Procedia of Economics and Business Administration
ISSN: 2392 – 8174,
ISSN-L: 2392 – 8166

Available online at www.icesba.eu

International Conference on Economic Sciences and Business Administration
24-25 October 2014, Bucharest, Romania

Sustainable Growth with the Help of Quality Scheduling Index

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Abstract: The paper presents a new way for small and middle size companies to sustain their growth using the Quality Scheduling Index. The aim of the paper is to provide the managers from not only the private sector, i.e. manufacturing companies, a tool which can help them improve Just-In-Time delivery of the products to the market, reduce manufacturing costs related with time usage for manufacturing the products on parallel production lines and also increase the quality according to the ISO norms as well as according to each and every customer requirements. In this way the Pull principle is applied and the company will produce and deliver the right products, at the right time and according to the customer's specifications. The Quality Scheduling Index is presented and partial results of its implementation are shown from a managerial as well as juridical point of view. The goal is to extend Total Quality Management in areas little explored, working in Just-In-Time mode, by eliminating the temporal variations from the contractual delivery terms regarding time. Among other things, the new management tool, Quality Scheduling Index, is able to capture the desired degree of temporal variations and the associated costs. Its implementation methodology goes to business practice, eliminating the company's risk of failure from the enterprise supply chain.

Keywords: Quality Scheduling Index, sustainable, growth, management, improve.

JEL classification: L23, O21, M11, L15, K20

1. Introduction

In today's market when the customer enters the shop and places an order, he expects to receive the ordered goods at the right price, within the specified time and quality features' requirements.

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The Just-In-Time (JIT) manufacturing and delivering of the ordered goods to the final user should also involve the Quality requirements of each and every customer, Quality which in our conception should be part of the manufacturing schedule and not its adversary. If we have to sacrifice quality to meet schedule requirements, is because we are doing the job wrong from the very beginning and here is where our paper finds its place and can stop this situation to occur. The goal of the paper is to maintain the quality requirements and meet the schedule in the same time through a new way of managing the time consumption, quality features and manufacturing costs in close relation with the macroeconomic environment in which all the Small and Middle size Enterprises (SMEs) compete and interact with the global final customer.

The business practice shows that in the Just-In-Time (JIT) environment is expensive to delay the production lines of the finalists, because it must be paid and for this pays everyone in the manufacturing supply chain. Therefore, today's quality should also include a module of the time accuracy of the supplies.

Our article, through the newly developed Quality Scheduling Index (QSI), integrates indicators of quality of the supplies to the final assembly of the producer of engineering products. Thus we introduce a new approach to modern requirements for understanding the quality of time structure of production processes. Basically, it is the elimination of time deviations (quality) from the contractual delivery time. This corresponds to the following secondary goals (targets):

A. Creating a new management tool that is capable of containing a degree of temporal variations from the standard (quality) process with delivery costs sooner or later;

B. Determination of the appropriate methodology for the implementation of the new management tools (Quality Scheduling Index - QSI) into practice;

C. Construction of a unique evaluation scale for assessing the quality achieved through index QSI in small and medium-sized engineering companies.

In other words we focus on achieving a higher level of supplies reliability (in contractual terms - quality) in terms of compliance with manipulation between production processes at the workshop level of production and operations management.

2. Sustainable growth from an EU perspective

The online encyclopaedia Wikipedia states that: “Sustainable growth is defined as the annual percentage of *increase in sales that is consistent with a defined financial policy* [...]”. [Higgins, 1977]

According to the 11th President of the European Commission, José Manuel Barroso said in the “COMMUNICATION FROM THE COMMISSION, EUROPE 2020, A strategy for smart, sustainable and inclusive growth” that: “Europe has many strengths. We have a talented workforce; we have a powerful technological and industrial base. We have an internal market and a single currency that have successfully helped us resist the worst...The Commission is proposing five measurable EU targets for 2020 that will steer the process and be translated into national targets: for employment; for research and innovation; for climate change and energy; for education; and for combating poverty. They represent the direction we should take and will mean we can measure our success.” [European Commission, 2010]

With our paper we aim at achieving the EU targets: for employment and education (by training the right people for the specific jobs which have to be fulfilled as part of the supply chain, according to the material and informational flow), for research and innovation (with QSI the managers will be able to produce only the products which will be bought by the targeted market segment) and for climate change and energy, because by optimizing the production process within public and private sector, productivity will increase and thus more qualitative products will be made with the same or less resources than before in a unit time.

