SHOP FLOOR KEY PERFORMANCE INDICATORS IN AUTOMOTIVE ORGANIZATIONS

MariaVirginia IUGA[1], Claudiu Vasile KIFOR[2] and Liviu Ion ROSCA[3]

ABSTRACT: The selection of optimal key performance indicators is a central process step for organizations and companies world-wide. Within this research paper the authors identify the appropriate key performance indicators (KPI) pool for automotive organizations from a large pool of KPIs recommended from literature reviews and quality standards. The authors perform a systematization analysis comprising three steps. First recurrences within previous research are analyzed and documented, followed by a systematization of KPIs based on three perspectives (3W). Finally, the authors analyze the frequency of occurrences. Throughout this filtering process the authors reach a pool of optimal KPIs which is ten times smaller compared to the initial pool. The research remains open for further analysis in order to establish if the number of remaining KPIs is the appropriate one or if it must be reduced through further selection methods.

KEY WORDS: KPI, automotive, selection, shop floor.

1 INTRODUCTION

From an organizational perspective, the objective of information management is to provide valuable information that can be acquired and exploited to the fullest extent. The activities of information management can imply the creation, representation, organization, maintenance, visualization, reuse, sharing, communication and disposal of information. At a conceptual level, these elements can involve adding value to information by how it is organized, visualized and represented and allowing information to flow to the end-user. Moreover, it is preferable that these elements are executed efficiently, meaning with minimum waste. Within this paper identify the key performance indicator (KPI) pool used by organizations in order to measure, lead their processes and analyze which are the most appropriate KPIs to be implemented at shop floor.

[1] S.C. Marquardt SCS Sibiu, Zona Industrială Vest, Strada Munchen 2, Sibiu, România; Universitatea "Lucian Blaga" Sibiu, Bulevardul Victoriei 10, Sibiu, România

[2] Universitatea "Lucian Blaga" Sibiu, Bulevardul Victoriei 10, Sibiu, România

[3] Universitatea "Lucian Blaga" Sibiu, Bulevardul Victoriei 10, Sibiu, România

E-mail:virginiaiuga@gmail.com; claudiu.kifor@ulbsibiu.ro; liviu.rosca@ulbsibiu.ro

The focus of the research paper lies in underlining the optimal KPIs for the automotive industry. Within the next chapters, the most suitable KPIs discovered in literature reviews and quality standards are gathered together.

Chapter 3.1 describes an initial systematization of these KPIs through an analysis of recurrences while Chapter 3.2 describes a second systematization step which is performed through selecting the KPIs based on three perspectives (3W). At the end the frequency of occurrences in cited sources is analyzed in Chapter 3.3 leading to the optimal KPI selection. This way, the pool of optimal KPIs will be more as ten times smaller compared to the initial pool. The research remains open for further analysis in order to establish if the remaining KPI number is the appropriate one or if it must be shortened even more through further selection methods. Future research should concentrate on closing the above mentioned gap.

2 KPI POOL: LITERATURE REVIEW

Using the Balanced Score Card (BSC) to drive organizational performance, Kaplan and Norton (2005) described metrics falling into two categories: results and drivers. Result metrics are generally outputs, as they report after the fact and are difficult to dissect to determine causes (e.g. financial metrics). Driver metrics have a direct impact on the performance of a business because they provide immediate feedback on how a process is running. They facilitate immediate improvement and provide a tool to allow managers to change immediately the

behaviors that are causing the issues (Kaplan & Norton, 2005).

Michalska`s BSC also proposes a set of KPIs related to the organization`s strategy as "sale value ratio", "rentability ratio", "quality costs ratio", "the quality of customer service", "the quality products", "competing", "efficiency ratio", "complaint's amount", "production ratio", "training (Michalska, 2005). To define organizational leanness Krichbaum proposes five categories of metrics: Safety; People; Quality; Responsiveness and Financial Performance (Krichbaum, 2007). More specifically, he proposes indicators as: "Days worked without a lost time accident", "Ergonomic Management", "Targeted Training Hours", "Voluntary Turnover", "Production to Skilled Trades Ratio", "Targeted Training Hours", "Voluntary Turnover", "Delivered Quality", "On Time Delivery", "Manufacturing Lead Time", "Inventory Turns", "and Rework / Repair Cost ", " Customer Complaints".

