Production Cost Reduction through the use of Information Systems: The IMMO Model

Nelson Duarte, Carla Pereira

Abstract—Production cost is an issue that is present in daily management. This paper addresses the issue of production cost reduction focusing in inventory optimization and waste reduction. The final goal is to contribute for firm’s competitiveness. In order to fulfill our goal we propose a conceptual model (IT supported) based in the traditional supply chain in the wood industry. This model (IMMO Model) will be supported by an information system that will optimize inventories management, and will also address the cutting stock problem (CPS). This model emerges from a research project in the wood industry aiming to promote efficiency along the production process. The methodology adopted consisted of a previous field research (in loco analysis) to identify the wood industry inefficiencies at the production level. Then it was identified that the main problems arose at cutting activities and waste generation from those activities. The inefficiencies identified in the cutting processes leaded to the identification of other inefficiencies at the stocking level. Once identified the main problems we went through the state-of-art in order to identify the main issues and solution approaches. After that it was possible to create draw a supply chain diagram. Considering the state-of-art on the supply chain (in)efficiencies and crossing it with the knowledge on the IT we will suggest a new diagram representing the IMMO Model. Along with the model we will explain the expected improvements at the supply chain in the wood industry. Those improvements will be achieved mainly through the development of algorithms developed under the operational research science that will optimize stock management and cutting activities.

Keywords—Information Systems, Inventories, Optimization Models, Wood Industry.

I. INTRODUCTION

How do firms determine the ideal level of stocks? According to customers’ requirements? Quantity discounts? Storage capacity? How much does the inventory represent on firms cost structure? The inventory costs vary from firm to firm and according to the activity sector. Some businesses are inventory-intensive, whereas others, just require a few office supplies. Anyway, inventories are essential, both at upstream and downstream levels. “Typically, manufacturers located further back in the supply network incur an explosion of excess inventory and costs because they must carry additional safety stock to cope with added demand uncertainty, distortion, and lead time adjustments caused by the Bullwhip Effect” [1].

These effects along with operation costs (procurement, warehousing, non-fulfillment and information) represent a significant percentage of industry costs, leading to a more expensive final product, thus less competitive. This issue assumes a relevant role for decision making since in most industries, the prices are no longer defined by the function:

\[ \text{Price} = f(\text{Costs, Profit Margins}), \]

Market competition led to a new equation where the dependent variable is no longer price but cost:

\[ \text{Cost} = f(\text{Price, Profit Margins}). \]

This means that product costs (manufacturing and nonmanufacturing) are dependent on market prices (that tend to decrease due to competition) and profit margins (that are a key element for firm survival and success).

Manufacturing costs are classified into three types: (1) labor costs, (2) overhead costs, (3) material costs. The latter includes the inventory costs.

In order to become competitive, a firm must be able to reduce its production costs. Manufacturing costs assume an important role due to its weight on costs, and mainly due the necessity to control and reduce them. There are many ways to decrease production costs. In this paper we will focus in cost reduction, through process-performance, focusing in inventory and raw materials usage. By acting at the inventory level the results may present a wave effect through the production process. In brief this wave effect might be presented as lower quantity purchases, that leads to less capital requirements, less warehousing needs, and less overhead costs.

In several industries such as the wood industry, the raw material needs a cutting operation in order to obtain smaller items to fulfill the demand or production requirements. This procedure is referred in the literature as a Cutting Stock Problem (CPS) and it arises mainly, due to the losses (trim loss) that occur during this activity. The waste generated from those losses also represents a cost. In order to minimize the trim loss it is necessary to optimize the cutting plan (consists of a series of cutting patterns with an associated frequency -

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2 Supply chain phenomenon presented by [38]
how many objects have to be cut with each pattern). By doing it, the waste will be minimized and a more efficient consumption of raw materials will be achieved.

An efficient raw material usage will reduce the acquisition and warehousing costs. Moreover, a larger amount of raw materials leads to a more complex decision making process. The workers (labor costs) must decide about (1) the best input for each item to be produced, (2) how to incorporate it in the process, and (3) the best cutting plan. This workflow is a time consumer that might lead to higher lead-times. Furthermore, even with economies of experience the trim loss might be quite significant. Reducing stock quantities, a firm is also reducing the number of options to cut materials, and saving decision making time, saving like this some labor costs (time usage). Reducing the amount of raw materials and decision procedures consequently the firm will also reduce overheads.