2.1 Quality Scheduling Index

From a juridical point of view, when signing a contract, the parties bound themselves to fulfil the contractual terms and deliver the products or services within the required schedule at the required quality standard, which must comply with ISO standards, but might not necessary, comply with customer requirements. Time can be considered as a negative factor, namely delaying the decision of the public institution as a negative influence on the market and the business environment. Thus an important business decision may create a state of uncertainty affecting business productivity and therefore profitability [Gruia & Gruia, 2013]. In this manner the managerial tool Quality Scheduling Index can be implemented in private as well as into public sector, which is of a great importance and affects through its political decisions [Gruia, 2014] the good development of the private sector. In the same time, by implementing the Quality Scheduling Index (QSI) in public or private sector the productivity of the company increases and at a macroeconomic level we can achieve the state of sustainable growth in terms of target debt to equity ratio, target dividend by payout ratio, target profit margin or target ratio of total assets to net sales. The QSI concept provides a starting point for the development of a comprehensive financial framework and formula for any SME specific to sustainable growth rate calculations.

To achieve the previous defined secondary goals (targets) we had to mathematically formulate the necessary input and output variables. The model was developed and considered only from a private sector perspective [Gruia & Kavan, 2014], however the range can be broaden with application in the public sector (state own companies as well as public administration institutions), and from a macroeconomic point of view, applied even at the level of European Union. Rationalized organization of work achieved with the help of Quality Scheduling Index can be explained in a simplified manner according to the following figure.

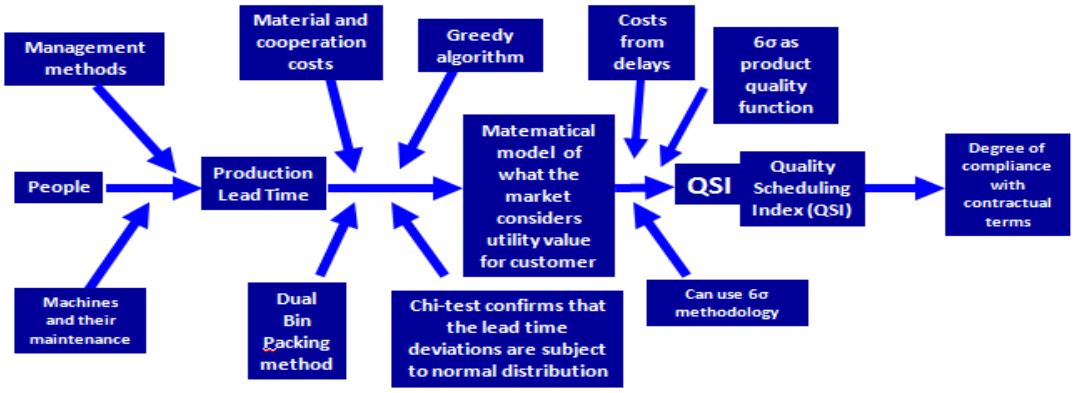

Figure 1: Mind map in the form of cause and effect diagram

Source: Own contribution

Based on the requirements of the market and of the shareholders, on optimization model is born with a new and unique Quality Scheduling Index (QSI) as the degree of elimination of schedule deviations from the production plans:

$$QSI = \frac{\sum_{i=1}^{h}\sum_{k=1}^{f}(ew_{ki}E_{ki}y_{ik}+tw_{ki}T_{ki}z_{ik}+w_{ki}C_i)}{\sum_{i=1}^{h}\sum_{k=1}^{f}\frac{q_i}{tc_i*(E_{ki}+T_{ki}+C_i)}} = min$$

In this way the secondary goal A was fulfilled.

2.2. Implementation methodology and QSI's evaluation scale

We had to theoretically test the proposed Quality Scheduling Index (QSI) and tune it experimentally and then test its functionality in business practice. Thus was developed and tested implementation methodology of the Quality Scheduling Index (QSI) and thus was fulfilled the second target B.

The first part of the methodology consists of collecting and sorting the necessary information - what is specified in the formula for the calculation of the Quality Scheduling Index to be applied in the production plans as well as public enterprises (while in the private sector there are production processes, in the public sector we will have public administration processes):

1. Creation of main management strategic directions: pessimistic, most likely, optimistic.
2. Division of processes depending on the business model and jobs (with one and with more than one operation).
3. Arrangement of jobs / processes in parallel:

   3.1 Schedule jobs according to our own priority rule FFBR (jobs with one operation), or

   3.2 According to other newly established priority rules NoBtl and MaxQminT, with partial use of SPT rule (for more than one operation) and

   3.3 Based on Greedy algorithm so that each process has added maximum value before passing to the next job.
4. Determination of optimistic, pessimistic and most probable procedure of the production / public administration process, the determination of the production batch/batch of documents to be sent.
5. According to the CRM / CI find utility value of products / services.
6. Identification of primary and secondary processes that affect the utility value directly or indirectly.
7. Identification of processes that should be carried out in exactly the given time interval, or those who may be delayed, or those that can be done in advance

(according to the optimistic and pessimistic strategic directions of work planning the production / public administration line).

