

Lean manufacturing: Costing the value stream

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1. Introduction

Global competition has prompted many companies to adopt new manufacturing approaches such as lean manufacturing in order to be more competitive (Shah and Ward, 2003).

The term “lean manufacturing”, (Womack *et al.*, 1990), refers to the generalization of the Toyota Production system (TPS), also called Just-in-Time (JIT). One feature of such system is the reduction of costs through elimination of waste (Sugimori *et al.*, 1977). Waste or *muda* (in Japanese) is anything that does not add value to a product. Elimination of *muda* is done by means of continuous improvement activities (Fullerton and Mcwatters, 2001).

While traditional production systems rely on inventories to absorb problems in processes, lean manufacturing considers both inventories and overproduction two main types of waste and therefore pieces are produced only when they are necessary.

Lean manufacturing places emphasis on the flow of materials from when a product begins to be manufactured until it is completed (McNair *et al.*, 1989). According to Womack and Jones (1996), a lean company has to view their processes as value streams and make products flow down the value stream and continuously improve the system. In order to monitor flow and spot ways to remove waste, lean companies use value stream maps (Rother and Shook, 1998). This tool that show the flow of materials and information through all manufacturing operations and it give information on cycle time, downtime, inventories, and so on.

Interestingly enough, many firms find that their accounting and measuring methods clash with their lean manufacturing initiatives (Ahlstrom and Karlsson, 1996; Womack and Jones, 1996), but there is no real agreement as to how accounting practices should be adapted (Ward *et al.*, 2003).

Despite its practical relevance, the issue of the lack of adaptation of costing systems to lean manufacturing is still unresolved (Hansen and Mouritsen, 2007) and it has been scarcely discussed in the academic literature.

Some alternative costing techniques have been developed and are now included in the term “lean accounting”. One of these techniques, termed Value Stream Costing (VSC), has been implemented in several companies but the only paper on VSC published in a leading academic journal deals with a comparison between traditional accounting, Activity-Based Costing (ABC) and VSC using a computer simulation (Li *et al.*, 2012).

In this paper, we address the following issues:

- Why do traditional costing methods cause problems to lean companies? What sort of problems? Do companies that apply lean principles and practices need a new approach to cost management?
- What kind of management accounting system would be right for lean companies? (Womack and Jones, 1996). Is VSC a valid method?

A complete review of the literature has been made to analyse whether companies that implement lean manufacturing need a new approach to cost management. The main idea was to pinpoint the problems that stem from using traditional absorption costing systems and ABC system and also to discover why lean manufacturing is different from other approaches. The relevant literature on management accounting and lean manufacturing has been reviewed to find the independent aspects of the issue under research and then order them into a conceptual framework.

Next, we want to determine whether VSC supports the development of lean manufacturing. Different positivist, interpretative and critical approaches to management accounting can be found in literature (Ahrens and Chapman, 2007). For each one of them, qualitative and quantitative methods may differ in many ways, but neither of them is right or wrong, although one or the other may be more appropriate depending on the aim and circumstances of the research work (Hancock and Algozzine, 2011). The qualitative approach may be useful when little is known about an issue. Since VSC is a very recent technique, there are few articles on VSC and they do not describe in detail the application of VSC. We have chosen to test how VSC could be applied to a previous literature example of a lean manufacturing system. Case based papers that address the emergence of accounting practices in companies are common in previous research literature.

The aims of this experimental case study (Scapens, 1990) are to explore the technical factors that both allow and prevent the application of VSC, to identify its benefits and its drawbacks and to evaluate whether VSC reflects the operational improvements made on the process and thus it supports lean manufacturing. No organizational aspects are considered.

This research is intended to serve as a basis for further research on VSC. The external validity and generalization of results in case-based research is problematic because it is difficult to make the results applicable to all companies. Nevertheless, the elements of accounting (labour, overhead, raw materials, etc.) in our example are common to all companies and only the quantity of shared tasks between value streams depends on the organization of each company.

Since lean manufacturing places emphasis on operational measures, this paper also tests the integration of value stream mapping (VSM) with VSC in order to measure both operational and financial improvements. Previous attempts to integrate VSM with other forms of costing have been done by Sobczyk and Koch (2008) and Abuthakeer *et al.* (2010).

2. The limitations of traditional costing systems

Traditionally, companies have used cost accounting as a means to control manufacturing performance: Deviations between actual costs and standard costs show how well each cost centre is doing. To determine the cost of a product, besides direct materials and direct labour, indirect manufacturing costs (overhead) are allocated to the product. Overhead allocation rates are usually based on volume-related cost drivers such as labour.

