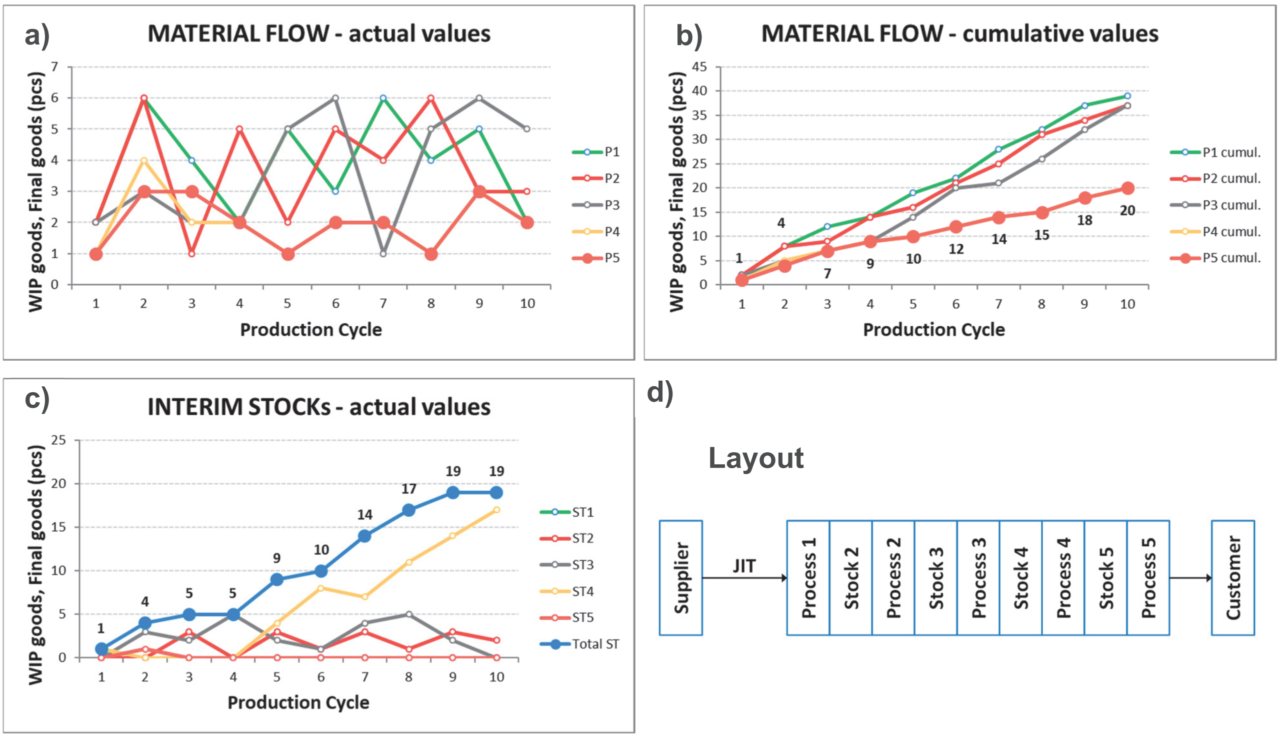

Figure 1 Performance of the processes *Pi, i = 1,2,3,4,5*, a) actual values; b) cumulative values; c) Status of the interim stocks *STi, i = 1,2,3,4,5*, actual values; d) Layout of the production line. Source: own study

Unlike the previous situation, let's assume now that the performance of respective processes *Pi, i = 1,2,3,4,5* can be the only one integer value. - for example number 3. It means that applies:

$$N = \{3\}, \quad Pi \in N\ , \quad i = 1, 2, 3, 4, 5 \qquad (2)$$

This situation corresponds to the results of the simulation experiment in the **Figure 2**.