In order to establish the importance of various indicators from a large table of performance indicators available, Bhatti questioned organizations in four areas: automotive, electronics, sports and textile. The conclusion was that for the entire manufacturing industry the most important indicator refers to product quality and particularly for automotive industry to customer satisfaction, which includes product quality (Bhatti, 2014). He suggested as categories of performance metrics: quality (customer satisfaction, input quality, output quality, cost quality, number of customer complaints, reworks, quality system costs, returned goods); cost (the manufacturing cost, value added cost, total product cost as a function of lead time, direct labor cost, indirect labor cost, scrap costs etc.); financial (sales, profits, percentage return on equity, assets, scrap cost as percentage , cash flows, days in inventory); flexibility (the ability of organizations to perform multiple tasks at given level of resources); time (lead time, cycle time, speed, order processing time, etc.); delivery reliability (percentage on-time delivery, percentage of orders with incorrect amount, average delay); employees' satisfaction (absenteeism, percentage of staff working flexible hours, employees' satisfaction per survey, employees 'complaints resolution effectiveness, empowerment index and length of service of staff who has left); customer satisfaction (revenue gained from top customers in a week, number of complaints, customer loyalty index, customer lost, new customers, number of customer referrals, market share in term of customers, on time delivery, number of quality service guarantee issued and order frequency); safety (accident rate, time on accident); environment/ community (waste and scrap produced, dollar donated to community, percentage of local residence in total workforce, number of media coverage events, number of photos in papers, number of sponsorships undertaken by organizations, number of environment complaints received in a year, percentage of current projects that are environment friendly and the environment safety awards); learning and growth (percentage of managers having IT literacy, percentage of employees having required education, employees certified for skilled job function or position, investment for training, number of internal promotions of managers who have performance management training, number of new staff, times in training and number of research paper) (Bhatti, 2014).

The National Council of Small and Medium Private Enterprises in Romania (CNIPMMR), within the pilot project RO/03/B/F/FP-175017 regarding methods to reduce costs, suggests that lean indicators should be grouped in a BSC containing the following four elements: productivity, calculated as the ratio between output and input; quality, calculated as a percentage of good parts; safety and costs. For the last two elements they do not propose a specific indicator. Moreover, a fifth performance indicator is suggested: the overall equipment effectiveness (OEE) (CNPIMMR, 2003).

MacDuffie and Pil mention a very similar categories of indicators as the previous authors: productivity: labor costs (direct and indirect), total factor productivity (total inputs), hours/ product; quality: defects/ hundred vehicles, first time through capabilities (cars that require no rework); HR (employee well-being): fluctuation, absenteeism and incidents number and severity; environmental performance: energy usage and emissions (MacDuffie & Pil, 1995).

Starting from the literature suggestion, that companies should use non-financial measures more intensively comparing to the usage of the financial measures, Gosselin performed a survey in more than 100 Canadian firms and finally demonstrated that the financial measures are more used, despite the literature prescriptions (Gosselin, 2005). The author classified the 73 most usual measures that he identified in 12 categories: customer and products sales (e.g. average sales orders number of warranty claims), production information (e.g. inventory

turnover, net profit), financial rate (e.g. return of sales, cash flow), employee data (e.g. trainings, absenteeism), non-financial ratio (e.g. energy consumed, labor hours used), variance of labor and material (e.g. labor efficiency variance, labor rate variance), stock market measures (e.g. stock price), order and delivery (e.g. backlog on delivery schedule), quality (e.g. cost quality, market share), revenues and profit (e.g. cost of goods sold), return on investment (e.g. ROE, ROI) and account receivable (e.g. total sales per employee). Within this framework, he showed the need to develop tools, which orient the company's performance measurements to the non-financial measures in order to optimize the manufacturing performance (Gosselin, 2005).