Equation 1 shows how absorption costing methods compute the unit cost C of each product i in period t , where j are different materials and parts and k are different cost centres or departments.

$$C_{i,t} = \frac{\sum_j \text{Material cost}_{j,i,t} + \text{Direct labour cost}_{i,t} + \sum_k \text{Overhead allocated}_{k,i,t}}{\text{Equivalent units of production}_{i,t}} \quad (1)$$

When there is a beginning inventory of raw materials and of work in process (WIP) at different levels of completion, either the weighted average or the first-in, first-out methods of costing must be used to compute both the cost of materials (Equation 2) used in the process and the equivalent number of units of production (Equation 3).

$$\text{Cost of materials}_{j,i,t} = \text{Purchases}_{j,i,t} - (\text{Inventory}_{j,i,t+1} - \text{Inventory}_{j,i,t}) \quad (2)$$

$$\text{Equivalent units}_{i,t} = \text{Units completed}_{i,t} + (\text{WIP}_{i,t+1} - \text{WIP}_{i,t}) \quad (3)$$

Equations 4 and 5 show how overhead in cost centre k is allocated to product i . We accumulate all indirect costs (sometimes budgeted costs replace actual costs because they are not available) and we divide them by the desired surrogate of production activity (direct labour hours, production volume...) to get an overhead rate. Then, overhead is allocated to product i according to the amount of the cost driver consumed by the product.

$$\text{Overhead rate}_{k,t} = \frac{[\text{Employee cost} + \text{depreciation} + \text{tooling} + \text{utilities} + \dots]_{k,t}}{\text{Budgeted activity units}} \quad (4)$$

$$\text{Overhead allocated}_{k,i,t} = \text{Overhead rate}_{k,t} \cdot \text{Allocation basis}_{i,t} \quad (5)$$

By the 1980s, in many companies product lines had proliferated and the significance of direct labour, formerly the highest conversion cost, had diminished, while overhead costs had dramatically increased. Some companies started claiming that their costing systems yielded distorted costs. Since then, there has been a lot of research on the problems associated with using absorption costing systems for cost management (Lockamy, 2003).

Johnson and Kaplan (1987) describe how original management accounting was replaced by costing procedures developed in order to value inventories for financial reports. They contend that reports are outdated and too aggregated for process control because the purpose of cost accounting is neither product costing nor process control. Consequently, cost accounting emphasizes financial management, not operating management.

Cooper and Kaplan (1988) conclude that costing methods originally created for plants that make large runs of a single product are not acceptable for plants that manufacture families of different products. Miller and Vollmann (1985) point out that traditional cost systems hide the causes of overhead and that the primary cost drivers for overhead are transactions, not volume of production, so support costs should not be allocated to products by volume-related drivers. Since those support costs are increasingly important, incorrect allocations lead to big errors (for example, high-volume products seem to cost more than customized products).

Furthermore, the key yardsticks for operations management in a traditional costing system are labour efficiency and machine utilization (Lockamy, 2003), which lead to keeping operators and machines busy (Plenert, 1999), producing large batches and accumulating inventory, which are the antithesis of lean manufacturing.

3. The rise (and fall) of Activity-Based Costing

The 1980s saw the rise of ABC. In order to fix the shortcomings of traditional cost accounting, a new approach was presented (Chen, 1996). Since departments are too large for traceability and tasks would be too detailed and numerous, ABC considers intermediate cost pools termed “activities”. ABC assigns resources to activities and then activities to products according to actual consumption by each.

Equation 6 shows how ABC computes the unit cost C of each product i in period t , where j are different materials and k different manufacturing and non-manufacturing activities related to product i .

$$C_{i,t} = \sum_j \text{Material cost}_{j,i,t} + \sum_k \frac{[\text{Labour+all other costs considered}]_{k,t}}{\text{Total amount of driver}_k} \cdot \text{amount of driver consumed}_{k,i,t} \quad (6)$$

ABC provides more accurate product costs than traditional costing methods, but many companies do not use ABC in their external reports because on such reports, individual product costs are not disclosed. Besides, ABC does not conform to generally accepted accounting principles (GAAP) because product costs exclude some manufacturing costs and include some non-manufacturing costs.