Comparing the results in **Figure 1** and **Figure 2**, we can make one interesting conclusion. It is more important for a company to have its processes working synchronously, than having processes with too high power. Even we can say that stable and synchronously working systems with reduced performance can achieve much better results than not synchronously working systems with very high performance. And stable synchronously working systems have also another advantages. For instance, in this case we can optimize the workload of the people, number and power of the equipment and most of all, it is not necessary to accumulate excess stock. It means we can spare much money because of not investing into redundant people, equipment, performance and inventory (pls. compare **Figure 1 b,c** and **Figure 2 b,c**). So, unstable systems are too expensive.

4. STABILIZATION OF TRUCK TRANSPORT PROCESSES

In the previous chapter, we briefly explained why process stabilization is so important. In this chapter we will try to point out the same problem, but already on a practical case.

Large metallurgical companies in the Czech Republic use both railway transportation systems and truck transportation systems. Railway dominate in raw material imports and internal WIP goods transport, trucks in turn predominate in export of finished goods. Compared to railway transport, truck transport is far more flexible.

This is also the main reason why customers prefer truck transportation today. (In addition, some customers have already abolished their internal railway infrastructure to reduce operation costs.) Coordination of both transportation systems is not easy at all. Their stability can be influenced by many factors. Even greater problems arise when it is necessary to coordinate both of these transportation systems with automated production lines. And all with minimal stock. We were invited to help solving one such problem in a large metallurgical company in the Czech Republic.

