Evolutions in manufacturing cost deployment

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Abstract: The paper investigates the development of cost deployment and focuses specifically on the new aspects of this methodology as well as on the tangible benefit it brings within a world class manufacturing (WCM) strategy. The research was conducted through a case study involving a plant of a multinational firm and presents findings regarding two specific research questions investigating the differences between current methodology and previous theories and practices and the ability to track cost savings. Our research suggests that cost deployment methodology has evolved from the framework previously developed and it can impact positively on manufacturing firms in terms of overall efficiency and quality. The research has strong practical implications for both managers and entrepreneurs. Future developments of this research are fundamental to test our hypotheses in other organisations.

Keywords: cost deployment; world class manufacturing; WCM; management accounting.

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1 Introduction

The US manufacturing model declined after nearly 60 years of hegemony as the Japanese manufacturers developed more sophisticated and efficient production techniques – such as just in time and total quality management – which were later gathered under the label of 'world class manufacturing' (WCM) by US Academics Hayes and Wheelwright (1984) and Schonberger (1982, 1986).

Indeed, the Japanese lean practices became popular after that Womack et al. (1990) among the others showed the effectiveness of the Toyota production system (TPS). Many researchers underline how the adoption of these methodologies has been the key to manufacturing success over the last decades (Nandhakumar et al., 2011; Gunasekaran et al., 2018; Ruìz-Benitez et al., 2018) and, considering the fact that organisations continuously adapt and react to different challenges and market conditions, introduced the new concept of agile manufacturing. Kumar and Vaishya (2018) stress the fact the lean strategies are still adopted by manufacturing firms and are now supported by new technologies, such as the cloud computing.

Among those techniques, 'cost deployment' – firstly theorised by Yamashina and Kubo (2002) – played a key role allowing the enhancement of productivity in Japanese plants as it represented a scientific method to identify and eliminate wastes and losses in the production process. Cost deployment, as described by their founders, represented a valuable tool to understand where and how to intervene in the production process to achieve higher efficiency levels.

Several authors studied cost deployment after its first introduction focusing on the peculiar tools it has or on the interaction with the other techniques of WCM (Silva et al., 2013; De Felice et al., 2013; Kirkham et al., 2014; Posteucâ and Zapciu, 2015; De Felice and Petrillo, 2015), but none of them analysed extensively its implementation in a plant highlighting differences with the theoretical framework set by Yamashina and Kubo.

In this sense the paper aims to fill in this gap in the literature, by analysing the evolution of cost deployment and its current state of art through a case study conducted in a manufacturing firm. Thus, the paper aims to answer a first research question (RQ1):

how is the cost deployment methodology actually implemented in a plant and what are the main differences compared to the theoretical framework set by Yamashina and Kubo?

Moreover, to the extent of our knowledge, none of the authors that studied cost deployment focused on the tangible short-term results that the adoption of this methodology can bring in terms of savings – i.e., cost reductions – in a plant.

This led to the second research question (RQ2), i.e.: what are the main short-term results and the main key success factors?

Our hypotheses are that the theoretical framework initially proposed by Yamashina has evolved since its introduction, therefore it should be possible to notice differences in current practices and that the methodology should be effective even in short-term. This would allow managers and entrepreneurs to better evaluate the adoption of this peculiar methodology and to estimate the impact in can have on their firms.

A case study was conducted in order to investigate the hypotheses and to fill in the gaps in the literature: it was selected a plant of an automotive firm in the north-west of Italy in which cost deployment was recently introduced as part of a WCM strategy. Several semi-structured interviews were carried out involving directors and managers of different departments.

Our preliminary findings suggest that cost deployment methodology has been enriched by practitioners with new tools that enable the organisation to make budgets and forecasts of the cost savings.

In addition, findings suggest that the methodology is able to provide tangible results allowing waste reductions even on a short period of time.

The paper is organised as follows: Section 2 presents the literature review on the topic, Sections 3 and 4 present the methodology and findings while Sections 5 and 6 conclude the paper discussing the results and highlighting major limitations to the study.

2 Literature review

‘WCM’ phrase was coined by several authors referring to the set of practices in operations management that could lead any manufacturer to an excellence standard (Hayes and Wheelwright, 1984; Schonberger, 1982, 1986).