“The stock size is optimal when the expected total costs of trim loss, warehousing, and non-fulfillment are minimum... A lower trim loss effect is also achieved if the stock is significantly less than the total order but in this case other costs such as the costs of non-fulfillment rise rapidly [2].

The main question is how to perform the necessary savings to increase competitiveness, along the supply chain, without incurring in non-fulfillment costs.

According to [3] supply chains generally have two generic functions from which process-performance advantages can be gained in this regard—the production planning (inventory) and controlling processes and the distribution/logistics processes. With this paper is intended to present a model supported by an information system (IS) to contribute for improvements in terms of inventory acquisition and cutting optimization.

This model will be designated as IMMO – Integrated Management Materials Optimization – and is based in the lean methodologies (strongly related to inventory (re)organization), in this particular case lean manufacturing. The lean strategy that supports our model is presented in Table 1.

<table>
<thead>
<tr>
<th>Objective</th>
<th>To maximize customer value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General strategy</td>
<td>Focus on cost reduction and incremental improvements for existing products. Focus on waste and non-value added activities elimination, along the supply chain</td>
</tr>
<tr>
<td>Value chain strategy</td>
<td>Optimization of the flow of products and services through entire value streams that flow horizontally across technologies, assets, and departments</td>
</tr>
<tr>
<td>Inventory Strategy</td>
<td>Generates high inventory turnover and minimizes inventory needs due to more efficient usage, and reduces wastes through the supply chain</td>
</tr>
<tr>
<td>Lead time focus</td>
<td>Shortens lead-time only so long as doing so does not increase delivery or inventory costs</td>
</tr>
<tr>
<td>Manufacturing focus</td>
<td>Maintains high average capacity utilization rate</td>
</tr>
<tr>
<td>Product design strategy</td>
<td>Reduces the cost of production. At the same time it allows a more efficient response to customers’ needs</td>
</tr>
</tbody>
</table>

Source: Adapted from [4]

Bearing in mind the lean strategy we intend with this paper to identify the main issues on production cost reduction focusing, as previously stated, in inventorying and raw materials usage. Since this model will be supported by an IS, we will also identify the role and importance of those systems in cost reduction. Based on the literature review we will suggest a model to optimize raw materials acquisition and consumption. In order to test the model, the wood industry was the chosen sector to focus during this project. The main objective is to increase competitiveness by decreasing production costs.

Having into consideration the Hardin’s Tragedy of the Commons [5] and the concept of Sustainable Development [6], [7], with this model it is expected to present benefits on efficient production both in the economic perspective through the waste and dead stock reduction. At the same time it is expected lower capital needs. At the environmental level the benefits will arise, mainly by the reduction consumption needs (forestry wood). Those benefits will be achieved by transferring some decisions from humans (labor cost) to an IS that enables the optimization of purchases and materials consumption/cutting. With this model we expect to present a solution that is interesting not only at the firm level but also for their stakeholders.

II. LITERATURE REVIEW

A. Inventory Cost Reduction Models

Nowadays, either a firm is offering distinctive products or the main goal is to present quality products at a competitive price. In order to achieve this goal, it is necessary to approach the production system bearing in mind that managers can act mainly at the cost level [2].

At the inventory level, that represents a significant percentage of production cost in industry, there are several types of costs, such as fixed or variable, direct or indirect, but most of them fit in the classical operational costs (procurement, warehousing, non-fulfillment and information).

Sarkar & Moon [8] presented a table comparing the contributions of different authors about inventory models. As identified by those authors, cost related variables in inventory models are:

- Order Quantity; [9]
- Distribution Free Approach; [10]
- Setup Cost Reduction; [11]
- Quality Improvement; [11]
- Fixed Backorder Cost; [12]
- Variable Reorder Point; [12]
- Variable Lead-time; [13]
- Variable Backorder Cost; [14]

In the same work [8] is presented a mathematical model that considers all the identified variables but fixed backorder costs. By considering all these variables they obtained the minimum cost at the optimal values of the decision variables.

Other studies such as [15]–[18] suggest models to minimize inventories at different stages, or to optimize the purchasing quantities [9], [19]. That means that there is not only an entrepreneurial, but also academicals concerns about...
production cost reduction. To reinforce it, there are several
studies focusing in inventory models.