In order to achieve the quality standards requirements of measuring the processes and continuous improvement, it is necessary to have a measuring system of efficiency and effectiveness (ISO:TS 16949, 2009). The most frequently used KPIs to measure the organization's performance according to these requirements are regarding human resources as absenteeism, health rate, trainings, fluctuation, process machines and gauges capability such: cp, cpk, cm, cmk, cg, cgk, first run defects rate (ppm), product quality such: rate of defect parts, customer complains, internal scrap.

In the automotive industry, the original equipment manufacturers (OEM's) develop own standards such as "Formel Q-Konkret" (VW Group) or "Special Terms" (Daimler) asking for concrete indicators measuring process capabilities (cp, cpk) or product quality (ppm). They require from their suppliers to follow up some specific indicators such as QPN (Qualification program of new products), recovery volume, warranty costs, etc.

Stamm and Neitzert propose the measurement of KPIs using a concept consisting of five dimensions: costs, quality, time, people respectively organization performance and leadership performance. They propose some specific KPIs for each dimension (number of improvements suggestions per manager, jobs on time, rework costs, etc.) (Stamm & Neitzert, 2008).

According to the Toyota philosophy, it is essential to measure the big five metrics QCDSM: Quality, Costs, Delivery, Safety and Morale. In case of deviations from target, it is necessary to "go and see" what real the problem is and then develop root cause orientated actions to solve them (Liker & Meier, 2006).

Further on, the official KPI Institute states yearly the most popular KPIs in different domains (KPI Institute, 2014). The first important twenty-five KPIs in 2011-2012 regarding each of the following domains: human resources, production, maintenance and quality management are listed yearly (KPI Institute, 2014).

In total 294 indicators were identified within previous researches and quality standard requirements.

3 KPI POOL: SYSTEMATIZATION PROCESS

3.1 Systematization step I: eliminating recurrences

Out of the 294 indicators found throughout the literature review, some were found to be identical but listed under different names. The indicators were grouped according to their significance, analyzed and their names were adapted in order to avoid recurrences. The indicators which were found in different literature sources were grouped in one single indicator, due to their similarity. The title of these indicators was composed from the names of the components in order to assure the traceability to the original source. The frequency of occurrence, which represents the number of literature sources where an indicator was found, was also documented. Table 1 summarizes an example of a possible combination.

Table 1. Analysis example

Within the analyzed literature pool, the following indicators regarding work accidents were identified:	
Accident rate	Kaplan, 2005
	MacDuffie and Pil, 1995
	Bhatti et al., 2014
Weight indicator of accidents	Lean Romania, 2014
Rate of accidents injuries	Gosselin, 2005
Lost time injury frequency rate	KPI Institute, 2014
Accident severity	MacDuffie and Pil, 1995

These five indicators which were found in six different literature sources were grouped in one single indicator, due to their similarity. The name of this indicator can be composed from the names of the five identified indicators.

Therefore, the resulting indicator is: "Accident rate/ lost time injury frequency rate/ severity".