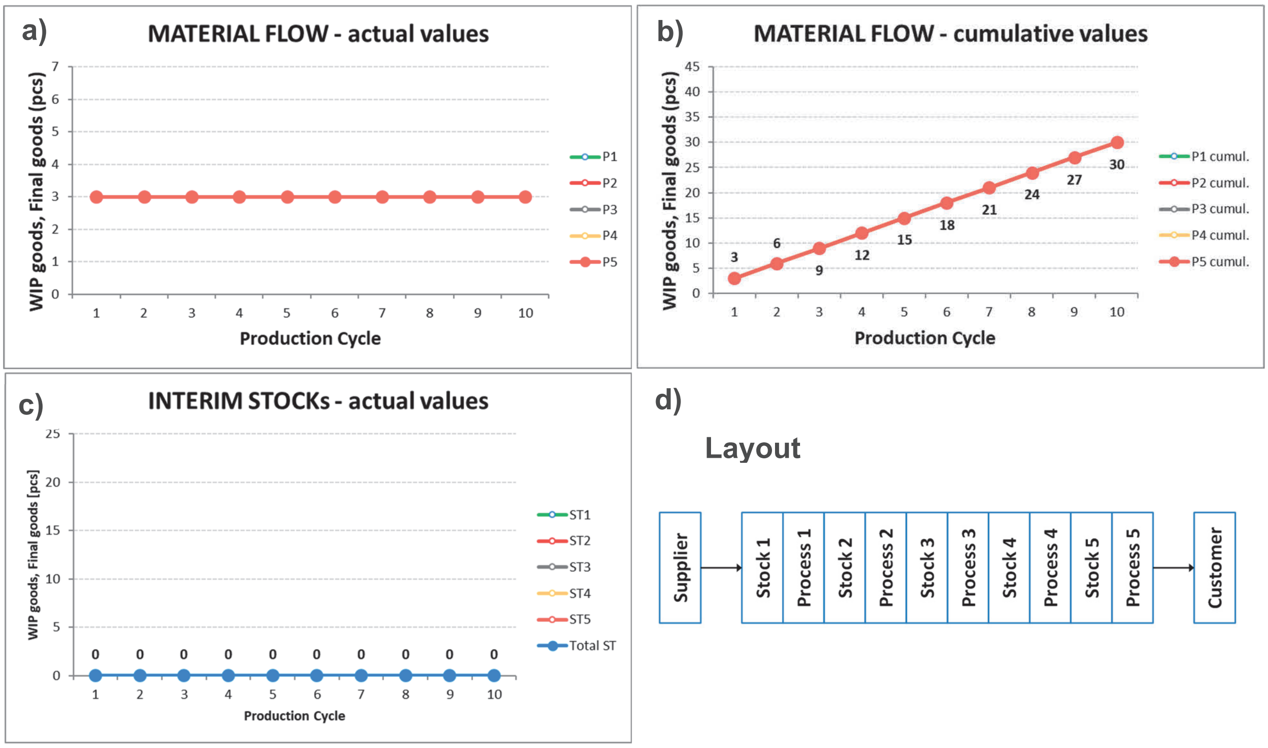

Figure 2 Performance of the processes *Pi, i = 1,2,3,4,5*, a) actual values; b) cumulative values; c) Status of the interim stocks *STi, i = 1,2,3,4,5*, actual values; d) Layout of the production line. Source: own study

In the company, the truck loading is organized by transport coordinators. They organize (of course by means of information systems) the trucks arrivals to individual storage areas called as export stores. As was said already, the truck transportation can be influenced by many factors (by people, by weather, by traffic jams, etc.). And it is one of the main reasons, why the truck transportation processes have great variability (even though each truck is given a time window for arrival). The variability is then characterized by loading large numbers of trucks at one time, by dangerous situations in front of the export stores and in the export stores themselves, unacceptably long waiting time and loading time, unnecessary extra costs on all sides, etc.

The analyses, that we carried out in the company, lasted almost a year. To find out the variability infection source, we analysed decisive transport processes and a large amount of data from various company data stores. The analysis revealed many interesting issues. Unfortunately, due to limited extent of the contribution we can present only a couple of findings related to the trucks transportation process stability.

The results of some analyses are shown in **Figure 3** and **Figure 4**. These analyses represent the results of 6 months of measurement we did at several export stores. **Figure 3** shows that the company customers preferred for a long time Monday to load trucks. By contrast, Wednesday was the least used working day. This phenomenon is partly due to the trucks arrived to the company only after unloading material in other companies. This unloading usually takes place around six o'clock in the morning.

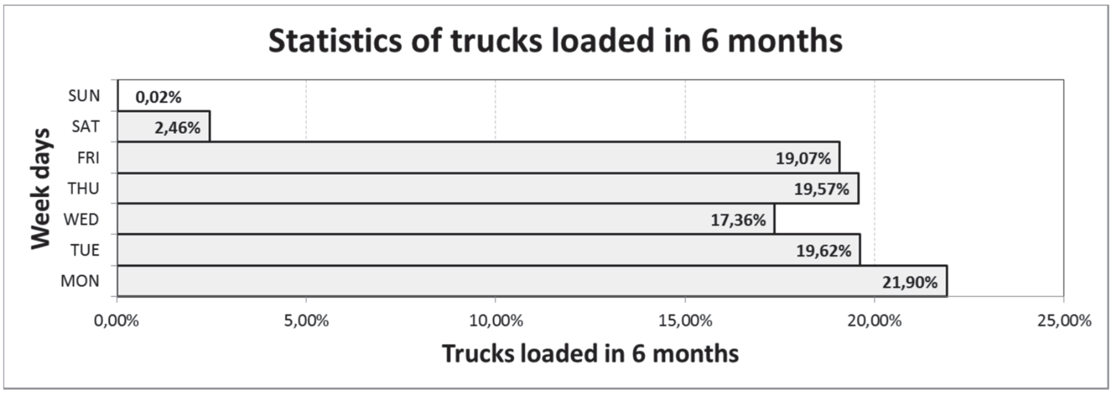

Figure 3 Percentage of trucks loaded for 6 months on each calendar day. Source: own study