Since ABC reveals the links between activities and the necessary resources, it can give managers a picture of how products, brands, customers or regions consume resources. And because ABC allows the elimination of non-value added activities in processes, some authors consider that ABC supports the principles of JIT (Cooper, 1996). For example, Beheshti (2004) suggests that activity-based cost management can help in continuous improvements on the value chain. Ward *et al.* (2003) show that even though the ABC system may not be exactly the right one for a lean environment, the logic of ABC can be applied.

On the other hand, other authors consider ABC a source of wasteful activities (Plenert, 1999). Womack and Jones (1996) point out that ABC is not necessarily compatible with lean manufacturing, since it can encourage manufacturing in large batches because ABC is merely another method for allocating overhead.

ABC has also been criticised for being subjective because part of the information it requires is estimated by employees (namely, the percentage of time devoted to each activity). In a continuous improvement environment, such process to keep the system updated would be neverending.

ABC has not been implemented by many companies (Moisello, 2012) and some adopters have finally abandoned it. One cause is the amount of resources (people, time and money) it requires (Huntzinger, 2007).

4. Cost management for lean manufacturing

According to Cooper (1995), competition between lean companies is different to competition between mass producers. They compete on a strategy based on developing low-cost high-quality products demanded by customers. Nonetheless, Ohno, the father of the Toyota Production system, stated that accountants had to be banished from the plant to make lean manufacturing succeed (Sillince and Sykes, 1995).

Lean manufacturing is different from traditional manufacturing due to several reasons (Foster and Horngren, 1987; Swenson and Cassidy, 1993; DeFilippo, 1996):

- In lean manufacturing inventories are low. Inventories are considered *muda* because they conceal management problems. Traditional accounting would consider a reduction as a loss (Plenert, 1999).
- Direct labour is low and overhead becomes very important. The issue is to control it (Holzer and Norreklit, 1991) not to allocate it.
- Purchases are adjusted to consumption and manufacturing is adjusted to demand.
- Functional areas are replaced by manufacturing cells. The costing system has to track costs at the cell level. If a machine is replaced by a slower one, cost accounting would record an increase in cost per piece and vice versa, but if this machine is not the constraint (slowest) of the value stream, there is no real effect on expenses.
- One-piece flow replaces batches. Flow and response to the customer are more important than machine utilization. New performance criteria are necessary.
- Cross trained workers and teams are common (Plenert, 1999). Reports on the performance of single employees or departments are not needed.
- Since lean manufacturing relies on worker involvement, information has to be understood by all employees.
- Costs of activities that do not add value (including accounting) have to be controlled.

The previous list outlines the elements that lean accounting has to bear in mind.

Besides the pitfalls of cost accounting, we glimpse another key element. Failure rates for lean programs are high. One of the causes is that managers consider lean manufacturing an isolated set of manufacturing practices or a short-term cost reduction program and not a company-wide strategy that requires a change in mentality (Fiume, 2007). Managers keep using traditional performance indicators. They look at financial information and expect that improvements on the shop floor will immediately impact net profit. And that is not necessarily the case (Fullerton *et al.*, 2003). The elimination of non-value-added operations may lead to a reduction in lead time and an increase in capacity. If a worker is moved to a different line, no savings exist. However, the increase in flexibility becomes a source of future profits. Seen as a business strategy, lean manufacturing requires a complete change both in thinking and also in physical operations. Lean thinking affects all departments, including accounting. Thus, the accounting people must simplify their own processes and change their minds. Lean thinking considers that everything is oriented towards on-going improvement; therefore the emphasis of accounting must be on improvement, not on compliance with standards. Lean manufacturing is an operationally driven culture, focused on continuous improvement and standards –no matter how reliable they may be- are not useful because they should be constantly updated. Lean manufacturing considers that the target is not to allocate costs but to reduce them, and, to reduce costs, it is necessary to change physical aspects of the manufacturing process, and not just better cost information. As a result, lean companies need other financial and operational metrics to support operations.

5. Value Stream Costing

While batch-and-queue manufacturing plants have confusing mixed flows of products (and that makes difficult gathering cost data), in lean manufacturing, products with similar flows are grouped together in the same value stream via flexible manufacturing cells, like mini-plants within the factory. These changes eliminate the complexity of flows and reduce the need for information (Huntzinger, 2007) because all activities take place within the cells and it is possible to “see” if everything is under control.

Rather than categorizing costs by departments (as full costing does), Womack and Jones (1996) propose an organization by value stream (everything done in order to create value for the customers, associated with a product or product line). While the idea of functional departments is related to the concept of job shop, the idea of value stream is related to the concept of flow shop (cellular or line layouts that process a product or family of products).