Going a bit further, if the inventory assumes this
importance, it is also relevant to consider the activities that are
consuming raw materials, in particular when they need to be
processed before being incorporated in the production process.
These activities may cause waste, long lead-times, over
warehousing due to dead stock, or non-fulfillment costs. To
avoid excessive production costs it is necessary to get
information about all the activities, in order to take the best
decisions at each stage. These activities are presented in fig. 1.

Another important and also explored issue in the academic
world is the material waste, in particular those originated by
cutting problems (trim loss). In the literature, as it was already
mentioned, this issue is addressed as a Cutting Stock Problem
(CPS) [20], [21] and assumes two basic groups of data: the
information representing the stock of available objects (related
to inventory minimization) and the information about the
items that have to be obtained from the objects (CPS).

In SMEs in the wood industry, there is a lack of
technological equipment and most of decisions are taken by
human being (cutting activities, items to be incorporated,
purchasing quantities, among others). That might be
interesting when a firm is able to achieve economies of
experience, but on the other hand, the risk of taking a second
(or third) best decision may represent higher production costs.
Under certain conditions such as uncertainty the human
performance tends to be worst [22].

Considering the traditional supply chain, operational costs,
and CPS, the industrial supply chain (namely in the wood
industry) may be simplified into fig. 1.

In fig. 1 is presented the typical supply chain process, where
is possible to identify the emergence of dead stock, and waste.
As previously mentioned dead stock and waste originates
mainly from the non optimized cutting activities. These
elements along the supply chain are somehow contributing for
a higher cost in the final product (B2B or B2C). Moreover, the
waste created during the process might be normal or
abnormal, and the final product become more expensive
independently from the accounting methods used for those
records. Either spreading the waste costs over the final
products, or posting it as loss for abnormal spoilage, at the
end, firm’s total cost will increase. Dead stock will also
generate into waste or originate overhead costs for its
maintenance.

All the identified costs might be higher or lower according
to the decisions that are made along the supply chain. But
when the decision is dependent on the human being, the
results may not be the desired ones [23]. When it comes to
decide what to buy, what to incorporate in the process and
how to cut the materials in order the minimize the waste, each
individual as a different approach [22], [24].

Considering the CPS and the inventory minimization as
already suggested by [2] a lower trim loss effect might be
achieved by reducing the stock quantities. However this policy
increases lead times when it comes to choose the best items to
cut for one particular production order, and the risks of non-
fulfillment.

The problem of non-fulfillment costs could be minimized,
for instance by information sharing. “The retailer has an
incentive to voluntarily share the information with the make-
to-stock manufacturer if the magnitude of demand uncertainty
is intermediate. This stands in sharp contrast with the existing
studies, which show that the retailer never shares information
when the manufacturer is make-to-order... While sharing
information has a direct negative impact on the retailer—the
informational advantage disappears, it has a positive impact
by inducing the manufacturer to build up enough stock for the
high demand market” [25]. This solution in theory seems to be
a good solution, however it requires a fully commitment and
constant communication among the stakeholders along the
supply chain.

In summary, the models discussed in the literature are
important but most of them are focusing in specific variables,
or issues along the supply chain. By identifying the main
problems in the wood industry supply chain, gathering
available information on the models discussed in the literature,
and looking to the potential offered by the new technologies,
we will try to redesign the traditional supply chain model, by
using the information technologies.

B. Information Systems on Cost Reduction Models

“Despite the often cited essay in the Harvard Business
Review stating that IT doesn't matter (Carr, 2003),
information technology plays an important role in many
organizations. In our contemporary world, business
environments have become global and there is a major
challenge to deliver adequate computing services which meet
stringent performance goals and operate at low cost” [26].

Over de last years the role of IS has been important to help
with the “tremendous demand on companies to lower costs,
enlarge product assortment, improve product quality, and
provide reliable delivery dates through effective and efficient
coordination of production and distribution activities...

In the 90’s Enterprise Resource Planning (ERP) systems
have emerged as an enabling technology, which integrates
various functional (operations, marketing, finance)
information systems into a seamless suite of business

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Fig. 1. Traditional Supply Chain Model
applications across the company and thereby, allowed for streamlined processing of business data and cross-functional integration. Thus, ERP systems provide an enticing solution to managers who have struggles with incompatible information systems and inconsistent operations policies” [27].

