Improving the Price Control Phase and developing a Bid Price Control Model at Tata Steel Tubes

Master thesis Industrial Engineering and Management

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Preface

This thesis is the last step of my Master in Industrial Engineering and Management at the University of Twente (NL). I'm grateful of my decision to start this Master program, first of all for the fact that I have absolutely learnt a lot, and then because I am sure that much knowledge learned will be the base for my future career. Looking back to this experience I think that not only I developed my intellectual skills but I have absolutely improved my capacity on thinking out of the box and I'm sure that it will be helpful in both my personal and working life.

The Netherlands have been the third country where I studied, previously Italy and Spain. The way how the University of Twente manages the cooperation of students from around the world has absolutely impressed me. Multicultural minds are able to feel home with their study programs and for that reason I would like to thank Cornelis ten Napel for doing an impressive job on the integration of the international students.

I would also like to take this opportunity to thank those who made this thesis possible. First of all my supervisors: Peter Schuur and Wieteke de Kogel - Polak; your guidance and critical reviews of my work, made it, I personally think, a successful project of Master thesis.

Sanne Kramer, my supervisor at Tata Steel Tubes, has been an exceptional guide not only with his advices and guidance but also with his ability to put me in contact and build a bound with different departments of the company. The entire Production department in Zwijndrecht has always been disposable to share with me knowledge and advices. And the same I can say for the Sales department in Oosterhout (Paco Nooijens and Marten Banus) and the Financial and Control department (Mark Steenbergen and Marian Bink) who helped me in the data analysis and in the conceptual thinking of the project. For that I would like to thank all these people of Tata Steel Tubes.

Ruggero Jan Veniero

Management summary

Purpose of this research

The production of the construction centre of Tata Steel Tubes in Zwijndrecht is reaching its growth limits. Since there is the feeling that the customer's demand will increase in the next future, the company wants to avoid losing market opportunities. However there seems to be a strategic conflict between the Sales and the Production departments about how to achieve this goal.

An improvement of the order acceptance phase is needed given the presence of the "luxury problem" that during some periods of the year there are more order requests than those that Tata Steel Tubes (Zwijndrecht) can handle.

This research is focused to analyse the manufactured products, to identify the inefficiencies related to the calculations of the production process costs and to develop a model that tries to improve the order acceptance phase and to align the Production and Sales departments' objectives.

Methodology

The main objective of this research is to improve the order acceptance phase, to this end we make the next structure for the investigation:

I. An analysis of the production process and the manufactured products is made based on the current situation of the Tata Steel Tubes construction tubes factory in Zwijndrecht (chapter 2,3).
II. Recommended improvements regarding pricing strategies of the production process phases are presented (chapter 4,5).
III. A literature review about the order acceptance phase and the prices control approaches is made (chapter 6).
IV. Two models designed for the Sales department are developed: the "Incremental Order Acceptance Model" (chapter 7) and the "Market Independent Model" (chapter 8).
V. Conclusions and recommendations regarding all the points presented above are reported (chapter 9).

Results & Conclusions

I. Analysis of the production process and the manufactured products.

The production process of the construction tubes made in Zwijndrecht by Tata Steel Tubes can be seen in the next figure.

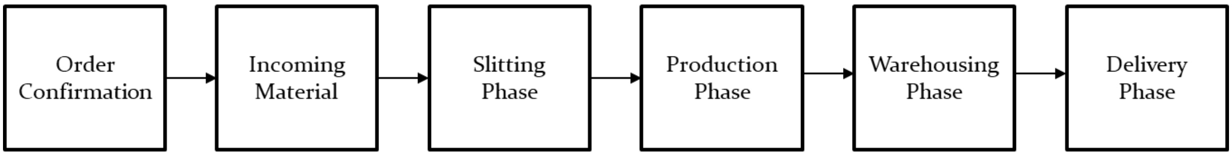

Figure 0.1 Production Process

If one of these steps delays or is out of order the delivery to the costumer is automatically late. Indeed the price of the final products is the function of all these phases.

The Sales, the Production and the Finance and Control departments have different roles in the production process:

- The Sales department is the one that is in charge of the yes/no order acceptance phase.
- The Finance and Control department is in charge of the evaluation of the costs (the pricing) related to the production process.
- The Production department is in charge of ensuring that the production is on time and that it respects the customer's request (quality, dimensions and tolerances).

The analysis of the manufactured products is made doing a shape and material quality analysis.

Shape analysis shows that there is not a consistent difference between the three types of shapes: round, rectangular and square (table 0.1). The amount of tons, the revenues and the margin per tons are close to a third for each shape type.

	Round	***Rectangular***	***Square***
Number of SKUs	119	1286	1280
% of Tot SKUs	4.43%	47.90%	47.67%
Tot tons	92,517.03 tons	104,880.82 tons	124,143.76 tons
% Amount of Tons	28.77%	32.62%	38.61%
Margin €	€ 1,840,102.27	€ 2,073,426.12	€ 2,039,535.76
Margin € per ton	€ 19.89	€ 19.77	€ 16.43
Total Revenue €	€ 53,369,781.64	€ 61,047,578.26	€ 71,690,528.73

Table 0.1 Shape analysis (2015-2018)

The material quality analysis shows that with a higher amount of tons the revenue is higher (logical) but the percentage of the total margin is not always higher for higher revenues (table 0.2). In particular, the standard products ColdS235, that are influenced by a high competition in the market, are characterized by a negative total margin (-9%) and a revenue equal to 25%.

	Number of SKUs	***% of Tot SKUs***	***Tot tons***	***% Amount of Tons***	***Margin $***	***Margin $ per ton***	***Total Revenue €***
Cold S235	230	8.57%	85,066.15 tons	27.88%	-€ 574,340.84	€ -6.75	€ 45,477,749.18
Cold S275	761	28.34%	56,946.09 tons	18.51%	€ 1,705,493.66	€ 29.95	€ 31,829,439.35
Cold S355	1637	60.97%	146,701.95 tons	47.43%	€ 2,220,805.48	€ 15.14	€ 86,881,320.13
HSS structural	31	1.15%	1,481.78 tons	0.48%	€ 106,644.95	€ 71.97	€ 1,061,030.61
Precision Appl. Base	18	0.67%	17,492.03 tons	5.66%	€ 1,833,919.88	€ 104.84	€ 12,343,563.98
Precision Automotive	3	0.11%	8.49 tons	0.00%	-€ 5,960.15	€ -701.87	€ 357.69
Special Test Tube Cold	1	0.04%	30.38 tons	0.00%	-€ 1978.56	€ -15.43	€ 546.47
Test Tube Cold	4	0.15%	113.96 tons	0.04%	-€ 2,673.46	€ -23.46	€ 76,596.84

Table 0.2 Material quality analysis (2015-2018)

The average margin per ton of the SKUs is not following the same pattern of the revenue (figure 0.2). We would have expected that the products that are sold less would have a higher margin per ton, but that is not happening. The margin per ton results are volatile and often negative. Figure 0.2 shows that some SKUs have an extremely negative margin per ton values. These values are related to "Special Test Tubes"; these products are made as a test for customers that want to know if it is feasible to produce a determinate new product.

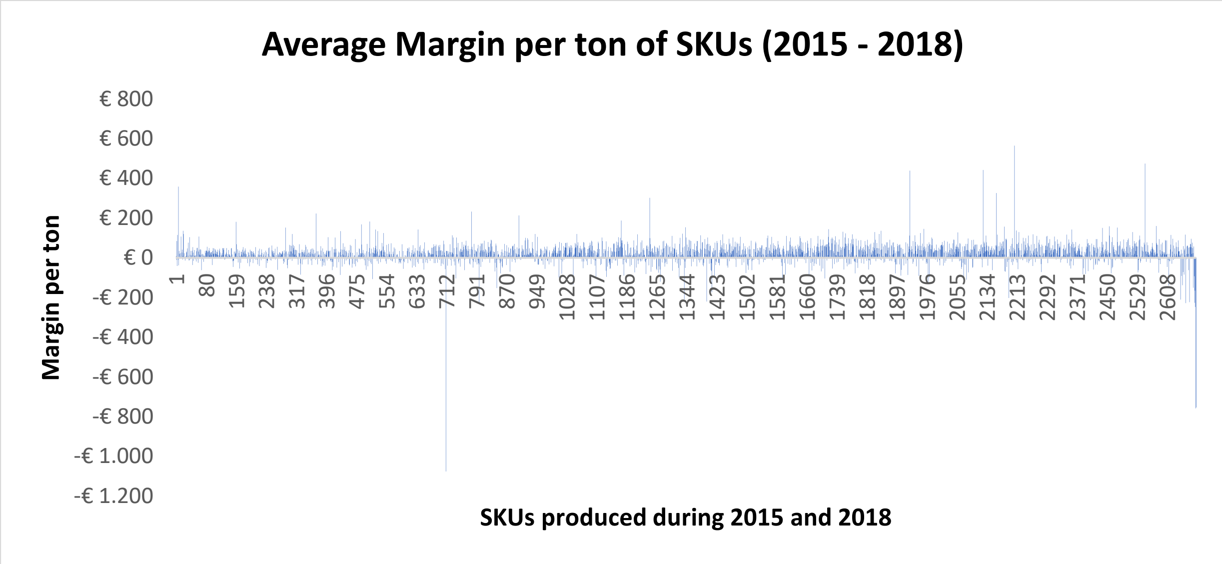

Figure 0. 2 Average margin per SKU (2015-2018). The ranking of the SKUs is decreasing starting from the SKU with the highest revenue

II. Recommended improvement regarding pricing strategies of the production process phases.

The analysis of the current Cost-based pricing strategy has produced the following outcomes:

- The production costs are currently evaluated by a price that considers the speed of a product during the production phase. The production costs are currently calculated with norms speed values (specific for a determinate product); this evaluation of the production costs results on average 6.08 euro per ton under-priced if we compare the costs with the price calculated from the average historical speed values of the SKUs. The Precision Tubes group results on average 34.04 euro per ton under-priced.
- The warehousing cost is currently calculated considering a fixed price per stored ton. This pricing methodology, in the warehouse of Tata Steel Tubes in Zwijndrecht where the space is limited, does not precisely reflect the different characteristics of the SKUs.
- The data related to the slitting costs present a lot of extreme values and infeasible values. These data are considered not statistically significant.
- The Sales department costs estimation is considered to be a valid approximation for the aim of this research.

III. Proposed improvement in the Cost-based pricing strategy:

We propose to calculate the warehousing costs based on: the effective space utilizable in the warehouse, the effective space utilized in the warehouse by each SKU and the use of the internal or the external warehouse.

We propose to calculate the production costs considering a weighted average between the historical speed values and the norms speed values (currently only the norms speed values are considered). At the historical data we will apply penalties for the items that have nominal thickness of 8 mm and 10 mm. Moreover, we propose to apply price penalties if the tube has a determinate length procuring more complications in the production process (e.g. tubes of 20m present different logistic difficulties compared to tubes of 12m or 6m). The production costs calculation we propose considers a dynamic price that is dependent on the expected produced tons and the production plan of a specific SKU.

IV. Literature review

We review how the order acceptance problem is discussed in the literature and how companies in different fields apply Revenue Management tools trying to be more efficient and to increase their revenues. Then we describe the Bid Price Control strategy.

We explain the structure of the Optimal Controls and how approximately we can arrive at the next formulation that defines a Bid-Price Control (table 0.3 Symbols meaning).

$$u_j(t, \boldsymbol{x}, p_j) = \begin{cases} 1 \; if \; p_j \geq \sum_{i \in A_j} \pi_i(t, \boldsymbol{x}) \\ 0 \; otherwise \end{cases}$$

Symbols	***Meaning***
u_j	Bid price control of product j
t	Time
$\boldsymbol{x}$	Capacity available per week
p_j	Price of product j
$i \in A_j$	Indicates that resource *i* is used by product j
π_i	Bid price of resource *i*

Table 0.3 Symbols meaning

Then, in two models developed by us to improve the order acceptance phase, we apply this function in order to calculate the bid prices of the construction tubes and in this way to predict a price that the products made by Tata Steel in Zwijndrecht should have in a specific moment of time to cover the expected production process costs.

V. Improvement of the Order Acceptance phase:

Two models are developed to improve the Order Acceptance phase:

1. The Incremental Order Acceptance Model

The model shows how products prices change according to the expected production week and the time before production starts. The price of the manufactured products is structured to be dynamically changing, differently from the current pricing methodology used by Tata Steel Tubes that can be defined static given the fact that the products' prices are always the same whatever the production process conditions are.

This model has the limitation that the price deriving from the model is difficult to compare with the actual end prices, because the end price of Tata Steel products is highly influenced by the steel index price. For this reason the Sales department has a critical opinion about the efficiency of this model.

However we believe that the main limitation on the use of this model is that the sales strategy of Tata Steel Tubes is not clear. To understand what products are more convenient to be sold and what prices are necessary to cover the production process costs of the manufactured products is mostly based on the seller experience. A strategy to try to reduce the selling of products with negative margin seems not be present.

The Sales department has the idea that the model recommended price output will often be distant from the actual sell price that will be influenced by strategic considerations like the forecasting of the steel index in the next weeks. We think that the index price could be easily constantly uploaded and forecasted if a strategy is developed.

The "Incremental order acceptance Model" has not yet been tested with the Tata Steel Tubes Sales department, but it will be delivered to Tata Steel Tubes as a suggestion for further research.

We believe that the model could be an extremely useful tool for the sales phase especially during the negotiation phase. We think (hope) that in a near future the potentiality of this model will be reconsidered. Certainty, the model needs to be completed with a strong collaboration of the Sales department so that the outcomes will at best represent the company strategy and after that a testing period is needed.

2. The Market Independent Model

The model gives the Sales department three tools:

a) Find the products that have the smallest production process costs per week
b) Production process costs of a specific Product ID for a specific week
c) Decide between a certain number of requests which one to accept

The three tools give the possibility to the seller to compare the dynamic price found with the proposed new pricing strategy, and the static price found with the current used pricing methodology. These tools give the seller a better overview of the impact of the decision to prioritize a certain product or another one. They also give a more realistic overview of the costs involved in the process.

To validate the Market Independent Model we compare its outcomes with the strategies used/suggested in the order acceptance phase by the Sales, the Production and Logistic and the Finance and Control departments. The Sales and the Production and Logistic departments were interviewed by us; as for the Finance and Control department we decide to consider the outcomes of the current static pricing methodology used by Tata Steel Tubes.

The pricing methodology of Tata Steel Tubes is made by the Finance and Control department, that is also in charge of updating it. We analyse the next week planning "lasweek 16" to compare the strategies.

Welding diameter	Article Characteristics	Plan	Booked
152.4	120 x 120 4wk / 160 x 80 4wk	874	874
323.9	Ø 323.9 4wk	191	191
244.5	200x200 4wk / 250x150 4wk / 300x100 4wk	795	795
T & H	Ø 162.0 + 162.4 4wk	269	269
156.7	133 x 133 Jost *	25	25

Figure 0.3 Week planning "lasweek 16" Construction tubes Tata Steel Tubes Zwijndrecht. Welding diameter (mm), Plan(tons), Booked(tons). We do not consider the welding diameter 156.7 in the validation analysis because are products of the group "Special Test Tubes"

In this way we want to see if the three departments are reasoning in the same way when a decision has to be made on what products they recommend to be sold and how the model that we have developed is currently working. We asked each department the ranking of the welding diameter group of products they would push first to the customers given the plan of figure 0.3 and in a condition where there is an extra capacity available of 100 tons that can be sold (so a decision on what products are more profitable to push to the customers has to be made).

The ranking expressed by each department and the ranking of the Independent Market Model developed in this research is shown in the next table (we do not consider the welding diameter 156.7 in the validation analysis because it is part of the group "Special Test Tubes").

	Sales	Production and Logistic	Finance and Control (Static pricing)	Independent Market Model (Dynamic pricing)
I.	244.5mm	323.9mm	244.4mm (54.92€/ton)	152.4mm (60.15€/ton)
II.	152.4mm	152.4mm	323.9mm (55.01€/ton)	244.4mm (60.48€/ton)
III.	323.9mm	244.4mm	152.4mm (66.91€/ton)	323.9mm (76.44€/ton)
IV.	T&H	T&H	T&H (68.11€/ton)	T&H (100.64€/ton)

Table 0.3 Welding diameters rankings "lasweek 16". T&H is a special welding diameter made for the T&H company it is also measured in mm and is part of the Precision Tubes group

Comparing the results we conclude that:

T&H group is always the last one of the ranking. The Independent Market Model with a price cost estimation of 100.64 euro per ton for the best ranked T&H product seems to represent well this situation.

Between the evaluation of the T&H group of the Finance and Control department and that of the Independent Market Model there is a difference of 32 euro per ton (a high difference). The Finance and Control department seems to under-price these products comparing the outcomes with the Independent Market Model prices and those given in the interviews with the Sales and the Production departments.

The four rankings shown in table 0.3 result all different, which confirms how the different departments have not a same strategy/view on what products to push to the market.

The Production and Logistic department's outcome shows how the idea of pushing products that can be stored outside (323.9 weld diameter) has to be prioritized.

The Independent Market Model that considers a decrease of the warehousing costs of the groups that can be stored outside, shows a price that is conditioned by the fact that the warehouse capacity booked for this product is relatively low compared with the groups 244.4 and 152.4.

The group 152.4 is ranked at the second position for both the Production and Logistic and the Sales departments. The products of this group have the advantage to use less space per ton in the internal warehouse (bottleneck of the Zwijndrecht factory) compared with the 244.4 group and that is also why the Market Independent Model prioritizes this group.

The Finance and Control department does not consider the length of the SKUs in the cost evaluation, which instead is done by the Market Independent Model developed in this research and proved to be important by the interviews with the Sales and the Production and Logistic departments.

The Market Independent Model does not prioritize square products, contrary to the Finance and Control department, and promoted by the Sales and the Production and Logistic departments in the interviews.

Recommendations

Given the results of our study, we would like to give the following recommendations.

1. We suggest to calculate the warehousing costs based on: the effective space utilizable in the warehouse, the effective space utilized in the warehouse by each SKU and the use of the internal or the external warehouse. The Production and Logistic department interview outcomes show how the idea of pushing products to customers that can be stored outside confirms the need of a modification of this cost evaluation.
2. We suggest to calculate the production costs considering historical speed values and applying price penalties if the tube has a determinate length procuring more complications in the production process. That seems to give a more realistic overview of the costs involved in the process.
3. We believe that the Market Independent Model can be a useful tool during the order acceptance and negotiation phase. The use of a dynamic price that is dependent on the expected produced tons and the production plan of a specific SKU can clarify if it is better to prioritize a certain product or another one.
4. The different departments have not a same strategy/view on what products to push to the market; there seems to be a lack of communication and therefore we recommend to define a global company strategy.

Further research has to be conducted in the following areas:

1. We suggest revaluating the profitability of T&H products particularly and in general that of the Precision tubes. It seems that it could be more profitable to accept more standard products orders instead of the T&H products orders.
2. The Market Independent Model does not prioritize square products, contrary to the Finance and Control department, and promoted by the Sales and the Production and Logistic departments in the interviews. We suggest furthering

investigating the vantage of producing square products instead of rectangular or circular.

3. A clarification of the main goal of the company has to be done to understand if it is more convenient to accept orders where the steel material margin is higher (more profit for the "mother company" that supplies the steel) or those where the production process costs are lower. If the steel material margin would be prioritized we recommend to correct the model developed in this research adding the contribution of material.

Glossary

Abbreviation	***Name***	***Meaning***	***Introduction on page***
MTO	Make to order	Manufacturing process in which manufacturing starts only after a customer's order is received.	2
RV	Revenue management	Revenue management is the application of disciplined analytics that predict consumer behaviour at the micro-market levels and optimize product availability and price to maximize revenue growth.	5
OA	Order acceptance	Tactical managerial activity that deals with accepting and rejecting customer orders.	1
MTOS	MTO specific products	Make To Order tubes that are specifically made for a particular client's request, in other words tubes related to particular customer's needs.	13
SP	Standard products	Standard tubes that are used by different customers, they are common in the steel world market and fast movers.	13
PL	Piling tubes	Tubes that are characterize by the fact that the stock can be done outside, because the final customer does not need a product with a high superficial quality. These tubes are usually made to be positioned in the subsoil.	13
PT	Precise tubes	Tubes that are characterized by excellent superficial and	13

		internal qualities. These products follow a specific production process that needs considerable more time (almost double of the time) to be produced and generate a significant number of discarded products.	
ABC	ABC Analysis	This analysis categorizes items based on their annual consumption value using a Pareto's Principle for classification.	17
FSN	FSN Analysis	This analysis classifies inventory based on quantity, rate of consumption and frequency of issues and uses.	17
VED	VED Analysis	This analysis classifies inventory according to the relative importance of certain items to other items, like in spare parts.	17
HML	HML Analysis	Classifies inventory based on how much a product unit costs.	17
SDE	SDE Analysis	This analysis classifies inventory based on how freely available an item or scarce an item is, or the length of its lead time.	17
FMCG	Fast-moving consumer goods	Are products that are sold quickly and at a relatively low cost.	17
ColdS235	ColdS235	Type of steel material quality.	24
ColdS275	ColdS275	Type of steel material quality.	24
ColdS355	ColdS355	Type of steel material quality.	24

HSS	Hollow Structural Sections	Type of steel material quality.	24
PAB	Precision Appl. Base	Type of steel material quality.	24
TTC	Test Tube Cold	Type of steel material quality.	24
BPC	Bid Price Control	Sets a threshold price, such that a request is accepted if its revenue exceeds the threshold price and rejected if its revenue is less than the threshold price.	5

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Chapter 1 Introduction

In the framework of my Master at the University of Twente I have made this research at Tata Steel Tubes as final project to obtain my Master in Industrial Engineering and Management.

This research is focused on analysing the manufactured products and identifying the inefficiencies related to the calculations of the production process costs. Our aim is to develop a model that improves the order acceptance phase and aligns the Production and Sales departments' objectives.

In this chapter we start describing Tata Steel and in particular Tata Steel Tubes the subsidiary company of Tata Steel that produces tubes in the Netherlands and the UK. The description is focused on the factory located in Zwijndrecht where construction and automotive tubes are produced and on the central Financial and Sales department of Tata Steel Tubes located in Oosterhout. Subsequently after having an introduction of the scheme of the processes that are needed to produce a tube, we describe the order acceptance process.

These two processes (production and the order acceptance) are the base of the price determination of the construction tubes which will be deeper investigated during this research. We then describe the problems that Tata Steel Tubes wants to solve and the purpose of this research. The main goals of the research are expressed and a series of subsidiaries research questions are developed to structure the research.

1.1 Company description

Tata Steel is one of Europe's largest steel producers, with steelmaking in the UK and in the Netherlands, and manufacturing plants across Europe. The company supplies steel products to demanding markets such as construction, automotive, packaging and engineering. The business approach of Tata Steel is usually based on building a collaborative relationship with customers aiming at improving the quality of their products.

Tata Steel Tubes supplies tubes for the construction, the conveyance and pressure, the energy, the automotive and engineering and the precision markets. In the Netherlands there are three sites where Tata Steel produces tubes: Oosterhout which is the main location and where is also situated the central administration of Tata Steel Tubes Netherlands, Zwijndrecht and Maastricht. The factory in Zwijndrecht consists of two cold rolling mills; one that makes tubes for the construction market and one for the automotive market. The process cycles of the construction and automotive tubes are different and the warehouses are separated. This research is focused on the Make-To-Order construction tubes centre.

In the next figure a detailed description of Zwijndrecht's factory plant is presented. M92 indicates the automotive tubes centre, M93 the construction tubes centre and SHZ the slitting centre. The different halls, doors and the main offices are indicated in the figure.

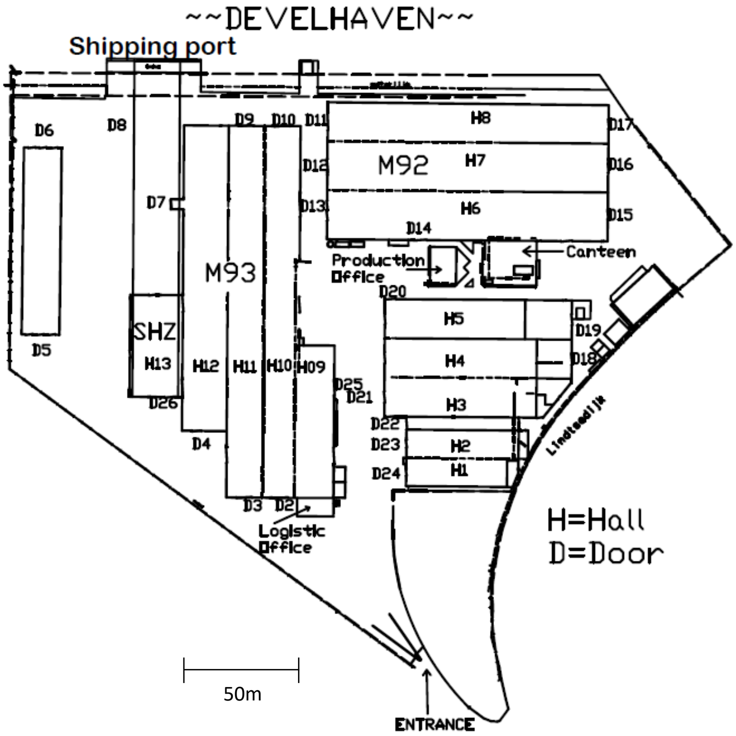


Figure 1. 1 Zwijndrecht's factory plant

1.2 The production process of a Construction Tube

Tata Steel Tubes in Zwijndrecht follows the make to order approach for the production of the construction tubes. Make to order is a production approach where products are not built until a confirmed order for products is received. The construction tubes are characterized by a high product variety and Tata Steel is constantly seeking to supply the customer with the exact required product specification.

In the next chart we describe the operational steps that are done from the confirmation of an order until the delivery of the final products.

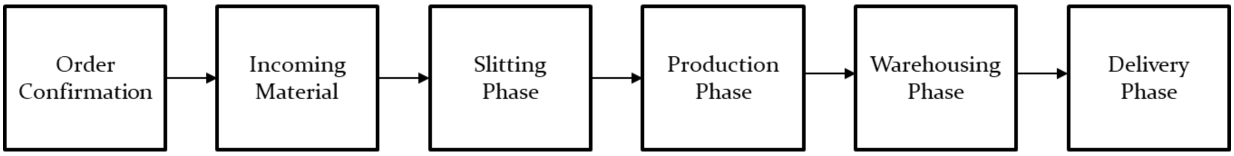


Figure 1. 2 Production process

If one of these steps delays or is out of order the customer delivery is automatically late. Indeed the price of the final products is the function of all these phases. The costs related to all these steps will be investigated during this research analysis to understand the impact of each of them.

- Order Confirmation

The Sales department located in Oosterhout is in charge of the quotation of the orders' requests and of the confirmation of the orders to the production factory.

- Incoming Material

With incoming material we mean the steel coils produced by Tata Steel Ijmuiden. The coils have specific characteristics depending on the type of tube that will be generated from them.

- Slitting phase

The slitting phase consists in the cutting of the coils. After having been slit the coils become rings. The rings will then be processed in the production phase.

- Production phase

The production phase consists in a continuous process done by different machines. It starts with a steel ring and it ends with a bundles of tubes.

- Warehousing phase

After having been produced the tubes are directly moved to the warehouse and stored. Tata Steel tries to keep this phase as short as possible. When all the products ordered by a customer have been produced and are present in the warehouse, the order is ready to be picked up by the trucks.

- Delivery phase

The delivery of the tubes is done by trucks. The delivery phase starts with a truck entering the warehouse and a crane raising the tubes and inserting them in the truck. After the loading the truck is ready to drive to the customer.

1.3 The order acceptance process of a Construction Tube

In the next flowchart we schematically describe the Order acceptance phase of Tata Steel Tubes.

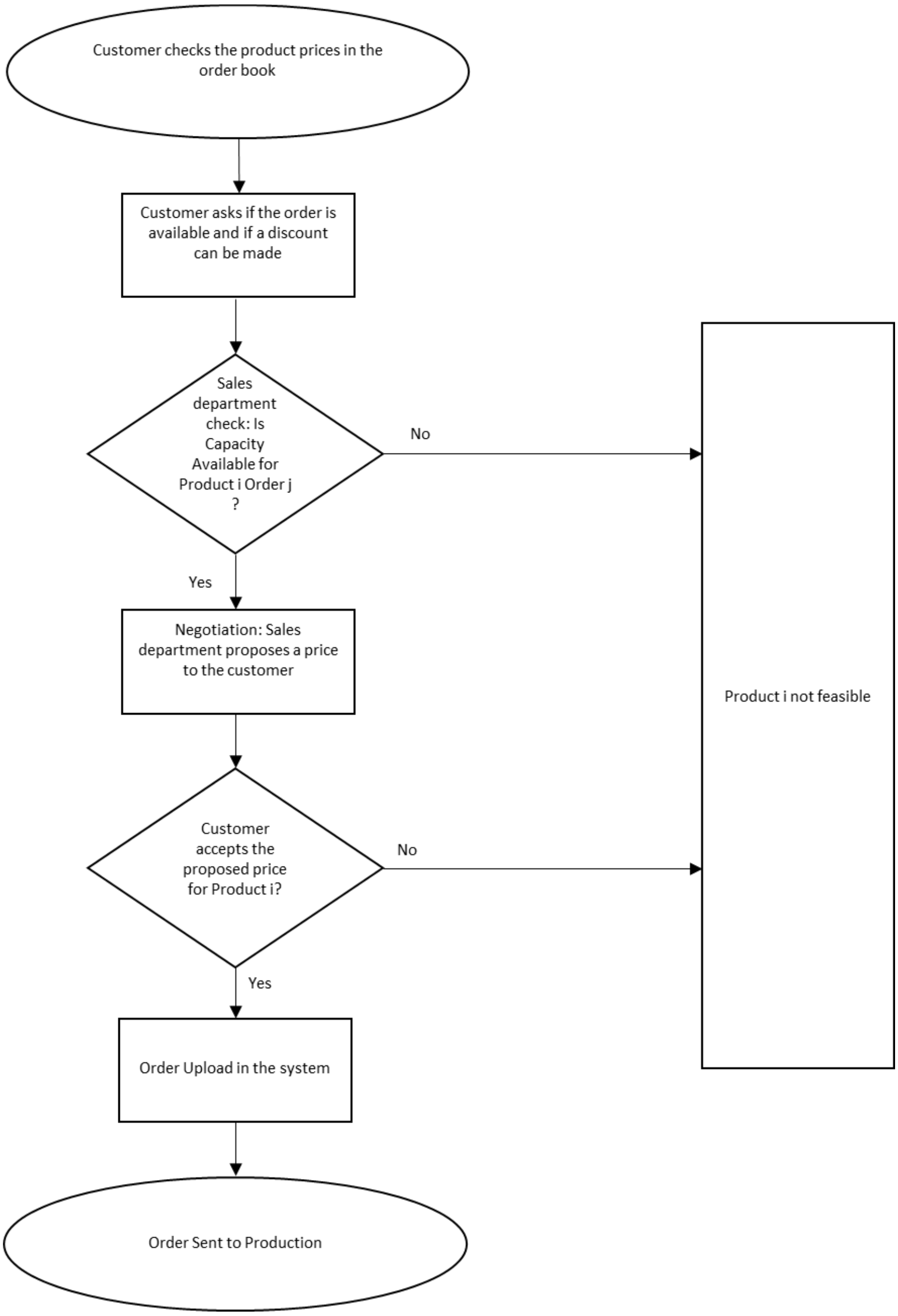


Figure 1. 3 Order Acceptance flowchart

The customer can pre-calculate the current product price from the order book of Tata Steel Tubes. After this pre-calculation there is always a negotiation phase where the customer tries to obtain a discount from the Tata Steel Tubes Sales department. Normally, customers use to approach different firms and decide where to buy considering principally the next two characteristics: price and delivery time. The Sales department is in charge to constantly monitor the tubes price market in a way to have a competitive price compared to others competitors. Other than these factors, between customers and Tata Steel a "fidelity bound" is often generated (especially with long terms customers) that influences the decision of the customer in the choice of the supplier. The "fidelity bound" consists in a relationship between the Tata sellers and the customer's buyer that is based on extra values that can be for example the possibility to make a request of a delivery delay by the customer or some engineering advices.

The Sales department bases the pricing of the products on the order book that is yearly generated considering the costs of the different steps described in the production process chart of figure 1.2 and the current steel demand. If the steel demand is high in that period of the year, Tata Steel is not willing to decrease the price of the products.

The strategies used/suggested in the order acceptance by the Sales, the Production and the Finance and Control departments should be the same and should reflect the Tata Steel Tubes strategy.

The three departments have different roles in the production process:

- the Sales department is the one that is in charge of the yes/no order acceptance phase
- the Finance and Control department is in charge of the evaluation of the costs (pricing) related to the production process
- the Production department is in charge of ensuring that the production is on time and that it respects the customer's request (quality, dimensions and tolerances)

What products are the best to be sold from the Tata Steel Tubes' point of view should be clear for the three departments, in chapter 8 we compare their strategies related to the order acceptance phase.