Baggaley and Maskell (2003) developed a cost management model based on value streams called Value Stream Costing (VSC) that can only be implemented after a company has achieved the maturity stage of lean manufacturing:

- Value streams have been organized.
- Reporting needs to be by value stream and not by departments.
- People in the company must be assigned to value streams with no overlap.
- Few (or no) shared services departments.
- JIT purchases and JIT manufacturing.
- Production processes under control. Great control over the rate of output. Low variability.

- “Out-of-control” situations and exceptions like scrap or rework thoroughly tracked.
- Low lead times.
- Inventory relatively low and stable.

Under the above conditions, VSC attempts to focus a company’s attention on the resources that are being used throughout a complete value stream rather than on individual products.

The cost associated to a value stream k (Equation 7) in a period t (week, fortnight or month) includes all the costs of the activities in the value stream (purchasing, manufacturing, quality assurance, engineering, design, maintenance, accounting, shipping, customer service...), with no distinction between direct costs and indirect costs.

Material costs are calculated from how much material has been purchased for the value stream over the period. For this approach to be valid, there needs to be low raw materials and work-in-process inventories, which must be under good control. If inventories are low, then the materials will be used quickly and will accurately reflect the material cost of the product manufactured during that time. The costs of consumables, supplies, and other day-to-day expenses are similarly assigned to the value stream.

All labour costs are included (Maskell and Baggaley, 2003). Value streams cut across functional departments. Ideally, each resource is assigned to a single value stream, rather than being split among several. Otherwise, allocation (A_{kt}) will be necessary (Ward *et al.*, 2003). The space occupied by the value chain is allocated to the value stream to encourage value stream team members to reduce the amount of space.

$$\text{Cost of a value stream}_{k,t} = \left[\begin{array}{l} \text{Materials} \\ + \text{Outside processing} \\ + \text{Depreciation, supplies} \end{array} \quad \begin{array}{l} \text{Labour and supervision} \\ + \text{Engineering + procurement} \\ + \text{Utilities + facility costs} \end{array} \right]_{k,t} + \left[\text{Shared resources} \right]_t \cdot A_{k,t} \quad (7)$$

Costs outside the value stream are excluded from value stream costing. Corporate overhead costs are accounted for but shown below the line on internal value stream reports because employees working in the value stream cannot control them. Costs are collected for the total value stream and are summarized over the selected period.

Maskell and Baggaley (2006) point out that the full cost of specific products need not be known. They contend that all sales, unless a product is being sold at a price below its direct material costs, contribute to the profitability of the company and that decisions on a product are taken according to criteria related to the value chain as a whole.

If individual product cost are needed, total value stream expenses other than direct materials (total conversion costs) are divided by the number of units (of all kinds) (Equation 8). If products are very different, some features and characteristics of the product (Maskell and Baggaley, 2003) or the flow speed of a product (Buzby *et al.*, 2002) can become cost drivers.

$$\text{Average unit cost}_{i,k,t} = \frac{\text{Direct Material}_{i,k,t}}{\sum_j \text{Units produced}_{j,k,t}} + \frac{[\text{Other value stream costs}]_{k,t}}{\sum_j \text{Units produced}_{j,k,t}} \quad (8)$$

VSC considers all conversion costs as fixed and it considers material cost as the only cost relevant in decision making. In practice, some aspects may be fixed while other elements are variable. Costs are generally fixed in the very short term and variable in the long term so classifying a cost as either fixed or variable depends on the time frame considered.

6. Applying Value Stream Costing to an assembly process

In this section, we apply Value Stream Costing to an assembly process described by Cuatrecasas (2003). The process is devoted to the assembly of point-of-sales (POS) terminals (electronic cash registers). In the past, the plant had a process-oriented layout where products moved on a batch-and-queue basis, and the plant adopted the principles of lean manufacturing in order to raise production from 19 to 70 units per day.

6.1. Organisation of manufacturing operations at the outset

Figure 1 shows a line layout with 8 workstations after implementing lean manufacturing. Manufacturing batch size is 35 units (adjusted to demand). All product operations are shown in Figure 2 and in Table I. Table I shows the distribution of tasks among workstations. The plant manufactures two models of POS terminals. Time figures correspond to the most complex model. Transports between operations are included but some of them are not necessary because of the layout.