“The decision to implement an ERP system in a SME usually has a profound impact on the organization and on all members of the supply chain. The ERP implementation should be planned very carefully. The needs and business processes of the SME must be clearly identified and each business process meticulously documented. There must be a clear and documented understanding of the impact of an ERP implementation on each business process and on the supply chain. Modern ERP software is flexible and customizable and encompasses some of the best practices in a given industry. However, the ERP implementation team must understand its organization or client’s business processes and create an implementation that is in harmony with the users. This is critical for SMEs, due to their particular characteristics” [28].

According to [4] a critical aspect of successfully managing the supply chain lies in measuring and monitoring information about its key operational and performance parameters. It is therefore important for a firm to adopt IS that are aligned to its supply chain. That is, adopt IS that facilitate the particular processes of its supply chain and provide information about parameters that assess specific goals of its particular supply chain strategy. For instance, if minimizing inventory or achieving leanness is a key objective of the supply chain, what kind of applications should be adopted to support leanness in the processes? Or, which applications are required for effectively addressing the information processing requirements emanating from the objective of inventory minimization?

In order to fulfill the above requirements, the model that we are proposing (IMMO), results from a research project that started by the identification of the wood industry needs in terms of cost production reduction. This analysis allowed to identify that most firms do not use technological support during the production process originating like that high trim losses. Normally, when it is necessary smaller items, the most frequent is to get a larger item and to cut it into the required sizes. This procedure originates dead stock when the smaller, and frequently, not used items are stocked. Typically these smaller items either are immediately treated as waste, or will be classified as waste after a stocking period.

In order to improve productivity and contribute to a cost reduction strategy, the research team decided to develop a model that will be the ground zero for an IS that will be firstly applied in the wood industry. This model will focus mainly in the cutting optimization and inventory minimization contributing like this for a lean strategy in this industry.

However, according to [29] the effects of R&D in manufacturing industries on stocks appear within 4 years. “Recent data shows a trend growth rate, measured as 5-year-moving average, of 3% annually. Simultaneously, the trend growth rate of labor productivity increased to about 4.5% annually compared to less than 3% in the eighties and the first half of the nineties. A similar development can be observed for total factor productivity. It is worth mentioning that this rebound in productivity growth is not limited to Germany or Europe. Similarly, maybe even more optimistic results are found for the US economy.” [29]. This time-lag on positive effects on productivity is also identified by [30] on what regards ERP’s implementation.

The identified time lag on positive effects from R&D in manufacturing may also be justified by the type of benefits that derive from the implementation of computerized solutions. The effects are not direct, thus not immediately identified on firm results. This type of innovation according to the Oslo manual [31] can be classified into technological and process innovation. The innovation incorporated in the process by the use of IS, or in particular Manufacturing Execution Systems (MES) can be classified in incremental innovation that involve a reformulation or an amendment to existing products. This type of innovation differs from radical one, where the changes lead to a new and completely different solution from the existing ones [32]. In general the results from radical innovation, even though with a higher financial requirement, present a faster effect on firm results.

On what regards other ERP benefits [33] highlighted five accounting benefits: IT accounting benefits, operational accounting benefits (time and cost), organizational accounting benefits, and managerial accounting benefits. Other authors [34] argue that the interface between management control and information technology is an under-developed research area with a knowledge gap concerning its implications for financial performance. However the same study suggest that manufacturing plants will reap the greatest financial performance benefits from management control investments, when combined with information technology integration.

Even with positive results, the implementation of these systems, must be planned very carefully as argued by [28]. It is necessary to integrate these solutions, in particular the IMMO solution with other systems such as Material Flow Cost Accounting (MFCA) [35], in order to use all the relevant information to support decision making. The main advantage that we expect from this model is the intelligent use of information, based on historical data, but developing also predicting data models that will allow smarter purchases, a more efficient inventory organization, and better performances on producing activities. All these expected benefits would generate into a production cost minimization, promoting like that firm competitiveness.

III. IMMO MODEL

A. The IMMO Model

As it was previously mentioned, the main goal is to present a supply chain model, supported by an IS, focusing in wood cutting optimization and inventory minimization. This model will contribute for the development of a lean strategy in the wood industry.