1.4 Problem description

The production of the construction centre in Zwijndrecht is reaching its growth limits. It seems to come principally from several supply chain management problems and from a strategic conflict between the Sales and the Production departments. Since there is the feeling that the customer's demand will increase in the next future, the company wants to avoid losing market opportunities. Due to the expected growth the challenge is to balance the market opportunities with the cost of upscaling and the timeliness of the options. Moreover in tubes making production is not always the bottleneck, given that tubes are mostly air and thus take a lot of space the warehousing phase is one of the main bottlenecks. Improving the order acceptance strategy might increase the company's profits and align the Sales and Production departments' goals. To this end a bid price control model will be developed.

1.5 Objective of the research

Given the market growth expectation, it is necessary to do a business analysis to check if there are opportunities to generate more value for the business and to avoid lost opportunities. The analysis of the currently produced stock keeping units (SKU) and the SKUs pricing phase is needed to understand the present situation. Revenue management tools will be applied in the make-to-order company, in a way to assess the opportunity costs of the orders, and consequently to support the order acceptance decisions.

The goal of the research is firstly to analyse the profitability of the different produced SKUs and make a classification of them in base of their impact in the Tata Steel Tubes business. Secondly to improve the order acceptance methodology in a way to improve the performance of the company and to guarantee that the profit margin exceeds the product oriented opportunity costs. Finally a pricing control tool is created which is based on a deep investigation of the value chain costs. The pricing control model is made to give a different quotation of a customer's order depending on time and capacity constraints. If the model results are robust, the Sales department would be able to use the model as a tool in the negotiation phase for a better understanding of the costs impacts on the factory of Zwijndrecht in producing a product in a specific moment of time and of the cost fluctuation depending on the production scheduling. The model will give a recommended price that has to be asked to the customers to guarantee that the costs in the production factory needed to produce a specific order are all covered. The central questions that we want to answer are:

- *What is a suitable price that should be asked to a customer for a specific order so that the factory's costs are covered?*
- *Towards which products should the Sales department push the customers in order to fully use the week by planning capacity?*

1.6 Research questions

After having discussed the objective of the research and the main questions it wants to answer, we will discuss the research questions that are developed to structure the research.

I. Types of the produced SKUs

Different types of tubes are produced to satisfy the customers' demand. All tubes have to respect some specific dimensions and tolerances in order to be producible by the Zwijndrecht factory. Some tubes, given their complexity, are particularly problematic in the production or the logistic phase. An analysis of the currently produced SKUs is needed to understand if a product is moneymaking. Hence, we formulate the next questions:

1. *How can the tubes be classified?*
2. *In what groups can the SKUs be subdivided?*
3. *What is the last years' demand of the different types of tubes (SKUs)?*

II. Profitability analysis

The price of the tubes needs to include material, production, logistic and sales costs. The production cost is the most difficult to evaluate because it is related to many variables as production time per ton and the number of discarded items. As is easy to understand a product that reduces considerably the production speed has to be carefully priced considering the production problematics. This analysis is made to understand how the pricing phase is made and what variables are considered in setting up the tubes' prices. The following research questions should be answered:

1. *How are SKUs prices structured?*
2. *To what extent are sellers' and production goals aligned?*
3. *To what extent are all produced SKUs profitable?*
4. *What are the most lucrative products?*
5. *What are the profit margins for each SKU?*

III. Pricing Strategies

The current SKUs' pricing strategy is mainly set up considering the costs derived from the material, production, slitting, commercial and logistic phases. In this research, the current pricing phase is first analysed and then a research of possible alternatives is made. Pro and contra of applying different pricing strategies will be discussed in search of improvement. Hence, we formulate the next research questions:

1. *What is the current price strategy?*
2. *What other pricing strategies can be applied on Tata Steel Tubes?*
3. *What pricing strategy should we apply in this research?*

IV. Order Acceptance: Bid Price Control Model

Order Acceptance (OA) is a tactical managerial activity that deals with accepting and rejecting customers' orders. The Sales department tends to accept all orders, regardless of the available capacity in the Production department, because their goal is to increase turnover. The Production department tries to maximize utilisation and minimize the number of tardy deliveries. Given these conflicting goals of turnover and tardiness, order acceptance decisions are often made without involving the Production department or with incomplete information on the available capacity in the Production department. Decisions made about whether to accept a customer request or not, might have a significant effect on the overall contribution margin of the company. The following questions have been developed to generate an order acceptance model:

1. *To what extent is the Sales department considering the strategy of maintaining flexibility to avoid lost opportunities?*
2. *What is the capacity consumption (hours/tons) of each SKU?*
3. *What are the bid prices of each SKU?*
4. *How should the Order Acceptance phase be modified?*

1.7 Research approach

The research is divided into a number of research questions that have been discussed above. In the first two groups of research questions we describe the existing processes used to create a tube, the types of SKUs produced by the Zwijndrecht factory and their profitability. We work on improving the current order acceptance phase and the pricing methodology applied to price the produced tubes. We search for appropriate literature regarding order acceptance phase and bid price control application. The literature review has the goal to find a structure for a pricing control model and to understand what factors have to be investigated by the company. We then analyse the current pricing methodology applied by Tata Steel Tubes considering the costs related to all the steps indicated in figure 1.2. Using the information collected from the first groups of research questions and the analysis of the current pricing strategy we propose different solution approaches and pricing strategies. We look for improvement when it is possible and for that reason different applicable approaches will be reviewed. An implementation of the pricing strategy is a prime goal of the research, indeed we want to make a model using the implemented pricing strategy and test it with the collaboration of the Sales department. If the model will result solid, it can be a useful tool for the Sales department during the future negotiation phases. Finally, we present recommendations for implementing the proposed solutions.

1.8 Deliverables

The main objective of this research is to improve the order acceptance phase and to align the Production and Sales departments' objectives. To this end, with this investigation we will deliver:

- An analysis of the manufactured products (chapter 2,3)
- An analysis of the production process (chapter 2,3)
- Recommended improvement regarding pricing strategies of the production process phases (chapter 4,5)
- Literature review about the order acceptance phase and prices control approaches (chapter 6)
- Two models designed for the Sales department: the "Incremental Order Acceptance Model" (chapter 7) and the "Market Independent Model" (chapter 8)
- Conclusions and recommendations (chapter 9)

Chapter 2 Description of the existing situation

In this chapter we first introduce the steel hollow sections and then we make a description of the production cycles of a general construction tube in Zwijndrecht. After that we describe the main characteristics of the construction tubes, how they are produced and the different types of SKUs produced in the Zwijndrecht site. We then introduce the logistic processes to give an understanding about the influence of these processes in the pricing phase of the SKUs. Finally, the current order acceptance policy and the tactical and operational planning phases are described.

2.1 Introduction of steel hollow sections

Steel hollow sections are particularly useful because they offer the unique combination of good welding properties with guaranteed strengths. Structural steel is an extremely adaptable product, used by engineers in order to maximise the strength of a structure while minimising its weight.

Tata Steel in Zwijndrecht uses generally three types of structural steel to generate the construction tubes: S235, S275 and S355 (other specific types of steels are used to supply specific clients' requests). Where S denotes the fact that it is a structural steel and 235, 275 or 355 the minimum yield strength of the steel (tested at a thickness of 16mm). The yield strength of structural steel measures the minimum force required to create a permanent deformation in the steel. The structural steel grades are designed with specific chemical compositions and mechanical properties formulated for particular applications. The chemical composition of structural steel is extremely important and highly regulated. It is a fundamental factor which defines the mechanical properties of the steel material. Depending on the desired application, an engineer will specify a grade of steel (often to meet minimum strength, maximum weight and or weathering requirements) and the sectional shape, relative to the desired location and expected load to be carried or job to be performed. Tata Steel produces different types of tubes depending on the customer's requests; Tata Steel Tubes in Zwijndrecht produces according to the make-to-order principle. The tubes differ for the next characteristics: dimensions, steel chemical composition, mechanics properties, tolerances, external and internal qualities.

Tata Steel Tubes produces in Zwijndrecht cold formed steel sections. The term “cold” indicates that the production cycle of a desired shape occurs at room temperature. We will introduce the production cycles in next paragraph.

2.2 Production cycles of a general construction tube

The production of the construction tubes start from a steel ring (figure 2.1).

Figure 2.1 Steel rings

A steel ring is a portion of a steel coil that was slit in the ZVH centre (figure 1.1) to get the right proportions, specifically needed for the production of a particular tube. The output of the production cycle is a bundle of tubes that are successively placed in the warehouse. The most relevant steps needed to complete the production cycle of a generic construction tube are (figure 2.2 schematic representation):

1. Uncoil a ring. After this process it becomes a narrow strip.
2. The narrow strip goes through the straightening machine.
3. Once the narrow strip exits the straightening it is welded with the next narrow strip that exits the straightening. In this way the tube production becomes a continuous process.
4. A buffer is created. It is needed because it consents to conclude the welding process before the next step starts.
5. The narrow strip goes in the pinch roll machine where it is bent.
6. The narrow strip after having been bent goes to the finpass machine where it gets a round profile.
7. The round narrow strip is welded to obtain a tube.
8. The tube goes through a cooling machine.
9. The tube then passes through a forming machine. Here the tube can be made rectangular or square if requested.
10. The tube is sawed to obtain the right length.

11. The singular tubes with the right profile and length are bundled together (the number of tubes in a bundle depends on the type of tube).
12. At the end the products are stored in the construction warehouse.

During the process different tests are effectuated and treatments with emulsion are applied. The next figure gives a visual idea of the production steps.

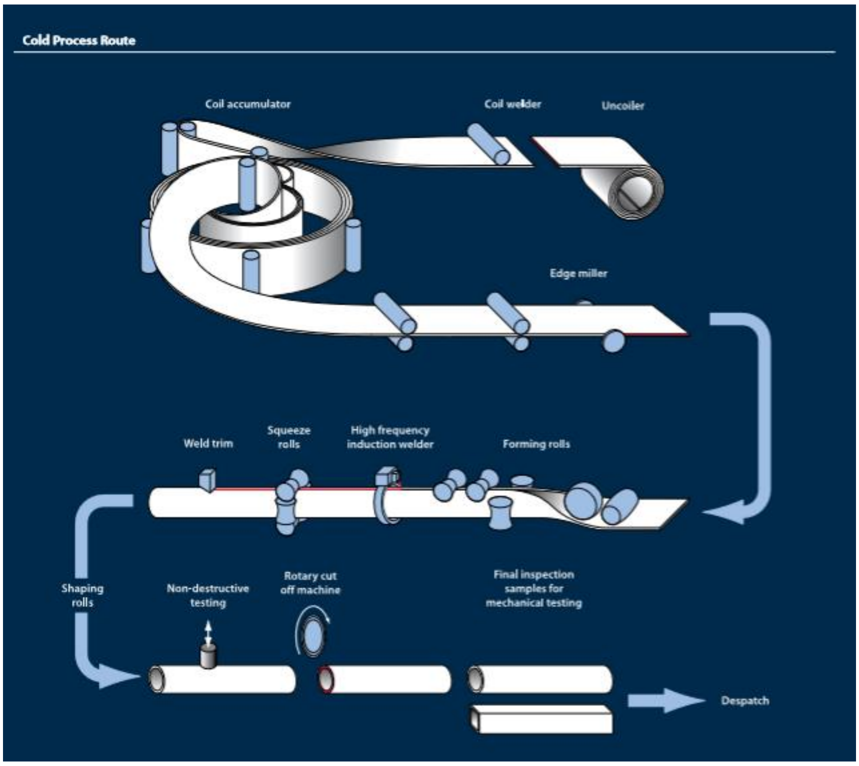


Figure 2.2 Schematic representation of the production of a generic construction tube

As described the production of the cold forms has different steps each with is variability and probability of disorders. The production of the tubes can be considered as a sequential continuous process.

2.3 Types of produced tubes

The tubes produced in the construction tubes centre vary for dimension, tolerance, mechanical and chemical steel characteristics. During the last year (2018) 1192 different types of tubes have been produced.

The tubes can be classified according to product shapes, material groups, material descriptions and characteristics of tubes produced:

- Product shapes:

Three types of product shapes are produced in the Tata Steel Tubes factory of Zwijndrecht: Square, Rectangular and Round. In the next graph we show how the percentage of tons produced are distributed around the three categories.

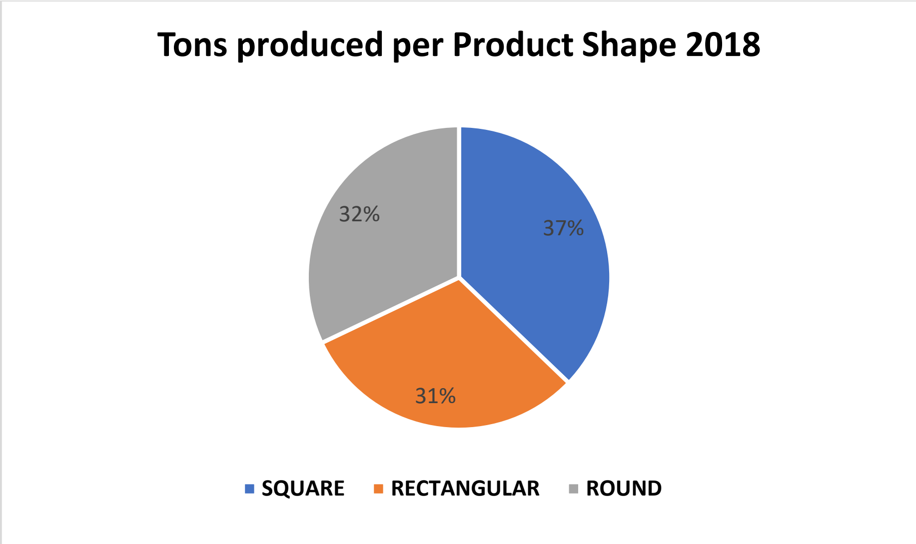


Figure 2.3 Tons produced per product Shape 2018

- Material group:

The principal material groups of the SKUs produced are Cold S235, Cold S275, Cold S355, HSS Structural, Precision Application Base and Test tube Cold. In some cases other kinds of material are used to meet a special customer's request (these cases are less than the 1% of the total produced tons).

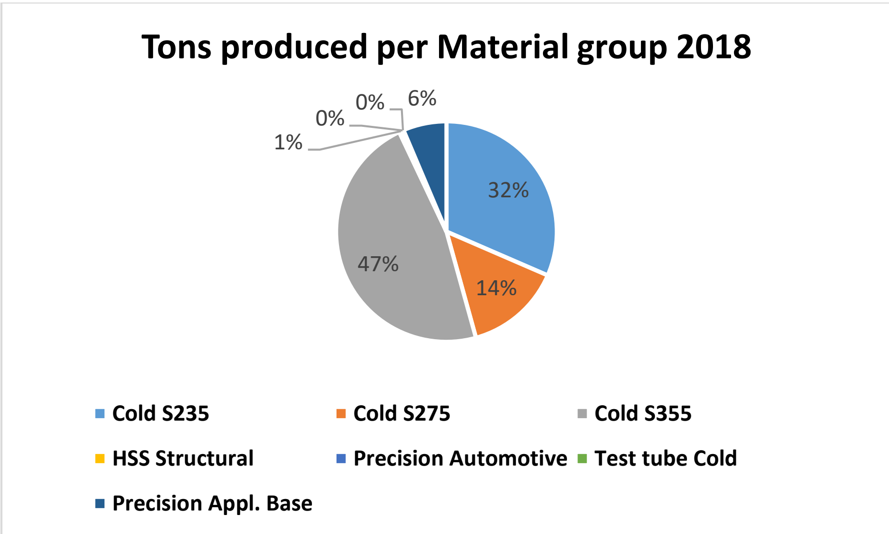


Figure 2.4 Tons produced per Material group 2018

- Material description:

The material description is based on: height (mm), width (mm), thickness (mm), length (mm) and diameter (mm) (in case of round tubes).

- Characteristics of produced tubes:

The tubes produced in the construction centre of Zwijndrecht can also be subdivided in the next groups considering some specific characteristics: Make to order specific products (MTOS), Standard products (SP), Piling tubes (PL) and Precision tubes (PR).

MTOS are Make To Order tubes that are specifically made for a particular client's request, in other words tubes related to particular customer's needs.

SP are standard tubes that are used by different customers, they are common in the steel world market and fast movers.

PL tubes are characterize by the fact that the stock can be done outside, because the final customer does not need a product with a high superficial quality. These tubes are usually made to be positioned in the subsoil.

PR are characterized by excellent superficial and internal qualities. These products follow a specific production process that needs considerable more time (almost double of the time) to be produced and generate a significant number of discarded products.

2.4 Logistic processes

2.4.1 Warehousing

The warehousing phase of structural hollow sections has to deal with the fact that tubes are mostly air and thus take a lot of space. The volume of the SKUs fluctuate between: 0.0576m^3 and 1.4831m^3. Given the limited space in the warehouse of Zwijndrecht, it is fundamental to manage the warehouse in a way to have always space for the output products coming from production. The price of the stock phase has to be carefully evaluated considering the risk of an eventual stopping of production given the restricted capacity of the warehouse.

2.4.2 Dispatching

Tubes are picked up by an external company P&O ferry, that sends every day some trucks to load the tubes. The effective number of trucks arriving each day is known at the end of the day before. The number of trucks is variable in function of the trucks needed and in function of the available trucks of P&O ferry. The Logistic department prepares the orders near the pick-up locations so that when a truck arrives it is possible to start directly with loading. Only a few customers pick up the orders with their private trucks. The prices applied to the dispatching phase are pre-established between Tata Steel and P&O ferry. They vary for different factors as for the distance (km) to the customer, the time used to load the trucks and the amount of transported tons. Given the high influence of the dispatching costs on the total product costs, the market of Tata Steel Tubes is highly related to nearby regions, especially for the standard products where competition is extremely high.

Given the fact that the dispatching costs are regulated with an external company in charge of the dispatching phase of all Tata Steel factories in the Netherlands and in the United Kingdom, in our analysis we study the prices of the SKUs without considering the dispatching costs.

2.5 Receiving of the incoming materials

The steel coils are generally provided by the steel production factory of Tata Steel in IJmuiden (NL), in some cases by the UK Tata Steel production centres and only in rare cases by an extern provider (e.g. ArcelorMittal). The steel coils are generally delivered by ships or in some cases by trucks or trains. From the ships moored in the shipping port (figure 1.1) the coils are lifted up with a crane and positioned outside the SHZ centre (or indoor in case the steel has to be protected from atmospheric agents). The coils as raw material have the highest impact on the future sell price. Around 80-85% of the SKUs prices have to be repaid to the steel production company.

2.6 Production planning: Tactical and Operational

The Sales department makes a year forecasting plan of the quantity of tons that will be sold per month during the next year. The production of a specific tube can be made every four weeks. Depending on the moment when a customer's order is accepted, the lead time will be usually somewhere between zero and four weeks plus the transportation time. The Sales department, after receiving an order from the customer, checks the enterprise resource planning software (ERP) if there is still production capacity available. In that case it adds an order for the next production cycle. If the capacity is not enough, the order is refused or postponed to the next production cycle (if the customer is willing to wait). The production plan is made considering that a specific ring can be the base to create different products. The planners aggregate the orders so that the products derived from the same ring are processed one after the other.

The SCP department sends every week the aggregate orders that have to be processed for the next week to the planners in Zwijndrecht. Here the planners have the function to schedule the daily orders for the current week considering the warehousing capacity and the production status. The official plan for a day is made only the day before.

The order acceptance is made considering the available capacity left in the booking plan. A ranking of the customers is made every year in order to give priority to loyal customers, especially to end-users. End-user customers are higher ranked because they give the opportunity to cut the stock-holders from the supply value chain.

The Sales department has the feeling that the current used order acceptance strategy, that considers only capacity as constrain to accept/not accept an order, has several limitations. Some examples of these limitations are:

1. Suppose that the capacity of a specific week is almost completed and different order requests arrive (with the same profit margin), what order is more profitable to accept from the production factory point of view?

The impact of adding a specific order in the production planning is not visible with the current order acceptance methodology. Therefore, it is not possible to compare the theoretical effect of adding to production an order A or an order B.

2. Suppose that the capacity of a specific week is almost completed and the Sales department wants to push to the customers some orders in such a way to complete the capacity left. What are the products that have less impact on the production costs (given the current production planning)?

In a hypothetical situation in which the Sales department wants to stimulate customers to buy, it is necessary to understand what products are more profitable in the production phase. That is also helpful during the negotiation phase; indeed the seller will have more knowledge about what strategy to apply (e.g. making a discount given the high production profitability).

With this research, as already introduced, we try to align sales and production goals, in chapter 8 we will try to answer to these questions with a pricing control model.

2.7 Current Pricing Phase

The pricing phase is a critical stage for the ongoing success of a steel products company. Steel being a commodity is characterized by the fact that its price is fluctuating during the year. Steel tubes are highly influenced by the steel price changes and at the same time by the costs related to the location of production and the moment when it is sold. Tata Steel Tubes generates the price of the produced articles on the base of the next main pricing strategies:

- Market pricing
- Cost-based pricing
- Competition-based pricing

2.7.1 Market pricing

The cost of a final product is principally based on the material cost. On average the material cost is 80-85% of the final selling price (Interview, Head of the Commercial Department). Steel tubes are derived from steel coils, coil prices differ for the quality of the products. Given the fact that steel is a composition of different materials, principally iron, carbon and scrap material, the price of steel is influenced by the fluctuating index of these commodities. A periodic overlook of the base material quotation is fundamental. The material cost is what affects most the final price of a tube and it is continuously updated in the order book. The customers, especially the no end-user customers, try to take advantage of the moment when the steel price is low to create stocks and then sell them again when the price is rising. Therefore, the policy of Tata Steel Tubes is to prioritize end-user customers that buy depending on their needs and not with the goal to make speculations in the market. On the other hand to generate a certain volume of steel sold per year it is necessary to sell products also when the price is low. Thus the Sales department has the difficult task to carefully balance the sells during periods of low steel price. The Sales department tries to predict the yearly trend from historical experiences.

2.7.2 Cost-based pricing

Beside the material cost, the rest of the price of the steel product (around 20%) is based on the production, logistic and sales processes. In the next table we show how the costs are calculated for the construction tubes. The production and the slitting phases are valuated with a specific price per hour of utilization. The warehouse and sales phases are valuated with a specific price per sold ton.

Processes	***Costs***	***Units***
Sales	11	€/ton
Slitting	2962	€/hour
Production	3163	€/hour
Warehousing	16.94	€/ton

Table 2.1 Cost based pricing

2.7.3 Competition-based pricing

The prices that the main competitors apply on the standard steel tubes are kept in consideration by Tata Steel Tubes to be sure to be in a competitive position in the market. It has a lower influence on the final SKU price compared to the other two categories but it is a fundamental tool during the negotiation phase.

2.8 Conclusions

In this chapter we have described the existing situation regarding the construction tubes produced in Zwijndrecht by Tata Steel Tubes. First of all we have introduced the steel hollow sections and we have described the production cycle of a tube produced in the factory of Zwijndrecht by Tata Steel.

After that the types of tubes that are currently produced have been described considering classifications based on:

- Shape
- Material quality
- Material description

Then the logistic processes of warehousing and dispatching, and the production planning, both operational and tactical, are described. At the end the currently used pricing strategy is explained.

Chapter 3 Classification & Profitability Analysis

In this chapter we make an analysis of the profitability of the different SKUs produced by Tata Steel Tubes in Zwijndrecht. We first describe the different types of SKUs classifications available in the supply chain literature depending on the type of company and the benefits searched by the analysis. Then we choose the method that better fits Tata Steel Tubes and we provide a classification. After the classification phase we analyse the profitability of the SKUs considering the different shapes and material groups.

After this chapter that is based on the current situation of the Tata Steel Tubes factory in Zwijndrecht, in chapter 4 we make a pricing analysis that is fundamental to understand what can be improved in the current pricing strategy. Then in chapter 5 we propose different improvement solutions for the cost evaluation of the production process of the construction tubes.

3.1 Classification

The classification of items in FMCG (Fast-Moving Consumer Goods) companies is mainly used to manage inventory, that is why it is often reported as Inventory Analysis. In this research the benefits of an item classification are: better cost management and future identification of possible opportunities or losses. The most common Inventory Analysis methods are:

- ABC Analysis

This analysis categorizes items based on their annual consumption value using a Pareto's Principle for classification. Pareto's Principle classifies the important items in a certain group that usually constitute a small portion of the total items in the group. Then, the majority of the items, as a whole, will seem to be of minor significance.

- FSN Analysis

This analysis classifies inventory based on quantity, rate of consumption and frequency of issues and uses. Here is the basic depiction of FSN Analysis: F stands for Fast moving, S for Slow moving and N for Non moving items.

- VED Analysis

This is an analysis whose classification is dependent on the user's experience and perception. This analysis classifies inventory according to the relative importance of certain items to other items, like in spare parts. In VED Analysis, the items are classified into three categories which are: Vital, Essential and Desirable.

- HML Analysis

HML Analysis classifies inventory based on how much a product unit costs. The classification is as follows: High Cost (H), Medium Cost (M) and Low Cost (L).

- SDE Analysis

This analysis classifies inventory based on how freely available an item or scarce an item is, or the length of its lead time. This is how the inventory is classified: Scarce (S), Difficult (D) and Easily available (E).

The ABC classification seems to be the most proper for our scope and the characteristic of the company. Tata Steel Tubes tries to avoid making inventory and generates products only for customers' requests (Make To Order). The goals of the ABC classification analysis here applied are: to understand the profitability of the different SKUs generating a ranking and investigating the different material groups results on revenue and margin. Given the growing of the Tata Steel Tubes customer's requests our analysis could be used as a tool to have a clear view of the products that in the last years (2015 to 2018) have generated more revenues and margins.

The analysis starts with producing the Distribution by Value Curve (DBV) of the SKUs produced in the last four years (2015 to 2018). The DBV curve is developed as follows: the value v (euro per ton) and the four year usage (or demand) D of each SKU are identified. Then, the product Dv is calculated for each SKU, and the Dv values for all SKUs are ranked in descending order starting with the largest value, as in Table 3.1. After that, the corresponding values of the cumulative percent of total euro usage and the number of SKUs are plotted on a graph (Figure 3.1).

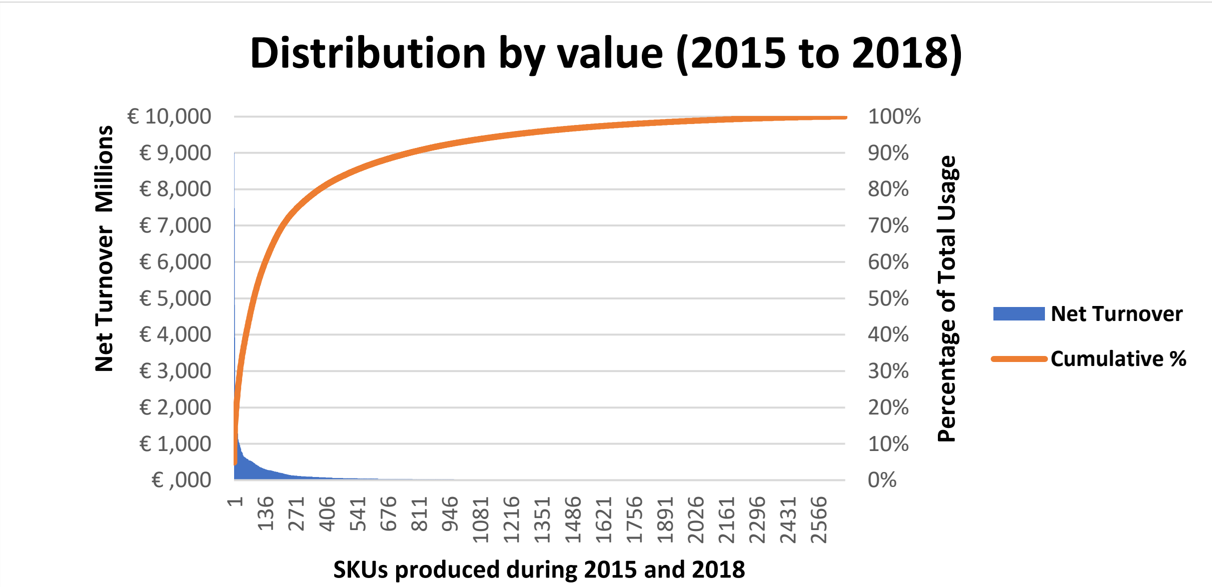


Figure 3.1 Distribution by Value Curve (DBV). The ranking of the SKUs is in decreasing order starting from the SKU with the highest revenue

The chart above shows how 80% of the total usage is made by 379 SKUs, so by only 14% of the total construction tubes produced in the last four years by Tata Steel Tubes.

#	*Material Description*	*Net Turnover*	*%Total Turnover*	*Cumulative Turnover %*	*% Of Total SKUs*
1	219.1 X 4.00 12000 ZW 37	€ 8,791,681.18	4.82%	4.82%	0.04%
2	168.3 X 4.00 12000 ZW 37	€ 7,403,187.80	4.06%	8.88%	0.07%
3	156,0X3,00X6000 ;RO;THIEL;01;	€ 4,642,892.46	2.55%	11.43%	0.11%
4	273.0 X 4.00 12000 ZW 37	€ 3,874,625.91	2.13%	13.56%	0.15%
5	158,0X4,00X6000 ;RO;THIEL;01;	€ 2,398,559.48	1.32%	14.87%	0.19%
6	273.0 X 4.00 12000 ZW 37 B=2	€ 2,014,252.82	1.10%	15.98%	0.22%
7	323.9 X 4.00 12000 ZW 37	€ 1,813,654.38	0.99%	16.97%	0.26%
8	200 X100 X10.00 12000 52 31B	€ 1,542,186.87	0.85%	17.82%	0.30%
9	200 X200 X 8.00 12000 52 31B	€ 1,469,959.27	0.81%	18.63%	0.34%
10	120 X120 X 8.00 12000 52 31B	€ 1,413,356.72	0.78%	19.40%	0.37%
11	200 X200 X10.00 12000 52 31B	€ 1,366,211.12	0.75%	20.15%	0.41%
12	168.3 X 3.00 12000 ZW 52 31B	€ 1,341,912.46	0.74%	20.89%	0.45%
13	162,4X5,00X6000 ;RO;THIEL;01;	€ 1,294,897.26	0.71%	21.60%	0.48%
14	120 X120 X10.00 12000 52 31B	€ 1,263,240.94	0.69%	22.29%	0.52%
15	200 X100 X 8.00 12000 52 31B	€ 1,251,173.87	0.69%	22.98%	0.56%
16	150 X150 X10.00 12000 52 31B	€ 1,225,894.48	0.67%	23.65%	0.60%
17	219.1 X 4.50 12000 ZW 37	€ 1,195,399.18	0.66%	24.30%	0.63%
18	120 X120 X 4.00 12000 37	€ 1,126,307.29	0.62%	24.92%	0.67%
19	160 X160 X 8.00 12000 52 31B	€ 1,108,408.60	0.61%	25.53%	0.71%
20	180 X 80 X 8.00 10400 52 31B	€ 1,033,786.13	0.57%	26.10%	0.74%
21	162,0X6,00X6000 ;RO;THIEL;01;	€ 1,011,277.07	0.55%	26.65%	0.78%
22	140 X140 X 8.00 12000 52 31B	€ 994,911.97	0.55%	27.20%	0.82%
23	160,0X5,00X6000 ;RO;THIEL;01;	€ 994,763.39	0.55%	27.74%	0.86%
24	323.9 X 5.00 12000 ZW 37	€ 963,659.30	0.53%	28.27%	0.89%
25	100 X100 X 8.00 12000 52 31B	€ 963,401.10	0.53%	28.80%	0.93%
26	150 X150 X 8.00 12000 52 31B	€ 947,594.31	0.52%	29.32%	0.97%
27	150 X100 X 8.00 12000 52 31B	€ 905,194.30	0.50%	29.82%	1.01%
28	120 X120 X 6.00 12000 52 31B	€ 901,149.56	0.49%	30.31%	1.04%

Table 3.1 List of SKUs by decreasing euro usage

Table 3.1 shows the SKUs that are the most important in terms of revenues. To these SKUs will be assigned a higher priority in the allocation of management time and financial resources in any decision system we design. Now the priority ranking can be applied:
A (most important), B (intermediate in importance), and C (least important). The appropriate number of categories depends on its circumstances and the degree to which

we wish to differentiate the amount of effort allocated to various groupings of SKUs. The ABC classification needs not be done on the basis of the DBV curve alone, some SKUs can be shifted among categories for a number of managerial reasons. We have decided to assign the first 28th SKUs to group A, this group contains 1.04% of the total number of SKUs produced in the last four years and these SKUs have generated 31.31% of the total revenues. In group B we have decided to assign the SKUs ranked from 29th to 380th in base of revenue, these SKUs generated 49.65% of the total revenues and are the 13.10% of the total number of SKUs produced in the last four years. The rest of the SKUs are assigned to group C. The next table summarizes the division of groups.

Group	*From - to*	*% of SKUs*	*% of Revenues*
A	1th to 28th	1.04%	31.31%
B	29th to 380th	13.10%	49.65%
C	381th to 2685th	85.86%	19.04%

Table 3.2 ABC Classification

3.2 Margin analysis

In the next graph we show the average margin of the SKUs with the same ranking as in figure 3.1 (ranked in decreasing order starting with the SKU with the highest revenue).