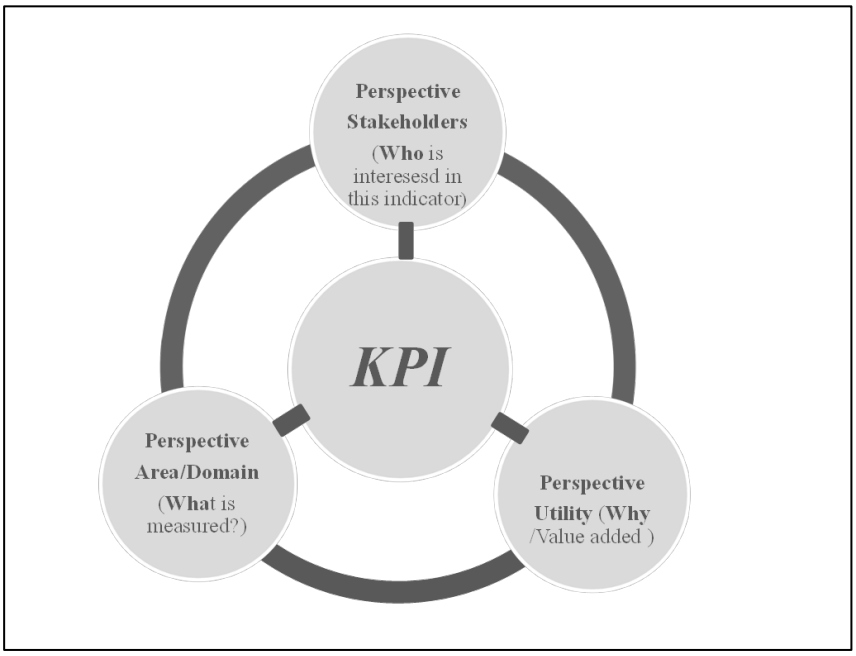

Figure 1. 3W perspectives

Table 2. KPI classification

No.	Why? Purpose/ Organizational target		What? Organizational area		Who? Perspective
1	Growing the product quality	1	Customer satisfaction	1	Customer
2	Increase the customer loyalty				
3	Increase the customer satisfaction				
4	Increase delivery reliability	2	Customer confidence		
5	Meet the customer requirements				
6	Increasing the market share	3	Market occupancy		
7	Increase employee well being	4	Employees satisfaction	2	Employees
8	Learning and growth	5	Knowledge Management		
		6	Leadership		
9	Increase work safety	7	Work safety		
10	Promote company image & assure the respecting of law requirements	8	Social/Environmental performance	3	Environment/Community
11	Cost optimization	9	Costs structure	4	Financial
12	Improve the financial dynamic	10	Dynamic of financial operations		
13	Growing rentability	11	Rentability		
14	Increase the process conformity	12	Conformity to standards	5	Internal processes
15	Improve dynamic	13	Process dynamic		
16	Increase the flexibility of processes	14	Flexibility performance		
17	Increase the competitivity	15	Innovation and growth		
18	Increase quality of supplied parts	16	Internal quality		
19	Increase internal quality				
20	Improve internal logistic	17	Process efficiency		
21	Increase maintenance efficiency				
22	Increase the layout efficiency				
23	Increase the production process efficiency				

The frequency of occurrence was state to six, which represent the number of literature sources where this indicator was found. After applying the systematization as in the example above, the number of indicators was reduced from 294 to 184.

3.2 Systematization step II: 3W

The following step of KPI systematization consisted in grouping these indicators according to three essential questions (3W): Why, What, Who.

The indicators that resulted from the above-mentioned sources were listed within a table and grouped according to fundamental questions: "why", "what" and "who" as followed:

- Why is the respective indicator used within a company? - Target/ Utility
- What does the respective indicator measure within the organization? - Area
- Who is interested to know the values of the respective KPI? - Stakeholder /Perspective
- The grouping procedure according to the three perspectives is described in Figure 1.

The "Why" perspective regarding the KPI utility is addressed for each indicator. According to this perspective, 23 utilities were highlighted. The "What" perspective assigns each indicator to the organizational area which the respective indicator is meant to measure. Therefore, 17 organizational areas resulted as shown in Table 2. The "Who, whom" perspective lies in assigning the KPIs perspective model suggested by Kaplan and Norton: employees, customer, internal processes and financial. Due to the increasing globalization and the rising importance of the environment and civil society nowadays, the four perspectives described by Kaplan and Norton in 2005 must be complemented by the one of the interested parties: civil society, administration, government, shareholders.