Applying the theoretical concepts presented in Table 1, we will start to present the model contribution for the development of a lean strategy (Table 2).
Table 2. Lean Strategy supported by the IMMO Model

<table>
<thead>
<tr>
<th>Objective</th>
<th>To maximize customer value reducing production cost → Lower prices, higher revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>General strategy</td>
<td>Decision making supported by an optimization algorithm; Cost reduction through inventory and cutting optimization; Purchases optimization, lower stock levels, efficient raw materials usage.</td>
</tr>
<tr>
<td>Value chain strategy</td>
<td>The algorithm analyzes the best solutions from inventory, and best cutting plans (better items to be used for each production order)</td>
</tr>
<tr>
<td>Inventory Strategy</td>
<td>The algorithm will identify the best items to be used according to the production order needs, and will also help during the procurement process</td>
</tr>
<tr>
<td>Lead time focus</td>
<td>By transferring some decisions from human to a technological solution, the information on the best cutting plans will be faster and will promote resources optimization</td>
</tr>
<tr>
<td>Manufacturing focus</td>
<td>Efficient raw material consumption at the stock level and during the process</td>
</tr>
<tr>
<td>Product design strategy</td>
<td>By promoting production cost reduction it may allow to provide a higher quality service according to customer’s expectations</td>
</tr>
</tbody>
</table>

In order to develop this model we will follow the traditional supply chain model (fig. 1) and to adapt it to the use of an IS as presented in fig. 2.

![Fig. 2. Supply Chain (IMMO Model)](image)

The IMMO Model intends to present a solution that has the flexibility to be connected to any Enterprise Information System, in order to optimize the quantity stocks and minimize the waste generated by the cutting activities in the wood industry [4]. By achieving these two objectives, a third one is achieved: the warehousing minimization. Consequently, it is expected a production cost reduction.

By getting all the information in an IS, another advantage is the chance to extract interesting information for the accounting system, in particular to management accounting, that is a powerful tool for decision making. Real time information about inventory, production and costs helps the managers’ in their decision process. The accumulation of historical data about the characteristics of the purchased items, the output requirements, the cutting activities, and above all the integration into optimization models of these data will also allow to identify future production patterns and to suggest purchasing and stocking strategies for an efficient inventory management.

B. The Model Step-by-Step

Considering the model presented in fig. 2 we will now discuss the advantages of this solution. From fig. 1 to fig. 2 it was replaced the information gathering by the IMMO Solution. This means that instead of dispersed information that is normally gathered when it is necessary to make a decision, all the production process information will be collected by this solution [28], [29]. This data collection might be done automatically or manually depending on the firm’s computerization level. By gathering all the information in an IS, the output (information) will take into consideration all this data, combining backward and forward information, requirements and restrictions. These outputs will be based in optimization models from operational research in order to help on the decision making process. Once we will get optimal, or near optimal decisions from an IS the human factor on decision making will be less relevant along the supply chain [23]–[25] as it is represented in fig. 2 with the dash symbol (-).

The reduction on human decision-making does not mean that the human factor is completely excluded from the process, since they must approve the computer-generated solutions. However, computer information processing capacity is able to consider higher volume of data, is faster, and will continuously be looking for an optimal solution. In fact, this solution is close to a Manufacturing Execution System [36] but minimizing the gap between the system and the practices that are done in firms, improving, however, those practices to promote productivity.

The optimal solution will consider at first the best cutting items available in firm’s stock, regarding the expected output (smaller items) [20], [21]. By providing this information on the best cutting plans it will be possible to reduce the lead-time on this process [4].

By making a better use from raw material there will be a decrease in the waste (smaller items) that result from the cutting activities and are not suitable for production) [4]. Sometimes these smaller items are restocked which leads to an over warehousing. When we optimize the cutting procedures, it is possible to reduce the number of items in stock, thus it is also expected an inventory and lead-time decreases, by the application of the IMMO Model [37]. The cutting optimization process will also lead to a reduction in the number of smaller items that are normally stocked in order to be used later, since they are not considered as waste after the initial cut. By reducing the amount of those items firms are also reducing dead stock. Most of times those smaller items
are not used any more. If those items are correctly organized and cataloged they will be just dead stock. Normally employees pick a larger item and cut it on the sizes that are needed at the moment. By having a system that firstly minimize those smaller items in stock, and identifies those smaller items, when they are necessary (according to the output requirements) the system will let the user know that an item with the necessary size exists in stock. This will promote the incorporation of that item in the production and will eliminate it from stock. Sometimes this smaller items even not presenting the exact needed sized is the best option to be incorporated. That might happen because those smaller items require less cuts and the leftovers might be waste and not dead stock.