FIGURE 1

FIGURE 2

TABLE I

Following Rother and Shook (1998), in Figure 3, we use value stream mapping (VSM), a fundamental tool of lean manufacturing, to represent the process and the flow of materials. The map shows the same data that Table 1 and detailed information about each step of the process. VSM helps isolate the value stream that will be used in VSC.

FIGURE 3

With a cycle time (C_i) of 857 seconds (the longest operation), daily capacity is 33 POS terminals in an eight-hour shift (Equation 9). In a month (25 days or 200 working hours), the value stream produces 825 units.

$$\text{Daily capacity} = \frac{\text{Effective daily work time}}{C_i} \quad (9)$$

Since times per each operation are given in Table I and in Figure 3 (VSM), it is possible to compute (Table II) how much of the value stream's resources are used productively (Equation 10), how much time is devoted to non-value added activities (Equation 11), and how much available capacity is within the value stream (Equation 12). Non-productive time also includes waiting between cycles (Equation 13). In these equations, j represents workstations, while i , k and z are operations.

TABLE II

$$\text{Productive time}_j = \sum_i \text{Capacity} \cdot \text{Value added task time}_{i,j} \quad (10)$$

$$\text{Non - Productive time}_j = \sum_k \text{Capacity} \cdot \text{Non - Value added task time}_{k,j} + \text{Wait time}_j \quad (11)$$

$$\text{Idle time}_j = \text{Working time} - (\text{productive time}_j + \text{non - Productive time}_j) \quad (12)$$

$$\text{Wait time}_j = \text{Capacity} \cdot (\text{Process cycle time} - \sum_z \text{task time}_{z,j}) \quad (13)$$

VSC uses the information from the VSM to calculate the cost of the whole value stream (Table III). The average cost of the value stream per POS terminal is 58.68 €

TABLE III

In order to calculate the cost of the value stream, we have considered the costs of materials, labour costs and machine depreciation as well as other costs such as soft tooling and consumables which are directly related to the productive tasks at each workstation, in one month. Unlike full absorption costing, other departments (shared among several value streams) have not been considered in order to avoid allocations.

Material costs (for each step i) are calculated according to equation 14 (*Production* is 825 units). The amounts of raw materials and parts in each step of the process (Unit material cost) have been previously estimated (0, 2, 4 or 5.5 Euros per unit). In a lean enterprise, with a JIT procurement system, material cost would equal the purchases in period t .

$$\text{Material cost}_t = \sum_i \text{Unit material cost}_i \cdot \text{Production}_{i,t} \approx \text{Purchases}_t \quad (14)$$

Labour costs are computed according to equation 15. The monthly cost of each employee j is 2,000 Euros. In a lean company, labour costs would be taken from the payroll. In the example, *Working time* is one month.

$$\text{Labour costs}_t = \sum_j \text{Monthly salary}_j \cdot \text{Working time}_{j,t} \approx \text{Payroll}_t \quad (15)$$

In a similar way, machine depreciation in period t is computed according to equation 16. The monthly cost of each machine k is 2,000 Euros. In the example, $Time$ is one month.

$$Depreciation_t = \sum_k Monthly\ depreciation_k \cdot Time_{k,t} \quad (16)$$

The costs of other resources associated with each step of the process are computed according to equation 17. The productive time for each workstation i is taken from Table II. Only productive time is considered. When a workstation is idle, auxiliary materials are not consumed. Unit costs are 0, 5 or 10 Euros per hour, depending on the workstation.

$$Other\ costs_t = \sum_i Unit\ cost_i \cdot Productive\ time_{i,t} \quad (17)$$

Next, several improvement activities will be undertaken on the shop floor in order to make the process more efficient. VSM and VSC will be used at each stage. We will study whether the operational improvements are mirrored in the costs.

6.2. Stage one

In order to improve flow, we focus on the bottleneck (the workstation that carries out tasks 38 to 40). Task 38 will now be done in a way that requires 720 seconds. Furthermore, as the four work posts in EM have longer processing times than the others, it seems necessary to implement a parallel assembly line with four more people. Next, the constraint workstation is the one carrying out operations 50 to 53. The improvement consists in making operations 50 and 51 in a single workstation (with a 390 s cycle) and making operations 52 and 53 in a different post (a 372 s cycle). Figure 4 describes the new plant layout after the aforementioned improvement actions.