Starting from those studies, other researchers discussed the possibility to achieve simultaneously different competitive advantages through the adoption of WCM (Flynn and Flynn, 1996; Flynn et al., 1999).

On the other hand, Womack et al. (1990) depicted birth and rise of the TPS and studied the reasons behind its success. Yamashina (1995) focused on a peculiar aspect of Japanese manufacturing strategies, total productive maintenance.

With reference to the Italian context, after fiat (FCA) decided to develop its own WCM programme, many researchers studied it during the last decade: for example, De Felice et al. (2013) and De Felice and Petrillo (2015) focused on a concrete case study in one of FCA’s plants; Chiarini and Vagnoni (2014) tried to make comparisons between the fiat auto production system and TPS highlighting similarities and major differences. They underlined the innovation of fully developed set of managerial practices that allow involving the entire organisation. Cipriani et al. (2014) investigated the impact of the introduction of a WCM programme in terms of cultural changes inside the company. At the same time, they carried out a survey involving the plant workforce. Ferraris et al.

(2017) studied the impact that external sources have in improving the innovative performances of MNC's subsidiaries.

Recent studies on manufacturing techniques stress the key role of ICT in the agile manufacturing (Gunasekaran et al., 2018) or the importance of an efficient supply chain management within an organisation (Ruìz-Benitez et al., 2018).

Several researchers dealt with the topics of cost accounting and management accounting investigating the birth and the evolution of these matters (Scott, 1931; Littleton, 1933; Garner, 1954).

Moving forward, Johnson (1981) underlined new emerging tools in cost and managerial accounting such as activity-based costing and balanced scorecard, while Chan (1993) provided evidences of activity-based costing describing the implementation of an ABC system into a context other to manufacturing as a hospital.

Despite these new methods developed by companies and researchers, Johnson and Kaplan (1987) highlighted how managerial accounting lost its relevance and Cooper and Kaplan (1988, 1994) argued that cost accounting could potentially provide misleading results.

Kaplan (1984a, 1984b) argued that managerial accounting systems should have gone towards a better understanding and representation of manufacturing performance. In this sense, Jazayeri and Hopper (1999) provided a case study investigating the relationship between the management accounting system and a WCM programme. More recently, Broccardo et al. (2017) analysed the management accounting tools that Italian SMEs adopt.

Yamashina (2000) highlighted a rather similar concept and first introduced a new method named 'manufacturing cost deployment' in order to achieve a better measurement of operations performance (Yamashina and Kubo, 2002).

In this sense, also Vikram et al. (2015) underline the benefits that a lean strategy can bring to organisations, while Alonso et al. (2017) show some peculiar WCM practices that can be adopted in order to create added value through the supply chain.

Cost deployment became a breakthrough and several companies adopted it: for example, FCA decided to customise its own system into a general WCM framework (IlSole24Ore, 2010). Silva et al. (2013) studied FCA's cost deployment system. Nonetheless, they did not highlight major differences with the theoretical framework proposed by Yamashina and Kubo.

Kirkham et al. (2014) investigated how companies assess and choose the improvement projects in relation to their size.

Recently, Posteucâ and Zapciu (2015) discussed a method implemented to reduce the potential losses of new products already during the development phase, while Carmignani (2017) showed an application cost deployment as part of a 'scrap value stream mapping' process.

3 Methodology

3.1 Research design

The case study deals with the implementation of the cost deployment methodology as part of a WCM strategy adopted by a company in order to reach higher levels of overall efficiency and quality in its operations.

The company (named here alpha), an Italian subsidiary of an US listed company, is mainly involved in the production of brake pads and gaskets, which represents one of the core businesses of the US group. The plant produces around 100 million brake pads per year, employing around 1,000 workers. The group is one of the largest global actor in this business, supplying many original equipment manufacturers, original equipment suppliers and the after-market segment as well.

Brake pads manufacturing in the plant relies heavily on automated production system (e.g., automatic robots load the machineries on many working station) and requires very high-quality levels to guarantee the safety of the products: the combination of these can bring to major losses related to breakdowns and quality defects.