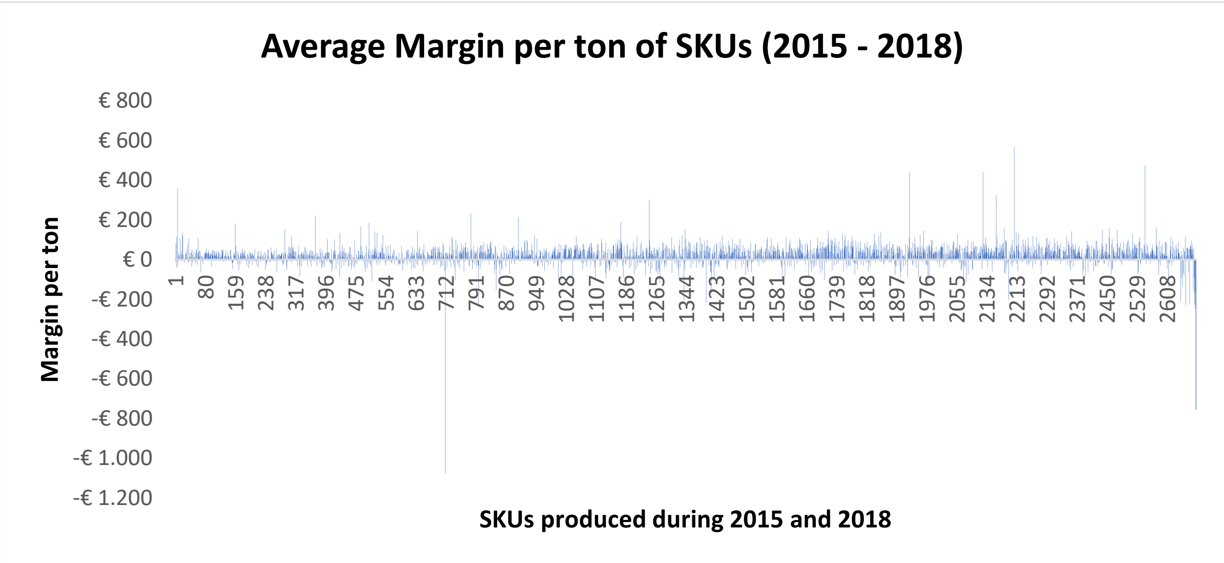


Figure 3. 2 Average margin per SKU (2015-2018). The ranking of the SKUs is decreasing starting from the SKU with the highest revenue

The graph shows that the margin is not following the same pattern as the revenue (figure 3.1), it results really volatile and often it is negative. The negative margin is frequent for both items with high or low revenue. Given that Tata Steel Tubes is a subsidiary firm of

Tata Steel that produces the steel coils, the goal of the Zwijndrecht site is to prioritize the selling of products with high margin but as well to generate a certain steel volume per year (Tata Steel annual plan). The volume per year goal explains why Tata Steel Tubes is often selling products with negative margins.

Figure 3.2 shows that some SKUs have an extremely negative margin per ton values. These values are related to "Special Test Tubes", these products are made as a test for customers that want to know if it is feasible to produce a determinate new product.

3.3 Shape and Material profitability

We now analyse the revenues and margins obtained by Tata Steel Tubes for each type of shape and quality material.

3.3.1 Shape Analysis

Three types of shapes are produced in the Zwijndrecht factory, the tubes can be: round, square and rectangular. As visible in the next chart the highest total revenue is made by the square shape, considering production between 2015 and 2018.

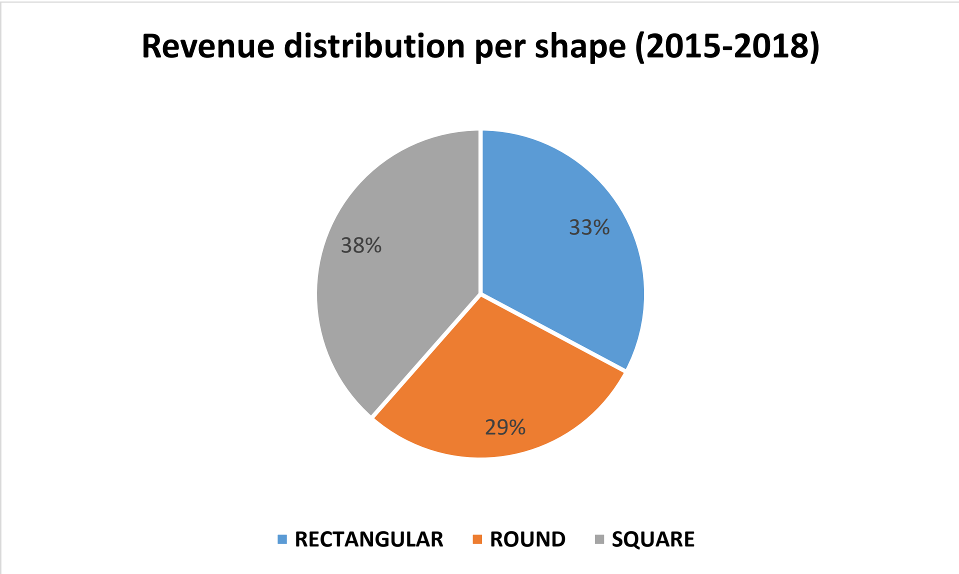


Figure 3. 3 Revenue distribution per shape (2015-2018)

The same result if we consider the shapes in amount of tons per shape type (figure 3.4).

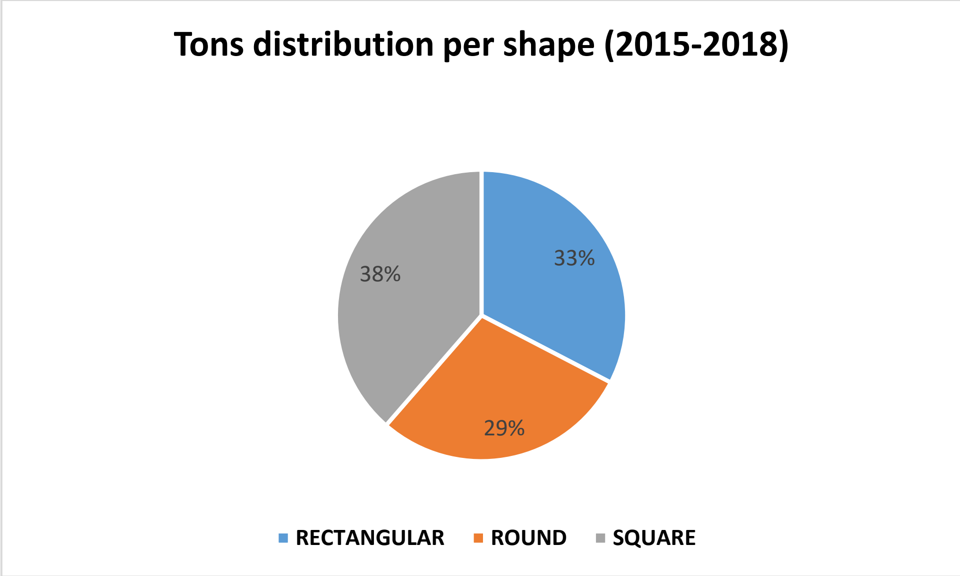


Figure 3. 4 Amount of tons per shape (2015-2018)

The amount of total margin is higher in the square type given the higher amount of tons produced, but as is shown in the next table the margin per ton of each shape is very close, and they have a standard deviation of 1.60€ (derived from margin euro per ton per shape type, table 3.3).

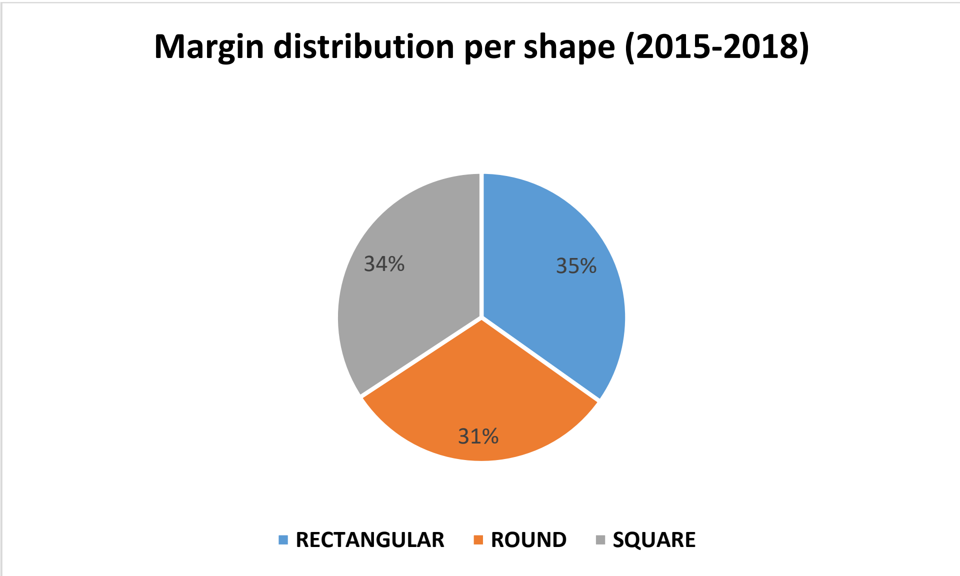


Figure 3. 5 Total margin per shape (2015-2018)

	Round	*Rectangular*	*Square*
Number of SKUs	119	1286	1280
% of Tot SKUs	4.43%	47.90%	47.67%
Tot tons	92,517.03 tons	104,880.82 tons	124,143.76 tons
% Amount of Tons	28.77%	32.62%	38.61%
Margin €	€ 1,840,102.27	€ 2,073,426.12	€ 2,039,535.76
Margin € per ton	€ 19.89	€ 19.77	€ 16.43
Total Revenue €	€ 53,369,781.64	€ 61,047,578.26	€ 71,690,528.73

Table 3.3 Shape characteristics analysis (2015-2018)

There is not a consistent difference between the three types of shapes (round, rectangular and square), the amount of tons, the revenues and the margin euro per ton are close to a third for each shape type. We can so conclude that the influence of the geometric form is not correlated to the revenues and margins of the SKUs.

3.3.2 Material quality analysis

Compared to the shape analysis, different considerations can be derived from the material quality analysis. Comparing the revenues with the amount of tons produced it can be seen that for a higher amount of tons the revenue is higher, which seems to be logical (figure 3.6 and 3.7).

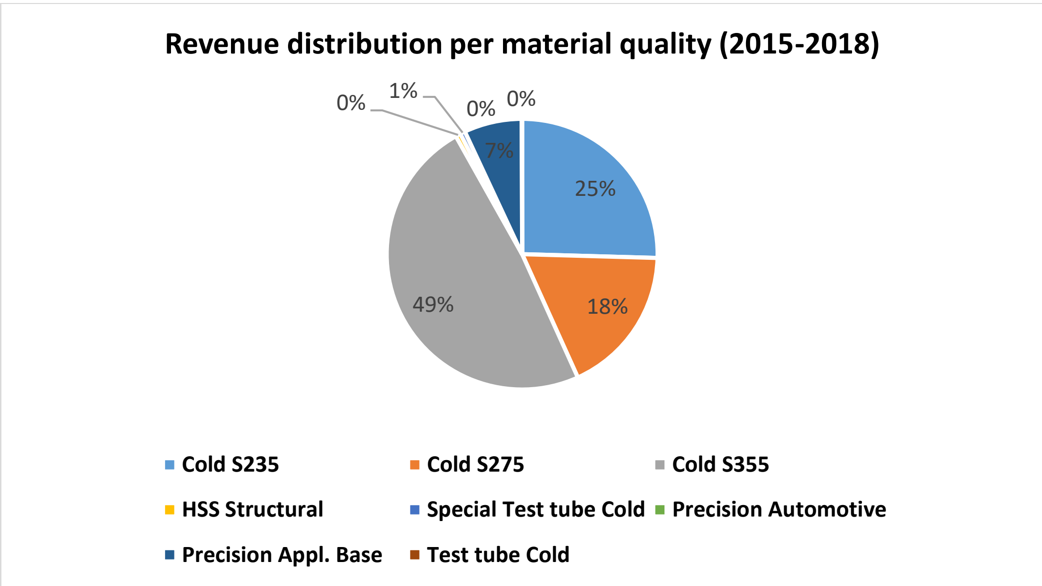


Figure 3. 6 Revenue distribution per material quality (2015-2018)

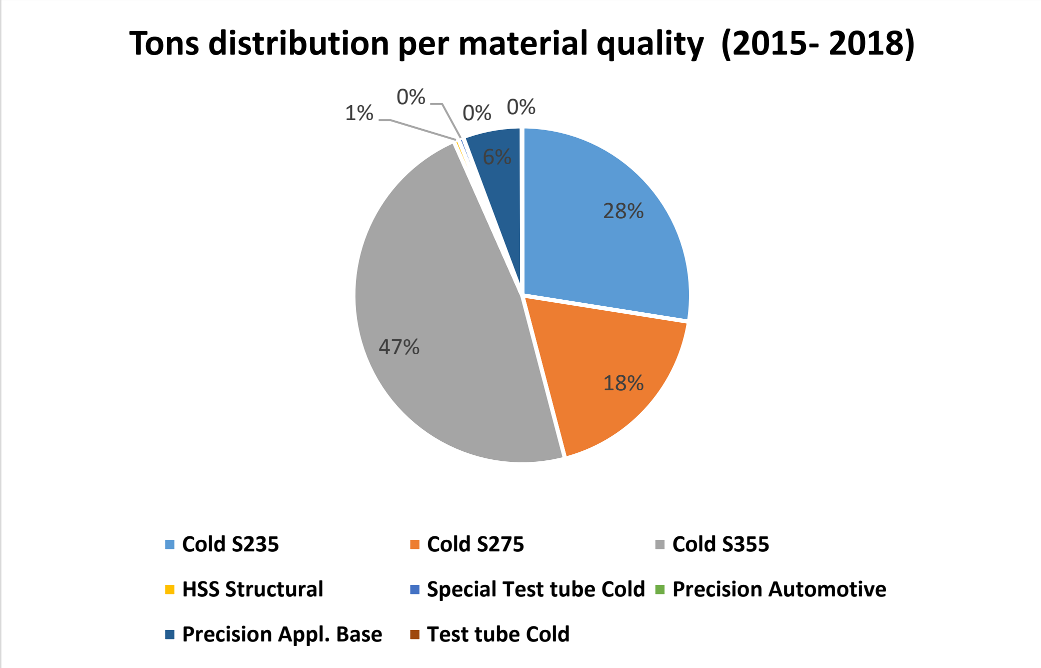


Figure 3. 7 Tons per material quality (2015-2018)

Interesting are the results derived from the margin chart (figure 3.8). The margin chart shows that ColdS235, one of the materials that generates more revenue (25%, figure 3.6), is the material that has the lowest impact in the total margin (negative -9%, figure 3.8). On the other side the Precision Application Base consists in more than 28% of the total margin obtained during the last four years given a total revenue of only 7%.

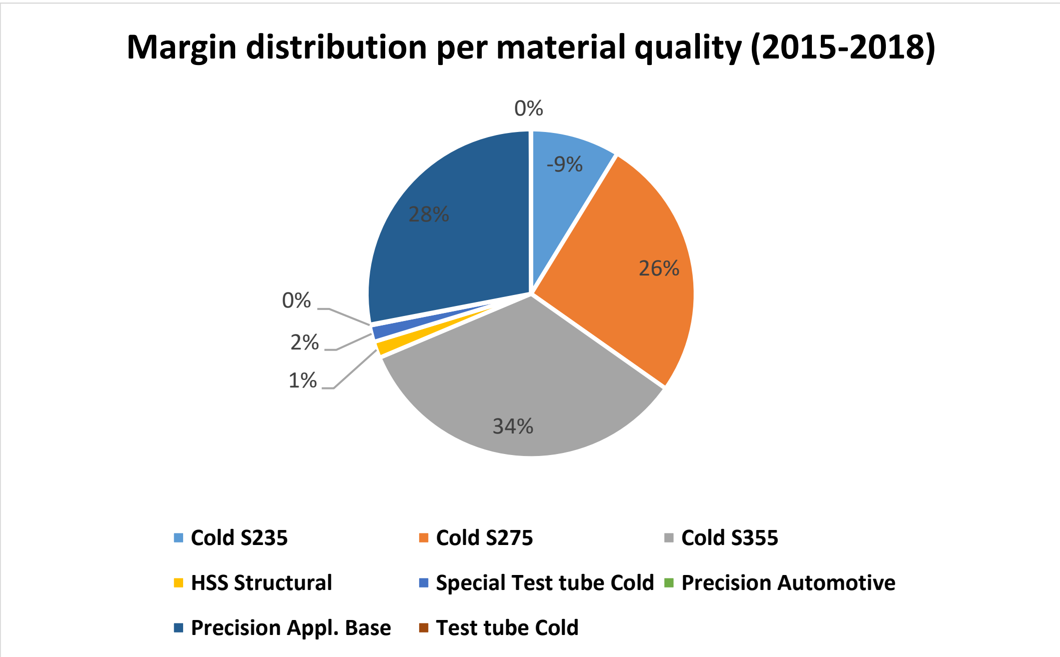


Figure 3.8 Total margin per material quality (2015-2018)

The next data table reveals us that the margin per ton per material quality and the amount of tons produced per material quality by Tata Steel Tubes do not follow the same ranking. The items that Tata Steel Tubes produces more are the ones were the margin is lower.

	Number of SKUs	*% of Tot SKUs*	*Tot tons*	*% Amount of Tons*	*Margin $*	*Margin $ per ton*	*Total Revenue €*
Cold S235	230	8.57%	85,066.15 tons	27.88%	-€ 574,340.84	€ -6.75	€ 45,477,749.18
Cold S275	761	28.34%	56,946.09 tons	18.51%	€ 1,705,493.66	€ 29.95	€ 31,829,439.35
Cold S355	1637	60.97%	146,701.95 tons	47.43%	€ 2,220,805.48	€ 15.14	€ 86,881,320.13
HSS structural	31	1.15%	1,481.78 tons	0.48%	€ 106,644.95	€ 71.97	€ 1,061,030.61
Precision Appl. Base	18	0.67%	17,492.03 tons	5.66%	€ 1,833,919.88	€ 104.84	€ 12,343,563.98
Precision Automotive	3	0.11%	8.49 tons	0.00%	-€ 5,960.15	€ -701.87	€ 357.69
Special Test Tube Cold	1	0.04%	30.38 tons	0.00%	-€ 1978.56	€ -15.43	€ 546.47
Test Tube Cold	4	0.15%	113.96 tons	0.04%	-€ 2,673.46	€ -23.46	€ 76,596.84

Table 3.4 Material characteristics (2015-2018)

The table above shows how the Precision Application Tubes is the group with the highest margin € per ton (104.84 €). We have decided to analyse in detail the production costs of this group. The production cost, as introduced in chapter 2, are current calculated considering the product of the machine time utilization (derived from the norms speed value of a specific SKU) and the production machine shadow price (3163€/hour). First of all we have compared the norms speed values with the values of the average real speeds of the last four year of the SKUs part of the Precision Application Tubes group. The next chart shows the values of both for all Precision Application Tubes produced during the last four years by Tata Steel Tubes in Zwijndrecht.

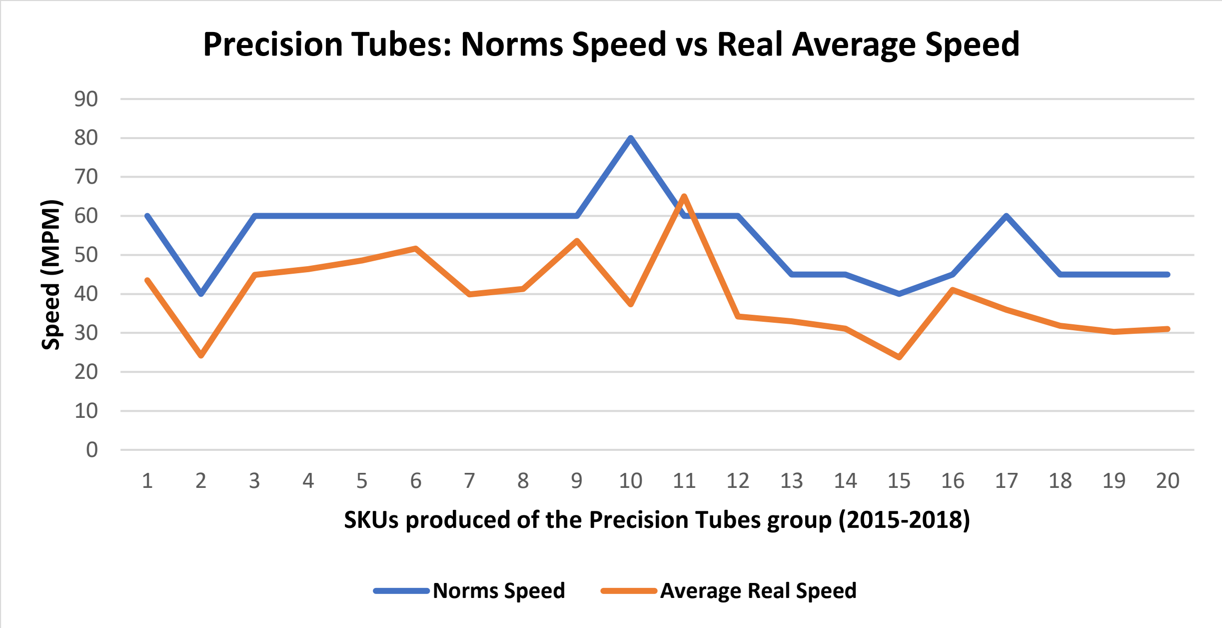


Figure 3. 9 Speed comparison, Precision Tubes group

It is visible from the figure above that the norms speed values are always optimistic (except one case) compared to the average real speeds values. The prices calculated by the norms speed result under-pricing the values of the SKUs. This can be derived from the next figure where we compared the SKUs prices calculated with the norms speed and the prices calculated with the historically average speeds of the SKUs of the Precision Application Tubes group produced during the last four years.

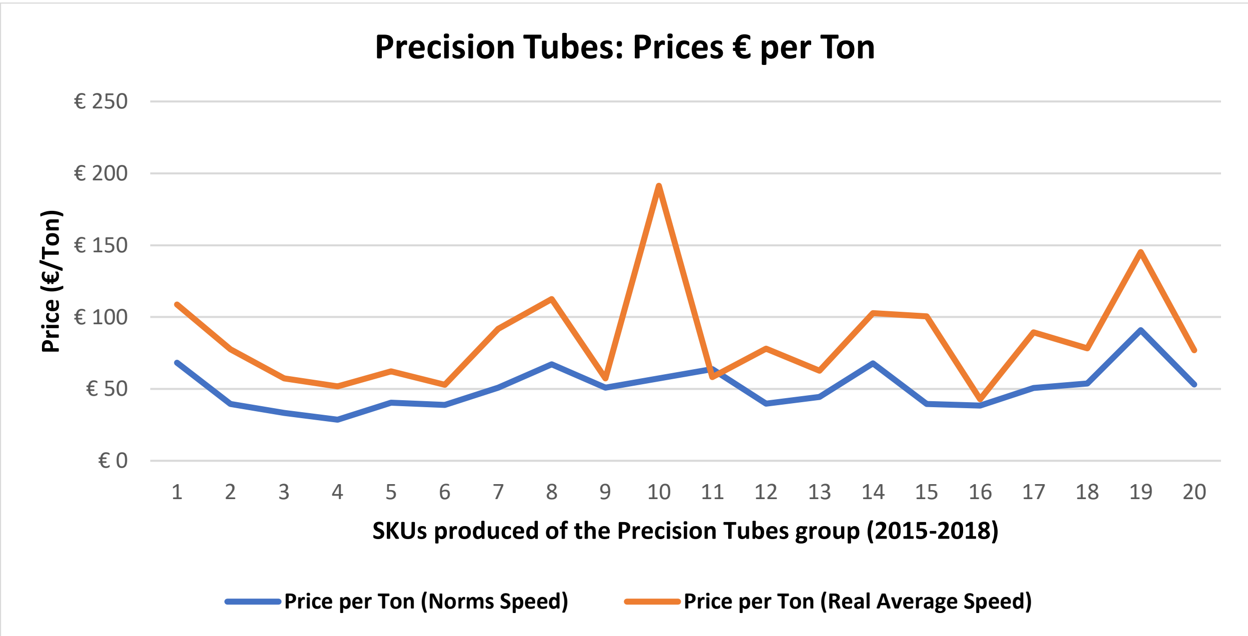


Figure 3.10 Comparison of the prices calculated with the Norms Speed and with the Real Average Speed for the SKUs of the Precision Tubes group

On the base of the production data it can be seen that if we consider the difference between the average real production price (derived from the historical average real speeds) per ton and the expected price (derived from the norms speed values), the Precision Application Tubes group results on average 34.04€ per ton under-priced in the production process.

In the next chart (figure 3.11) we compare the norms speed values of the ColdS235 group with the historically average speeds values of the last four years. Figure 3.11 shows that, differente then the Precision Application Tubes group view before (figure 3.9), the ColdS235 group has many products that actually result to have a historically average speed higher that the norms speed.

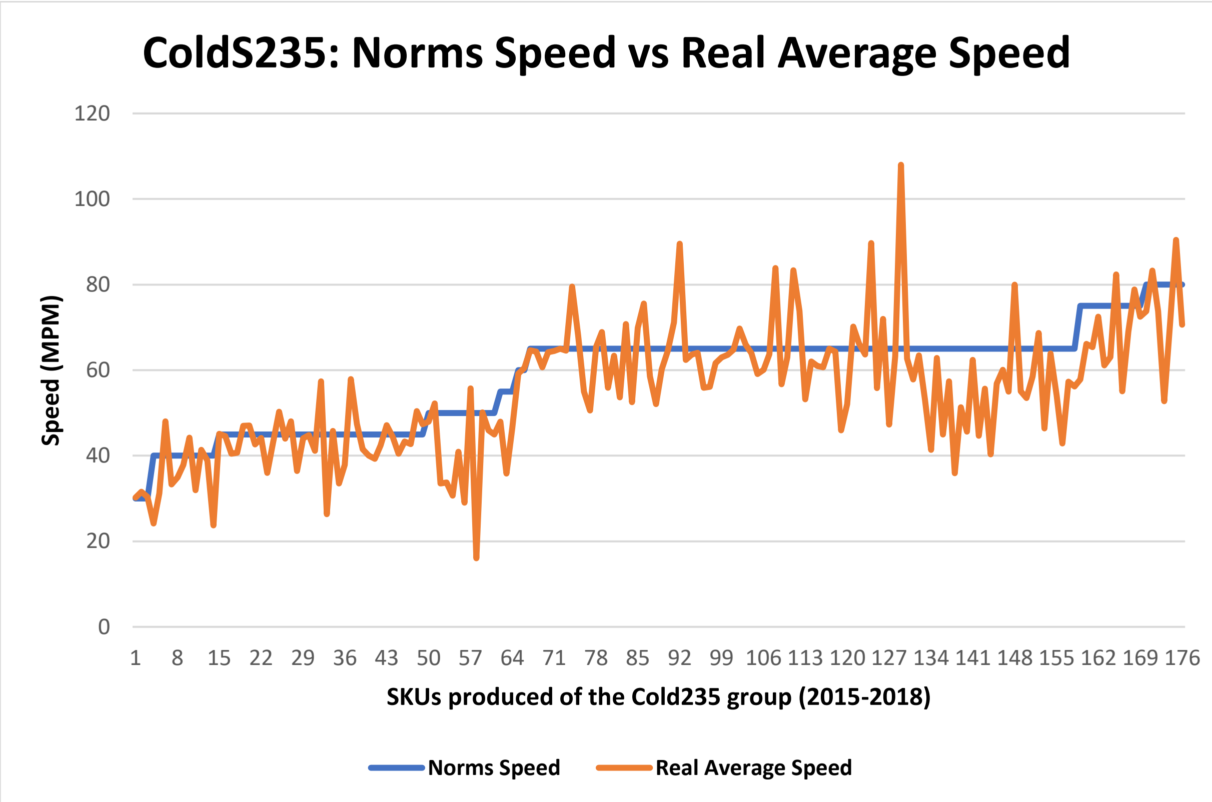


Figure 3.11 Speed comparison, ColdS235 group

Looking to the next chart where we compare the prices of the SKUs calculated with the norms speed values and the historically average speeds values for the ColdS235 group it can be seen that the prices follow a really similar trend. On average the group ColdS235 result 4.57 € under-priced in the production process. A really smaller difference if we compare it with the results of the Precision Tubes group (34.04€ under-priced).

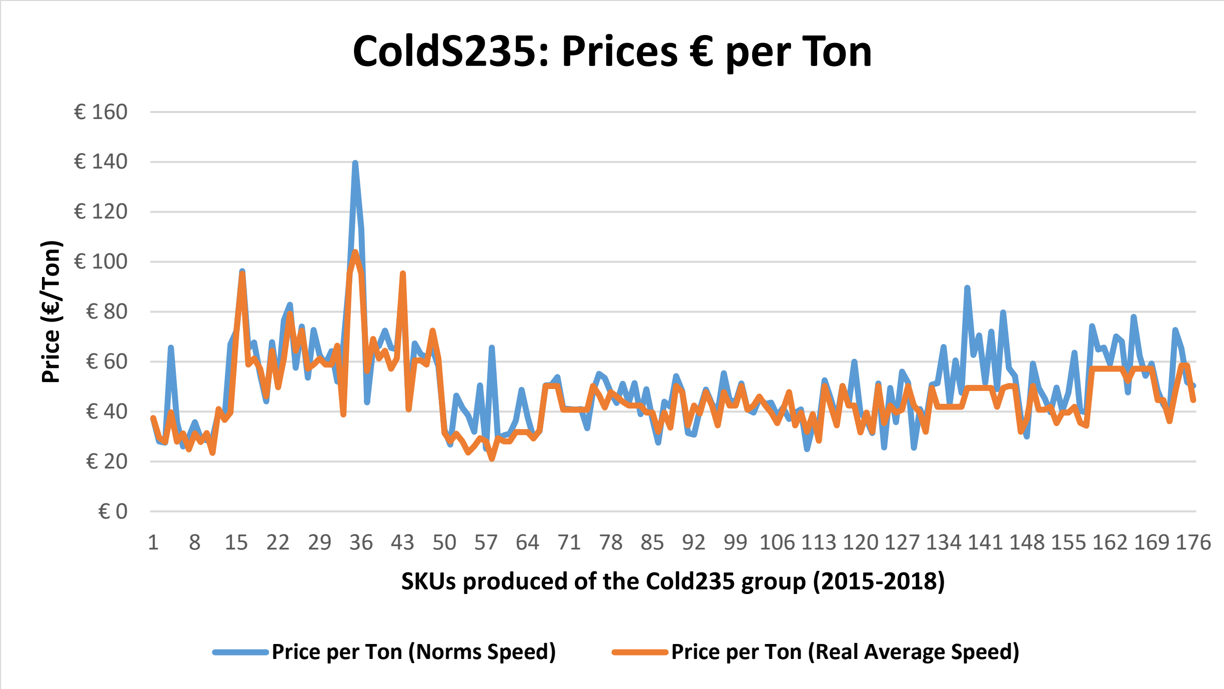


Figure 3.12 Comparison of the prices calculated with the Norms Speed and with the Real Average Speed for the SKUs of the ColdS235 group

Similar results can be derived from the ColdS275 and the ColdS355 groups. In the next two charts we show the comparison of the real average speeds values and the norms speed values for the two groups. It can be seen that as viewed in the ColdS235 analysis the norms speed values and the real average speeds values follow the same trend for both the groups. However, for both groups it is visible how for many SKUs the real average speeds is twice faster or twice slower that the norms speed. That indicate that the production machine has considerable volatile performances producing these kind of tubes.