FIGURE 4

Figure 5 shows the Value Stream Map of the new situation. For this arrangement, the bottleneck is the operation with a cycle time of 390 s. Using Equation 8, daily capacity is 73 units. Improvements are also reflected in flexibility (time reduction), labour efficiency and work-in-process reduction.

FIGURE 5

Labour costs have increased (Table IV) because of the new operators. The effect of allocating external costs on the basis of labour might be devastating. However, the cost of the value stream per POS terminal has fallen because of the higher efficiency.

TABLE IV

6.3. Stage two

The second stage of efficiency boosting is devoted to line balancing. It was observed that the time of the first post in the TM process (the constraint at stage one) could be

reduced to 375 seconds by performing two operations simultaneously. The CCM and PA posts were merged. In the first EM workstation, only one person is necessary. Figure 6 describes the layout at stage 2.

FIGURE 6

The value stream map of this stage is shown in Figure 7. Table V shows the capacity for each workstation. Due to a better balance, the output has increased with less resources and capacity usage has increased. Now the daily production is 76 units.

FIGURE 7

TABLE V

Operational improvements in labour efficiency, cycle time and lead time should be reflected in costs. Table VI shows the calculation of the cost of the value chain for a monthly production of 1,900 units. The cost of the value stream per unit drops again.

TABLE VI

Lean accounting uses a box score to monitor the performance of a value stream. It is divided into three sections: operational performance, capacity information, and financial performance. At each step of the improvement process, data are collected from the VSM, the VSC and the capacity analysis table. Table VII is a box score that allows comparing the key parameters after stage two, after stage one, after implementing one-piece flow and before lean manufacturing. It shows that the plant has improved both its operational and financial results

TABLE VII

Finally, in Table VIII, we calculate the cost of a product by using ABC techniques. First, activities are defined. Each task of the process is considered as an activity. A cost driver is chosen for each one. Since those activities are steps of an assembly process, the best cost drivers are man hour and machine hour. Next, the cost per unit of cost driver should be computed. Such costs include labour, depreciation, auxiliary materials and all the resources necessary to perform the activity. Therefore, a man hour may be 30 Euros per hour in one activity and just 20 Euros per hour in another activity. In our example, the quantities of man hours and machine hours consumed by each activity are taken from the value stream map in Figure 7. In real companies, they are usually estimated by employees and are not frequently updated (probably after stage two, the company would keep using the standard from Table I). There is a difference between the values yielded by VSC (41.20 €) and ABC (37.24 €). This is because VSC allocates all actual labour and depreciation costs to the products. In ABC, a fixed cost such as depreciation is allocated according to a standard consumption of resources (drivers). Then if machines are under-utilized, only a fraction of the plant depreciation is allocated to products. ABC does not take into account the operator wait time (due to a poor line balance).

TABLE VIII

7. Conclusions

The main aims of this paper are to highlight the causes why companies implementing lean manufacturing need alternative costing methods and to test Value Stream Costing as a valid possibility.

Traditional costing lost credibility in the 1980s. It had been created to support a certain manufacturing environment but such environment had changed with the years. Cost distortion in multiproduct/multiprocess companies is caused by the allocation of overhead to products on the basis of volume-related drivers such as labour. Besides, late and aggregate reports, intended for inventory valuation and for external reporting needs, do not help improve operations. Traditional performance indicators drive behaviours against lean principles such as overproduction. Some companies moved to ABC. If well executed, it assigns costs by identifying cause and effect relationships and identifies non-value added activities. It is very accurate, but it consumes a lot of resources and it may be subjective.

Nevertheless, the main problems are not the lack of reliability of costing systems. Not even that lean manufacturing considers data collection a wasteful task. On one hand, absorption costing systems drive non lean behaviour such as overproduction and on the other hand lean manufacturing should not be seen as a short term cost reduction technique but as a long run company strategy that needs changes in thinking and in physical operations. Lean companies focus on flow, elimination of waste and continuous improvement. They face a different type of competition and organize manufacturing in a different way. Companies that expect that their operational improvements will immediately yield net profits will be disappointed.

Lean companies do not need a more precise costing method. Lean is not a financial-oriented culture but an operations-focused culture and thus it is interested in simple measures that timely support on-going improvement. New methods to assess the financial impact of lean improvements are necessary. Since financial accounting and management accounting serve different purposes, it is not necessary to integrate them. Several tools may be used for inventory valuation and external reporting while others are used to support manufacturing.

This paper has described a new approach for lean companies: Value Stream Costing, which is validated with a case that serves to describe a practical application of the model.