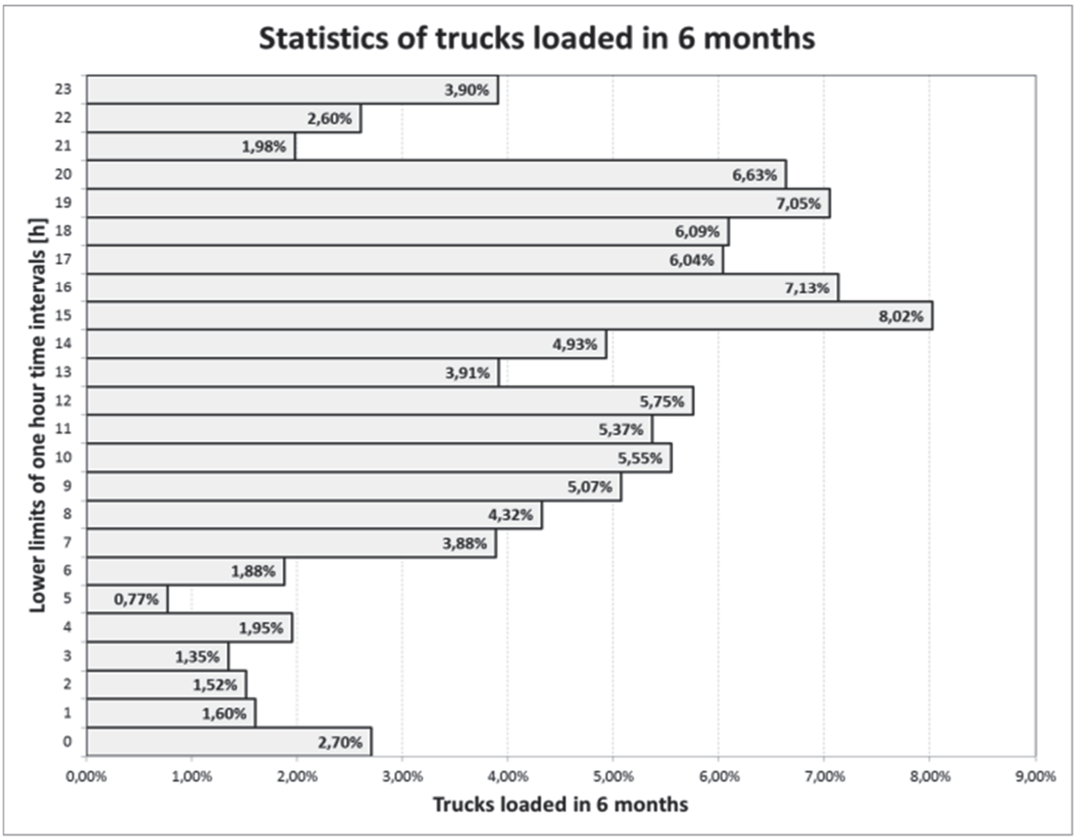

Figure 4 Percentage of trucks loaded for 6 months in each time window. Source: own study

Figure 4 shows fluctuations over a 24-hour cycle. Fixed working shifts of the company starts at 06:00, 14:00 and 22:00. It is evident from **Figure 4** that the beginnings and ends of shifts had a significant effect of the goods expedition. It means that work organization of export stores can also have another considerable impact on the smoothness and variability of goods expedition.

It was also quite interesting to observe the time windows that were given to the trucks beforehand. For example, in the period of truck transportation monitoring only 49 % of trucks arrived on time, 19 % of trucks arrived too late and 2 % of trucks arrived too early. This fact also affected the variability of processes in the export stores.

5. CONCLUSION

The analyses showed that the variability of export logistics was significantly influenced by variability of the trucks transportation. This variability was then amplified by other process variabilities in the export stores. Therefore, a number of measures had to be taken to limit all these kinds of variability. This was the only possibility because the capacity of the export stores did not allow to compensate efficiently both variability from the production lines side and the variability from the trucks transportation side. While minimizing the variability of the processes, the means of advanced industrial automation proved to be very helpful and successful [9], [10]. They enabled better monitoring, better measurement and better control of majority of the processes we were interested in. Today's variability of the logistics processes we presented in the contribution is much better than ever before.

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