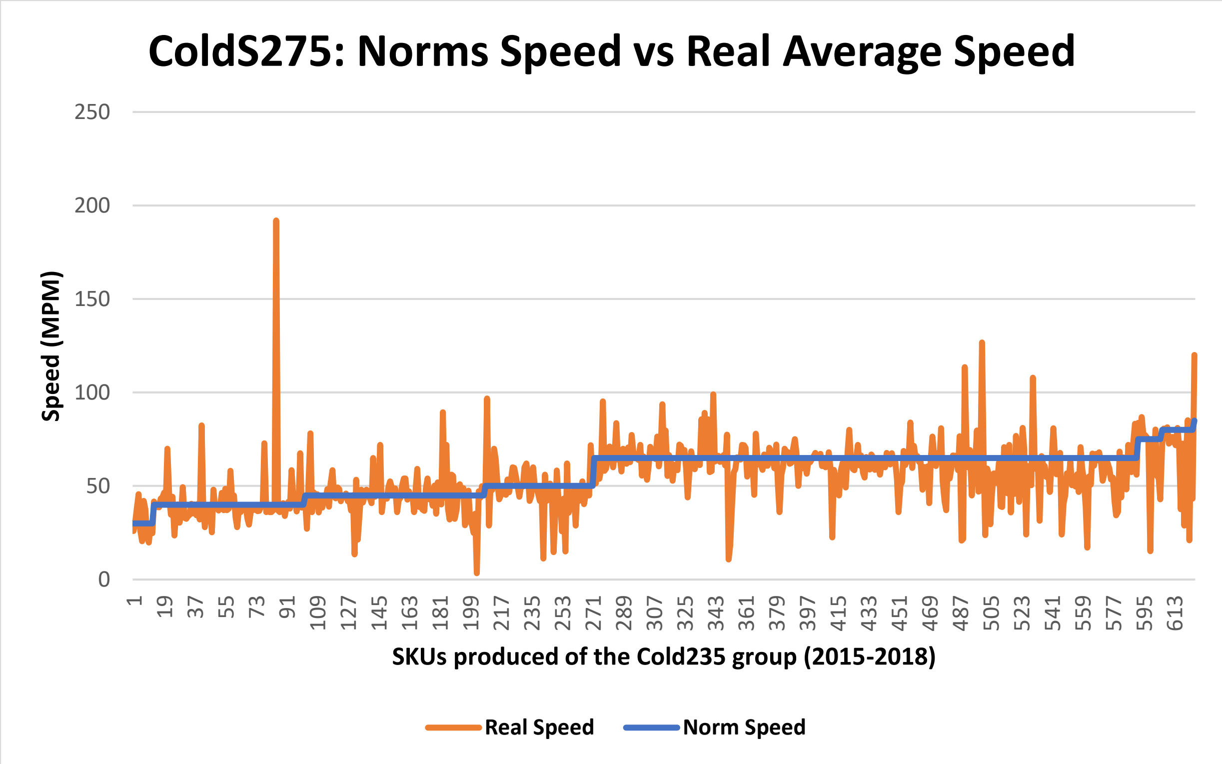


Figure 3.13 Speed comparison ColdS275 group

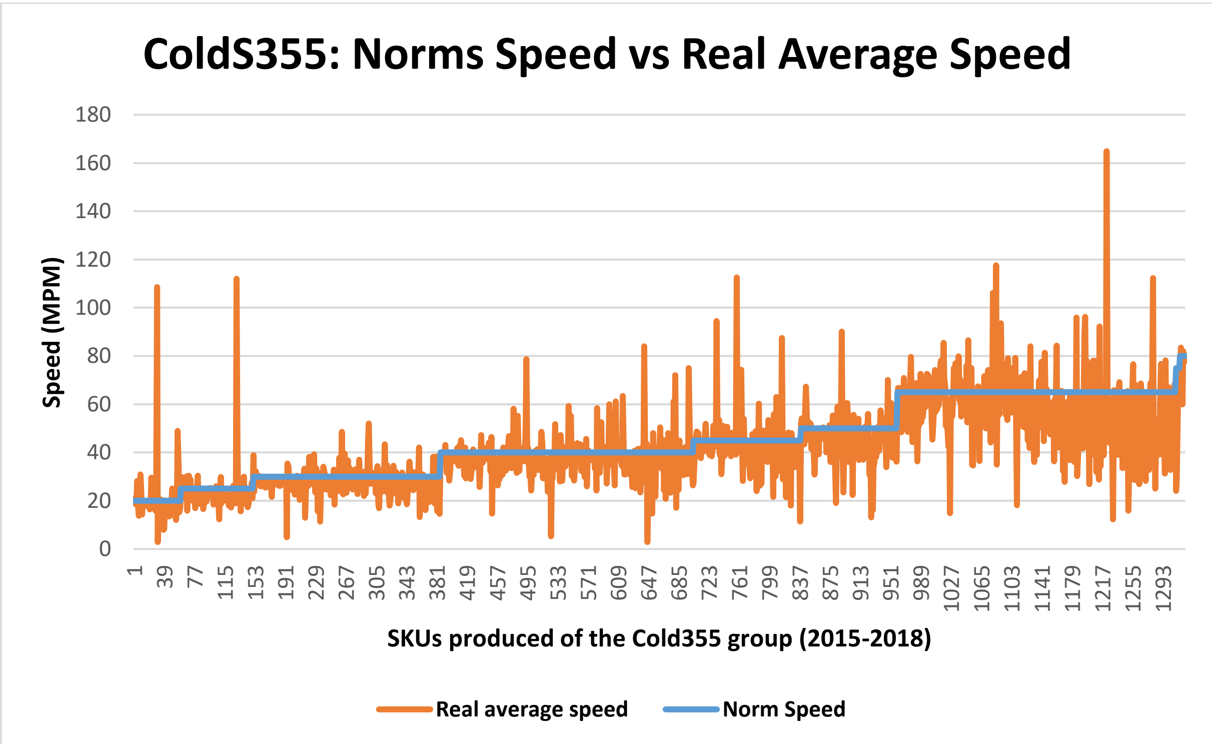


Figure 3.14 Speed comparison, ColdS355 group

If we analyse now what the estimate SKUs prices will be if we use the real average speeds instead of the norms speeds for the groups ColdS275 and ColdS355 is evident that the price derived from the norms speeds value is also in this cases optimistic. Indeed from the prices analysis the ColdS275 group results on average 5.92€ under-priced and the group ColdS355 6.09€ (under-priced) on average.

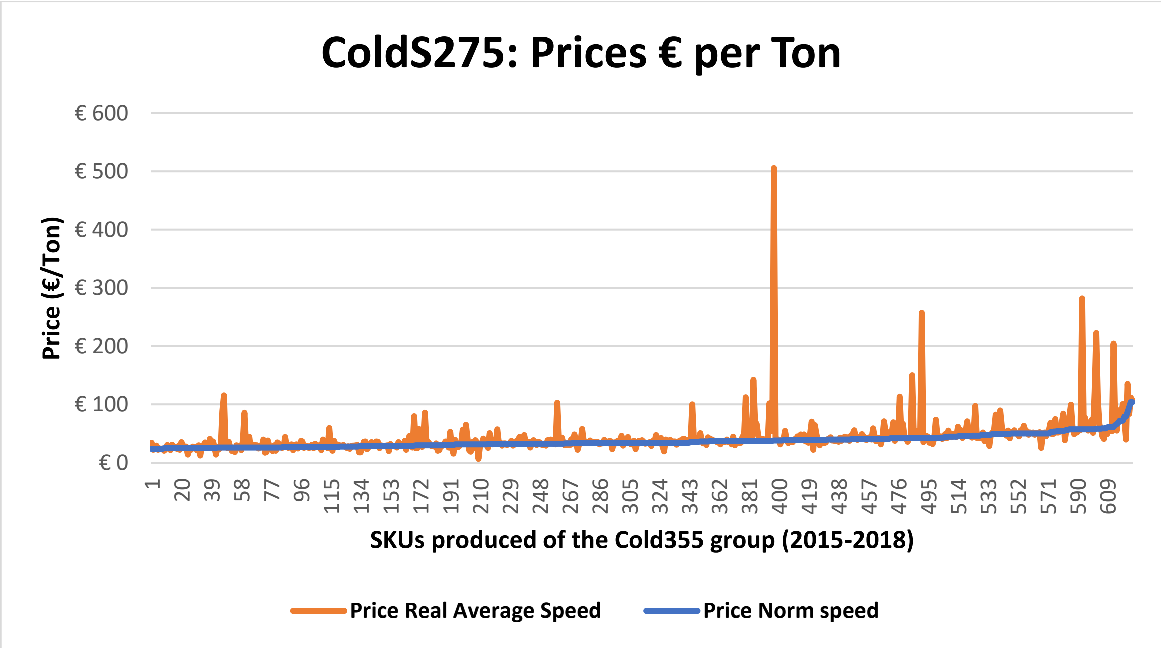


Figure 3.15 Comparison of the prices calculated with the Norms Speed and with the Real Average Speed for the SKUs of the ColdS275 group

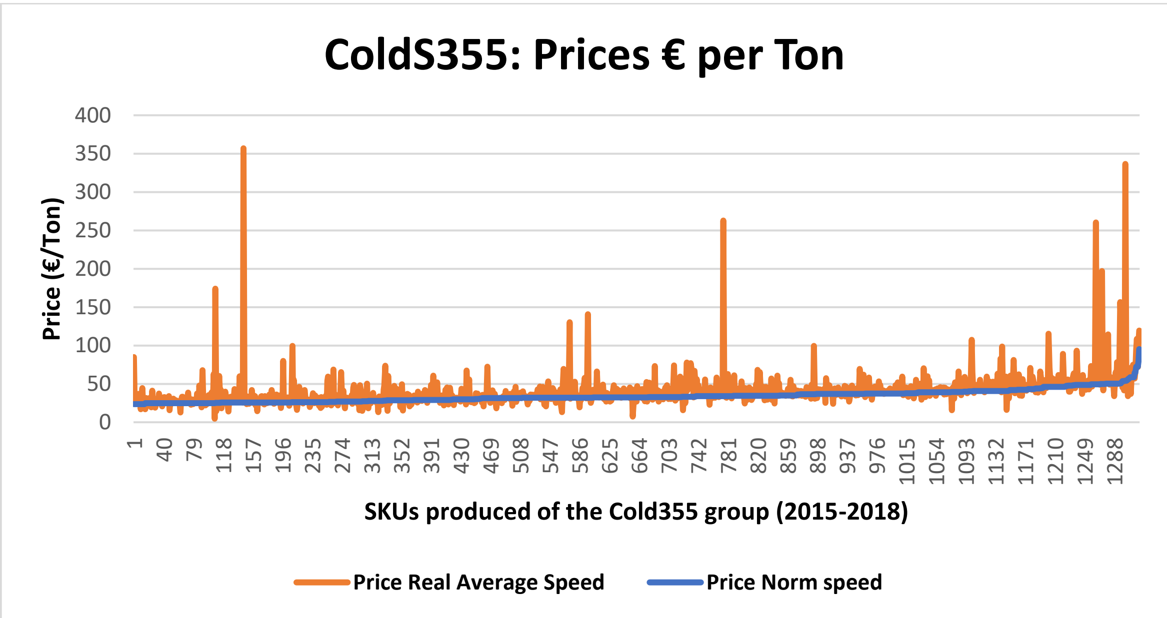


Figure 3. 16 Comparison of the prices calculated with the Norms Speed and with the Real Average Speed for the SKUs of the ColdS355 group

3.4 Conclusions

The chapter starts by introducing the different classification strategies present in the literature for FMCG companies. The ABC classification is considered the most proper one for the characteristics of Tata Steel Tubes and the conducted analysis points out that 80% of the total net turnover is made by 14% of the total construction tubes. A margin analysis is then conducted and it shows that the margin is not following the same pattern as the revenues and it results volatile.

After that a shape and a material quality profitability analysis are conducted.

The shape analysis points out that there is not a consistent difference between the types of shapes concerning: the amount of tons produced, the revenues and the margin euro per ton.

Different are the results of the material quality analysis. Comparing the revenues with the amount of produced tons these result correlated (for high revenues high amount of tons), the margin euro per ton does not result higher for products with less production (as expected). Some material quality groups have negative margin euro per tons; this happens because one of the goals of Tata Steel Tubes is to produce a certain amount of tons per year (Tata Steel yearly plan).

Chapter 4 Pricing analysis

In this chapter we start introducing the key factors that generally determine steel products prices. We then describe what pricing strategies are presented in the literature and we explain what approach Tata Steel Tube is currently using. The approach used to price the construction tubes in Zwijndrecht, is mostly based on the production process costs and market price analysis. We investigate how the pricing phase is currently made and we try to point out the weakness of the current pricing strategy and to propose improvements. The costs related to the production and warehousing phases are particularly investigated.

4.1 The Key Factors that determine Steel Product Prices

To be able to price steel products it is necessary to know well the steel market. This means paying attention to factors that influence the price of steel, or can cause disruption or fluctuation in the market. Like other commodities, metal prices are always shifting in ways that are critical to company businesses and those in adjacent industries. So it is fundamental to rigorously monitor circumstances that impact steel prices. The main factors to monitor are ranked in order of importance and are below described:

I. Supply and Demand

As with any commodity, supply and demand is a huge factor that determines steel prices. The higher the demand, the lower the supply, the higher the price. Price of steel is determined not just by current supply and demand, but by forecasted supply and demand. The more information available, the better this can be predicted, and the less volatile prices will be. This is considered the most important factor in the determination of the steel price. In the last few decades, it sometimes happened that the price of steel products rapidly doubled compared to the average price of the year before. That happened for example in 2005 when the China's demand drastically increased and the world supply was not enough to cover such incremented demand, therefore there was a shortage in the global market[1].

II. Costs of Materials

Scrap metal and iron ore are two of the main materials used to create steel. If there is a limited amount of these resources available, demand exceeds supply, and the cost of materials will jump up.

III. Industry Trends

Price is also influenced by the demand of the various industries using steel. For example if the construction industry is strong, the demand for steel may be higher.

IV. Costs of Shipping

Materials used to create steel products can be costly to ship. If shipping overseas, politics could play a role (e.g. Brexit), and the same goes for the costs of labour and fuel. We must also consider the risk and lead time associated with the given shipping mode. In a volatile steel market, selecting a transport method with a longer transit time can have a huge implication.

V. Time of the Year

Time of year has its effect on many industries, also on those that use steel. Holidays, weather, and seasonal factors affect the output of new products, either raising or lowering demand. Seasonality can impact shipping patterns and transit modes. And with changing demand, of course, comes pricing fluctuations.

A constant conversation with customers and suppliers on these topics is absolutely necessary.

4.2 Theoretical Pricing strategies

According to Kotler and Armstrong (2012)[2], in the literature on pricing, there are three fundamental strategies one can use in the process of deciding the price. Cost-based Pricing is from the corporation's perspective and Customer Value-based and Competition-based are from the customer's and competition's perspectives, respectively. In figure 4.1 the difference in the processes of the three pricing strategies can been seen.

- Customer Value-based pricing relies on the fact that, in the end, it is the customer who chooses whether or not the price is right, not the business, and the price should reflect the customers' perceived value of the product or service.

- Competition-based pricing relies on the assumption that the customer's decision to buy depends on the prices that competitors charge for similar products [2].

- Cost-based pricing relies on the fact that the business's total costs need to be covered and that the business's desired profit margin have to be applied on top of those costs.

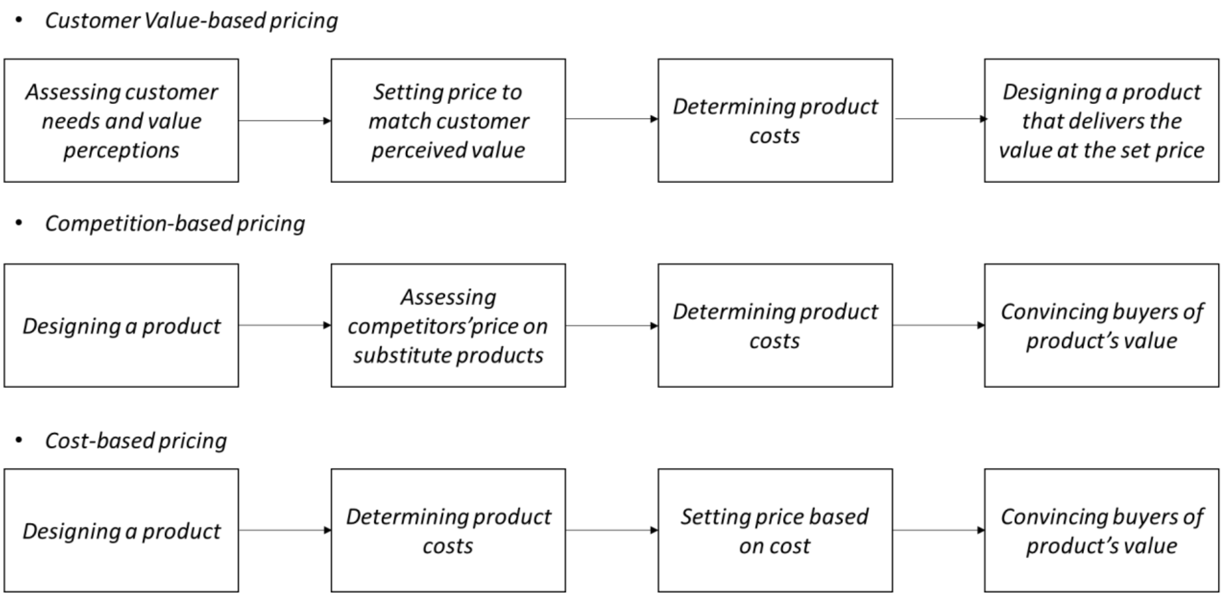


Figure 4. 1 The processes of the three pricing strategies

4.2.1 Drawbacks of the strategies

- Customer Value-based pricing

Among the three pricing strategies proposed by Kotler and Armstrong's (2012)[2], the Customer Value-based pricing strategy is the most favoured pricing strategy in the literature. However, it has its drawbacks since it could require extensive customer analysis in terms of customers' preferences, willingness to pay, price elasticity and market segments. It also has its drawbacks when it comes to the value assessment of the product. It is difficult for businesses to obtain reliable value assessments and to communicate the value to the consumer. Nagle et al. (2011)[3] also highlight that consumers have an incentive to conceal their true purchasing power, and thus, making it even harder for the businesses with the value assessment.

- Competition-based pricing

The Competition-based pricing strategy is probably the least favoured in the literature. Nagle et al. (2011)[3] state that in the minds of the managers, this approach is 'pricing strategically', while he implies that it is not. The drawbacks of this approach are that the demand is not considered and it could be problematic to look at other competitors and compare since they might have low margins. In addition, the competitor might have developed a more efficient production process, which makes price comparisons further problematic. Moreover, market data and price information become outdated quickly, which makes the strategy difficult to implement.

- Cost-based pricing

Among the three, the most well-used pricing strategy in practice is the Cost-based pricing strategy. However, according to Nagle et al. (2011)[3], this strategy results in mediocre financial performance. Since unit cost is variable, it is not possible to determine the price before determining the unit costs. Changing the price in hindsight due to unexpected production costs can lead to long-term losses in profitability. Nagle et al. (2011)[3] state that it is difficult for manufacturing industries to try to determine products' unit costs in advance. Other complicating factors in implementing this strategy is the pressure from the competition and the business size. The business size is crucial in order to work as a price leader and to obtain economies of scale.

4.3 Analysis of the Cost-based pricing strategy used by Tata Steel Tubes

The pricing strategy currently used by Tata Steel Tubes as introduced in chapter 2, is a combination of Cost-based pricing, Competition-based pricing and Market pricing. The Cost-based price per SKU, is calculated by the order book to predict the SKU's prices. The other two strategies are used to refine the SKU's prices during the negotiation phase. Given the aim of this research to align the production and Sales department goals and to create a pricing control model, we will now analyse the different cost phases, how they are evaluated and in what way they can be improved. The negotiation phase that determines the final pricing corrections are not considered in this research because they are based on the Sales department experience and relationship with the customers.

4.3.1 Production costs

The production costs are currently calculated in function of the hours needed during the production process and is based on the production speed (3163 €/hour). The production speed is a variable that has an high volatility. That is because during the continuous production process, as discussed in chapter 1 and 2, different steps have to be done and if only one of them stops or goes slower than expected, all the production process will be influenced. At Tata Steel Tubes in Zwijndrecht the production costs are calculated through an expected speed that varies for each type of tube. The expected speed is predicted by Tata Steel trying to be as close as possible to the real speed. These norm speeds are used in the quotation of a customer's order.

During the production phase waste material and some defected products are coming out. The quantity of waste material and defective products generated are different for each type of tube. Usually products with an higher superficial quality, low engineering tolerances and small thickness produce more defected items given the higher difficulties during the production process.

Analysing the production performances during 2015 and 2018 of the all construction tubes produced in Zwijndrecht by Tata Steel Tubes, it came out that the expected production speeds were a bit optimistic compared to the real speeds values (figure 4.2). Comparing the average real speed values based on historical data and the norms speed values of all the products produced during 2015 and 2018 we discover that using the norms speed a product is expected to be on average 4.54 MPM faster than what would be the average historical production speed. That means that the speed during the production phase of the SKUs produced in Zwijndrecht is overestimated and that generate an under-pricing of the production phase (given that the production cost evaluation is based on the speed of the products).

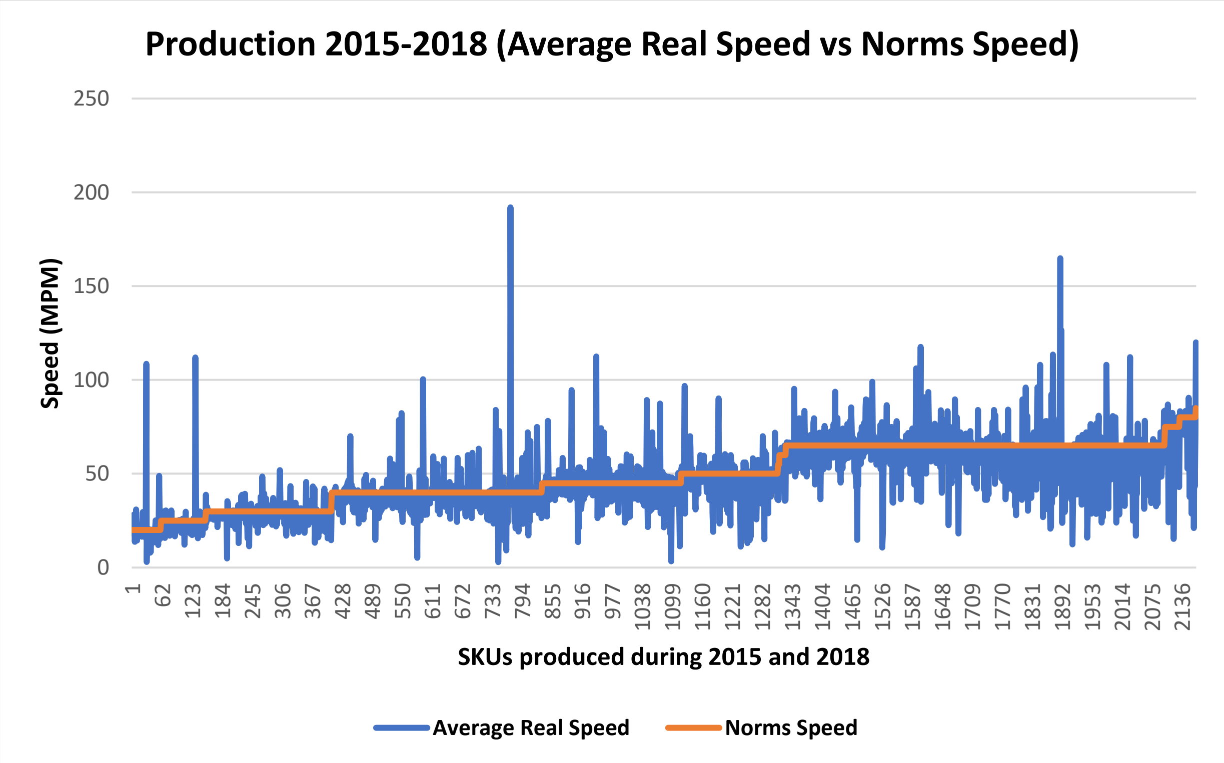


Figure 4. 2 Construction tubes production speeds. Comparison between the average historical speed and the norms speed

In the next graph we compare the production price calculated with the real average speeds and the expected price derived from the expected speed. It can be seen that generally the two pricing methodology follow the same trend, indeed each product result on average 6.08 euro under-priced but many peak values (extreme values) are visible in the next chart.

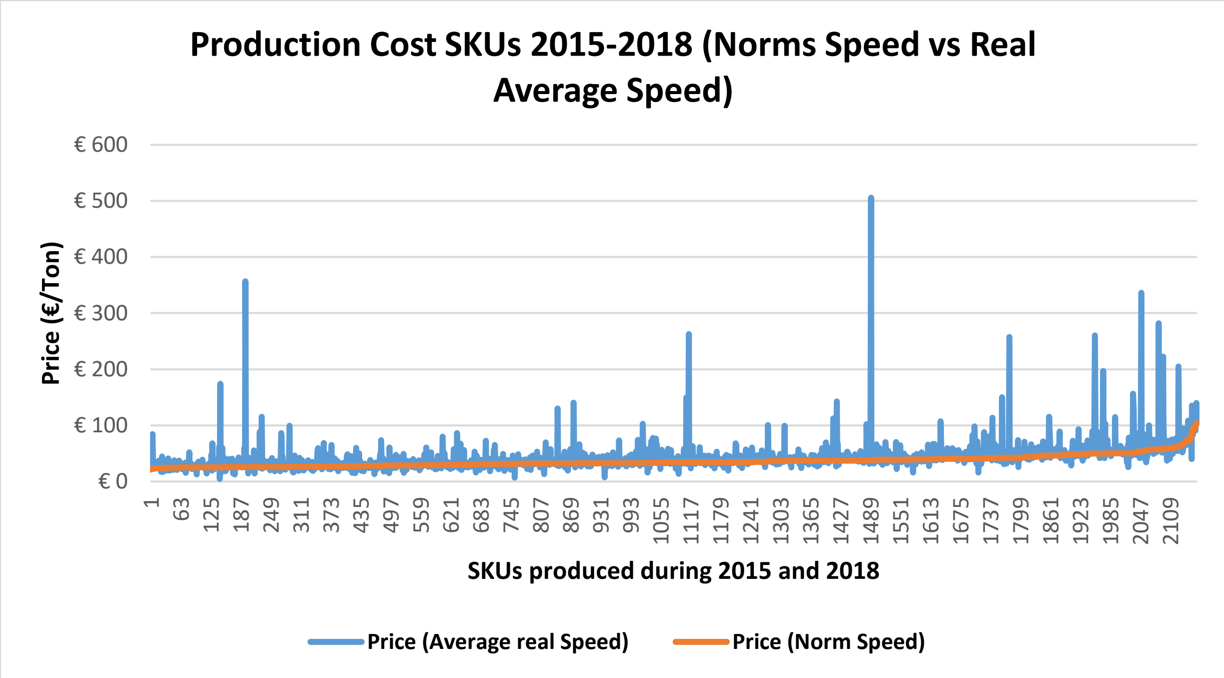


Figure 4.3 Construction tubes production price. Comparison between the price calculated with the historical average speed and the price calculated with the norms speed

4.3.2 Warehousing costs

The cost of operating a warehouse can vary on average between 1 and 5 per cent of the total sales price, depending on the type of company and the value of its goods. As a result, warehouse managers require a comprehensive knowledge of all costs and cost drivers within the warehouse as they are under significant pressure to reduce costs yet continue to produce optimum customer service with the added pressure of reducing inventory. Managers are also expected to contribute data to the company budget and continually reassess the resource and cost budget in line with the actual operation [4].

Tata Steel Tubes warehousing costs are calculated considering a fixed price per stored ton. The price per one ton is estimated as 16.94 € in the current pricing methodology. This pricing method in a warehouse with limited capacity is not precisely reflecting the different characteristics of the SKUs, especially the effective volume occupied by them, that compared to the weight has a greater impact on the warehousing utilization. From different interviews (Interview: Logistic Manager and France/Benelux seller) it came out that this pricing strategy is causing managerial conflicts between the Logistic and Sales departments. That is because the warehousing cost is not perfectly reflecting the SKU warehouse utilization. The effective volume occupied and the time spent in the warehouse by the SKUs in Zwijndrecht are not considered in the cost estimation. The warehousing phase is highly correlated to the production performances, in fact the complete utilization of the warehouse capacity or the postponement of a delivery caused by lack of space can result in a mandatory break of production, which means a high waste of money for Tata Steel Tubes.

4.3.3 Slitting costs

During the slitting phase the coils are cut in rings. Depending on the quality and thickness of the coils the slitting phase invests different amount of time. The slitting costs are calculated considering the norm slitting speed of the specific coil and are evaluated as 2962 euro per hour. An analysis to compare the expected speed (norm speed) and the historical speeds values has been done. However the data related to the slitting phase present a lot of extreme values, mostly infeasible values (e.g. some seconds to slit a coil). We consider the conclusions coming from this analysis as not statistically significant. It seems that the procedure of collecting this data is not working well. Given that the procedure of collecting these data in not working well, it is so not possible to compare the norms values to the historical speed values.

4.3.4 Sales costs

Tata Steel tubes sales' costs depends on the amount of the sold tons. A cost per ton is applied to every SKU that is sold. The fixed cost is evaluated 11 euro per ton. As this current estimation is considered to be a valid approximation for the aim of this research, it will not be investigated in search of improvements.

4.4 Conclusions

This chapter starts identifying the key factors that determine the price of steel products. Then we present the theoretical pricing strategies discussed in the literature and the drawbacks of these strategies.

The current Cost-base pricing strategy used by Tata Steel in Zwijndrecht is examined for the different production phases: production, warehouse, slitting and selling.

The production and warehousing costs calculations result not perfectly depicting the real costs of the Zwijndrecht factory, for this end in the next chapter we will search for improvement.

The conclusions coming from the slitting costs evaluation cannot be considered, given that these data are not statistically significant because of a not accurate data collecting procedure.

The sales costs evaluation is considered a valid approximation for the aim of this research.

Chapter 5 Proposed improvement in the Cost-based pricing strategy

After having described the current pricing methodology and the weakness of some strategies used to calculate the cost related to the production processes, we will now search for improvements in the cost-based pricing strategy applied to the production process phases.

A new pricing strategy will be developed and a comparison of the two procedures will be made in order to better understand their implementation on the pricing phase.

The warehousing costs in the new procedure are calculated based on the effective space occupied in the warehouse, whilst in the methodology currently used by Tata Steel Tubes it is calculated by considering a fixed price per ton. Moreover in the new methodology a difference is made for the pricing of SKUs that can be stored in the external warehouse. As for the production costs, in the new methodology they are calculated considering the production speed of the tubes, as is currently done by Tata Steel Tubes. However, different in the new pricing method is that the production costs are calculated considering the historical average speed per welding diameter of the tubes and price penalties are applied if the tube has a determinate length procuring more complications in the production process.

5.1 Warehousing costs

Having the ability to properly calculate and report the actual warehouse storage costs is a key element in the financial, logistic and inventory planning. There are many factors which must be considered when calculating these expenses. Capturing these data can be challenging, but is critical if a company wants to know the real costs and profits, and determine where improvements can and should be made. In practice the available volume has to be modified by an utilization factor which will always be less than one. How much less than one depends on a number of additional factors, including:

Storage method: The two basic methods are fixed and fluid. In fixed-location storage, each (SKU) is always kept in a specific location. No other SKU can be stored in that location, even if the location is empty. In fluid-location storage, any SKU can be assigned to any free location. It is possible to have both fixed and fluid systems operating in a warehouse simultaneously.

Dimensional compatibility: The way in which the product fits the available storage space. For example a tube that is 15 m long will make poor use of a 20 m long space.

Space occupied by additional elements: The construction tubes produced in Zwijndrecht have only a plastic bundle as additional element but it does not have any relevant impact on the occupied space.

Unsuitable zones: Some areas may be unsuitable for storing particular products due to SKUs characteristics. For Tata Steel Tubes only a few products are able to be stored in the external warehouse, namely products that are mainly used for underground constructions; therefore a particular superficial quality is not needed.

Considering the factors explained above for the calculation of the warehouse costs and after different consultations with the Logistics department we have decided to investigate:

1. The effective space utilizable in the warehouse
2. The effective utilization space of the warehouse used by each SKU
3. The use of the internal or the external warehouse

5.1.1 The effective space utilizable in the warehouse

To calculate the warehouse space utilizable in the Tata Steel Tubes warehouse in Zwijndrecht (figure 5.1) the next factors have to be considered:

- The piling of tubes' bundles is related to stability issues.
- A certain flexibility to be able to move easily with the cranes in the different warehouse halls is needed.
- Some buffer zones are required to facilitate the phase of uploading the delivery trucks.

Figure 5. 1 Warehouse construction tubes Tata Steel Tubes in Maastricht, it has the same space design of the Tata Steel Tubes warehouse for the construction tubes in Zwijndrecht and the product produced are comparable

The piling operation of the steel tubes has to be made with a certain number of precautions to guarantee the safety of the workforce firstly and secondly to prevent damage to the products. Stability rules are applied by the Logistic department to assure that these two points are guaranteed within a minimal risk. The application of these logistic rules makes effectively usable around 60% of the actual total space (in terms of height of the storage areas) of the warehouse.

The need of flexibility in the cranes' movement is solved by reducing the height of the utilized space compared with the effective available one.

Buffer zones are positioned next to the doors in order to facilitate the uploading of the trucks that enter the warehouse. These buffer zones are necessary to group the SKUs that will be picked up by the next coming truck. In this way the uploading phase will result faster. In our analysis we exclude these buffer zones from the calculation of the total available warehouse space for the SKUs storage.

The fixed location method seems to be more appropriate for the characteristics of the internal warehouse. The fixed location method has to be applied considering the length of the SKUs, so SKUs with same length (or between a certain interval) have to be positioned in the same area. In this way we try to fit tubes with a certain length in areas with approximately the same length.

In the two tables below we report the length and width of the areas available for storage in the different factory halls dedicated as warehouse. We indicate also the length of the tubes that can be positioned in a specific area. The total space available in the warehouse is 10,536m^3 and the effective volume of the SKUs given the space dimensions of the warehouse zones is between 0.0576m^3 and 1.4831m^3.