In 2015, the top management of the firm started to evaluate the opportunity to embrace a WCM strategy within the plants. It was decided then that the Italian plant would have been the first one to adopt WCM in the brake pad business unit as it is the oldest and largest production site of the group. Therefore, top managers decided that this plant had all the resources to implement and follow up such a complex strategy.

One of the authors had the opportunity to spend around nine months alongside the plant controller – who was appointed pillar leader of cost deployment – and other directors and facilitators involved in the WCM strategy. This allowed the authors to carry out an in-depth analysis of the cost deployment process and to build the case study analysing different areas of the company and their involvement in implementing cost deployment pillar.

Data were collected interviewing directors and managers from operations, maintenance, quality, technologies and logistic areas. The research involved also the cost deployment pillar leader (controlling manager). This helped following up the entire process and understanding the major differences between the current cost deployment methodology and the system proposed by Yamashina and Kubo and to fill the gaps that studies made by Silva et al. (2013), Chiarini and Vagnoni (2014), De Felice et al. (2013).

The study of the implementation process within this plant constitutes a starting point for our analyses. Moreover, it will allow carrying out more researches and making comparisons with other companies and productive sites. The case study methodology seems to be the most appropriate to the extent of our research because it allows a more in-depth analysis of the phenomenon also considering the studies from Gerring (2007, 2011) and from Simons (2009). Further, this interpretive case (Scapens, 1990; Ahrens and Dent, 1998; Lukka, 2007) sheds light on the mobilisation of a phenomenon within a national context.

3.2 Data collection and procedure

The case study was conducted over a period of nine months from June 2016 to February 2017. During this time, semi-structured interviews of an open-ended nature represented the main method of the research. At the same time the continuous collaboration with the plant controller made possible to carry over an in-depth analysis on the procedures and tools adopted by the method.

The interviews were not limited the controlling/finance department only, but also managers, directors and facilitators from maintenance, operations, supply chain and quality departments in order to acquire information to build a single-case study model as suggested by Yin (2003).

Main goals of the present case study are to understand how the cost deployment method is implemented and what the main results are over the period, assuming that differences from the model developed in the early 2000s may emerge.

Coherently with the aims of the research (Ferraris and Grieco, 2015), the single case study approach is here adopted to provide evidences of the main evolutions and differences between the previous theoretical framework rather than to provide a generalised conceptual framework.

Moreover, the study aims to formulate research questions by problematising some dominant assumptions in existing research (Davis, 1971). In particular, the main research questions are the following:

- *Research question 1*: how is a cost deployment actually implemented in a plant and what are the main differences compared to the theoretical framework set by Yamashina and Kubo (2002)?
- *Research question 2*: what are the main short-term results and the main key success factors?

This approach would support a more reflective-scholarly attitude (Abbott, 2004) and consider a different epistemological approach.

In this case, the epistemological approach is that of induction because it finally helps reach a verdict and elaborate a theory that derives from a number of testable consequences that have been verified.

4 Findings

The WCM programme should be able to lead a manufacturing organisation to an optimum level of quality and efficiency resulting in no wastes, no quality defects, no breakdowns and no excess in stock.

The WCM strategy adopted by the company in which we conducted the case study relies on standardisation of processes and of the improvements progressively obtained to achieve these goals, maintain them through the time. The aim is to set the ideal operational conditions to achieve the 'zero' level (zero scraps, losses and quality defects).

The WCM strategy is divided into 20 pillars, ten defined as 'technical' and ten as 'managerial'. Technical pillars help the concrete development of WCM techniques while managerial pillars support the cultural change in the organisation.

Cost deployment is a key pillar in the WCM programme as it detects scientifically wastes and losses and it leads the choice of the improvement projects within the organisation. The method we observed presents many similarities with the framework originally set by Yamashina and Kubo (2002), and some new peculiar features.

First of all, the implementation of cost deployment methodology is held through a seven-step approach: each step involves analyses that are progressively more complex and detailed. Usually, the results of the analyses undertaken in each step feed a matrix which represents the output of a part of the implementation process. This approach is consistent and similar to the one proposed by Yamashina and Kubo. Silva et al. (2013) noted similarities as well.