8. Identification of the priorities of processes, the most important process will denote with a value of 1 and the least important gets the value of the total number of operations of the manufacturing / administrative process.
9. Sorting the processes into 3 groups (by the previous paragraph 8) with the appropriate priority.
10. Calculating the total cost of the product or batch of products / services (according to data availability).
11. Calculation of the total cost of one product (the product / services batch), in compliance with the processes and time requirements.
12. Calculation function of the quality of $q_i=x_i^2+x_i+1$ where x_i is the utility value of the product / service, number of employees is i ∈ {1,2, ..., h}, with a direct impact on customer satisfaction.

The second part of the implementation methodology is devoted to of calculating of QSI - corresponding to the maximum level of quality and minimum value in losses of time and money.

13. Run the developed software at least 10 thousand cycles of repetition, with previously obtained and the relevant inputs.
14. Repeat the previous point at least five times consecutively, in order to reduce the likelihood of errors.
15. Compare calculated values with those in the rating scale and select the essential values of the interval defined rating scale.

The third part of the methodology concerns the elimination of cyclic error (which can occur) and the determination of the definitive measures for improving the quality of processes based on the values of the Quality Scheduling Index (QSI).

16. In the graph of the calculated QSI values - eliminate values that are outside the specification limits – which are set by the customer base.
17. Adjust the final values of quality (time completion, the total cost) according to your business model (note that the production period, calculated by the program is in minutes; the program is set up to work for 12 hours per shift (for reasons of practical applications performed in a specific company and the specific conditions), so if you have an 8-hour shift, just multiply the value of the time rate of 8/12).
18. Return to the quality equation and find the corresponding values of the coefficient x_i and accordingly set the workplaces' adding value.
19. Do the same for the total cost and completion time of the work, when including the most likely strategic directions and implement measures arising from the calculated values.

20. If the calculated value of QSI is not in the "good" rating scale - take steps to reduce costs and improve the time usage and then repeat the calculation of the Quality Scheduling Index (QSI).

Thus was fulfilled the secondary target B.

2.3 Sustainable growth using QSI

The Quality Scheduling Index (QSI) can be used as a useful tool by SMEs' managers, which with the help of the newly developed Quality Scheduling Index evaluation scale can find out exactly in what state they are in the business production processes before (and after) the implementation of the QSI in the company. It is listed in the following table, thereby meeting the secondary target C.

Table 1: Evaluation scale of the Quality Scheduling Index

Parallel identical machines		**Parallel uniform machines**		**Parallel unrelated machines**		
-workers 1-100 -jobs 1-100 QSI $[1\cdot10^{8};5\cdot10^{8}]$	- workers 101-250 -jobs 101-250 QSI $[16\cdot10^{9};51\cdot10^{9}]$	- workers 1-100 -jobs 1-100 QSI [145;215]	- workers 101-250 -jobs 101-250 QSI [405;422]	-workers 1-100 -jobs 1-100 QSI [60;168]	-workers 101-250 -jobs 101-250 QSI [277;842,6]	**Good**
-workers 1-100 -jobs 101-250 QSI $[108\cdot10^{8};13\cdot10^{9}]$	-workers 101-250 -jobs 1-100 QSI $[34\cdot10^{8};134\cdot10^{8}]$	-workers 1-100 -jobs 101-250 QSI [278;353]	-workers 101-250 -jobs 1-100 QSI [423;455]	-workers 1-100 -jobs 101-250 QSI [220;355]	-workers 101-250 -jobs 1-100 QSI [217;505]	
-workers 1-100 -jobs 1-100 QSI $[5,1\cdot10^{8};9\cdot10^{8}]$	-workers 101-250 -jobs 101-250 QSI $[51,1\cdot10^{9};9\cdot10^{10}]$	-workers 1-100 -jobs 1-100 QSI [215,1;273]	-workers 101-250 -jobs 101-250 QSI [422,1;520]	-workers 1-100 -jobs 1-100 QSI [168,1;343]	-workers 101-250 -jobs 101-250 QSI [843;1680]	**Average**
-workers 1-100 -jobs 101-250 QSI $[131\cdot10^{8};22\cdot10^{9}]$	-workers 101-250 -jobs 1-100 QSI $[134,1\cdot10^{8}154\cdot10^{8}]$	-workers 1-100 -jobs 101-250 QSI [353,1;394]	-workers 101-250 -jobs 1-100 QSI [455,1;502]	-workers 1-100 -jobs 101-250 QSI [356;453]	-workers 101-250 -jobs 1-100 QSI [506;634]	
-workers 1-100 -jobs 1-100 QSI>10^{9}	-workers 101-250 -jobs 101-250 QSI>10^{11}	-workers 1-100 -jobs 1-100 QSI>273,5	-workers 101-250 -jobs 101-250 QSI>520	-workers 1-100 -jobs 1-100 QSI>344	-workers 101-250 -jobs 101-250 QSI>1680	**Bad**
-workers 1-100 -jobs 101-250 QSI>$221\cdot10^{8}$	-workers 101-250 -jobs 1-100 QSI>$154\cdot10^{8}$	-workers 1-100 -jobs 101-250 QSI>394	-workers 101-250 -jobs 1-100 QSI>502	-workers 1-100 -jobs 101-250 QSI>454	-workers 101-250 -jobs 1-100 QSI>635	