	H11 - Door 3,9		**H10 - Door 2,10**		**H9 - Door 25**	
	Tubes from 18 to 20m		*Tubes 12m*		*Tubes from 6 to 12m*	
	Width(m)	Length(m)	Width(m)	Length(m)	Width(m)	Length(m)
	2	20	15	12	12	8
	Tubes until *6m*		15	12	12	8
	Width(m)	Length(m)	15	12	12	12
	4	6	15	12	12	20
	4	6	15	12	Tubes until *6m*	
	4	6	15	12	Width(m)	Length(m)
	Tubes until 6m		15	12	6	18
	Width(m)	Length(m)	15	12	6	18
	10	6				
	10	6				
	10	6				
	10	6				
	10	6				
	10	6				
	10	10				
	10	6				
	10	6				
	10	6				
Area (m^2)		752		1440		792
Height (m)		3		3		3
Volume (m^3)		2256		4320		2376

Table 5.1 Warehouse halls 9,10,11 spaces

	H1 - Door 24		H5 - Door 20	
	Tubes from 6 to 12m		*Tubes from 12 to 18m*	
	Width(m)	Length(m)	Width(m)	Length(m)
	3	12	18	4
	3	12	18	4
			18	4
			18	4
	Tubes *12m*		18	4
	Width(m)	Length(m)	18	4
	6	12	18	4
	6	12	18	4
	6	12		
	6	12		
Area (m^2)		360		432
Height (m)		2		2
Volume (m^3)		720		864

Table 5.2 Warehouse halls 1,5 spaces

5.1.2 The effective utilization space of the warehouse used by each SKU

Knowing the allocation of the tubes (table 5.1 and 5.2) with a different length is fundamental to be able to calculate the effective volume that a SKU uses in a determinate area. In fact a tube with a dimension between the minimum and maximum length storable, will effectively occupy the same area as a tube with different length but the same width and height. That is because the space left over is not usable. In the effective volume calculation of the SKUs this reasoning is used to calculate the effective space utilized by the SKUs.

5.1.3 The use of internal or external warehouse

As already discussed the main bottleneck of Tata Steel Tubes is the space occupied by the construction tubes in the internal warehouse space. For what concerns the available external warehouse space, nowadays it is sufficient to storage all the SKUs for whom it is requested, but the normal utilization is only half of the available one. For this reason the SKUs that can be positioned outside (only tubes with determinate material characteristics), should be priced significantly less that the tubes that are stored inside where there is much less space available.

Consulting the Logistic and the Financial and Control departments we have decided to estimate the price of the SKUs that can be stored in the external warehouse with a price of 11 euro per m^3.

5.1.4 Proposed warehousing cost calculation and comparison with the current pricing method

As discussed before storage capacity plays a fundamental role in the ongoing of production. The actual warehousing cost calculation prices a SKU in function of its weight (tons), without taking into account that tubes of the same weight may have a completely different volume. Considering that tubes have different thicknesses, calculating the cost only on the base of their weight means evaluating at the same price products that occupy different spaces in the warehouse.

To solve this problem, we propose a new pricing strategy based on the determination of the effective space occupied by a product in the warehouse. This new strategy guarantees that products with the same volume will have the same price also if their weights are different, due to different thicknesses or base material of the SKUs. This policy is based on the fact that the air inside the tubes (depending of the thickness) is never usable for storing items. For this reason it should be considered as occupied space. It is clear that this new pricing strategy generates very different outcomes compared to the current one based on the weight of the items.

The new pricing strategy starts with the calculation of the effective volume occupied by each SKU. The effective volume is determined by multiplying the width, height and corrected length. With corrected length we mean that the SKU's length is increased until the value of the highest length that could be stored in a specific area. For example if a tube is 11m long and it is positioned in the area of the 12m tubes, the effective length occupied will be 12m.

We converted the current pricing strategy used by Tata Steel Tubes (17 euro per ton) to a price per SKU (figure 5.2 SKUs in increasing volume order). The next graph makes clear how the cost generally increases (trending orange line) with the increasing of the effective volume occupied by a SKU. It results that many items with similar values of volume have a considerable variation of their warehousing cost. The reason is that volume and weight of the SKUs are not directly proportional given the different thicknesses of tubes and the different space inside the hollow sections.

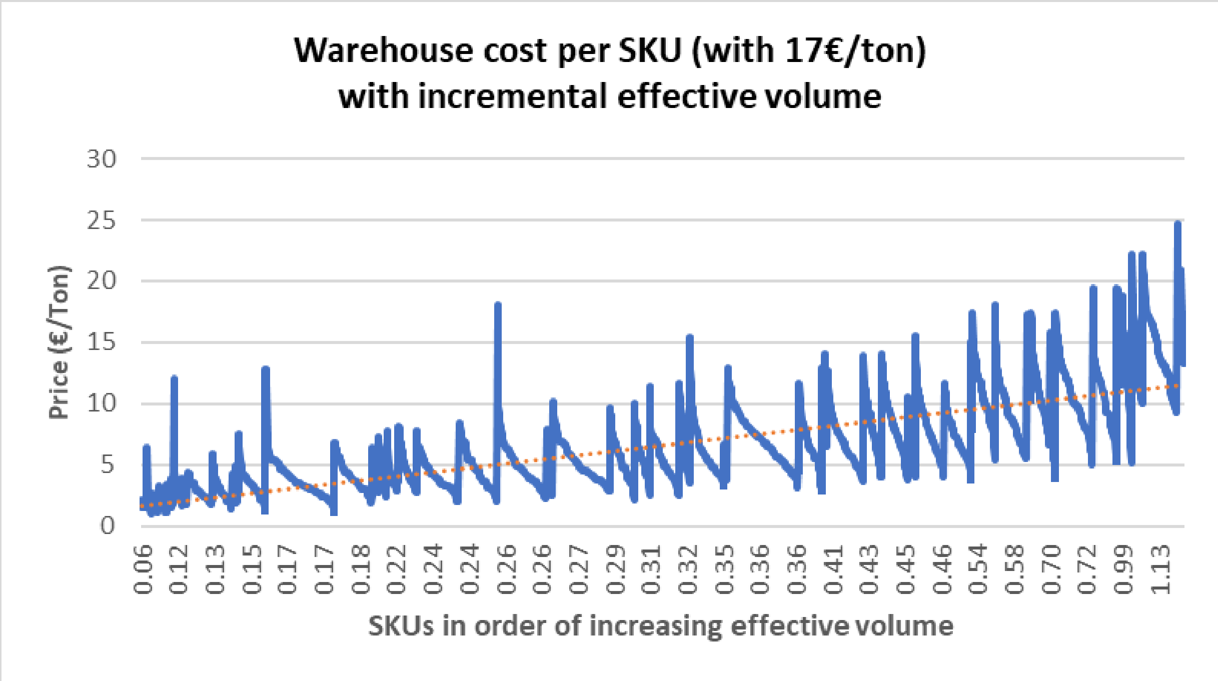


Figure 5. 2 Warehouse cost per SKU (incremental effective volume)

When converting the actual price per ton in a price per m^3 (figure 5.3), we can see on the trendline (orange line) that the products with higher volume tend to have a smaller price per volume compared with the products with low volume with the current pricing strategy used by Tata Steel Tubes (figure 5.3). The tubes with higher volume not only occupy more space in the warehouse but also generate more difficulties in the transportation and uploading phase (Interview: Manager logistics), and therefore their price per volume should be at least equal as the price per volume of the SKUs with smaller volume.

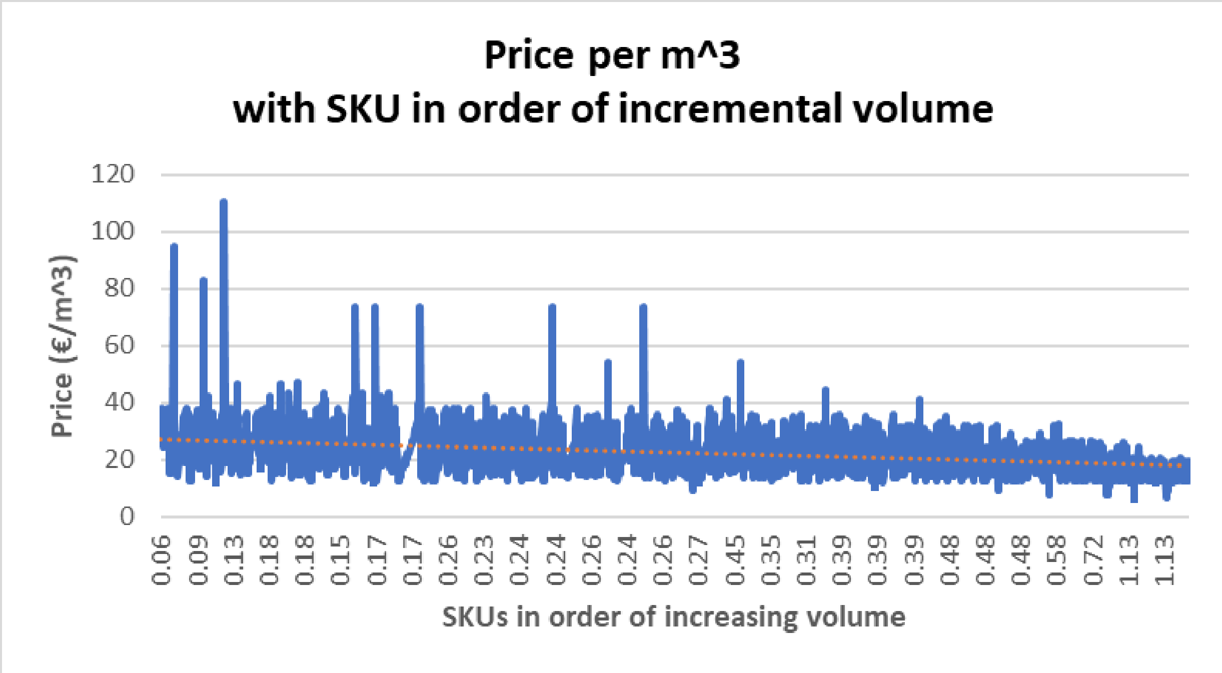


Figure 5.3 Warehousing costs per m^3

For this reason we propose to apply a new constant price per volume that we believe is more efficient considering the warehousing capacity limitation of the Zwijndrecht site. The constant price per volume we propose is built in such a way to prevent a too high variation with the cost derived from the current valuation, because in case of a too high increasing of the warehousing costs, we risk that customers will not accept. First we determine the prices per volume (m^3) deriving from the price per ton actually used for each SKU. Then we make an average of the prices per volume (m^3) obtaining the value of 22.423€/m^3. In the next graph we show the average price per m^3 according to the new pricing strategy (yellow line) and with the blue line the prices per m^3 for each SKU converting the price 17 euro per ton.

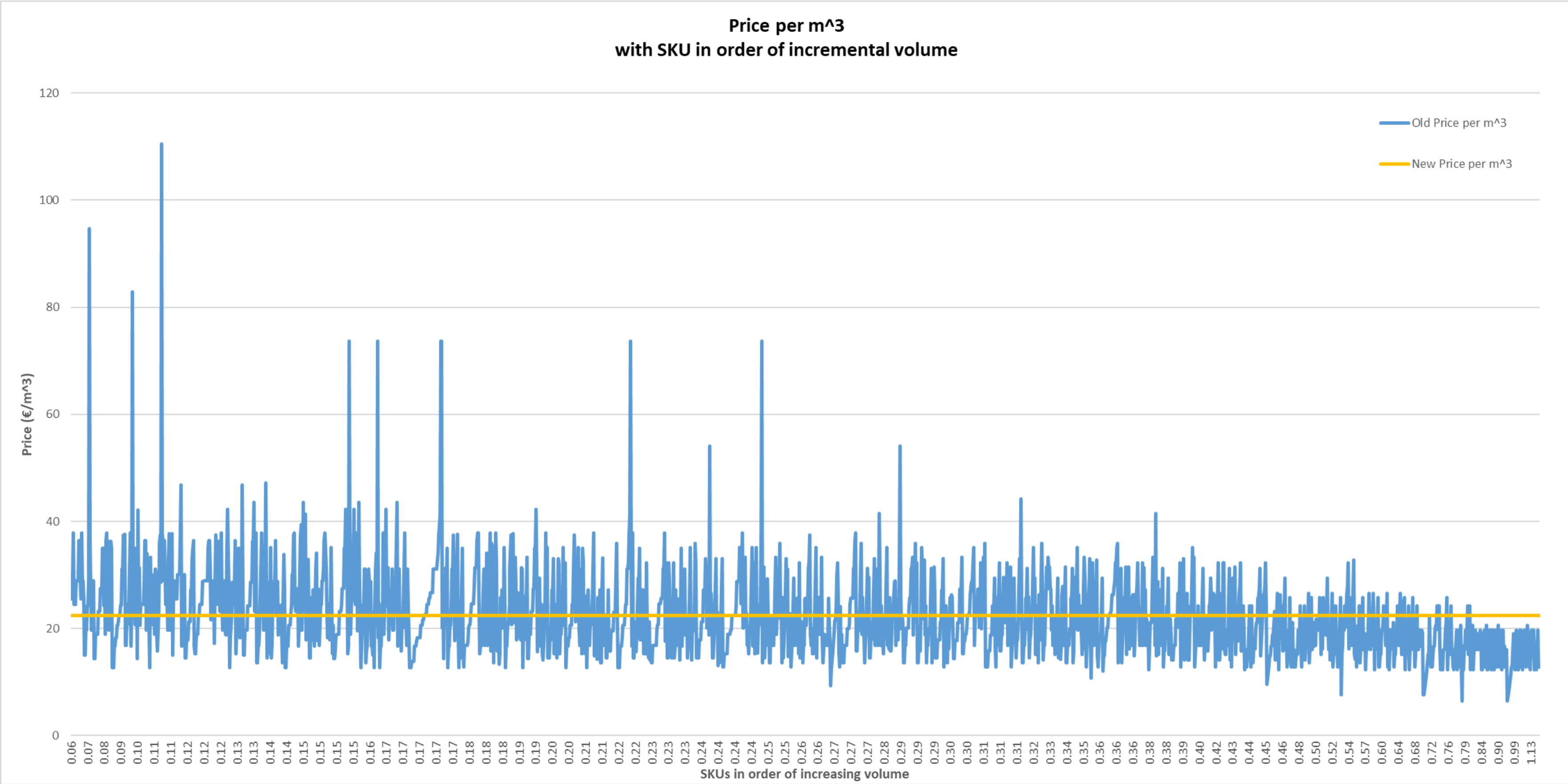


Figure 5.4 Comparison New vs Current price per m^3

In this new procedure the price is increasing with the effective space occupied in the warehouse.

5.2 Production Costs

As introduced in chapter 4 the current cost relative to the production machine are calculated considering the norms speed values of the specific SKUs produced. We saw how these norms values are different from the historical average speeds values and that every SKU end-price results, on average, in 6.08 euro under-pricing, calculating the final price with the norms speed value instead of with the average real historical speeds values. An extreme case was the Precision Application Tubes group that resulted being 34.04 euro under-priced.

Besides being influenced by the speed the cost of the tubes during the continuous production process we will see in chapter 7 how actually the production cost are also related to the expected production planned, which for a determinate week. That is because if the capacity planned is higher the fixed production costs are shared between more orders and that reduces costs per SKU (economy of scales).

5.2.1 Production performance per SKU

To understand how to effectively evaluate the performance of the SKUs during the continuous production process, different consultations with the Production department were done. The purpose of the consultations was to understand the factors that influence the speed of the tubes and how can we categorize them.

As we have seen before, the use of an average of the speeds of the historical data per singular SKU might give a wrong estimation of the expected performance of a future production. A categorization is therefore needed, because if two SKUs with all the same characteristic and only a different length, for example one 6 meter and the other one 9 meter, have to have similar estimated speed values.

5.2.2 Categorization of the SKUs for the production process

We have decided to first categorize the SKUs considering their welding diameter, these SKUs usually have the same height and width (or diameter in case of round tube), in the next figure we show the list of the different welding diameter and the height and width relations. With the result that the SKUs can be divided in 32 different welding diameter groups.

Welding diameter (mm)	*Shape*	*Measures (mm)*
125	Rectangular	100 X 100
125	Rectangular	120 X 80
139.7	Round	139.7
139.7	Rectangular	140 X 80
152.4	Rectangular	120 X 120
152.4	Rectangular	160 X 80
159	Round	159
159	Rectangular	150 X 100
159	Rectangular	160 X 90
164.4	Rectangular	180 X 80
168.3	Round	168.3
177.8	Rectangular	140 X 140
177.8	Rectangular	180 X 100
177.8	Rectangular	200 X 80
188	Rectangular	150 X 150
188	Rectangular	200 X 100
193.7	Round	193.7
202.3	Rectangular	160 X 160
202.3	Rectangular	200 X 120
219.1	Round	219.1
219.1	Rectangular	200 X 150
219.1	Rectangular	250 X 100
227.8	Rectangular	180 X 180
244.5	Rectangular	200 X 200
244.5	Rectangular	250 X 150
244.5	Rectangular	300 X 100
273	Round	273
312	Rectangular	250 X 250
312	Rectangular	300 X 200
323.9	Round	323.9
146.7	Round	146
156.7	Round	156
156.7	Rectangular	133 X 133
158.7	Round	158
159.1	Round	158.4
160.7	Round	160
162.7	Round	162
163.1	Round	162.4

Figure 5.5 Welding diameters

Other than the welding diameter another factor that influences the production process speed is the nominal thickness. Given a welding diameter, products with thickness of 8mm are estimated by the Production department to be 25% slower than the same product with smaller nominal thickness (e.g. 4mm, 6mm). And products with 10mm nominal thickness are estimated to be 50% slower.

Another factor that influences the SKUs performance is the length of the SKUs. The SKU's length varies from 5 meters to 20 meters. The continues production process, explained in chapter 2 (paragraph 2.2), is influenced by the length in the following steps (from paragraph 2.2):

1. The tube is sawed to obtain the right length.
2. The singular tubes with the right profile and length are bundled together (the number of tubes in a bundle depends on the type of tube).
3. At the end the products are stored in the construction warehouse.

Regarding the first point, it is easy to understand that if the length of the final product is smaller the tube is sawed more times to obtain the right length. From the second and third points the bundling and the moving of tubes with a longer length is more difficult, especially considering the extra safety precautions that have to be taken, and the added movement complications given the structure of the warehouse in Zwijndrecht.

5.2.3 Proposed production cost calculation

We propose to calculate the production costs considering the historical average speed per welding diameter of the tubes and applying penalties for the items that have nominal thickness of 8 mm and 10 mm. Penalties are also applied if the tube has a determinate length that causes more complications in the production process. The current production costs are calculated with the norms speed values. We have seen in the analysis made in chapter 4 how these norms values are overestimated, therefore we believe that the use of a combination of norms speed values (expected speed) and historical average speed values per welding diameter, corrected with the penalties expressed above, would give a closer estimation to the current production process performances.

The penalties to apply to the length have been estimated with the Production and Logistic departments. The estimation is based on the experience of the two departments and has been released after different interviews and consultations.

The penalties are structured as an increment of the percentage of the calculated production cost.

As already introduced, the tubes vary between five and twenty meters, therefore the penalties have been structured considering:

Tubes between 5 and 9 meters low penalty.

Tubes between 9 and 12 meters no penalty.

Tubes between 12 and 16 meters low penalty.

Tubes between 16 and 20 meters high penalty.

5.3 Slitting and Sales Costs Conclusions

Our decision is to evaluate the slitting and sales in the same way as these two categories are evaluated in the current pricing methodology described in chapter 4. This decision is made because there are no significant data about the slitting phase speed and because the sales costs evaluation is considered to be solid.

5.4 Conclusions

In this chapter we searched for improvements in the cost-based pricing strategy applied to the production process of the construction tubes. We developed a new pricing strategy that will be applied in the models developed in chapter 7 and 8.

The new pricing methodology suggests to evaluate the warehousing costs considering:

- The effective space occupied by each tube in the warehouse, whilst the current methodology considers the tons of the SKUs produced.
- If an SKU can be stored in the external or the internal warehouse. If it can be stored in the open air the warehouse cost for this product will be lower, given that the internal warehouse is a bottleneck of the Zwijndrecht factory.

The production costs are evaluated considering the production process speeds of the tubes, as is currently done by Tata Steel Tubes. The difference in the new strategy is that we use a weighted average between the historical data and the norms data (currently only the norms speed values are considered). At the historical data we will apply penalties for the items that have nominal thickness of 8 mm and 10 mm.

Moreover, penalties are applied if the tube has a determinate length procuring more complications in the production process.

Chapter 6 Literature review of the Order Acceptance phase. Toward a suitable price control approach: a Bid Price Control Model

As already introduced in this research, we try to align the Production and Sales departments' goals. We believe that a price control model will be capable to make substantial improvements to the current order acceptance phase. After having proposed a new pricing strategy in chapter 5 we now review the literature in relation to the Order Acceptance phase, focused on the revenue management field and the Bid Price control methodology. The structure of this section is:

- The Order Acceptance problem
- Revenue Management in Manufacturing MTO companies
- Introduction of Bid Price Control
- Bid Price control in Network Revenue Management
- Bid Price Network Controls Model
- The structure of Optimal controls
- Bid Prices controls
- Conclusions from the literature
- Approach for this research

6.1 The Order Acceptance problem

Order Acceptance (OA) is a tactical managerial activity that deals with accepting and rejecting customer orders [5]. Basically, OA involves for each order a 0/1 (i.e., reject/ accept) decision [6]. Traditionally, OA is solved as follows: always accept an order if sufficient capacity is available. However, such a policy can disable the system to accept more profitable orders in the future (opportunity loss). The idea of opportunity losses in order acceptance problems was for first recognized by *Guerrero and Kern 1988*. Always accepting an order when there is capacity available can be defined as a myopic strategy. Make-to-order (MTO) operations have to effectively manage their capacity to make long-term sustainable profits. This objective can be met by selectively accepting available customer orders and simultaneously planning for capacity often in combination with setting the correct price and due-date for the order [5]. The impact of order acceptance decisions on a supply chain, i.e. "an integrated process where in raw materials are manufactured into final products, then delivered to customers" [8], is often not reported

in a structured way. Lack of communication between the sales personnel and manufacturing, and commission based salaries for the sales workers led to unrealistic production requirements. Consequently, order due-dates are frequently missed resulting in penalties and/or loss of customer good will. *Ebben Hans and Weghuis* investigate the importance of order acceptance and the benefits of cooperation between the sales and planning function. They also described how OA may also deal with related decisions, such as due-date quotation and price determination.
Summed up, the order acceptance strategy has a main influence on the performance of a company.

6.2 Revenue Management in Manufacturing MTO companies

While Revenue Management (RM) is traditionally considered a tool of service operations, RM has shown considerable potential for application in manufacturing operations. The typical challenges in make-to-order manufacturing are fixed manufacturing capacities and a great variety in offered products, going along with pronounced fluctuations in demand and profitability.

If the demand exceeds manufacturing capacity on a regular basis, companies are confronted with the challenge to optimize order acceptance [5]. The objective is to maximize the overall profit by adequately selecting the best orders. Thus, companies are confronted with the decision to dynamically control the inflow of orders. This constitutes a classical environment for employing the techniques of RM, capacity control in particular. By quantitatively assessing the opportunity costs of an order, RM provides support for order acceptance decisions.
Failure to consider the order's capacity consumption and resulting effects on the bottlenecks in the production stream may lead to losses in capacity and inefficient order acceptance decisions.

The production capacity in M-T-O steel manufacturing should be considered as perishable inventory [8]. The common perception is that manufacturers do not face the problem of perishability. However, a company employing M-T-O production relies on the knowledge of the relevant specifications of quality, quantity, and delivery date from the customer before production can begin. This knowledge therefore serves as the so-called external factor, which is a production factor required for the production of goods and services which cannot be controlled by the company. In the context of M-T-O manufacturing, it is not the product itself that has to perish, only the capacity to produce it [8]. In order to apply RM in the order acceptance process, a company must have the ability to reject customer requests or to vary prices driven by its efforts to maximize the overall contribution margin.

There are several characteristics distinguishing RM at a steel manufacturing facility from its counterparts in service industries. For instance, Gallien, Le Tallec, and Schoenmeyr (2004)[9] point out that the production capacity in manufacturing settings is allocated over an infinite horizon, as opposed to the finite seat allocation period ending with a flight's departure. Further, it is possible to start production at any time during the day, whereas seats on a plane can only be sold for a specific departure time constrained by a reserved slot for take-off. Most manufacturers are free to shift their production activities in time, as long as the end-delivery date is met. In manufacturing it is not a pre-specified production time that is sold, but rather the certainty that an appointed activity will be performed somewhere within a specified period of time [10]. Despite the at-first-glance suspected additional degree of freedom, most customer orders are quoted for the soonest possible delivery date, which heavily relies on the upstream melting and casting routine. In addition, long lead times in production and high material costs further restrict the suspected additional degree of freedom making the available production capacity a perishable resource. Also, as a characteristic of the M-T-O production, significant variable costs need to be considered, influencing the profitability of order acceptance. Since Tata Steel Tubes offers Iron alloys, material costs take up a large percentage of the final product price quoted to the customer. In contrast to the homogeneous capacity consumption faced by the airlines (one customer requires one seat on the airplane), the capacity consumption and number of required production units in a M-T-O environment differ from each other. Therefore, the assumption that an increase in revenues automatically results in an increase in profits is not necessarily true. The objective of capacity control in the service industry to maximize revenues needs to be replaced by the maximization of the overall contribution margin.

Defregger and Kuhn (2007)[11] show that in order to effectively apply RM, a company needs to be able to segment the customers into classes of higher and lower price sensitivity. Due to the price negotiations between sales personnel and the customers, not only the products are customized, but to a certain extent, the price as well. It can therefore be assumed that the sales personnel are able to skim the customer's willingness to pay. The sales agent uses the customer's information about the desired product, specification and quantity to perform both the Available to Promise (ATP) and Capable to Promise (CTP) checks. Hereby, ATP identifies already-existing inventory that is available to fulfil the request. Due to the great product variability, no significant inventory of pre-products exists, increasing the importance of the CTP check in M-T-O manufacturing. The CTP check compares the request's specific capacity consumption with the available production capacity and thus, verifies if enough production capacity and material is available to fulfil the request, resulting in the soonest possible date of delivery. Afterwards, the profitability check results in a comparison of the lowest quotation price based on production costs and the customer's willingness to pay. The request is accepted and the available production resources updated if the customer's willingness to pay exceeds the lowest quotation price. If the customer's willingness to pay is exceeded by the lowest quotation price, the request is marked as not profitable. This information is used in further negotiations with the customer, resulting either in the customer's acceptance of a price exceeding the lowest quotation price, the change of specifications ("new request") or the rejection of the request. In practice, sales agents often take a more active role in the actual interaction with the customer, which is frequently a process of iterative negotiation. The sales personnel at Tata Steel Tubes face a difficult task when classifying an incoming customer request as profitable to accept or not. Since it is the policy of Tata Steel Tubes that every request for a quotation is answered within 24 hours, it is not possible for the sales agents to delay a response for tactical reasons.

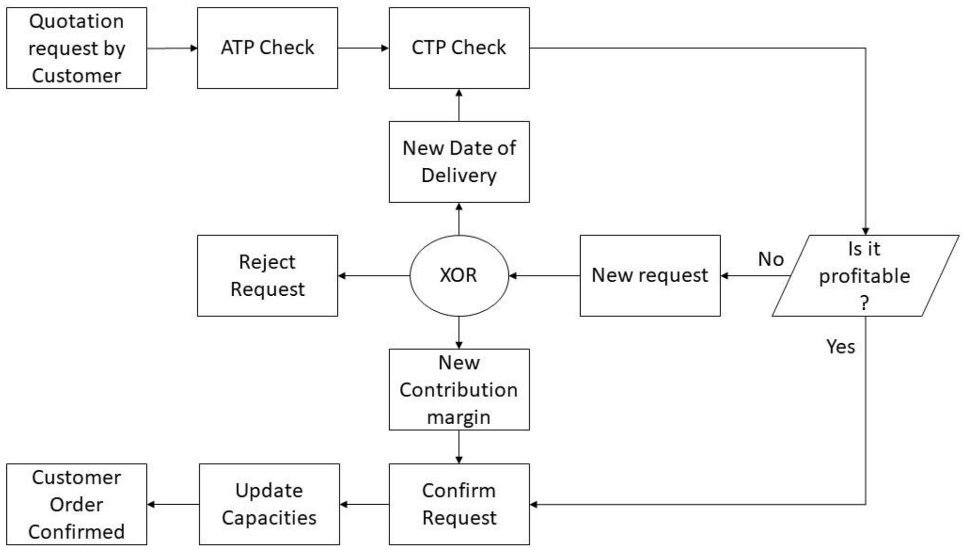


Figure 6.1 Interaction sales and customer during order acceptance process

The contribution margin of the tubes produced has a high variance, that is mainly due to the large variety of products offered by Tata Steel Tubes and the price negotiations. The large offered variety of products results in a abroad spectrum of contribution margins. Each product achieves different average contribution margins. Generally, the highly customized products achieve higher average contribution margins than the volumeintense SKUs. Therefore, the volume is not always a good indication of the resulting capacity consumption of an order. Even if the width, the length, and the type of SKUs of two orders are identical, the capacity consumption in the production phase of each order is heavily influenced by the specified thickness. Evaluating an order's profitability regarding contribution margin per ton, while failing to consider its capacity consumption, leads to erroneous information during times of excess demand. The speed of the production process depends on the type of tube, geometric measurements and type of steel. The capacity requirements for a particular resource fluctuate heavily in relation to the ordered alloy and geometric specifications, i.e. length, width, and thickness.

6.3 Introduction Bid-Price Control

The airline industry has elaborate different Revenue Management strategies to develop the order acceptance phase and maximize profits. The most recognized approaches are Booking-Limits, Protection-Levels and Bid-Price Controls. What distinguishes Bid-Price from the other two tactics is that it is a revenue-based control rather than class-based. It is possible to apply the method of the revenue-based control to a Make To Order manufacturing company. A bid-price control sets a threshold price (which may depend on variables such as the remaining capacity or time), such that a request is accepted if its revenue exceeds the threshold price and rejected if its revenue is less than the threshold price.

Bid-price controls require only storing a single threshold value at any point in time; Booking-Limit or Protection-Level controls a set of capacity numbers, one for each class. That makes in principle Bid-Price controls easier to apply, but to be effective, bid prices must be updated after each sale and passing of time.

The logic of the Bid-Price control strategy is first that capacity should be allocated to a request if and only if its revenue is greater than the value of the capacity required to satisfy it. Secondly, the value of capacity should be measured by its (expected) "opportunity cost" which is the expected loss in future revenue from using the capacity now rather than reserving it for future use. Theoretically, the opportunity cost idea is captured by using a value function, $V(x)$, that measures the optimal expected revenue as a function of the remaining capacity x. The displacement cost is then the difference between the value function at x and the value function at $x-1$, or $V(x)- V(x-1)$. Conceptually, the logic is simply to compare revenues to opportunity costs when making the decision to accept or to deny a request for a product.

6.3.1 Bid-Price Control in Network Revenue Management

Quantity-based revenue management of multiple resources is commonly in literature referred as Network Revenue Management. When customers buy bundles of resources in combination, problems can arise. Problems that are common in airline, railway, cruise-line and hotel management and also visible in manufacturing Make To Order companies. In the manufactory Make To Order industry it is often complicated to manage the capacity of different resources such as production machines, warehouse and dispatch capacities.
When products are sold as bundles of different resources, the lack of availability of any one of the resource in the bundle limits sales. This creates interdependence among the resources, and hence, to maximize total revenues, it becomes necessary to jointly manage (coordinate) the capacity controls of all resources.

In a network setting, a bid-price control sets a threshold price or "bid price" for each resource in the network. This bid price is normally interpreted as an estimate of the marginal cost to the network of consuming the next incremental unit of the resource's capacity. When a request for a product comes in, the revenue of the request is compared with the sum of the bid prices of the resources required by the product. If the revenue exceeds the sum of the bid prices, the request is accepted; if not, it is rejected. Bid-price controls have many advantages. First, even in a network setting the structure of the control remains simple: we have to specify only a single value for each resource (not each product), so the number of parameters involved is minimal. Secondly, evaluating a request for a product requires only a simple comparison of revenue with the sum of bid prices for the requested resources, so the transaction-processing task is quick. Thirdly, bid prices are intuitive and have a natural economic interpretation as marginal cost for the network of each resource[12].