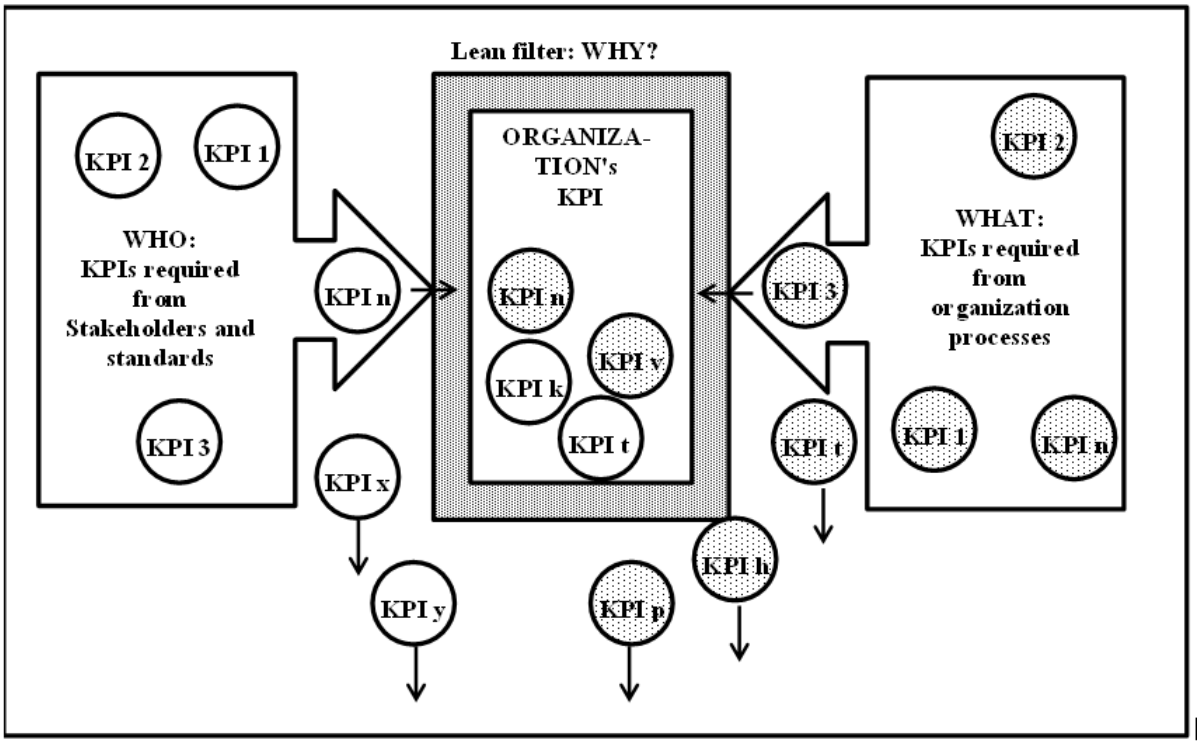

Figure 2. Lean filter to select the value added KPIs

Table 3. KPI frequency according to state of the art

Perspective	Organizational area	Organizational target	Frequency.	Source	KPI
Customer	Customer satisfaction	Growing the product quality	9	1, 2, 3, 4, 5, 6, 7, 8, 11	Delivered product quality/ Failures rates /Customer complains
		Increase the customer satisfaction	4	1,2, 11,12	Customer satisfactions: survey ratings
	Market occupancy	Increasing the market share	3	1, 2, 6	New customers/Percentage
			3	1, 2, 6	Market share in term of customers/Participation in market
Emplo-yees	Employees satisfaction	Increase employee well being	6	2, 3, 6, 8, 11, 12	Health condition/ Absenteeism caused of disease (%)
			4	3, 6, 8, 11	Employee fluctuation (%)
			3	6, 8, 12	Employee commitment/ engagement/cooperation/satisfaction (index)
	Knowledge Management	Learning and growth	5	1, 2, 5, 6, 8	Training Hours/ Times in training/ Training hour per full time equivalent (FTE)/ Investment for training
			3	8, 10, 12	Improvement ideas process (new/ implemented improvement suggestions/ improvements per manager/ per employee)
	Work safety	Increase work safety	6	2, 3, 5, 6, 8, 12	Accident rate/ lost time injury frequency rate/ severity
Financial	Costs structure	Cost optimization	5	3, 5, 6, 8, 12	Labor costs (direct/indirect/% of sales)
	Dynamic of financial operation	Improve the financial dynamic	3	1, 2, 6	Cash flow
	Rentability	Growing rentability	4	1, 2, 6, 11	Sales/sales ratio/turnover/net income/sales per employee
			4	1, 2, 11, 12	Profit/Rentability ratio
			3	1, 2, 6	Return on equity (ROE)
Internal processes	Internal quality	Increase internal quality	3	8, 9, 11	Internal quality (complains/failure rate)
			8	1, 2, 5, 6, 8, 10, 11, 12	Quality costs ratio/ cost of rework/ scrap cost
	Process efficiency	Improve internal logistic	6	2, 5, 6, 8, 11, 12	Stocks/ days in inventory/ inventory turns
		Increase the production process efficiency	7	1, 2, 3, 8, 9, 11, 12	Productivity (%)/ process efficiency ratio (%)
			5	2, 6, 8, 11, 12	Process optimization (savings, cost reduction, improvements in output, Kaizen activities)
			4	1, 2, 5, 6	Lead time (order processing time)/ lead time reduction (%)
			3	2, 8, 11	Interruption time/ downtime/ breakdowns (%)
			3	8, 9, 12	Machine utilization in production (%)/ OEE
			3	1, 6, 12	Throughput time (length of cycle)