With this model we aim to reduce production costs, by promoting a lean manufacturing strategy. The cost reduction will be promoted in a first stage through a more efficient usage of the raw materials (wood). Secondly, efficiency will also promote a lower level of inventory that reduces the capital investment in raw material, and overhead costs that occur due to the stocking activity. Taking the model a bit further and being more ambitious it can promote a third stage of efficiency at the procurement level. The IMMO model also intends to integrate an external perspective. Information sharing in order to minimize stock quantities, but enough to fulfill the market demand [25] could be done through the dashed line. The main idea is to perform an external integration with suppliers (and customers) in order to identify the best items on supplier stock, approaching thus the just in time methodology, both at input and output inventories.

By processing the information about the available input items, and output requirements, IMMO solution will also generate information about the best items to have in stock. Since this integration means information sharing, we shall not assume in advance that it will happen in the reality. It is possible, but it will depend on firm and stakeholders (partners) willing. However, by the implementation of web searching engines (not predicted as the standard solution, but possible to implement for specific users) it will be possible to have a constant search on the best web solutions for raw materials. However, even presenting it as a possible solution we believe that historical information about suppliers, such as quantity discounts, seasonal prices and/or delivery times, introduced in the system will be more efficient and cheaper than a web searching engine.

This model is presented, as a base for a further research in operation research field to find the best model to meet the wood industry needs in terms of process-performance, and production cost reduction.

IV. CONCLUSION AND FURTHER RESEARCH

In this paper were analyzed the main inefficiencies that contribute to unnecessary production costs in the wood industry. At first, was taken a field research by visiting some firms acting in this sector. During this activity it was possible to identify the main inefficiencies along the production process. Those inefficiencies were also identified by some studies in the academic field. The main issues identified were: (1) waste creation (trim loss) due to cutting activities; (2) poor inventory management due to purchasing policies and non-optimized materials consumption. This poor management leads to (3) dead stock warehousing; most of those inefficiencies occur due to a lack of technological support. (4) The lack of technological support transfers the decision making process to workpeople (human being). (5) In turn, work people decision originates longer lead-times. All together (even less relevant inefficiencies) promote a higher production cost, through material, labor and overhead costs.

In order to reduce, or even eliminate these inefficiencies, we suggest a new supply chain model designated as IMMO Model. It intends to reduce the human decision making by transferring it to an IS (IMMO solution). This system intends to present a solution that has the flexibility to be connected to any Enterprise Information System, in order to optimize the quantity stocks and minimize the waste generated by the cutting activities.

By adopting this solution efficiencies will emerge at optimizing stock management, and cutting procedures. This optimization will lead to less inventory needs (capital savings), lower lead-times, lower overheads and lower labor cost. Moreover, the implementation of this solution by optimizing the cutting activities will reduce waste generation as well as dead stock (smaller items that hardly will be reintroduced in the production process).

The model itself includes two perspectives: internal (Stock management and cutting activities) and external (model development) by integrating suppliers’ information (Procurement) in order to optimize the purchasing activities. At that step, purchases orders must consider not only the external price, but also conditions offered, and materials efficiencies during the cutting activities.

This external perspective opens up new research possibilities in management and IS sciences. The main goal, in the future, is to integrate in the model, information from raw material prices, availability, discounts, delivery times, among others, in order to find the optimal solutions to order raw materials. At the management level it will be necessary to identify the best Procurement practices, and then to design a system to get those decisions powered by a computer brain.

At the management level it is also expected to test the savings achieved by the firms that adopted the IMMO solution. For those firms it will be designed a study in order to compare the raw materials costs and productivity during a period before and after IMMO implementation. By doing this analysis it might be possible to conclude about the efficiency of this model.

However this study might need some time to be taken, according to the literature the positive effects from R&D in manufacturing present a time lag of 3 to 4 years. We believe that this model will promote efficiency in a shorter period, but there is also another issue to research about in the future.

Further, and once identified the percentage increase in
use of raw materials (wood), it will also be possible to develop new models for other industries and compare the results on raw materials efficiencies. From industry to industry the raw materials and the processes are different, however, we believe, that is some changes in the model, and a good scientific support, it will be possible to promote efficiency at raw materials usage in several industries.

Since this is a continuous improvement process we believe that with the application of this model further research might be needed in the specific issues of our model.

REFERENCES