6.3.2 Bid-Price Network Controls model

A Bid-Price Network Controls model is structured considering a company that has:

- m resources
- n products

Each network product is a combination of a bundle of the m resources sold with certain purchase terms and restrictions at a given price. We define

$$a_{ij} = \begin{cases} 1 \text{ if resource } i \text{ is used by product } j \\ 0 \text{ otherwise} \end{cases}$$

And the *incidence matrix:*

$$\boldsymbol{A}=[a_{ij}]$$

Thus, the j^{th} column of $\mathbf{A}$, denoted $\mathbf{A}_j$, is the *incidence vector* for product j; the i^{th} row, denoted $\mathbf{A}^i$, has an entry of one in column j corresponding to a product j that uses resource i. We let Aj denote the set of legs used by product j and A^i to denote the set of products that use resource i, so that the notation $i \in Aj$ indicates that resource i is used by product j , and $j \in \mathbf{A}^i$ indicates that product j uses resource i. The state of the network is described by a vector $x = (x_1,\ldots x_m)$ of resource capacities. If product j is sold, the state of the network changes to $\mathbf{x} - \mathbf{A}_j$.
Time is discrete, there are T periods, and the index t represents the current time (with the time indices running forward, so t = T is the time of service). Within each time-period t, we assume that at most one request for a product can arrive. Demand in period t is modelled as the realization of a *single* random vector

$$P(t) = (P_1(t),\ldots,P_n(t)) \text{ if } P_j(t) = p_j > 0$$

this indicates a request for product j occurred and that its associated price is p_j; if $P_j(t) = 0$, this indicates there is no request for product j . A realization $\boldsymbol{P}(t) = 0$ (all components equal to zero) indicates that no request for *any* product occurred at time t. Given the current time t, the current remaining capacity $\mathbf{x}$, and the current request $\mathbf{P}$(t), the quantity-based RM decision is as follows: Do we or do we not accept the current request? Let the n-vector $\boldsymbol{u}(t)$ denote this decision[13]:

$$u_j(t) = \begin{cases} 1 \text{ if we accept a request for product } j \text{ in period t} \\ 0 \text{ otherwise} \end{cases}$$

The decision to accept, $u_j(t)$, is a function of the remaining capacity vector $\mathbf{x}$ and the price p_j of product j that is:

$$u_j(t)= u_j(t, \boldsymbol{x}, p_j)$$

and hence,

$$\boldsymbol{u}(t) = \boldsymbol{u}(t,\boldsymbol{x}, \boldsymbol{p})$$

Since we can accept at most one request in any period and resources cannot be oversold, if the current capacity is $\mathbf{x}$, then $u(t)$ is restricted to the set

$$U(x) = \{\mathbf{u} \in \{0, 1\}^n : \mathbf{Au} \leq \mathbf{x}\}.$$

6.3.3 The Structure of Optimal Controls

To formulate a dynamic program to determine optimal decisions $\mathbf{u}^*(t, \mathbf{x}, \mathbf{p})$, let $V_t(\mathbf{x})$ denote the maximum expected revenue to go, given remaining capacity $\mathbf{x}$ in period *t.* Then $V_t(\mathbf{x})$ must satisfy the Bellman equation[13]:

$$V_t(\boldsymbol{x}) = E\left[max_{u\in U(\boldsymbol{x})}\{\boldsymbol{P}(t)^T\boldsymbol{u}(t,\boldsymbol{x},\boldsymbol{p}) + V_{t+1}(\boldsymbol{x}-\boldsymbol{A}\boldsymbol{u})\}\right]$$

with the boundary condition

$$V_{T+1}(\boldsymbol{x}) = 0\,, \forall \boldsymbol{x}$$

It is easy to show that $V_t(\mathbf{x})$ is finite for all finite $\mathbf{x}$. Moreover, an optimal control $\mathbf{u}^*(\cdot)$ satisfies:

$$u_j^*(t,\boldsymbol{x},p_j) = \begin{cases} 1 \; if \; p_j \geq V_{t+1}(\boldsymbol{x}) - V_{t+1}(\boldsymbol{x}-\boldsymbol{A}_j) \; and \; A_j \leq \boldsymbol{x} \\ 0 \; otherwise \end{cases} \qquad (1)$$

This control says that an optimal policy for accepting requests is of the form: accept a request for product *j* (at price p_j) if and only if we have sufficient remaining capacity and

$$p_j \geq V_{t+1}(\boldsymbol{x}) - V_{t+1}(\boldsymbol{x}-\boldsymbol{A_j})$$

where $Pj(t)= p_j$ is the price of product *j* . This reflects the rather intuitive notion that we accept a booking request for a product *j* only if its price exceeds the *opportunity cost* of the reduction in resource capacities required to satisfy the request.

6.3.4 Bid Price Controls

The displacement cost intuition of (1) leads naturally to bid-price controls for network RM, and indeed the analogy to the role of dual prices in deterministic optimization motivated the early development of bid-price control schemes by Simpson and Williamson [14].

If we suppose, in a heuristic sense, that the value function $V_{t+i}(x)$ has a gradient $\boldsymbol{\nabla} V_{t+i}(\mathbf{x})$, then the condition for accepting product *j* can be approximated by

$$\begin{aligned} p_j &\geq V_{t+1}(\boldsymbol{x}) - V_{t+1}(\boldsymbol{x}-\boldsymbol{A_j}) \\ &\approx \boldsymbol{\nabla V}_{t+1}^{\boldsymbol{T}}(\boldsymbol{x})\boldsymbol{A}_j \\ &= \sum_{i\in A_j} \pi_i(t,\boldsymbol{x}) \end{aligned}$$

Where

$$\pi_i(t, \boldsymbol{x}) = \frac{\partial}{\partial x_i} V_{t+1}(\boldsymbol{x})$$

This line of reasoning motivates the following definition[14]:

A *control* $\boldsymbol{u}(t, \boldsymbol{x}, \boldsymbol{p})$ *is a* ***bid-price control*** *if there exist real-valued functions* $\pi_i(t, \boldsymbol{x}) = \left(\pi_1(t, \boldsymbol{x}), \dots, \pi_m(t, \boldsymbol{x})\right), t = 1,2, \dots T$ *(called* ***bid prices****) such that* (the notation $i \in A_j$ indicates that resources i is used by product j)*:*

$$u_j^*(t, \boldsymbol{x}, p_j) = \begin{cases} 1 \; if \; p_j \geq \sum_{i \in A_j} \pi_i(t, \boldsymbol{x}) \\ \quad 0 \; otherwise \end{cases} \qquad (2)$$

In other words, a bid-price control specifies a set of bid prices for each resource, at each point in time, and for each capacity level, such that we accept a request for a particular product if and only if there is available capacity and the price exceeds the sum of the bid prices for all the resources used by the product.

6.4 Conclusions from the literature

After having described how the order acceptance problem is discussed in the literature and how companies in different fields apply Revenue Management tools trying to be more efficient and increase their revenues, we described the Bid Price Control strategy. In particular we spoke about the Bid Price Control in Network Revenue Management that considers the case where multiple resources capacities have to be used to produce a specific good, and this is comparable with the Tata Steel Tubes production process. Indeed, to be able to sell a product, different production and managerial processes need to be done. We have seen the structure of the Optimal Controls and how approximating we can arrive at the formulation (2) that defines a Bid-Price Control. We now want to apply this function to calculate the bid prices of the construction tubes and predict the prices that the products made by Tata Steel in Zwijndrecht should have in a specific moment of time in order to cover the expected production process costs. In the next paragraph we will describe how we want to apply the Bid-Price Control function (derived in paragraph 6.3.4) in our specific case.

6.5 Approach for this research

In this research we want to create a price control model for the construction tubes produced by Tata Steel in Zwijndrecht. We will develop two models (chapter 7 and 8) will be made following the bid price theory explained above and the particular firm's characteristics of Tata Steel Tubes (e.g. make to order manufacturing firm).

We will now express the factors needed to create the models. The Objective is to create some tools that will be capable to answer these questions:

What is a suitable price that should be asked to a customer for a specific order so that the factory's costs are covered?

Towards which products the Sales department should push the customers in order to fully use the week planning capacity?

The next constrains have to be respected:

a) Delivery time

Customers give a time frame (e.g. four weeks from now). The ordered products have to be produced before the time frame. It is a hard constrain because sending an order late is not possible by contract clauses. Only during the negotiation phase can be proposed a delivery time out of the frame time.

b) Production plan

A plan of the next eight weeks is made in advance by the Planning department, it is based on a forecasting analysis made by the Sales department. The forecasting analysis is based on historical data and on predictions made based on conversations with customers. The production plan is a soft constrain, that is because it can be changed until the day before by the Operational Planning department.

c) Production capacity

The production capacity is limited, given that the production of the tubes is a continuous production process and it is needed to end the process before the next production process can start. The machines have to be assembled for the specific characteristic of the SKU that will be produced next.

The parameter used are:

a) Time (weeks)
b) Amount requested by a customer (tons)
c) Capacity available (tons)
d) Material cost (euro per ton)

The resources to process an order of a general tube in the Make To Order factory of Zwijndrecht are:

a) Warehouse
b) Slitting Machine
c) Sales Department
d) Production Machine

A cost for each of these resources is evaluated to obtain the final price. The final price of a product is function of the utilization (per resource) and a shadow price (per resource).

In order to make a Bid-Price model it is crucial to first determine the price strategies. For this research we will apply the strategies illustrated in chapter 5 and a new order acceptance strategy will be proposed. The model named “Incremental Order Acceptance Model” will be discussed in the next chapter and the model “Market Independent Model” in chapter 8. The models are created with Excel and they will remain at the Tata Steel Tubes Sales Department where they can be used as a tool during future negotiation phases.

Chapter 7 Incremental Order Acceptance Model

In this chapter, we develop a pricing control model that is able to estimate the cost-based price of the construction tubes produced by Tata Steel in Zwijndrecht and predict the recommended price that should be asked in such a way as to recover the production process and material costs. The model will show how prices change according to the expected production week and the time before the production started. The model was built to be a tool for the Sales department during the negotiation phase. During the research, the possible outcomes of the model that could be useful for the Sales department (department that will use the model) were discussed. This auxiliary model, named "Incremental Order Acceptance Model", is the basis of the "Market independent model" that will be discussed in chapter 8. The "Incremental order acceptance Model" has not been tested with the Tata Steel Tubes Sales department, but it will be delivered to Tata Steel Tubes as a suggestion for further research. At the end of the chapter, we will explain what the limitations of this model are from the Sales department point of view and what modifications will be applied in order to satisfy the Sales department.

7.1 Order acceptance strategy proposed

In the next flowchart, we describe the order acceptance strategy that we propose and that utilizes the model that we developed. A comparison with the current order acceptance strategy, that we presented in figure 1.3, can be made. With the new order acceptance strategy, when a quotation request arrives, we insert the request into the model. The model will provide a price for the production process of every product requested in the order by the customer. In the model the weeks that the customer is willing to wait and the quantity of tons of each product are uploaded before running the program. Once the program has run, we will get as an outcome the recommended price that the Sales department should ask in such a way to cover the production process costs for the coming weeks. The model will show a price estimation for the next eight weeks, starting from the current week zero. The choice of eight weeks derives from the fact that customers usually make orders for a short time horizon. Eight weeks which covers the next two production cycles, is usually the maximum time that the customers are willing to wait (Sales department interview). The model gives the seller an overview of the impact of uploading a product to be produced in a specific week. The seller will be able to present different offers to the customers depending on the production week chosen.

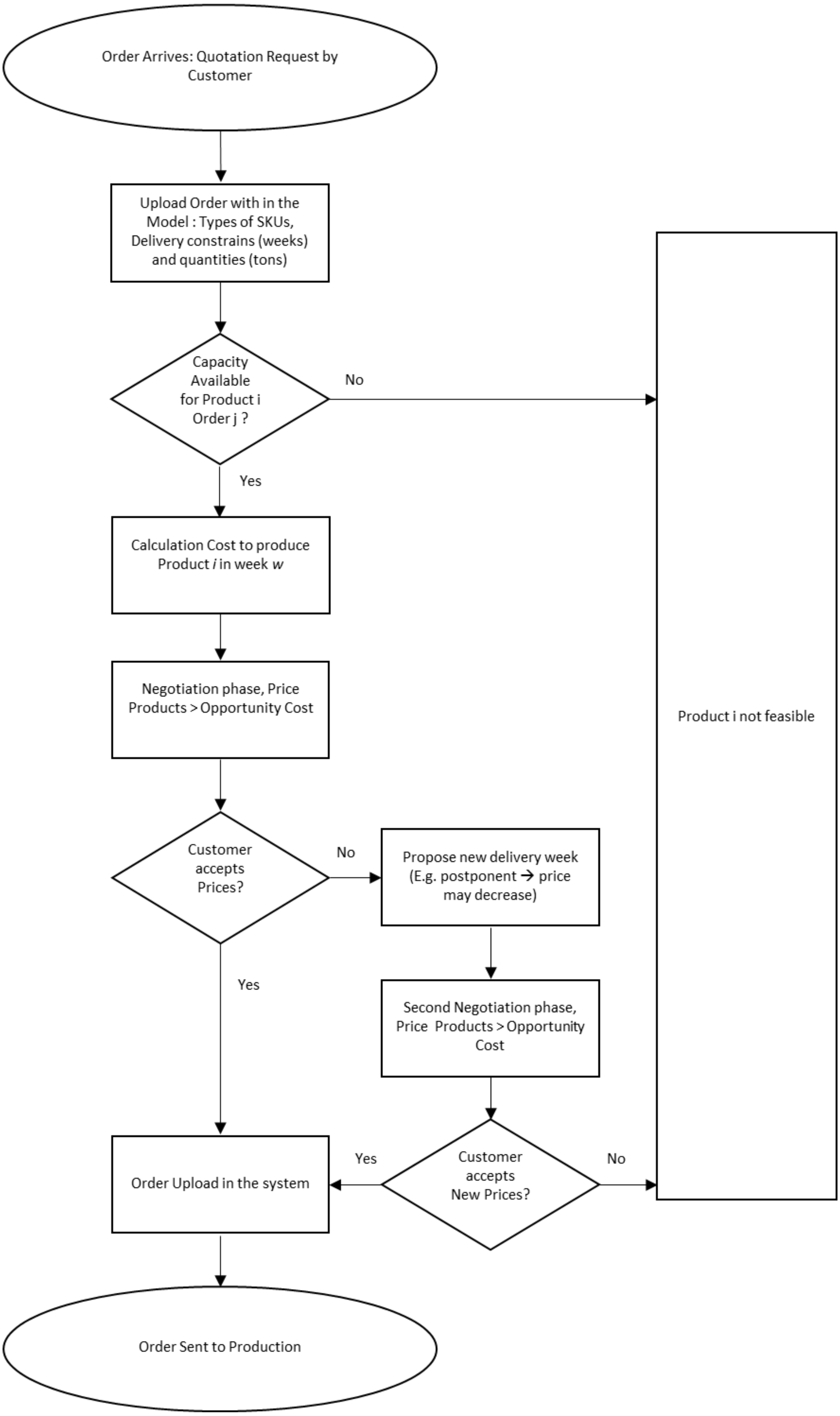


Figure 7.1 Order acceptance strategy proposed

7.2 Structure of the model

In the previous chapters, all resources (Sales, Production, Slitting, Warehouse) have been analysed and a strategy for each of them has been made, we will now create a pricing control model. As discussed previously, the objective of the model is to be an extra tool for the Sales department when calculating the quotation for a customer order and answer to the question:

What is a suitable price that should be asked to a customer for a specific order so that the factory's costs are covered?

The structure of the model follows the function (2) (paragraph 6.3.4):

$$u_j(t, \boldsymbol{x}, p_j) = \begin{cases} 1 \; if \; p_j \geq M_j + \sum_{i \in A_j} \pi_i(t, \boldsymbol{x}) \\ 0 \; otherwise \end{cases}$$

The function above has been modified compared to function (2) with the introduction of the material cost M_j. The other parameters already discussed in chapter 6 are summarized in the next table:

Symbols	***Meaning***
u_j	Bid price control of product j
t	Time
$\boldsymbol{x}$	Capacity available per week
p_j	Price of product j
M_j	Material cost of product j
$i \in A_j$	Indicates that resource *i* is used by product j
π_i	Bid price of resource *i*
η_j	Yield of the production phase

Table 7.1 Symbols meaning

A product *j* has a specific material cost depending on the material used to produce it. The material cost per product has to be periodically updated in the model, given that it is constantly changing depending on the steel market index.

u_j indicates the bid price control that can be 1 if the price of product *j* is higher that the factory's costs (we recommend to accept the order) or 0 in case it is lower (we recommend to reject the order). u_j is a function of:

a) *t:* Time in weeks *(t=1,2,3,4,5,6,7,8)*
b) ***x****:* Capacity available per week *(Assumed 1600 tons)*

c) p_j : Price of product j $(j=1,2,3,4,5...,n)$

A_j indicates the capacity requested by a customer. π_i indicates the bid prices for each resource i that is a function of the time t and the capacity available per week x that has to be higher or equal to the capacity requested A_j.

The bid-price control specifies a set of bid prices for each resource, the resources that are considered in the production process of the SKU are (as discussed in chapter 3):

a) Warehouse
b) Slitting Machine
c) Sales Department
d) Production Machine

The bid price of each resource i is equal to (variable for each product j):

$$\pi_{i_{\,i \in A_j}} = shadow\ price_i * \ utilization_i$$

Shadow price is referred to as a monetary value assigned to currently unknowable or difficult to calculate cost, in this case the cost of a resource i. The utilization indicate the extent to which the productive capacity of a resource i is used during a specified period of time.

a) Warehouse

Shadow price (if internal warehouse)= 22.42 €/m^3 (derived from the conversion of the 16.94€/ton estimated by Tata Steel Financial Control department).

Shadow price (if external warehouse)= 11 €/hour (derived from different consultations with the Logistic and Financial Control departments of Tata Steel Tubes).

Utilization different for each SKU and dependent on the effective space occupied in the warehouse as discussed in chapter 6.

b) Slitting Machine

Shadow price= 2962 €/hour (estimated by Tata Steel Financial Control department).

Utilization different for each SKU and dependent on the norm speed during the slitting phase.

c) Sales Department

Shadow price= 11 €/ton (estimated by Tata Steel Financial Control department)

Utilization depend on the amount of tons requested by a customer.

d) Production Machine

Shadow price= 3163 €/hour (estimated by Tata Steel Financial Control department)

The utilization is different for each SKU and dependent on different factors:

- Preparation Machine that indicates the time that is needed to assemble the machines to produce a specific SKU
- Speed Production that indicate the ton per hour produced of a product *j*
- Expected amount of tons that will be produced
- Requested ton that indicates the number of tons required of product j in a customer order
- η_j that is the yield of the production phase

The next equation represent the mathematically interpretation of the utilization.

$$Utilization_{pm} = \frac{Preparation\ Machine_j[h] + \frac{1}{Speed\ Production_j}\left[\frac{h}{ton}\right] * E[\ Ton\ produced]_j[ton] * \frac{1}{\eta_j}}{E[Ton\ produced]_j[ton]} * Requested\ Ton_j[ton]$$

The Preparation Machine for product j is dependent on the welding diameter and the measurements of a SKU. Given that the production is made at the same time for different orders, the cost derived by the preparation machine as to be split between the total amount of tons produced during that specific production process.

The Speed Production of a product j during the production phase is derived from historical data as discussed in chapter 6.

The exact amount of tons that will be produced is only know the day before the production starts, so it is necessary to calculate the expected amount of tons that will be produced.

$$E[Ton\ produced]_j = Ton\ already\ booked_j + \Pr(t) * (Plan\ Capacity_j - Ton\ already\ booked_j)$$

The probability *Pr(t)* is a function of the time and decrease from week eight to one. Ton already booked indicates the number of tons booked from previous orders plus the amount required in the new quotation. Plan Capacity is the capacity planned for a determinate production cycle of a product *j*.

η_j is the yield of the production phase, is equal to 72% (estimation made by the Financial and Control department), and it considers the fact that during the production phase waste material and unacceptable products are produced.

7.3 Model visualization

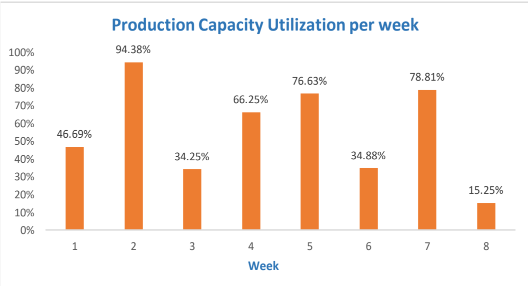
To start the calculation of the recommended selling price to apply to an order of an SKU (or more SKUs) the user has to upload the next data:

- Article Id: this is the designation that is specific to all the material and dimensional characteristics of an SKU.
- Ton requested: Indicates the number of tons that a customer requires for a specific SKU.
- Maximum waiting weeks: Indicates how many weeks the customer is willing to wait before the order will be delivered.

One condition for the correct estimations of the cost price of the SKUs is that the production planning and the material cost (depending on the index steel price) have to be continuously uploaded. In the next figure we show a visualization of the model.

TATA STEEL PRICE CONTROL MODEL CONSTRUCTION TUBES (ZWIJNDRECHT)

Order Characteristics				
Article ID	Article Characteristics	Las Diameter	Ton Requested	Maximal Waiting Weeks
808904	140x80x8.00120005231BTT	139.7	1	6
807956	323.9X7.1012000ZW37	323.9	1	4
807608	273.0X8.0012000ZW5231B	273	1	3



808904 140x80x8.00120005231BTT						
Week	Material Cost	Production Cost	Warehousing Cost	Sales Cost	Slitting cost	Recommended Price
1	€ 656.00	€ 8,422.73	€ 10.51	€ 11.00	€ 14.51	€ 9,114.75
2	€ 656.00	€ 9,801.20	€ 10.51	€ 11.00	€ 14.51	€ 10,493.21
3	€ 656.00	€ 11,722.37	€ 10.51	€ 11.00	€ 14.51	€ 12,414.39
4	€ 656.00	€ 83.53	€ 10.51	€ 11.00	€ 14.51	€ 775.55
5	€ 656.00	€ 19,307.25	€ 10.51	€ 11.00	€ 14.51	€ 19,999.27
6	€ 656.00	€ 28,569.57	€ 10.51	€ 11.00	€ 14.51	€ 29,261.59
7	€ 656.00	€ 54,984.31	€ 10.51	€ 11.00	€ 14.51	€ 55,676.33
8	€ 656.00	€ 71.00	€ 10.51	€ 11.00	€ 14.51	€ 763.01

807956 323.9X7.1012000ZW37						
Week	Material Cost	Production Cost	Warehousing Cost	Sales Cost	Slitting cost	Recommended Price
1	€ 670.00	€ 8,540.76	€ 33.30	€ 11.00	€ 21.52	€ 9,276.58
2	€ 670.00	€ 9,939.88	€ 33.30	€ 11.00	€ 21.52	€ 10,675.70
3	€ 670.00	€ 11,889.83	€ 33.30	€ 11.00	€ 21.52	€ 12,625.65
4	€ 670.00	€ 14,795.64	€ 33.30	€ 11.00	€ 21.52	€ 15,531.47
5	€ 670.00	€ 19,588.35	€ 33.30	€ 11.00	€ 21.52	€ 20,324.17
6	€ 670.00	€ 54.25	€ 33.30	€ 11.00	€ 21.52	€ 790.07
7	€ 670.00	€ 55,799.89	€ 33.30	€ 11.00	€ 21.52	€ 56,535.71
8	€ 670.00	€ 7,487.96	€ 33.30	€ 11.00	€ 21.52	€ 8,223.78

807608 273.0X8.0012000ZW5231B						
Week	Material Cost	Production Cost	Warehousing Cost	Sales Cost	Slitting cost	Recommended Price
1	€ 703.00	€ 55.26	€ 25.10	€ 11.00	€ 11.28	€ 805.64
2	€ 703.00	€ 11,871.99	€ 25.10	€ 11.00	€ 11.28	€ 12,622.37
3	€ 703.00	€ 14,203.30	€ 25.10	€ 11.00	€ 11.28	€ 14,953.68
4	€ 703.00	€ 17,677.41	€ 25.10	€ 11.00	€ 11.28	€ 18,427.79
5	€ 703.00	€ 46.02	€ 25.10	€ 11.00	€ 11.28	€ 796.40
6	€ 703.00	€ 34,647.09	€ 25.10	€ 11.00	€ 11.28	€ 35,397.47
7	€ 703.00	€ 66,700.94	€ 25.10	€ 11.00	€ 11.28	€ 67,451.32
8	€ 703.00	€ 42,889.51	€ 25.10	€ 11.00	€ 11.28	€ 43,639.89

Figure 7.2 Incremental Order Acceptance Model

For every SKU which we want to estimate the price, the estimation of the next eight weeks cost prices will be shown. The green colour indicates that the SKU is on time with the customer delivery request, if the colour is orange then it is a week later (it can be uses in the negotiation if the price is more convenient for the customer) and red indicates that it is more than a week later then the delivery request frame of the customer. The model ranks the final prices with a star, if the final price is less than 10% higher than the best price available in the eight weeks a complete yellow star will appear. The capacity utilization per week is shown in a column chart with the percentage utilization per week.

Figure 7.2 shows that the recommended price for the SKUs in certain weeks is extremely high (e.g. Article Id 808904 week 7, 55,676.33 euro/ton) what is due to the fact that the production cost is dependent on the planned capacity. When a high price is present, it means that the capacity booked for that specific week is zero or close to zero.

7.4 Conclusions and limitations of the model

The Sales department of Tata Steel Tubes criticizes The "Incremental Order Acceptance Model", mainly because of the limitation that the suggested price deriving from the model is difficult to compare with the actual end prices currently applied by the Sales department. That happens because in the Steel market, as made clear in the previous chapters, many factors are influencing the end sell price and often companies sell end steel products (in this case tubes) at a price that is lower than the one required to cover the production costs. We saw this in chapter 3 during the margin analysis, specifically in figure 3.2 where it is evident that Tata Steel Tubes sold different products with a negative margin during the last four years. That mostly because Tata Steel Tubes' (subsidiary firm of Tata Steel) target is a certain volume of tons per year.

We believe that the sales strategy of Tata Steel Tubes should be clearer, in such a way to understand what products are more convenient to be sold and what prices are necessary to cover the production process costs of the manufactured products. Moreover a strategy to try to reduce the selling of products with negative margin seems needed.

The Sales department has the idea that the model recommended price output will often be distant from the actual sell price that will be influenced by strategic considerations like the forecasting of the steel index in the next weeks. We think that the index price could be easily constantly uploaded and forecasted if a strategy is developed.

The Sales department recognises an interest in having an overview of the actual costs related to the production processes, because it is actually a limitation of the current pricing methodology that calculates prices in a static way. The current pricing methodology can be defined static because it does not consider the production planning or the expected sold tons in the SKUs cost-based pricing. The Sales department is interested in the cost of the production process to understand what is the impact of adding an order to the production planning. The Sales department desires to get information about which articles are recommended to be pushed to the costumers. With the “Market independent Model”, that we discuss in the next chapter, the Sales department will get as output this information. The “Market Independent Model” will be made, as the name suggests, without considering the market price of steel, so without the consideration of the material costs and only considering the costs related to the production process. In this way the Sales department will have an overview of the impact on the production process of selling a certain amount of tons of a product. Likewise the sellers will have the possibility to compare the outcome of the “Market independent Model”, a dynamic price that is function of the current production planning, with the current cost-based pricing used by Tata Steel Tubes (static pricing).

The “Market independent Model” that we describe in the next chapter has been developed to meet the Sales department interests and to have as output useful information for the current sales procedure applied by the Tata Steel Tubes Sales department.

We believe that the “Incremental Order Acceptance Model” could be an extremely useful tool for the sales phase. We think (hope) that in a near future the potentiality of this model will be reconsidered. Certainly, the model needs to be completed with a strong collaboration of the Sales department in order that the outcomes will at best represent the company strategy (e.g. the company decide to promote the selling of Precision Tubes). Then a testing period is required.

Chapter 8 Market independent Model

As introduced in chapter 7 the “Market Independent Model” is an alternative of the “Incremental Order Acceptance Model” developed to meet the information desired by the Sales department. The model wants to align the production and Sales departments in such a way that the Sales department is better informed about the real implication of the selling of a specific product. We start the chapter with an introduction of the model, and then we explain what are the possible uses and tools of the model that can be used by the Sales department. After that we analyse the structure of the model and we review its possible applications with some examples.

8.1 Introduction of the Model

During this research we have made an overview of the different production processes that are involved in the production of a tube. We have developed a new strategy to evaluate the costs of the production process and we have discussed the difference with the currently used methodology. We will now discuss the model developed to answer to the next Sales department dilemma:

Toward which products the Sales department should push the customers in order to fully use the week planning capacity?

The model is composed of three tools that are made for the next purposes:

1. To find the Products that have the smallest Production Process costs per week
2. To determine the Production process costs of a specific Product ID for a specific week
3. To decide between a certain number of requests what to accept

We will first describe what considerations are made to establish the production capacity available in the factory, which is the main factor in the use of the model. After that we will describe the difference between the dynamic costs evaluation (the proposed methodology) and the static one (the current methodology). Then we will analyse the three tools of the model that we have developed. The analysis consists in a description of the use of the model, the visualization of the outputs and the gain for the Sales department. These tools, required by the Sales department, try to go over some limitations of the current pricing methodology and try to make the impact in confirming an order clearer for the Sales department. The Sales department believes that these information will give them an advantage in the order acceptance phase.

8.2 Production process capacity

As already introduced in the previous chapters the production capacity is one of the main constrains in manufacturing companies. A certain amount of tons of products can be made every day and the Production department's goal is to maximize utilization so that the fixed production costs will be spread between more customers' orders in which way the products will be cheaper and more desirable for the costumers to buy them.

The utilization factor has to be carefully managed. Without planning, processes may become chaotic. But at the same time planning is complex and a trade-of between complexity and variability is needed. Normally, there are three main points of view in the planning process of a manufacturing company: the management wants to maximize utilization, customers desire to minimize waiting/access time and the staff wants to minimize overtime. When management wants to minimize costs (maximize utilization) the result is increasing fluctuations in workload and waiting times. Apparent opposite objectives can be attained by levelling workload.

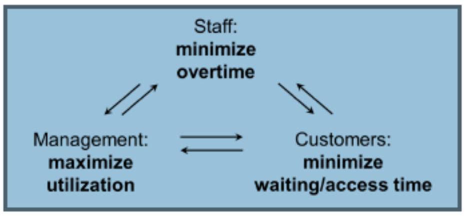


Figure 8.1 Point of view in the planning process

The management's dogma is to maximize utilization. Nevertheless, when you maximize utilization, you increase exponentially the waiting time (basic queuing theory). Queuing theory points out that generally with an utilization of 90% the waiting is 10 times the service time. If we reduce the capacity instead of maximizing the utilization, we obtain a higher utilization with less capacity and reduced overtime. There is more flow, so also reduced waiting times. Planning is to create and cleverly use flexibility to deal with variability in demand and supply.

The total capacity in the model is estimated as 70% of the total available production capacity for the construction tubes in the Zwijndrecht factory. That estimation has been made in collaboration with the Planning department of Tata Steel Tubes, by analysing the historical data of the production planning. As the total capacity is 2300 tons per week, we will consider in our model the 70% 1600 tons.

8.3 Static and dynamic cost evaluations methodologies

The developed model gives the possibility to the Sales department to compare the dynamic cost price of the production process found with the new proposed pricing strategy, with the static cost price obtained with the current used pricing strategy. We will now review the differences between the two methodologies.

- Static pricing – Current used strategy

The costs of the production process for a product is constant and does not depend on the tons already booked by the customers.

- Dynamic pricing – Proposed strategy

The price of the production process for a product depends on the current planned capacity and the quantity that a customer is willing to order.

8.3.1 Differences and similitudes of the two methodologies

We will now resume what are the differences and the similitudes between the strategy applied in the new model and the current strategy applied by Tata Steel Tubes for the production process costs evaluation (in the following phases: selling, slitting machine, production machine and warehousing).

- Selling phase

The selling evaluation in the new model is the same as in the current one. The costs related to the selling phase are calculated with a fixed price per ton. The price estimated by Tata Steel Tubes is 11 euro per ton. This estimation is considered to be correct and therefore no further investigation in this cost evaluation has been made.

- Slitting Machine phase

The Slitting Machine phase, as the Production Machine phase, is evaluated by the speed performance during the production phase. The speed of the machine during the production is the factor indicating the performance of the slitting phase. The current calculation of the speed values is made with pre-estimated norms values. During the research we have analysed the historical real data of the performance of the slitting machine; these data have been considered not statistically significant. For this reason we were not able to improve the current cost calculation.

- Production Machine phase

As introduced above the cost of the production machine with the current cost estimation are evaluated considering the speed of the tubes during the Production Machine phase.

We propose some changing in the cost evaluation. It is still in part based on the speed during the process but in this case we not use only the norms speed values to make the estimation. The proposed methodology considers:

1. Use of a weighted average between the historical speed values and the norms speed values (currently only the norms speed values are considered). At the historical data we will apply penalties for items that have nominal thickness of 8 mm and 10 mm.
2. Penalties per length.

We decide to use a weighted average between the historical speed values and the norms speed values for the next two reasons:

a) To guarantee that the outcomes of the model will not be too distant from the current pricing methodology used by Tata Steel Tubes.
b) The use of only the historical speed values data could not perfectly represent the expected speed of the production of certain products, especially in the case when the historical data of a product are limited (when only limited times a product has been produced in the past). In these cases the historical speed could be highly influenced by occasional malfunction of the production machines.