1=Michalska, 2005
2=Gosselin, 2005
3=MacDuffie and Pil, 1995
4=Formel Q Konkret
5=Kaplan, 2005
6=Bhatti et al., 2014
7=Special terms Mercedes Benz
8=The KPI Institute, 2014
9=CNIPMMR, 2003
10=Stamm&Neitzert, 2008
11=ISO:TS 16949:2009
12=Lean Romania, 2014
Not relevant at shop floor

3.3 Systematization step III: lean criteria and frequency analysis

One of the challenges of this study lied in defining a way through which organizations within the automotive sector can choose the right indicators for shop floor from a pool of 184 different indicators, which were identified within previous research.

The fundament of this limitation lies in the frequency of occurrence combined with a lean thinking model starting from the company and shareholder needs (Who is interested, What is measured in organization) and filtered through the Toyota Production System philosophy: avoid waste and having value added (Why is this KPI used, what is the value added create though his usage?). The filter acts as shows in Figure 2, through the elimination of those indicators that do not add value at shop floor.

The analysis highlighted following results:

- 160 KPIs were taken into consideration by maximum 20% of the analyzed previous research (133 KPIs were identified within only one source out of 13 literature sources analyzed and 27, were identified in two sources)

- 24 KPIs were found in at least three sources. This KPIs are illustrated in Table 3. Out of the 24 KPIs with a frequency of appearance of at least three times (within three sources), the ones which create no value added at shop floor, for example marketing or finance related, were eliminated.

After this elimination a final pool of 18 indicators resulted as shown in Table 4.

4 CONCLUDING REMARKS

Categories of KPIs can be defined in a logical way, starting from stakeholder's perspective related to area of activity and the organization's targets.

The analysis focused on the most frequent encountered indicators within previous research but also on those indicators which were most frequently utilized, recommended by specialists and requested by standards and clients within the automotive sector. A total number of 184 indicators, which were grouped according to five perspectives comprising 17 internal areas, resulted from the analysis.

Applying a frequency analysis, 18 indicators remained in the pool being the most relevant at shop floor.

However, in accordance to Maasaki`s statement the number of indicators will be more limited (Maasaki, 2004). The optimal number will be defined through a survey.

Further limitations of KPI number can be performed through defining selection criteria and analyze them through performing a multi criteria analysis. The criteria's weight and the relative weight of each indicator in relation to each criteria will be establish through performing a survey in automotive organizations. The authors will close the above mentioned gap through future research.

Table 4: Selected Indicators

Item No.	KPI
1	Production volume (ex. no. of produced pieces) /productivity
2	Equipment effectiveness (OEE)
3	Duration of order execution (lead time)
4	Cycle time of the production line
5	Production processes: unplanned Interruptions (duration)
6	Employees: presence / absence / causes
7	Accident rate
8	Employee fluctuation %
9	Improvement ideas process (suggestions per employee)
10	Employee commitment/ engagement/cooperation/satisfaction (index)
11	Personnel: internal trainings (hours)
12	Delivered Product quality/ Failures rates/Customer complains (number, ppm)
13	Customer satisfactions: survey ratings
14	Internal quality -complains/failure rate(number, %, ppm)
15	Logistical indicators: unsupplied components
16	Logistical indicators: stocks (value, quantity)
17	Financial: savings due to process improvements
18	Costs: quality costs (scrap and repairs)

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7 NOTATION

The following symbols are used in this paper:
Cp = process capability
Cpk = process capability index
Cm = machine capability
Cmk = machine capability index
Cg = gauge capability
Cgk = gauge capability index
Ppm = parts per million