We wanted to explore the technical factors that both allow and difficult the application of VSC. Manufacturing has to be organized in value streams, not in departments and lead time has to be short, because VSC is not as effective when resources are shared between value streams (because allocation is necessary).

We wanted to identify the benefits and drawbacks of VSC. The main benefits are i) that VSC simplifies the accounting process and it is really simple to compute, maintain and understand and ii) that it encourages continuous improvement since it reflects operational improvements. The main drawbacks are that it requires a completely lean company (organized around value streams) and that it only offers a rough estimation of the cost of the product. While avoiding allocations, VSC is less accurate than other

costing systems such as ABC. In practice, probably ABC is not frequently updated and therefore it yields wrong costs, while VSC is easily updated. Another drawback of VSC is that, a methodology treating all items as equal might work well for short-term performance measurement and short-term decisions, but not when considering the long term.

In our example we have seen how operational improvements in flow (capacity and lead time) go hand in hand with the cost of the value stream and the average cost per piece. As the system becomes more and more stable (less work-in-process, better balance, shorter lead times), the cost per part decreases. There is a positive correlation between lean practices and financial parameters.

We have seen how VSC integrates with other tools of lean manufacturing such as VSM. Both share one of the principles of lean manufacturing: flow. The VSC process begins with a value stream map which generates the necessary information (cycle time, production and lead time) that is the basis to compute some costs of the value stream and the average cost per piece.

8. References

Abuthakeer, S.S., Mohanram, P.V., and Kumar G.M. (2010), “Activity-based costing Value Stream Mapping”, *International journal of lean thinking*, Vol. 1 No. 2.

Ahlstrom, P. and Karlsson, C. (1996), “Change processes towards lean production: the role of the management accounting system”, *International journal of operations and productions management*, Vol. 16 No. 11, pp. 42-56.

Ahrens, T. and Chapman, C.S. (2007), Theorizing practice in management accounting research, in Chapman, C.S., Hopwood, A.G. and Shields, M.D. (Ed.), *Handbook of Management Accounting Research*, Vol. 1, Elsevier, Amsterdam , pp. 9-112.

Baggaley, B.L. and Maskell, B.L. (2003), “Value stream management for lean companies, Part I.” *Journal of cost management*, Vol. 17 No. 2, pp. 23-27.

Beheshti, H.M. (2004), “Gaining and sustaining competitive advantage with activity-based cost management system”, *Industrial management & data systems*, Vol. 104 No. 5/6, pp. 377-83.

Buzby, C.M., Gerstenfeld, A., Voss, L.E. and Zeng, A.Z. (2002), "Using lean principles to streamline the quotation process: a case study", *Industrial management & data systems*, Vol. 102 No. 9, pp. 513 – 520.

Chen, F.F. (1996), “Activity-based approach to justification of advanced factory management systems”, *Industrial management & data systems*, Vol. 96 No. 2, pp. 17 – 24.

Cooper, R. (1995), *When lean enterprises collide: competing through confrontation*, Harvard business school press, Boston, MA.

- Cooper, R. (1996), "Activity-based management and the lean enterprise", *Journal of cost management*, Vol. 9 No. 4, pp. 6–14.
- Cooper, R. and Kaplan, R.S. (1988), "How cost accounting distorts product costs", *Management accounting*, Vol. 69 No. 10, pp. 20-27.
- Cuatrecasas, Ll. (2003), *Gestión competitiva de stocks y procesos de producción* (in Spanish), Gestión 2000 Ediciones, Barcelona.
- DeFilippo, J. S. (1996), "Management accounting learns to adapt to Pratt & Whitney's manufacturing cells", *The learning organization*, Vol. 3 No. 2, pp. 4–10.
- Fiume, O. (2007), "Lean strategy and accounting: the roles of the CEO and CFO", in Stenzel, J. (Ed.), *Lean accounting: best practices for sustainable integration*, John Wiley & Sons, Inc. Hoboken (NJ), pp. 43-65.
- Foster, G. and Horngren C.T. (1987), "JIT: Cost accounting and cost management issues", *Management accounting*, Vol. 68 No. 12, pp. 19–25.
- Fullerton, R.R. and McWatters, C.S. (2001), "The production performance benefits from JIT implementation", *Journal of operations management*, Vol. 19 No. 1, pp. 81–96.
- Fullerton, R.R., McWatters, C.S. and Fawson, C. (2003), "An examination of the relations between JIT and financial performance", *Journal of operations management*, Vol. 21 No. 4, pp. 383 – 404.
- Hancock, D.R., Algozzine, B. (2011), *Doing case study research*, Teachers college press, New York.
- Hansen, A. and Mouritsen, J. (2007), "Management accounting and operations management: understanding the challenges from integrated manufacturing", in Christopher S., Chapman, C.S., Hopwood, A.G. and Shields, M.D. (Ed), *Handbook of management accounting research*, Elsevier Ltd. Oxford, pp. 729-752.
- Holzer, H.P. and Norreklit, H. (1991), "Some thoughts on cost accounting developments in the UK", *Management accounting research*, Vol. 2 No. June, pp. 3–13.
- Huntzinger, J.R. (2007), *Lean cost management: Accounting for lean by establishing flow*, J. Ross Publishin, Inc. Fort Lauderdale (FL).
- Johnson, H. and Kaplan, R.S. (1987), *Relevance lost: The Rise and Fall of Management Accounting*, Harvard business school press, Boston, MA.
- Li, X., Sawhney, R., Arendt, E.J. and Ramasamy, K. (2012), "A comparative analysis of management accounting systems' impact on lean implementation", *International journal of technology management*, Vol. 57 No. 1-3, pp. 33-48.