The production Machine cost calculation follows the equation (1) discussed in chapter 7, which we propose again:

$$Utilization_{pm} = \frac{Preparation\ Machine_j[h] + \frac{1}{Speed\ Production_j}\left[\frac{h}{ton}\right] * E[\,Ton\ produced]_j[ton] * \frac{1}{\eta_j}}{E[Ton\ produced]_j[ton]} * Requested\ Ton_j[ton]$$

This equation guarantees that the costs involved during this phase are changing in a dynamic way considering the Expected produced ton of a specific analysed product. The cost decreases when the expected produced ton is higher. With this new methodology we believe that the sellers will have a better overview of the costs involved in this phase and will be able to check at the moment the production costs. That is different from the current methodology where the price is static and does not change considering the time when it is checked or the current available production capacity.

- Warehousing phase

The warehousing costs evaluated by the current methodology used by Tata Steel Tubes consider a fixed price per ton as criteria. As discussed in chapter 5, with the proposed cost evaluation methodology we will consider the next factors to evaluate the costs involved during this phase:

1. Effective space utilization
2. Use of internal or External warehouse

The first point, as already introduced, guarantees that the price is dependent on the utilization of the warehouse (bottleneck of the production process of the tubes). The tubes are estimated in a different way, if they are using the internal or external warehouse. That because the warehouse bottleneck regards only the internal warehouse. The external warehouse is currently never full and the utilization results maximum around 60% of the available space. Therefore it is evident that the products that can be stored in the open air have to have a different price evaluation considering their external location.

We will now schematize in a table the differences between the current used methodology and the new one proposed for the model:

Phases	***Static Pricing (current used)***	***Dynamic Pricing (proposed for the model)***
Sales	Price per Ton sold	Price per Ton sold
Slitting	Price per Norms speed	Price per Norms speed
Production	Price per Norms speed	Price estimated considering a weighted average between the historical speed values and the norms speed values. Penalization for items that have nominal thickness of 8 mm and 10 mm. Penalization for length. Dynamic changing considering the planning.
Warehouse	Price per Ton	Price per m^3. Different prices for external or internal warehouse

Table 8.1 Statistic versus Dynamic Pricing

8.4 Model Description

We will now analyse the three main tools of the model that we have developed. The analysis consists in a description of the use of the model, the visualization of the outputs and the gain for the Sales department. These tools required by the Sales department try to go over some limitations of the current pricing methodology and try to make the impact in confirming an order clearer for the Sales department. The model tools are made for the next scopes:

1. To find the Products that have the smallest Production Process costs per week
2. To determine the production process costs of a specific Product ID for a specific week
3. To decide between a certain number of requests which accept

The Sales department believes that these information will give them an advantage in the order acceptance phase.

8.4.1 Products that have the smallest Production Process costs per week

This tool is useful when the seller wants to know what products are the best to push to the customers for a determinate week. With best products we mean the products that have the smallest impact in the production process costs.

As discussed in the precedent chapters, the production of a determinate product will have always some fixed costs that are related to the machines installation to create that determinate product. Given that products with the same welding diameter need only small change in the machines installation, it is easy to understand that when you add to the production products with a welding diameter already planned to be produced, it will be cheaper than with products that are not present in the plan.

With the current tools used by Tata Steel it is difficult to understand if it is more convenient to add to production a product of a welding diameter group present in the plan, instead of another also present in the plan. The same occurs when we want to understand what product inside the group of products with the same welding diameter is more convenient to produce. This is not clear with the current used pricing methodology. Instead with the new model we developed we will be able to answer to these doubts of Sales department. We will now explain how this tool works, step by step with an example of its use.

The user of the model has the overview of the capacity utilization per week (figure 8.2), suppose he wants to complete the production capacity of next week “Lasweek 16” (figure 8.2), the strategy in this case is to contact some customers and try to force them to buy determinate products. The next question during this phase comes usually up:

What products should the seller push to the customer to reduce production process costs?

With the model that we have made we can answer to this question. The next figure is a visualization of the model file.

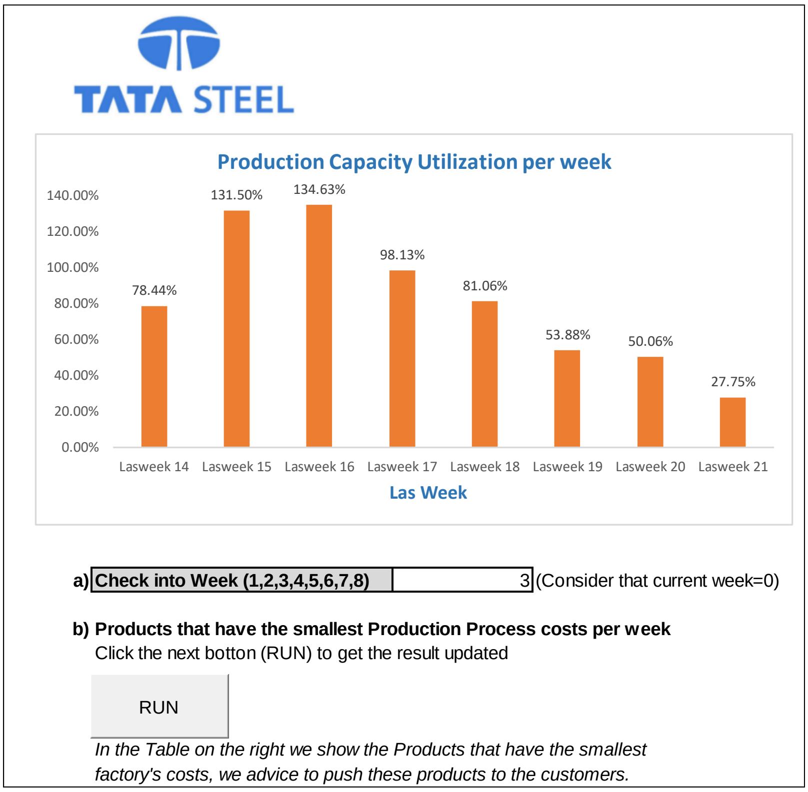


Figure 8.2 Model visualization

The first step that the seller has to make is to check the capacity utilization per a specific week. The utilization per week considers the 70% of the real possible capacity, as explained in the beginning of the chapter, which is made to avoid that the waiting time will exponentially increase (paragraph 8.1). Nevertheless the Sales department can check with the Production department if extra capacity can be added, that is done usually for the next weeks where the factory conditions are clear.

Given the situation of the graph (figure 8.2) the seller could consider for example what product to push to the customer in two weeks “Lasweek 16”. The information that the seller has without the use of the model is the current planning of that week (figure 8.3).

Welding diameter	Article Characteristics	Plan	Booked
152.4	120 x 120 4wk / 160 x 80 4wk	874	874
323.9	Ø 323.9 4wk	191	191
244.5	200x200 4wk / 250x150 4wk / 300x100 4wk	795	795
T & H	Ø 162.0 + 162.4 4wk	269	269
156.7	133 x 133 Jost *	25	25

Figure 8.3 Planning Next week "Lasweek 16". Welding diameter (mm), Plan (tons), Booked (tons). We do not consider the welding diameter 156.7 in the validation analysis because are products of the group "Special Test Tubes"

Certainly in choosing what product to be pushed to the customers, he will opt for products with welding diameter 152.4 or 244.5, because these are the products where most capacity is already booked and adding products will reduce the average costs (economy of scales).

What of these two groups is better to push?

Once he chooses the welding diameter group. What product is chosen to push, (considering that some welding diameters include 50 different products)?

To answer these questions he can use the model. The first step is indicating the week that he wants to analyse and then press the button "RUN". He will obtain the next output (figure 8.4). The output consists in a ranking of products that are more profitable from the production process point of view.

PRICE CONTROL MODEL CONSTRUCTION TUBES (ZWIJNDRECHT)

Ranking	Product ID	Welding Diameter (mm)	Article Characteristics	Production Cost	Warehousing Cost	Sales Cost	Slitting cost	Dynamic Pricing	Static Pricing
1	808451	152.4	160x80x10.00121005231B	€ 33.12	€ 9.02	€ 11.00	€ 7.00	**€ 60.15**	€ 76.78
2	809997	152.4	160x80x10.00130005231B	€ 33.12	€ 9.03	€ 11.00	€ 7.00	**€ 60.15**	€ 76.78
3	807735	152.4	160x80x10.00100005231B	€ 33.12	€ 9.03	€ 11.00	€ 7.00	**€ 60.15**	€ 76.78
4	807650	152.4	160x80x10.00150005231B	€ 33.12	€ 9.03	€ 11.00	€ 7.00	**€ 60.15**	€ 76.78
5	807648	152.4	160x80x10.00120005231B	€ 33.12	€ 9.03	€ 11.00	€ 7.00	**€ 60.15**	€ 76.78
6	810211	152.4	150X150X10.00100005231B	€ 30.92	€ 12.22	€ 11.00	€ 7.00	**€ 61.14**	€ 66.56
7	808273	152.4	160x80x10.0076005231B	€ 34.15	€ 9.04	€ 11.00	€ 7.00	**€ 61.19**	€ 76.78
8	807825	152.4	120x120x10.00122005231B	€ 33.71	€ 10.13	€ 11.00	€ 7.00	**€ 61.84**	€ 76.78
9	807440	152.4	120x120x10.00100005231B	€ 33.71	€ 10.15	€ 11.00	€ 7.00	**€ 61.86**	€ 76.78
10	808486	152.4	120x120x10.00101005231B	€ 33.71	€ 10.15	€ 11.00	€ 7.00	**€ 61.86**	€ 76.78
11	807364	152.4	120x120x10.00150005231B	€ 33.71	€ 10.15	€ 11.00	€ 7.00	**€ 61.86**	€ 76.78
12	807380	152.4	120x120x10.00120005231B	€ 33.71	€ 10.15	€ 11.00	€ 7.00	**€ 61.86**	€ 76.78
13	807928	152.4	120x120x10.00121005231B	€ 33.71	€ 10.15	€ 11.00	€ 7.00	**€ 61.86**	€ 76.78
14	807452	152.4	120x120x10.00130005231B	€ 33.71	€ 10.15	€ 11.00	€ 7.00	**€ 61.86**	€ 76.78
15	807337	152.4	120x120x10.00140005231B	€ 33.71	€ 10.15	€ 11.00	€ 7.00	**€ 61.86**	€ 76.78
16	807927	244.5	300x100x8.00103005231B	€ 29.85	€ 14.45	€ 11.00	€ 7.00	**€ 62.30**	€ 54.92
17	808379	244.5	300x100x8.00108005231B	€ 29.85	€ 14.45	€ 11.00	€ 7.00	**€ 62.30**	€ 54.92
18	807626	244.5	300x100x8.00112005231B	€ 29.85	€ 14.45	€ 11.00	€ 7.00	**€ 62.30**	€ 54.92
19	809064	244.5	300x100x8.00113505231BTT	€ 29.85	€ 14.45	€ 11.00	€ 7.00	**€ 62.30**	€ 54.92
20	807317	244.5	300x100x8.00120005231B	€ 29.85	€ 14.45	€ 11.00	€ 7.00	**€ 62.30**	€ 54.92
21	807901	244.5	300x100x8.001200044	€ 29.85	€ 14.45	€ 11.00	€ 7.00	**€ 62.30**	€ 54.92
22	808013	244.5	300x100x8.00104005231B	€ 29.85	€ 14.46	€ 11.00	€ 7.00	**€ 62.31**	€ 54.92
23	809415	244.5	300x100x8.00153005031BTT	€ 29.85	€ 14.46	€ 11.00	€ 7.00	**€ 62.31**	€ 54.92
24	809501	244.5	300x100x8.00121605231BTT	€ 29.85	€ 14.46	€ 11.00	€ 7.00	**€ 62.31**	€ 54.92
25	809440	244.5	300x100x8.00130005231B	€ 29.85	€ 14.47	€ 11.00	€ 7.00	**€ 62.32**	€ 54.92
26	807529	244.5	300x100x8.00150005231B	€ 29.85	€ 14.47	€ 11.00	€ 7.00	**€ 62.32**	€ 54.92
27	808885	244.5	300x100x8.00150005031BTT	€ 29.85	€ 14.47	€ 11.00	€ 7.00	**€ 62.32**	€ 54.92
28	807792	244.5	300x100x8.00107305231B	€ 29.85	€ 14.47	€ 11.00	€ 7.00	**€ 62.32**	€ 54.92
29	809495	244.5	300x100x8.00120005231BTT	€ 29.85	€ 14.47	€ 11.00	€ 7.00	**€ 62.32**	€ 54.92
30	807512	244.5	300x100x8.00100005231B	€ 29.85	€ 14.47	€ 11.00	€ 7.00	**€ 62.32**	€ 54.92
31	807521	244.5	300x100x8.00140005231B	€ 29.85	€ 14.47	€ 11.00	€ 7.00	**€ 62.32**	€ 54.92
32	808015	244.5	300x100x8.00121605231B	€ 29.85	€ 14.48	€ 11.00	€ 7.00	**€ 62.32**	€ 54.92
33	808388	244.5	300x100x8.00137005231B	€ 29.85	€ 14.48	€ 11.00	€ 7.00	**€ 62.32**	€ 54.92
34	808377	244.5	300x100x8.00125005231B	€ 29.85	€ 14.50	€ 11.00	€ 7.00	**€ 62.35**	€ 54.92
35	808296	244.5	300x100x8.00145005231B	€ 29.85	€ 14.51	€ 11.00	€ 7.00	**€ 62.36**	€ 54.92
36	809158	244.5	300x100x8.00139005231B	€ 29.85	€ 14.52	€ 11.00	€ 7.00	**€ 62.36**	€ 54.92
37	808667	152.4	160x80x8.00108005231B	€ 33.60	€ 10.86	€ 11.00	€ 7.00	**€ 62.46**	€ 72.61
38	809926	152.4	160x80x8.00136005231B	€ 33.60	€ 10.87	€ 11.00	€ 7.00	**€ 62.47**	€ 72.61
39	807769	152.4	160x80x8.00100005231B	€ 33.60	€ 10.87	€ 11.00	€ 7.00	**€ 62.47**	€ 72.61
40	808179	152.4	160x80x8.001500044	€ 33.60	€ 10.87	€ 11.00	€ 7.00	**€ 62.47**	€ 72.61
41	807372	152.4	160x80x8.00150005231B	€ 33.60	€ 10.87	€ 11.00	€ 7.00	**€ 62.47**	€ 72.61
42	809927	152.4	160x80x8.00140005231B	€ 33.60	€ 10.87	€ 11.00	€ 7.00	**€ 62.47**	€ 72.61
43	808007	152.4	160x80x8.001200044	€ 33.60	€ 10.87	€ 11.00	€ 7.00	**€ 62.47**	€ 72.61
44	807406	152.4	160x80x8.00120005231B	€ 33.60	€ 10.87	€ 11.00	€ 7.00	**€ 62.47**	€ 72.61
45	808477	152.4	160x80x8.00121005231B	€ 33.60	€ 10.87	€ 11.00	€ 7.00	**€ 62.47**	€ 72.61
46	809300	244.5	300x100x10.00101005231B	€ 32.78	€ 11.78	€ 11.00	€ 7.00	**€ 62.56**	€ 69.77
47	807766	244.5	300x100x10.00100005231B	€ 32.78	€ 11.80	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
48	807835	244.5	300x100x10.00104005231B	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
49	807914	244.5	300x100x10.00103005231B	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
50	810061	244.5	300x100x10.00118005231B	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
51	807311	244.5	300x100x10.00120005231B	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
52	807397	244.5	300x100x10.00140005231B	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
53	807546	244.5	300x100x10.00130005231B	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
54	807586	244.5	300x100x10.00150005231B	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
55	807844	244.5	300x100x10.00122005231B	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
56	808014	244.5	300x100x10.00141205231B	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
57	808294	244.5	300x100x10.00145005231B	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
58	809505	244.5	300x100x10.00120005231BTT	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
59	809849	244.5	300x100x10.00123505231B	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
60	810030	244.5	300x100x10.00141205231BTT	€ 32.78	€ 11.81	€ 11.00	€ 7.00	**€ 62.58**	€ 69.77
61	808275	152.4	120x120x10.0076005231B	€ 34.74	€ 10.10	€ 11.00	€ 7.00	**€ 62.83**	€ 76.78
62	808378	244.5	300x100x8.0094005231B	€ 30.38	€ 14.46	€ 11.00	€ 7.00	**€ 62.84**	€ 54.92
63	809405	244.5	300x100x8.0096005231B	€ 30.38	€ 14.46	€ 11.00	€ 7.00	**€ 62.84**	€ 54.92
64	807791	244.5	300x100x8.0097805231B	€ 30.38	€ 14.46	€ 11.00	€ 7.00	**€ 62.84**	€ 54.92
65	809967	244.5	300x100x8.0099005231B	€ 30.38	€ 14.46	€ 11.00	€ 7.00	**€ 62.85**	€ 54.92
66	809872	244.5	300x100x8.0095005231B	€ 30.38	€ 14.47	€ 11.00	€ 7.00	**€ 62.85**	€ 54.92
67	810101	152.4	120x120x10.0060505231B	€ 34.74	€ 10.14	€ 11.00	€ 7.00	**€ 62.88**	€ 76.78
68	807357	152.4	120x120x10.0060005231B	€ 34.74	€ 10.15	€ 11.00	€ 7.00	**€ 62.89**	€ 76.78
69	807355	152.4	120x120x10.0075005231B	€ 34.74	€ 10.16	€ 11.00	€ 7.00	**€ 62.90**	€ 76.78
70	807819	152.4	120x120x10.0085005231B	€ 34.74	€ 10.18	€ 11.00	€ 7.00	**€ 62.92**	€ 76.78
71	807789	244.5	300x100x8.00180005231B	€ 30.92	€ 14.47	€ 11.00	€ 7.00	**€ 63.39**	€ 54.92
72	808668	152.4	160x80x8.0096005231B	€ 34.54	€ 10.87	€ 11.00	€ 7.00	**€ 63.40**	€ 72.61
73	808370	152.4	160x80x8.0066705231B	€ 34.54	€ 10.87	€ 11.00	€ 7.00	**€ 63.41**	€ 72.61
74	808669	152.4	160x80x8.0092005231B	€ 34.54	€ 10.87	€ 11.00	€ 7.00	**€ 63.41**	€ 72.61
75	808800	152.4	160x80x8.0075005231B	€ 34.54	€ 10.87	€ 11.00	€ 7.00	**€ 63.41**	€ 72.61
76	808801	152.4	160x80x8.0068005231B	€ 34.54	€ 10.87	€ 11.00	€ 7.00	**€ 63.41**	€ 72.61
77	809788	152.4	160x80x8.0072435231BTTHF	€ 34.54	€ 10.87	€ 11.00	€ 7.00	**€ 63.41**	€ 72.61
78	807573	152.4	160x80x8.0060005231B	€ 34.54	€ 10.87	€ 11.00	€ 7.00	**€ 63.41**	€ 72.61
79	809902	152.4	160x80x8.00600044	€ 34.54	€ 10.87	€ 11.00	€ 7.00	**€ 63.41**	€ 72.61
80	807738	244.5	300x100x10.0075005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
81	807799	244.5	300x100x10.0066005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
82	807800	244.5	300x100x10.0067305231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
83	807814	244.5	300x100x10.0072005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
84	807972	244.5	300x100x10.0081005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
85	808000	244.5	300x100x10.0069005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
86	808347	244.5	300x100x10.0061005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
87	808348	244.5	300x100x10.0067005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
88	808547	244.5	300x100x10.0078005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
89	808927	244.5	300x100x10.0096005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
90	809156	244.5	300x100x10.0076005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
91	809231	244.5	300x100x10.0086005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
92	809301	244.5	300x100x10.0089005231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
93	809663	244.5	300x100x10.0075305231B	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
94	809904	244.5	300x100x10.0074005231BTT	€ 33.65	€ 11.81	€ 11.00	€ 7.00	**€ 63.46**	€ 69.77
95	808276	152.4	120x120x10.00170005231B	€ 35.77	€ 10.15	€ 11.00	€ 7.00	**€ 63.92**	€ 76.78
96	807432	152.4	120x120x10.00180005231B	€ 35.77	€ 10.15	€ 11.00	€ 7.00	**€ 63.92**	€ 76.78
97	807816	244.5	300x100x10.00180005231B	€ 34.52	€ 11.81	€ 11.00	€ 7.00	**€ 64.33**	€ 69.77
98	807429	152.4	160x80x8.00180005231B	€ 35.47	€ 10.87	€ 11.00	€ 7.00	**€ 64.35**	€ 72.61
99	808487	152.4	120x120x8.00104005231B	€ 34.43	€ 12.22	€ 11.00	€ 7.00	**€ 64.65**	€ 72.61
100	808782	152.4	120x120x8.001100044	€ 34.43	€ 12.23	€ 11.00	€ 7.00	**€ 64.66**	€ 72.61

Figure 8.4 Output model choosing of the product

Going back to the first question what group is more convenient to push to the customer, it looks evident that products with welding diameter 152.4 should be prioritized to the products with welding diameter 244.5, indeed in the first 15 products on the ranking result from the 152.4 group. The seller can then check what products the model recommends to prioritize and what are the costs related to each of the production process phases. The seller can compare the price calculated with the dynamic control model (price depending on the capacity planned) and the price from the static calculation that is currently made. With this comparison it is evident how for some products the difference between the dynamic and the static price can be close to 10%. So the costs related to the production process are estimated by the model to be less than the currently made static cost evaluation. That is an input for the seller to try to sell these products because the model suggests that the effective costs are overestimated by the current used methodology. On the other end, some products (for example these on figure 8.5) result to have a higher dynamic price that the static price, which shows that the cost related to the production of these products are currently higher than the estimated prices used by Tata Steel Tubes. This occurs because the Dynamic and Static models use different cost evaluation strategies as explained in the beginning of the chapter. The Market Independent Model therefore suggests that the Static pricing is under-pricing these products and gives the seller an overview of the difference between the two pricing strategies.

Ranking	Product ID	Welding Diameter (mm)	Article Characteristics	Production Cost	Warehousing Cost	Sales Cost	Slitting cost	Dynamic Pricing	Static Pricing
30	807512	244.5	300x100x8.00100005231B	€ 29.85	€ 14.47	€ 11.00	€ 7.00	€ 62.32	€ 54.92
31	807521	244.5	300x100x8.00140005231B	€ 29.85	€ 14.47	€ 11.00	€ 7.00	€ 62.32	€ 54.92
32	808015	244.5	300x100x8.00121605231B	€ 29.85	€ 14.48	€ 11.00	€ 7.00	€ 62.32	€ 54.92
33	808388	244.5	300x100x8.00137005231B	€ 29.85	€ 14.48	€ 11.00	€ 7.00	€ 62.32	€ 54.92
34	808377	244.5	300x100x8.00125005231B	€ 29.85	€ 14.50	€ 11.00	€ 7.00	€ 62.35	€ 54.92
35	808296	244.5	300x100x8.00145005231B	€ 29.85	€ 14.51	€ 11.00	€ 7.00	€ 62.36	€ 54.92
36	809158	244.5	300x100x8.00139005231B	€ 29.85	€ 14.52	€ 11.00	€ 7.00	€ 62.36	€ 54.92

Figure 8.5 Products Static vs Dynamic Pricing

This tool gives the seller a better overview of the impact of the decision to prioritize a certain product or another one.

The proposed methodology of production process cost calculation gives a more realistic overview of the cost involved in the process. As already discussed the goal of this model is not to propose an end-price to the customer, because, as discussed in chapter 7, it is mostly influenced by the market price, but to clarify the cost involved in the production process and to make it possible for the seller to have an extra tool in the negotiation phase.

8.4.2 Production process cost of a specific Product ID for a specific week

In the paragraph above we have shown how the seller is able to determine what products are recommended by the model to be pushed to the customer for a determinate week. The next tool that we will describe is made to give the seller the opportunity to estimate the costs related to a specific product in a specific week. Also this is something that is not visible with the current methodology used by Tata Steel Tubes. Indeed if a product is already planned or not the current static price estimation gives the same result. We will now show the visualization of the model, how it works and the outputs that we obtain. To better clarify we will follow an example of its use.

To use this tool the first step that the Sales department has to do is to indicate what week he/she wants to analyse. This has to be done in point a) (figure 8.2). Then the Product ID that he/she is looking for and the number of tons. The next figure shows the visualization that comes up from the model.

c) Production Process costs of a specific Product ID per a specific week

Insert in point a) the week.

Then insert in the table below Product Id and Number of Tons.

Product ID	807825
Article Characteristics	120x120x10.00122005231B
Welding diameter (mm)	152.4
Number of Tons	1

	All Tons	Per Tons
Dynamic Pricing	€ 61.83	€ 61.83
Static Pricing	€ 76.78	€ 76.78
Negotiable Advantage	€ 14.95	€ 14.95

Figure 8.6 Production Process costs of Product i per week j

The output indicates the cost coming out from the Static and Dynamic pricing strategies and shows what is the negotiable advantage. For negotiable advantage we consider the difference between the Static and Dynamic Pricing outputs. In case it is a positive number it means that we predict that the current costs related to the production process are lower than the ones coming out from the Static Pricing (current pricing strategy used). If the negotiable advantage is positive the seller could use these values in a negotiation phase, because then he would know how the effective costs are decreasing mostly given the economy of scales principle (indeed the capacity booked of this product is high). The seller can check for example how the price would change if there would be the possibility to conclude a deal of a high quantity of tons. In this way suppose he would had an order of 200 tons, he could check how the costs will variate per ton of product. Let see this with an example. Suppose an order of 200 tons of the same product as in figure 8.6 is made, the new output is shown in the next figure.

c) Production Process costs of a specific Product ID per a specific week

Insert in point a) the week.

Then insert in the table below Product Id and Number of Tons.

Product ID	807825
Article Characteristics	120x120x10.00122005231B
Welding diameter (mm)	152.4
Number of Tons	200

	All Tons	Per Tons
Dynamic Pricing	€ 12,108.88	€ 60.54
Static Pricing	€ 15,355.79	€ 76.78
Negotiable Advantage	€ 3,246.92	€ 16.23

Figure 8.7 Impact of 200 Tons

The cost per ton results to be decreased by 1.29 euro per ton, that is not an high decreasing, but the factor here that interests the seller is that the negotiable advantage is 16,23 euro per ton (comparison dynamic and static prices methodologies). That means for the seller that in an hypothetical negotiation phase he would be able to make a determinate discount (action to convince the customer to buy) being able to not exceed the costs related to the production of this product.

8.4.3 Decide between a certain number of requests; which one has to be accepted to complete the available capacity

In the last years the demand of the construction tubes produced by Tata Steel Tubes in Zwijndrecht is increased. Therefore it is evident that there is a difference between some years ago when almost all orders where accepted and the current situation where in some periods of the year a decision has to be made of what orders to accept and what not.

The tool that we will now describe is made for in the case that in a future the seller would have to deal with a period of high demand and would have to decide to accept what orders out of a certain number of requests, in order to complete the available capacity. The calculation of the costs is done with the same methodology described in the precedent paragraphs. We will now see, again with a practical example, how this tool can be used and what are the outcomes of it.

Let's suppose that after a consultation between the Production and the Sales departments, because of an expected high yield of the production processes, the selling capacity for the next week is increased of another 100 tons (next week "Lasweek 16" figure 8.2). Let's suppose as well that the demand is very high in this period of the year and the seller receives different requests. Given the high demand the margin per order would be the same, because Tata Steel is not willing to discount products. But what orders are better to prioritize is not evident from the current static pricing strategy because, as we already have expressed, the impact of the already and expected planned tons is not taken into account. Therefore the tool has the scope to clarify this situation, given as output the recommended orders to accept.

Suppose the Sales department receives the next requests for products that could be produced the next week:

Week	3
Max Capacity	100

Requests	**Product ID**	**Article Characteristics**	**Number of Tons**
1	809904	300x100x10.0074005231BTT	10
2	810061	300x100x10.00118005231B	32
3	808466	250x150x10.0079005231B	10
3	808466	250x150x10.0079005231B	10
4	809963	250x150x10.0075005231B	23
5	808605	250x150x10.0097005231B	78
6	807295	200x200x10.00120005231B	9
7	807370	200x200x10.00150005231B	12
8	807435	200x200x10.00140005231B	10
9	807519	200x200x10.0060005231B	10
10	807606	200x200x10.00130005231B	15
11	807709	200x200x10.00121005231B	5
12	808738	200x200x10.00134005231B	5
13	807843	300x100x8.00122005231B	6
14	810322	300X100X8.00122005231B	20
15	807311	300x100x10.00120005231B	14
16	807397	300x100x10.00140005231B	16
18	807586	300x100x10.00150005231B	10
19	807844	300x100x10.00122005231B	20
20	808014	300x100x10.00141205231B	1
21	808294	300x100x10.00145005231B	18
22	809505	300x100x10.00120005231BTT	10
23	809849	300x100x10.00123505231B	10
24	810030	300x100x10.00141205231BTT	10
25	807418	250x150x10.00140005231B	10

Figure 8.8 Requests by customers for week 3

The seller has to decide what bundle of orders to accept in such a way that the effect on the production process costs can be as low as possible. To do that the customer can use the model. The seller has to upload in the model the requests that have currently arrived, the available capacity and the week that he wants to analyse. Then he must press the button "RUN" and the model will give as output the dynamic and static prices, the negotiable advantage (both for the complete number of tons and for one ton) and in green the order that it suggested to be accepted or somehow prioritized (figure 8.9).

Week	3
Max Capacity	100

Requests	Product	Article Characteristics	Number of Tons	Dynamic Price	Static Pric	Negotiable Advantage	Negotiable Advantage Per Ton	Cumulative Tons
2	810061	300x100x10.00118005231B	32	€ 1,994.73	€ 2,232.67	€ 237.94	€ 7.44	32
19	807844	300x100x10.00122005231B	20	€ 1,248.53	€ 1,395.42	€ 146.89	€ 7.34	52
21	808294	300x100x10.00145005231B	18	€ 1,123.95	€ 1,255.88	€ 131.93	€ 7.33	70
16	807397	300x100x10.00140005231B	16	€ 999.32	€ 1,116.34	€ 117.02	€ 7.31	86
15	807311	300x100x10.00120005231B	14	€ 874.62	€ 976.80	€ 102.17	€ 7.30	100
18	807586	300x100x10.00150005231B	10	€ 625.04	€ 697.71	€ 72.67	€ 7.27	110
22	809505	300x100x10.00120005231BTT	10	€ 625.04	€ 697.71	€ 72.67	€ 7.27	120
23	809849	300x100x10.00123505231B	10	€ 625.04	€ 697.71	€ 72.67	€ 7.27	130
24	810030	300x100x10.00141205231BTT	10	€ 625.04	€ 697.71	€ 72.67	€ 7.27	140
20	808014	300x100x10.00141205231B	1	€ 62.58	€ 69.77	€ 7.20	€ 7.20	141
1	809904	300x100x10.0074005231BTT	10	€ 633.77	€ 697.71	€ 63.94	€ 6.39	151
25	807418	250x150x10.00140005231B	10	€ 665.07	€ 697.71	€ 32.65	€ 3.26	161
5	808605	250x150x10.0097005231B	78	€ 5,218.17	€ 5,442.15	€ 223.97	€ 2.87	239
4	809963	250x150x10.0075005231B	23	€ 1,547.41	€ 1,604.74	€ 57.33	€ 2.49	262
3	808466	250x150x10.0079005231B	10	€ 673.79	€ 697.71	€ 23.92	€ 2.39	272
3	808466	250x150x10.0079005231B	10	€ 673.79	€ 697.71	€ 23.92	€ 2.39	282
10	807606	200x200x10.00130005231B	15	€ 1,020.98	€ 1,046.57	€ 25.58	€ 1.71	297
7	807370	200x200x10.00150005231B	12	€ 817.07	€ 837.25	€ 20.19	€ 1.68	309
8	807435	200x200x10.00140005231B	10	€ 681.05	€ 697.71	€ 16.66	€ 1.67	319
6	807295	200x200x10.00120005231B	9	€ 613.01	€ 627.94	€ 14.93	€ 1.66	328
11	807709	200x200x10.00121005231B	5	€ 340.72	€ 348.86	€ 8.13	€ 1.63	333
12	808738	200x200x10.00134005231B	5	€ 340.72	€ 348.86	€ 8.13	€ 1.63	338
9	807519	200x200x10.0060005231B	10	€ 689.78	€ 697.71	€ 7.94	€ 0.79	348
14	810322	300X100X8.00122005231B	20	€ 1,291.24	€ 1,098.50	-€ 192.74	-€ 9.64	368
13	807843	300x100x8.00122005231B	6	€ 388.03	€ 329.55	-€ 58.48	-€ 9.75	374

RUN

Figure 8.9 Output tool

This tool gives the seller the possibility to be fast in the decision of what order to prioritize. Indeed it is faster than to check order per order and then compare their costs. With this tool an automatic output is calculated and the negotiable factor is visible that would be the principal factor that the seller would check.

8.5 Validation analysis

We have decided to validate the model by comparing it with the strategies used/suggested in the order acceptance by the Sales, the Production and the Finance and Control departments.

The three departments have different roles in the production process:

- the Sales department is the one that is in charge of the yes/no order acceptance phase
- the Financial and Control department is in charge of the evaluation of the costs (pricing) related to the production process
- the Production department is in charge of ensuring that the production is on time and that it respects the customer's request (quality, dimensions and tolerances)

What products are the best to be sold from the Tata Steel Tubes' point of view should be clear for the three departments.