Source: Own contribution

We have divided the scale (one for each of the cases of parallel identical, uniform and unrelated machines or working tables) in three main categories:

1. **Good** – which can act for the company as a stimulus that the process is in good limits and the company is manufacturing products according to the utility value requested by the customers and within the quality, time and costs specifications of the business model. If a company has the Quality Scheduling Index in this evaluation scale, it means that it can invest in the R&D of a new product and can invest in the innovation of the business model with any concerns regarding the actual business model, because the actual one is at the highest levels (every process runs smooth within specifications and according to the customers' requested utility value).
2. **Average** – this level states that the company should give more attention to the processes which don't add value in direct way, but in indirect one, because there are some discrepancies which can be easily adjusted. Also the values of QSI from this range indicate that the company has losses on the production line, which affect the delivery time and the quality of the requested products by the market.
3. **Poor** – the level indicates that there are major problems on the production lines and the processes should be evaluated in detail, from the quality, time and costs point of view. These values can act as an alarm signal for the management that something is wrong in the company which affects the image and reputation of the company. Additional managerial tools are needed to further evaluate the situation like: FMEA, evaluation of processes, Value Chain Analysis, Supply Chain Analysis, etc., according to the specific business model, the industry in which develops its business and experience of the management.

For better results each of the levels above are valid for four different situations:

a) For a number of workers between 1 and 100 and a number of jobs between 1 and 100;
b) For a number of workers between 101 and 250 and a number of jobs between 101 and 250;
c) For a number of workers between 1 and 100 and a number of jobs between 101 and 250;
d) For a number of workers between 101-250 and a number of jobs between 1 and 100;

The first two cases are valid for designing of experiment (and simulating different schedules according to the strategic directions in SMEs) on parallel machines for jobs with one operation, whereas the last two cases are valid for scheduling jobs with more than one operation (in our specific case the index works best for only up to three consecutive operations per each job which had to be done on different types of parallel machines, but we should know in advance the processing times of each operation in part).

The Quality Scheduling Index was also partially implemented in selective manufacturing companies from two European countries (Romania and Czech Republic) and it was shown that by implementing the QSI, it was obtained an increase in average of 27% in time consumption of the available time, and an increase in the production of qualitative products too, from 51 to 54, i.e. approximate 6% increase in the quality of the products with zero defects. In the same manner the costs of quality were considerably diminished, with up to 17% [Gruia & Kavan, 2014]. From a juridical point of view we consider that this

small managerial tool which combines time consumption, quality requirements as well as costs related to time usage, should be implemented through a directive from the European Council in every European country so that all Small and Middle size Enterprises to have the possibility and opportunity to consistently increase their sales and profits annually through a predefined financial European approved policy. The QSI can also be easily modified to answer SMEs from different industries and countries within European Union.

Conclusion

In this paper we have presented a new way of achieving sustainable growth using the Quality Scheduling Index, if applied at the European level in small and middle size enterprises, as well as into state institutions, according to our implementation methodology and based on the evaluation scale developed. The possibility of practical application of the index QSI is made through newly developed software that calculates it and can be used in practice for small and / or medium-sized enterprises to increase business productivity. For better understanding of the concept of our index QSI, we recommend the reader to get acquainted with the authors other works.

New information was brought to the scientific community in the field of management and economics, with some juridical recommendations and can act as a new way of attaining sustainable growth in a faster and free of charge way, in the development of Applied Operations Research and Production and Operations Management. It improves understanding of quality scheduling on parallel machines and combines distributed workflow maximizing the utilization of productive resources.

The paper presented not only the index QSI, but our research deals with a wide range of related optimization problems, including contribution to the fact that management can be more precise and faster in taking some strategic decisions when dealing with a global customer with easy access to information and to different companies from the competition. The actual need of Quality Scheduling Index (QSI) was commissioned by the philosophy Just-In-Time and can play a strategic role in the enterprise of the 21st century.

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