The first step requires the identification of the WCM perimeter, namely, the transformation cost. Transformation cost is the cost associated with actions that create/add value along the manufacturing and logistic cycles. Each activity which involves the transforms raw material and contributes to the finished product uses resources that are part of the WCM perimeter of cost. The transformation cost is determined starting from the profit and loss statement and includes: direct labour costs; indirect labour costs; overheads; scrap costs. On the other hand, the transformation cost does not include the cost of raw materials, since the WCM pillars have no tool to undertake improvement actions related to purchase activities, nor selling, general and administrative (SG&A) expenses for the same reason.

The first step is usually carried out by the controlling department since finance has a deeper knowledge of the cost structure of the plant. After the analysis, around 25% of total costs were identified as part of the WCM perimeter (or transformation cost).

After the detection of the transformation cost and the definition of the WCM perimeter the following steps aim to define which part of it represents wastes and losses.

Starting from step 2, the controller and other pillar leaders and operations managers (for example the focused Improvement leader) carried out an in-depth analysis over the manufacturing and logistic processes to track wastes and losses.

More specifically, step 2 required the study of the occurrence of losses inside the various departments of the plant and on the assembly line as well as a first assessment of the impact that losses have on the production process.

The cost deployment tool for this step is the ‘A-matrix’ which is made by the list of losses types on the Y-axis and by the various production stages on the X-axis.

The A-matrix represents the first output of loss analyses and it is usually prepared in two versions:

1 the quantitative ‘A-matrix’, which identifies the frequency of the losses along the productive process

2 the qualitative ‘A-matrix’ quality, which provides a first assessment of the impact of every loss type inside the plant.

At the end of the second step, cost deployment was able to set a ‘map’ of the losses inside the plant with reference to their frequency and their (negative) impact.

The third step requires further analyses about the causal relationships between causal and resultant losses inside the plant and the development of the ‘B-matrix’. The B-matrix constitutes a crucial tool for the cost deployment methodology, as it allows to fully understand the impact that a causal loss has over the production process. By causal loss indeed we mean a loss that results into further losses when it occurs.

Losses are then translated into costs in step 4 thanks to the so-called ‘C-matrix’. This tool is prepared starting from the list of causal and resultant losses gathered in previous steps which is then enriched with more detailed information about the area of the plant where they occurred, the line and even the machine associated. The C-matrix allows performing several analyses about the losses, included the so-called ‘stratification’: the database of the C-matrix makes possible establishing the losses that have a high impact on a certain area/line/machine of the plant. Therefore, it is possible as well to establish which are the most critical areas of the plant that generate losses, which are the underperforming machines and the causes of those losses. The C-matrix represents a first important tool to set priorities of intervention.

Step 5 adopts the D-matrix to individuate which are the most convenient losses to attack. Starting from the previous analyses the D-matrix lists the losses (costs) on the

Y-axis while on the X-axis are placed the WCM tools that can be adopted to reduce them and the KPIs that would benefit from their reduction. D-matrix relies upon an impact-cost-easiness (ICE) analysis to set priorities of intervention. The ICE analysis evaluates the economic impact of a loss reduction (saving), the investment needed to set up an improvement project and its feasibility.

By doing so, D-matrix gives the opportunity to establish an economically sound priority of intervention. Based on the D-matrix the other technical pillars can undertake their improvement projects, usually defined as ‘quick/standard/advanced Kaizen’ with reference to their complexity, people involved and expected savings.

Once projects are identified and approved by the plant controller they are undertaken and entered into the E-matrix which is the output of step 6. The plant controller and other WCM facilitators decided to develop a tracking system to monitor constantly the improvement projects implemented: in particular they decided to adopt a common document defined ‘project card’ including information about the controlled KPIs, the project leader, the team involved and the type of losses attacked.

These revealed useful tools to fill in the E-matrix with the expected cost savings coming from each project. Thanks to all of the analyses carried out, the plant controller can prepare also the last two matrices for the last step which aims to develop an improvement forecast and a budget for the coming years.

More in detail the F-matrix gathers all the savings coming from the improvement projects certified by the plant controller periodically, while the G-matrix constitutes the budget for the coming year. Steps 6 and 7 are new peculiar features compared to the model firstly introduced by Yamashina and Kubo.

It is important to underline that the cost deployment process does not stop with this last step, but it is rather an on-going process aiming to improve the knowledge about wastes and losses in the plant and aiming to track cost saving correctly. We also noticed that many matrices are updated on a monthly or weekly basis.