We have decided to interview the Sales and the Production departments to understand what strategies they apply in an order acceptance phase in case of many requests and limited available capacity. As for the strategy of the Financial and Control department we decided to consider the outcome of the current static pricing methodology used by Tata Steel Tubes. Indeed this pricing methodology is made by the Financial and Control department, that is also in charge of updating it.

In this way we want to see if the three departments are reasoning in the same way when a decision has to be made on what products they recommend to be sold and how the model that we have developed is currently working.

The two main questions of the interviews with the Sales and the Production departments were the following:

a) Given this planning. What products will you push to the customer in case there is an extra available capacity? What las diameter? Why?
b) What strategy would you follow to make your decision?

The two interviews were based on the planning shown in figure 8.3 related to "lasweek 16".
Then we will analyse the dynamic pricing outcomes (coming from the "Market independent model" developed in this research) and the static price outcomes (coming from the actual used pricing strategy) on the same week planning.

8.5.1 Sales department manager interview

Sales department manager's idea is, as expected, to push to the customers those products that are already planned in the production planning; adding orders of these groups will decrease the average cost related to the machines' preparation.
The next question was what welding diameter would you choose between the current planned. The manager in a first instance suggested to add T&H products because these products have a low planned capacity and when you increase the planned capacity the average costs of these products could be reduced. On the other end, the manager expressed that in a condition where the demand is high, the production of this group of products is normally the first to be avoided. Excluding the T&H products the manager suggested to push products with welding diameter 244.5, that because the products of welding diameter 152.4 are smaller and thinner and so the output is lower.

He suggested to follow the next rank in the order acceptance (ranked in order of importance):

1. Products with welding diameter 244.5 because the output is higher (prioritize with standard length and square)
2. Products with welding diameter 152.4 (prioritize with standard length and square)
3. Products of the 323.9 welding diameter group
4. T&H products

The Sales department manager mentioned also the importance to consider the contribution of material for Tata Steel (profit made from the steel coils by Tata Steel the "mother company"), which is not considered in this research given that we tried to view the research from the Tata Steel Tubes' point of view.

The manager confirmed that the 12 meters have always to be prioritized. Then smaller ones (from 6 to 12 meters) and medium products (from 12 to 16 meters). Only as last have to be accepted products with length higher than 16 meters.

T&H products have been criticized for the next reasons:

1. Production machines need considerable more time and produce more waste
2. Extra time in the cleaning phase
3. Four extra people needed

The manager has also expressed that he thinks that these products could be easily substituted by standard products. However he told us that for the current year 10,000 tons extra were requested of standard products and that they could not be accepted given the limited available capacity.

8.5.2 Production and Logistic department manager interview

The same questions mentioned above in point a) and b) were made to the Production and Logistic department.

The manager of this department as well expressed, as expected, to add to production those products that have an already planned welding diameter. He suggested to add first to production products with welding diameter 323.9, because they are considered to be produced particularly fast and can be stored outside (the inside warehouse is a main bottleneck of the production process, as discussed in the precedent chapters).

He suggested to follow the next rank in the order acceptance phase (ranked in order of importance):

1. Products that can be stored outside (323.9 in this case)

2. Then products of the 152.4 welding diameter with standard length (fast and easy to be stored)
3. Then products of the 244.5 welding diameter with standard length
4. At the end Precision tubes (T&H)

The manager confirmed that the 12 meters have always to be prioritized. Then smaller ones (from 6 to 12 meters) and medium products (from 12 to 16 meters), and only as last have to be accepted products with a length higher than 16 meters. These considerations are the same as those made by the Sales department manager.

T&H products have been criticized for the next reasons:

1. These products stay 3/4 weeks minimum in the warehouse
2. Sometimes these products stay until half a year in the warehouse
3. T&H use to much Tata Steel warehouse
4. Production machines need considerable more time and produce more waste
5. Extra time used for the cleaning phase
6. Four extra people needed

8.5.3 Financial and Control department: Static pricing outcomes

Now we check the cost evaluations of the production process for the different welding diameters using the Static pricing methodology currently used by Tata Steel Tubes. For every welding diameter we show the 10 best products (best in term of lower costs) and we check what products seem to be more profitable to be pushed to the costumer according to this methodology. The next figure shows the cost evaluations of the production process of the static pricing methodology for the welding diameter produced in the analysed week (“lasweek 16”).

Welding Diameter (mm)	Article number	Article Characteristics	Diameter (mm)	height (mm)	width (mm)	thickness (mm)	Length (mm)	Static Pricing
244.50	807391	200x200x8.00100005231B	0	200	200	8	10000	€ 54.92
244.50	807697	200x200x8.00109005231B	0	200	200	8	10900	€ 54.92
244.50	807822	200x200x8.0085005231B	0	200	200	8	8500	€ 54.92
244.50	808110	200x200x8.001000044	0	200	200	8	10000	€ 54.92
244.50	808332	200x200x8.00107005231B	0	200	200	8	10700	€ 54.92
244.50	808336	200x200x8.001080044	0	200	200	8	10800	€ 54.92
244.50	808365	200x200x8.00103005231B	0	200	200	8	10300	€ 54.92
244.50	808565	200x200x8.00820044	0	200	200	8	8200	€ 54.92
244.50	808750	200x200x8.001060044	0	200	200	8	10600	€ 54.92
244.50	808833	200x200x8.00115005231B	0	200	200	8	11500	€ 54.92

Welding Diameter (mm)	Article number	Article Characteristics	Diameter (mm)	height (mm)	width (mm)	thickness (mm)	Length (mm)	Static Pricing
323.90	808434	323.9X8.0011600ZW5231B	323.9	0	0	8	11600	€ 55.01
323.90	808435	323.9X8.0011500ZW5231B	323.9	0	0	8	11500	€ 55.01
323.90	808436	323.9X8.0011000ZW5231B	323.9	0	0	8	11000	€ 55.01
323.90	808437	323.9X8.009300ZW5231B	323.9	0	0	8	9300	€ 55.01
323.90	807609	323.9X8.0012000ZW5231B	323.9	0	0	8	12000	€ 55.01
323.90	808325	323.9X8.0012500ZW5231B	323.9	0	0	8	12500	€ 55.01
323.90	808375	323.9X8.0013000ZW5231B	323.9	0	0	8	13000	€ 55.01
323.90	808431	323.9X8.0015500ZW5231B	323.9	0	0	8	15500	€ 55.01
323.90	808432	323.9X8.0015000ZW5231B	323.9	0	0	8	15000	€ 55.01
323.90	808433	323.9X8.0013600ZW5231B	323.9	0	0	8	13600	€ 55.01

Welding Diameter (mm)	Article number	Article Characteristics	Diameter (mm)	height (mm)	width (mm)	thickness (mm)	Length (mm)	Static Pricing
152.40	807662	120x120x6.00105005231B	0	120	120	6	10500	€ 66.92
152.40	807767	120x120x6.00104005231B	0	120	120	6	10400	€ 66.92
152.40	807768	120x120x6.00110005231B	0	120	120	6	11000	€ 66.92
152.40	808092	120x120x6.001000044	0	120	120	6	10000	€ 66.92
152.40	808163	120x120x6.00800044	0	120	120	6	8000	€ 66.92
152.40	808496	120x120x6.00119005231B	0	120	120	6	11900	€ 66.92
152.40	808556	120x120x6.00108005231B	0	120	120	6	10800	€ 66.92
152.40	808710	120x120x6.0099005231B	0	120	120	6	9900	€ 66.92
152.40	808793	120x120x6.00113005231B	0	120	120	6	11300	€ 66.92
152.40	808794	120x120x6.00118005231B	0	120	120	6	11800	€ 66.92

Welding Diameter (mm)	Article number	Article Characteristics	Diameter (mm)	height (mm)	width (mm)	thickness (mm)	Length (mm)	Static Pricing
162.70	800069	162.0X7.00X7302 ROTHIEL01	162	0	7	7	7302	€ 68.11
162.70	800067	162.0X6.00X6000 ROTHIEL01	162	0	6	6	6000	€ 73.97

Figure 8.10 Static pricing outcomes

It can be seen that this methodology suggests to push products with welding diameter 244.5 or 323.9. The best items of the two groups result almost with the same production process price. The best products with welding diameter of 152.4 result with a static pricing of 66.92 euro and the best T&H product (162.7 welding diameter) results with a static pricing of 68.11 euro.

It is evident that this methodology prioritizes the square products, indeed all the best products (except of the circular ones) are squared. Another thing that can be seen is that products with a different length have the same price.

8.5.4 Market Independent Model

We will now analyse the output of the model developed in this research. The outcome in this case is the same as shown in figure 8.4. It can be seen that for the first 100 products the dynamic price forecasted is between 60.15 and 64.66 euro. All the 100 products are of the welding diameter 152.4 or 244.5, because the model costs evaluation is highly depending on the planning and the project that has a higher planned capacity will result with a lower price.

We will now check the dynamic prices related to welding diameter 323.9 and T&H (162.7 welding diameter) (figure 8.11). Both groups best prices are considerable higher compared to the 152.4 and 244.5 groups best prices, which seems to come principally from the fact that the planned capacity is not really high for these groups. But comparing T&H and the 323.9, the most convenient product of group 323.9 results almost 24 euro cheaper than the best T&H product, which comes from the fact that the Market Independent Model recognizes that these products can be stored outside, and lower warehousing costs decrease the total production process costs.

Article nr	Article Characteristics	Welding Diameter (mm)	Dynamic Pricing
800067	162.0X6.00X6000 ROTHIEL01	162.70	€ 100.64
800069	162.0X7.00X7302 ROTHIEL01	162.70	€ 106.18

Article nr	Article Characteristics	Welding Diameter (mm)	Dynamic Pricing
808510	323.9X12.0010100ZW52	323.90	€ 76.44
808363	323.9X12.0012000ZW52	323.90	€ 76.44
808683	323.9X12.0011000ZW5231B	323.90	€ 76.44
808383	323.9X12.0010000ZW52	323.90	€ 76.44
808391	323.9X12.0013200ZW52	323.90	€ 76.44
808591	323.9X12.0013400ZW5231B	323.90	€ 76.44
808381	323.9X12.006900ZW52	323.90	€ 76.99
808482	323.9X12.008500ZW5231B	323.90	€ 76.99
809033	323.9X10.0012000ZW5231B	323.90	€ 78.54
808434	323.9X8.0011600ZW5231B	323.90	€ 79.18
808433	323.9X8.0013600ZW5231B	323.90	€ 79.18
808435	323.9X8.0011500ZW5231B	323.90	€ 79.18
808375	323.9X8.0013000ZW5231B	323.90	€ 79.18
808325	323.9X8.0012500ZW5231B	323.90	€ 79.18
808432	323.9X8.0015000ZW5231B	323.90	€ 79.18
808436	323.9X8.0011000ZW5231B	323.90	€ 79.18
807609	323.9X8.0012000ZW5231B	323.90	€ 79.18
808986	323.9X8.0012000ZW37	323.90	€ 79.18
808431	323.9X8.0015500ZW5231B	323.90	€ 79.18
808437	323.9X8.009300ZW5231B	323.90	€ 79.72

Figure 8.11 Dynamic pricing weld diameter 162.7(mm) and 323.9(mm)

8.5.5 Comparison of the results

The three departments and the Market Independent Model have given different results on what products to push to customers.

In the next table the different rankings expressed by the three departments and the model developed in this research are shown.

	Sales	Production and Logistic	Finance and Control (Static pricing)	Independent Market Model (Dynamic pricing)
I.	244.5mm	323.9mm	244.4mm (54.92€/ton)	152.4mm (60.15€/ton)
II.	152.4mm	152.4mm	323.9mm (55.01€/ton)	244.4mm (62.30€/ton)
III.	323.9mm	244.4mm	152.4mm (66.91€/ton)	323.9mm (76.44€/ton)
IV.	T&H	T&H	T&H (68.11€/ton)	T&H (100.64€/ton)

Table 8.2 Rankings of different welding diameters made from the different departments and the Independent Market Model. T&H is a special welding diameter made for the T&H company it is also measured in mm and is part of the Precision Tubes group

Comparing the results we can conclude that:

- The four rakings have in common that the T&H group is always the last one of the ranking. As mentioned in the paragraphs 8.5.1 and 8.5.2 the Sales and the Production and Logistic departments have expressed how the T&H group has high extra costs compared to the standard products. The Independent Market Model with a price cost estimation of 100.64 euro per ton for the best ranked T&H product seems to represent well this situation.
- The Finance and Control department results also point out that the T&H group is the last in the ranking, but with a best price of 68.11 euro per ton, which is really close to the cost evaluation of the best product of the 152.4 group.
- Between the evaluation of the T&H group of the Finance and Control department and that of the Independent Market Model there is a difference of 32 euro per ton (a high difference). Indeed the Finance and Control department seems to under-price these products comparing the outcomes with the Independent Market Model prices and those given in the interviews with the Sales and the Production departments.
- The four rankings of table 8.2 result all different, which confirms how the different departments have not a same strategy/view on which products to push to the market.

- The Production and Logistic department outcome shows how the idea of pushing products that can be stored outside (323.9 welding diameter) is to be prioritized. The Independent Market Model that considers a decrease of the warehousing costs of the groups that can be stored outside, shows a price that is conditioned by the fact that the warehouse capacity booked for this product group is relatively low compared to the groups 244.4 and 152.4.
- The group 152.4 is ranked at the second position for both the Production and Logistic and the Sales departments. The products of this group have the advantage to use less space per ton in the internal warehouse (bottleneck of the Zwijndrecht factory) compared to the 244.4 group and that is also why the Market Independent Model prioritizes this group.
- The Finance and Control department does not consider the length of the SKUs in the cost evaluation, which instead is done by the Market Independent Model developed in this research and proved to be important by the interviews with the Sales and the Production and Logistic departments.
- The Market Independent Model does not prioritize square products, contrary to the Finance and Control department, and promoted by the Sales and the Production and Logistic departments in the interviews.

8.6 Extra considerations

The model we developed is made assuming that the demand of products will increase in the next future. That is why the model is thought to be a tool to decide what products are more convenient to sell in case of low available capacity in the warehouse. In a condition where the demand for the next week is low, the dynamic price will be always higher comparing to the static price. That is because the model considers in the cost evaluation the probability to obtain extra capacity (very low if we are analysing for the next week) and the already planned capacity (that we have assumed low in this case). The model is an order acceptance tool (in case of high demand) so in a case like the one described where the demand is low, the use of it by the seller is not necessary.

We might explain it better with an example. Consider the used capacity of production in figure 8.2 for the next week "lasweek 14", it can be seen that only 78.44% of the capacity is booked (consider 78.44% of 70% of the total capacity as explained in paragraph 8.2 to avoid increasing of the waiting time). In this case if we run the model to check what products are to be pushed to the customer, we will obtain the next output (figure 8.12).

Ranking	Product ID	Las Diameter	Article Characteristics	Production Cost	Warehousing Cost	Sales Cost	Slitting cost	Dynamic Pricing	Static Pricing
1	808353	312	300x200x10.00135005231B	€ 39.73	€ 18.51	€ 11.00	€ 7.00	€ 76.24	€ 61.54
2	807545	312	300x200x10.00130005231B	€ 39.73	€ 18.51	€ 11.00	€ 7.00	€ 76.24	€ 61.54
3	809398	312	300x200x10.00120005231BT	€ 39.73	€ 18.51	€ 11.00	€ 7.00	€ 76.24	€ 61.54
4	807477	312	300x200x10.00150005231B	€ 39.73	€ 18.51	€ 11.00	€ 7.00	€ 76.24	€ 61.54
5	808981	312	300x200x10.00100005231B	€ 39.73	€ 18.51	€ 11.00	€ 7.00	€ 76.24	€ 61.54
6	807334	312	300x200x10.00120005231B	€ 39.73	€ 18.51	€ 11.00	€ 7.00	€ 76.24	€ 61.54
7	807398	312	300x200x10.00140005231B	€ 39.73	€ 18.51	€ 11.00	€ 7.00	€ 76.24	€ 61.54
8	808706	312	300x200x10.0086005231B	€ 40.42	€ 18.54	€ 11.00	€ 7.00	€ 76.96	€ 61.54
9	808707	312	300x200x10.0083005231B	€ 40.42	€ 18.55	€ 11.00	€ 7.00	€ 76.97	€ 61.54
10	807438	312	250x250x10.00100005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
11	808361	312	250x250x10.00106005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
12	808484	312	250x250x10.00112005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
13	808686	312	250x250x10.00105005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
14	808880	312	250x250x10.00101005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
15	810046	312	250x250x10.00108005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
16	810057	312	250x250x10.00110005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
17	807335	312	250x250x10.00120005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
18	807381	312	250x250x10.00140005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
19	807542	312	250x250x10.00130005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
20	807562	312	250x250x10.00150005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
21	807661	312	250x250x10.00127005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
22	808088	312	250x250x10.00135005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
23	808421	312	250x250x10.00137005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
24	808480	312	250x250x10.00134005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
25	808526	312	250x250x10.00133005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
26	808685	312	250x250x10.00121005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
27	808716	312	250x250x10.00139005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
28	808788	312	250x250x10.00123005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
29	808848	312	250x250x10.00126505231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
30	809220	312	250x250x10.00126005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
31	809470	312	250x250x10.00136005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
32	809518	312	250x250x10.00147005231B	€ 39.71	€ 19.28	€ 11.00	€ 7.00	€ 76.98	€ 61.54
33	809723	312	300x200x10.0093005231B	€ 40.42	€ 18.57	€ 11.00	€ 7.00	€ 76.99	€ 61.54
34	810238	312	180X180X8.001500044	€ 41.63	€ 17.51	€ 11.00	€ 7.00	€ 77.14	€ 57.76
35	807567	312	300x200x10.00180005231B	€ 41.11	€ 18.51	€ 11.00	€ 7.00	€ 77.61	€ 61.54
36	808241	312	250x250x10.0097005231B	€ 40.39	€ 19.28	€ 11.00	€ 7.00	€ 77.67	€ 61.54
37	807931	312	250x250x10.0095005231B	€ 40.39	€ 19.28	€ 11.00	€ 7.00	€ 77.67	€ 61.54
38	808562	312	250x250x10.0093005231B	€ 40.39	€ 19.28	€ 11.00	€ 7.00	€ 77.67	€ 61.54
39	809297	312	250x250x10.0088005231B	€ 40.39	€ 19.28	€ 11.00	€ 7.00	€ 77.67	€ 61.54
40	809298	312	250x250x10.0074005231B	€ 40.39	€ 19.28	€ 11.00	€ 7.00	€ 77.67	€ 61.54
41	810045	312	250x250x10.0080005231B	€ 40.39	€ 19.28	€ 11.00	€ 7.00	€ 77.67	€ 61.54
42	810261	312	180X180X8.00165005231B	€ 42.83	€ 17.51	€ 11.00	€ 7.00	€ 78.34	€ 57.76
43	807463	312	250x250x10.00180005231B	€ 41.08	€ 19.28	€ 11.00	€ 7.00	€ 78.36	€ 61.54
44	807679	312	250x250x10.00200005231B	€ 41.08	€ 19.28	€ 11.00	€ 7.00	€ 78.36	€ 61.54
45	808183	312	250x250x10.00160005231B	€ 41.08	€ 19.28	€ 11.00	€ 7.00	€ 78.36	€ 61.54
46	808192	312	250x250x10.00165005231B	€ 41.08	€ 19.28	€ 11.00	€ 7.00	€ 78.36	€ 61.54
47	808260	312	250x250x10.00170005231B	€ 41.08	€ 19.28	€ 11.00	€ 7.00	€ 78.36	€ 61.54
48	808717	312	250x250x10.00163005231B	€ 41.08	€ 19.28	€ 11.00	€ 7.00	€ 78.36	€ 61.54
49	809544	312	250x250x10.00187005231B	€ 41.08	€ 19.28	€ 11.00	€ 7.00	€ 78.36	€ 61.54
50	808813	312	250x250x8.0095005231B	€ 42.22	€ 18.15	€ 11.00	€ 7.00	€ 78.37	€ 56.15
51	808266	312	300x200x8.001200044	€ 41.69	€ 22.77	€ 11.00	€ 7.00	€ 82.46	€ 56.15
52	808821	312	300x200x8.001380044	€ 41.69	€ 22.77	€ 11.00	€ 7.00	€ 82.46	€ 56.15
53	807310	312	300x200x8.00120005231B	€ 41.69	€ 22.77	€ 11.00	€ 7.00	€ 82.46	€ 56.15
54	807495	312	300x200x8.00130005231B	€ 41.69	€ 22.77	€ 11.00	€ 7.00	€ 82.46	€ 56.15
55	807553	312	300x200x8.00150005231B	€ 41.69	€ 22.77	€ 11.00	€ 7.00	€ 82.46	€ 56.15
56	808267	312	300x200x8.00135005231B	€ 41.69	€ 22.77	€ 11.00	€ 7.00	€ 82.46	€ 56.15
57	808711	312	300x200x8.00131005231B	€ 41.69	€ 22.77	€ 11.00	€ 7.00	€ 82.46	€ 56.15
58	808728	312	300x200x8.00138005231B	€ 41.69	€ 22.77	€ 11.00	€ 7.00	€ 82.46	€ 56.15
59	808913	312	300x200x8.00116005231B	€ 41.69	€ 22.78	€ 11.00	€ 7.00	€ 82.47	€ 56.15
60	808976	312	300x200x8.0082005231BTT	€ 42.26	€ 22.76	€ 11.00	€ 7.00	€ 83.02	€ 56.15
61	808790	312	250x250x8.00137005231B	€ 41.65	€ 23.70	€ 11.00	€ 7.00	€ 83.36	€ 56.15
62	808423	312	250x250x8.00155005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
63	807482	312	250x250x8.00140005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
64	808912	312	250x250x8.00159005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
65	808577	312	250x250x8.001100044	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
66	807394	312	250x250x8.00100005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
67	808558	312	250x250x8.00108005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
68	808560	312	250x250x8.00119005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
69	808561	312	250x250x8.00115005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
70	809328	312	250x250x8.00106005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
71	809361	312	250x250x8.00105005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
72	810056	312	250x250x8.00110005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
73	808091	312	250x250x8.001200044	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
74	808427	312	250x250x8.001310044	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
75	808789	312	250x250x8.001230044	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
76	808869	312	250x250x8.001260044	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
77	808940	312	250x250x8.001340044	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
78	808941	312	250x250x8.001300044	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
79	807405	312	250x250x8.00120005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
80	807481	312	250x250x8.00130005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
81	807810	312	250x250x8.00131005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
82	808695	312	250x250x8.00123005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
83	809029	312	250x250x8.00122005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
84	809175	312	250x250x8.00121005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
85	809282	312	250x250x8.00126005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
86	809469	312	250x250x8.00132005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
87	807420	312	250x250x8.00150005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
88	809281	312	250x250x8.00136005231B	€ 41.65	€ 23.71	€ 11.00	€ 7.00	€ 83.37	€ 56.15
89	808113	312	250x250x8.00134005231B	€ 41.65	€ 23.73	€ 11.00	€ 7.00	€ 83.38	€ 56.15
90	809176	312	250x250x8.00141005231B	€ 41.65	€ 23.76	€ 11.00	€ 7.00	€ 83.41	€ 56.15
91	809828	312	250x250x8.00135005231B	€ 41.65	€ 23.89	€ 11.00	€ 7.00	€ 83.54	€ 56.15
92	807627	312	300x200x8.00180005231B	€ 42.82	€ 22.76	€ 11.00	€ 7.00	€ 83.59	€ 56.15
93	808576	312	250x250x8.00760044	€ 42.22	€ 23.71	€ 11.00	€ 7.00	€ 83.93	€ 56.15
94	808933	312	250x250x8.00740044	€ 42.22	€ 23.71	€ 11.00	€ 7.00	€ 83.93	€ 56.15
95	808942	312	250x250x8.00700044	€ 42.22	€ 23.71	€ 11.00	€ 7.00	€ 83.93	€ 56.15
96	807963	312	250x250x8.0070005231B	€ 42.22	€ 23.71	€ 11.00	€ 7.00	€ 83.93	€ 56.15
97	807964	312	250x250x8.0090005231B	€ 42.22	€ 23.71	€ 11.00	€ 7.00	€ 83.93	€ 56.15
98	808705	312	250x250x8.0078005231B	€ 42.22	€ 23.71	€ 11.00	€ 7.00	€ 83.93	€ 56.15
99	809436	312	250x250x8.0091005231B	€ 42.22	€ 23.71	€ 11.00	€ 7.00	€ 83.93	€ 56.15
100	809479	312	250x250x8.0091005231B	€ 42.22	€ 23.71	€ 11.00	€ 7.00	€ 83.93	€ 56.15

Figure 8.12 Products to push to the customer "lasweek 14"

And the planning of this week is shown in the next figure:

Welding diameter	Article Characteristics	Plan	Booked
219.1	250 x 100 8wk	157	157
219.1	Ø 219.1 4wk	540	540
312.0	250 x 250 4wk / 300 x 200 4wk	385	385
145.5	124 x 124 Jost	25	25
T & H	Ø 146.0 + 160.0 8wk	148	148

Figure 8.13 Planning "Lasweek 14"

In this case the seller, given the low orders booked, does not really gain advice from the model, however he could check what the expected costs are for the production process of a specific product, but in this case there are no order acceptance decision doubts. So if an order arrives, given the low planned capacity and the low time before production (one week), the seller will always accept an order and in this case the seller is not in the position of pushing the market.

8.7 Conclusions

In this chapter we have discussed the Market Independent Model characteristics and tools. First of all a discussion of the production machines capacity was done to understand why the available capacity is estimated to be 70% of the total real available capacity. We explained that this is done to avoid that the waiting time would exponentially increase (basic queuing theory).

The differences between the Static pricing and the Dynamic pricing in the different production process phases have been reviewed and then the model tools scopes were explained.

After having described the utilization of the different tools, we analysed the views and strategies of the different departments related to the production process. On the basis of our interviews with the Sales and the Production departments, we made a ranking of what products should be prioritized during a real production week planning. The same week plan was analysed with the Static pricing and the Dynamic pricing methodologies. It results that the three departments and the model we developed consider different rankings when the question is what product to push to customers in a condition of high demand.

At the end we discussed the similarities and differences in the strategies of the three departments and the Market Independent Model.

Chapter 9 Conclusions and Recommendations

This research has focused on trying to align the Production and Sales department objectives of Tata Steel Tubes. We made an analysis of their products, the production process costs to create a specific tube and we analysed the order acceptance phase. Finally we have developed two models that have the scope to be tools for the Sales department during the negotiation phase.

In this chapter, we discuss the overall conclusion and recommendations of this research.

9.1 Conclusions

1. The analysis of the manufactured products has arisen the following outcomes:

- 2685 different products were manufactured during the last four years. 80% of the revenue is made by 379 SKUs, so 14% of the total construction tubes produced in the last four year by Tata Steel Tubes in Zwijndrecht.
- The average margin per ton of the SKUs is not following the same pattern of the revenue. We would have expected that the products that are sold less would have a higher margin per ton, but that is not happening. The margin per ton results really volatile and often negative. That is due to the fact that the goal of Tata Steel Tubes (subsidiary firm of Tata Steel) is not only to make profit but also to produce a certain amount of tons per year in order to respect the Tata Steel yearly annual plan.
- Shape analysis shows that there is not a consistent difference between the three types of shapes, the amount of tons, the revenues and the margin per tons are close to a third for each shape type.
- The material quality analysis shows that with higher amount of tons the revenue is higher (logical) but the percentage of the total margin is not always higher for higher revenues. In particular, standard product ColdS235, that are influenced by a high competition in the market, are characterized by a negative total margin (-9%) and revenue equal to the 25%.

2. The analysis of the current Cost-based pricing strategy has arisen the following outcomes:

- The production costs, currently calculated with the norms speed values, result on average 6.08 euro per ton under-priced if we compare them with the price calculated from the average historical speed values. For the Precision Tubes this is particularly extreme, indeed this group results on average 34.04 euro per ton under-priced.

- The warehousing cost is currently calculated considering a fixed price per stored ton. This pricing methodology, in the warehouse of Tata Steel Tubes in Zwijndrecht where the space is limited, is not precisely reflecting the different characteristics of the SKUs.
- The data related to the slitting costs present a lot of extreme values and infeasible values. These data are considered statistically insignificant.
- The Sales department costs estimation is considered to be a valid approximation for the aim of this research

3. Proposed improvement in the Cost-based pricing strategy:

- We propose to calculate the warehousing costs based on the effective space occupied in the warehouse and to price differently the SKUs that can be stored in the external warehouse and the SKUs that can be stored inside. That because the space in the internal warehouse is a bottleneck of the factory of Zwijndrecht.
- We propose to calculate the production costs considering the historical average speed per welding diameter of the tubes and applying on it penalties if the tube has a determinate thicknesses of nominal welding diameter and length that generates more complications in the production process. Moreover, the proposed production costs calculation considers a dynamic price that is dependent on the expected produced tons and the production plan of a specific SKU.

4. Improvement of the Order Acceptance phase

- The Incremental Order Acceptance Model we developed shows how prices change according to the expected production week and the time before production starts. The model has different limitations; the main one is that the suggested price deriving from the model is difficult to compare with the actual end prices currently applied by the Sales department. That because in the Steel Market many factors influence the end sell price and often the end price is lower than the one required covering the production costs.
  We believe that the model could be an extremely useful tool for the sales phase especially during the negotiation phase. We think (hope) that in a near future the potentiality of this model will be reconsidered. Certainty, the model needs to be completed with a strong collaboration of the Sales department so that the outcomes will at best represent the company strategy. Next a testing period is required.
  This auxiliary model is the basis of the Market independent Model.

- The Market Independent Model gives the Sales department three tools:
    a) Find the Products that have the smallest Production Process costs per week
    b) Production process costs of a specific Product ID for a specific week
    c) Decide between a certain number of requests which one to accept

The three tools give the possibility to the seller to compare the dynamic price found with the proposed pricing strategy, and the static price found with the current used pricing methodology. These tools give the seller a better overview of the impact of the decision to prioritize a certain product or another one. Moreover they give a more realistic overview of the costs involved in the process.

To validate the model we compared the outcomes of the Market independent model with the strategies used/suggested in the order acceptance by the Sales, the Production and the Finance and Control departments. The Sales and the Production and Logistic departments were interviewed and for the Finance and Control department we decided to consider the outcome of the current static pricing methodology used by Tata Steel Tubes.

Analysing a week production planning, we showed that the ranking of what group of products push first to customers results different for each department (and for the model developed in this research), which confirms how the different departments have not a same strategy/view on what products to push to the market.

T&H group is always the last one of the ranking. The Independent Market Model with a price cost estimation of 100.64 euro per ton for the best ranked T&H product seems to represent well this situation. Between the evaluation of the T&H group of the Finance and Control department and of the Independent Market Model there is a difference of 32 euro per ton (a high difference).

The Finance and Control department seems to under-price these products (T&H) comparing the outcomes with the Independent Market Model prices and those given in the interviews with the Sales and the Production departments. The Production and Logistic department outcome shows how the idea of pushing products that can be stored outside (323.9 welding diameter) is to be prioritized. The Independent Market Model that considers a decrease of the warehousing costs of the groups that can be stored outside, shows a price that is conditioned by the fact that the warehouse capacity booked for this product is relatively low compared to the other groups.

The Finance and Control department does not consider the length of the SKUs in the cost evaluation, which instead is done by the Market Independent Model developed in this research and proved to be important by the interviews with the Sales and the Production and Logistic departments.

The Market Independent Model does not prioritize square products, contrary to the Finance and Control department, and promoted in the interviews with the Sales and the Production and Logistic departments.

9.2 Recommendations

Given the results of our study, we would like to give the following recommendations.

1. We suggest to calculate the warehousing costs based on: the effective space utilizable in the warehouse, the effective space utilized in the warehouse by each SKU and the use of the internal or the external warehouse. The Production and Logistic department interview outcomes show how the idea of pushing products to customers that can be stored outside confirms the need of a modification of this cost evaluation.
2. We suggest to calculate the production costs considering historical speed values and applying price penalties if the tube has a determinate length procuring more complications in the production process. That seems to give a more realistic overview of the costs involved in the process.
3. We think that the Incremental Order Acceptance Model could be an extremely useful tool for the sales phase especially during the negotiation phase; therefore we suggest revaluating the use and the development of this model.
4. We believe that the Market Independent Model can be a useful tool during the order acceptance and negotiation phase. The use of a dynamic price that is dependent on the expected produced tons and the production plan of a specific SKU can clarify if it is better to prioritize a certain product or another one.
5. The different departments have not a same strategy/view on what products to push to the market; there seems to be a lack of communication and therefore we recommend to define a global company strategy.

Further research has to be made on the following areas:

1. We suggest revaluating the profitability of T&H products particularly and in general that of the Precision tubes. It seems that it could be more profitable to accept more standard products orders instead of the T&H products orders.
2. The Market Independent Model does not prioritize square products, contrary to the Finance and Control department, and promoted by the Sales and the

Production and Logistic departments in the interviews. We suggest investigating the vantage of producing square products instead of rectangular or circular.

3. A clarification of the main goal of the company has to be done to understand if it is more convenient to accept orders where the steel material margin is higher (more profit for the "mother company" that supplies the steel) or those where the production process costs are lower. If the steel material margin would be prioritized we recommend to correct the model developed in this research adding the contribution of material.

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