- Lockamy III, A. (2003), "A constraint-based framework for strategic cost management", *Industrial management & data systems*, Vol. 103 No. 8, pp. 591 – 599.
- Maskell, B.H. and Baggaley, B.L. (2003), *Practical Lean Accounting. A proven system for measuring and managing the lean enterprise*, Productivity press, New York, NY.
- Maskell, B. H. and Baggaley, B.L. (2006), "Lean accounting: What's it all about?", *Target magazine*, Vol. 22 No. 1, pp. 35-43.
- Moisello A.M. (2012), "ABC: Evolution, problems of implementation and organizational variables", *American Journal of Industrial and Business Management*, Vol. 2, pp. 55-63.
- McNair, C.J., Mosconi, W. and Norris, T. (1989), *Beyond the Bottom Line: Measuring World Class Performance*, McGraw Hill, Boston, MA.
- Miller, J. and Vollmann, T. (1985), "The hidden factory", *Harvard business review*, Vol. 63 No. 1, pp. 142-150.
- Plenert, G. (1999), "The new manufacturing-accounting interface", *Industrial management & data systems*, Vol. 99 No. 1, pp. 25 – 32.
- Rother, M. and Shook, J. (1998), *Learning to see: Value Stream mapping to create value and eliminate muda*, Lean enterprise institute, Cambridge, MA.
- Scapens, R.W. (1990), "Researching accounting management practice: the role of case study methods", *British accounting review*, Vol. 22, No. 3, pp. 259-281.
- Shah, R. and Ward, P.T. (2003), "Lean manufacturing context, practice bundles, and performance", *Journal of operations management*, Vol. 21 No. 2, pp. 129-149.
- Sillince, J.A.A. and Sykes, G.M.H. (1995), "The role of accountants in improving manufacturing technology", *Management accounting research*, Vol. 6 No. 2, pp. 103-124.
- Sobczyk, T. and Koch, T. (2008), "A Method for Measuring Operational and Financial Performance of a Production Value Stream", in Koch, T. (Ed), *IFIP International Federation for Information Processing, Volume 257 Lean Business Systems and Beyond*, Springer, Boston, pp. 151–163.
- Sugimori, Y., Kusunoki, K., Cho, F. and Uchikawa, S. (1977), "Toyota production system and Kanban system. Materialization of just-in-time and respect-for-human system", *International journal of production research*, Vol. 15 No. 6, pp. 553-564.
- Swenson, D.W. and Cassidy, J. (1993), "The effect of JIT on management accounting", *Cost management*, Vol. 7 No. 1, pp. 39-47.
- Ward, Y., Crute, V., Tomkins, C. and Graves, A. (2003), *Cost management and accounting methods to support lean aerospace enterprises*, University of Bath, Bath.

Available at: http://www.bath.ac.uk/management/aerospace/pdf/Lean_Measurement.pdf
(accessed 13 July 2012).

Womack, J. P. and Jones, D. T. (1996), *Lean Thinking: Banish Waste and Create Wealth in your Corporation*, Simon & Schuster, New York, NY.

Womack, J.P., Jones, D.T., and Roos, D. (1990), *The Machine That Changed the World : The Story of Lean Production*, Macmillan/Rawson Associates, New York, NY.