It is therefore, very important to implement an effective and reliable data collection mechanism that can guarantee almost real-time data: this can be achieved only with a full and coordinated cooperation with all the other pillars and departments.

Indeed, most of the times the data used by the finance department is prepared by operations or maintenance managers and these play a crucial role providing an appropriate explanation for the results.

5 Critical comments and discussion

The implementation of the cost deployment in the plant is aligned to the framework suggested by the literature and adopted all the typical tools of the methodology providing qualitative and quantitative analyses.

Nonetheless, the model suggested by Yamashina has evolved being formalised in seven steps as also underlined by Silva et al. (2013) and gained new peculiar tools as findings show: more specifically, cost deployment developed proper tools to track wastes and losses effectively and to build forecasts and budgets based on the expected cost saving coming from planned improvement projects. In this sense, the methodology can become a valid support to prepare plans thanks to the G-matrix.

In addition, the specific plant developed specific tools such as the project card that allow following up projects in a more effective way.

Customisation and introduction of new tools in the methodology stands in line with the findings of Carmignani (2017).

Moreover, not only cost deployment allows to achieve cost benefits as suggested by several authors (De Felice et al. 2013; De Felice and Petrillo 2015), but it can also make all operators more aware of the impact they have on the productive process as it translates physical measures into monetary terms. Among the most important key success factors we include, therefore, the involvement of the organisation – in this sense our case study supports findings by Cipriani et al. (2014) – and the cooperation among all of its departments. Expertise and know-how coming from different backgrounds are in fact vital to go across all of the detailed analyses required by the methodology.

The methodology can now rely on data that ICT systems collect inside the plant in real-time: the possibility to have a rich and complete database allows cost deployment to make accurate analyses and to correct wrong manufacturing practices.

This supports the importance of new ICT systems even in lean strategies as suggested by Gunasekaran et al. (2018) and Kumar and Vaishya (2018).

Table 1 below summarises the results of our case study.

Table 1 Summary of results

Original theoretical framework	*Results and new tools of cost deployment*
'Step-up' approach and matrices (A to E matrix). Scientific identification of wastes and losses that are translated into cost to take decision based on an economically sound logic.	Seven step approach. Practitioners enriched the methodology with new matrices (F and G) and tools (e.g., project cards) to forecast cost saving and control the improvement projects cyclically.
Yamashina and Kubo (2002) and Silva et al. (2013)	Continuous monitoring of the wastes and losses in the plant
	New tools to track improvement projects more effectively (e.g., project cards)
	Deeper understanding of the cost structure thanks to extensive data collection allowed by ERPs and data analytics
Short-term outcomes	Identification of the WCM perimeter (25% of total manufacturing costs)
Yamashina and Kubo (2002)	
Silva et al. (2013)	
De Felice et al. (2013)	
De Felice and Petrillo (2015)	
	Losses erosion up to 7% of WCM perimeter
Key success factors	Involvement of the organisation
Chiarini and Vagnoni (2014)	Accurate data collection
Cipriani et al. (2014)	Accurate financial analyses
Gunasekaran et al. (2018)	ICT technologies
Kumar and Vaishya (2018)	

6 Conclusions

The research analyses in depth the cost deployment implementation process and provides evidence that it can be a useful methodology to track and eliminate losses in a manufacturing plant. Findings suggest that:

- cost deployment has gained many tools to predict savings and it is evolving from the initial model proposed
- cost deployment has almost immediately been effective to give cost reductions to the organisation.

The findings of this paper can be useful both for managers and entrepreneurs willing to improve performances in their plants. Top level management of manufacturing firms should be aware of these results when deciding which strategy would be more effective to enhance quality and efficiency in their organisations.

This paper has interesting implications for academics too: they could investigate other manufacturing plants in order to confirm or discuss our findings. Differences could emerge in cost deployment methodology observing different organisations. For example, comparisons could be made with techniques adopted by SMEs rather than MNEs.

Further case studies should be carried out to support findings of this research. Indeed, a major limitation to our work is that we were only able to analyse a single plant. Similar findings from different organisations would strengthen our conclusion that the methodology has evolved giving more tools to enable the management to predict savings.

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