A benchmarking model for the customer order flow in semi-processing industries

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Abstract

The non-ferrous metal industry is representative of the “implosive” industries in which a very small number of bulk material varieties is converted into a large number of product varieties. The main goal of this work is to demonstrate the approach for benchmarking the critical business process of Customer Order Flow at two pilot user sites, i.e. ELVAL (GR) and TUBUSMETALL (D) through the development and use of performance models. The approach used for building the Benchmarking Model combines three methodologies coming from different science fields, i.e. the *systems analysis* field (ECOGRAI performance modelling), the *cost accounting* field (Activity Based Costing) and the *engineering economics* field (productivity-driven approach).

Keywords

Benchmarking, Performance Modelling.

1 INTRODUCTION

This is an account of work done within the benchmarking part of the Esprit Project REALMS (Reengineering Application Using Modelling and Simulation). Among the possible set of processes that represent material/information flows across the logistics chain, the *Customer Order Flow* (Rolstadas, 1993) has been chosen in this project as been the most critical from the pilot users' point of view, in order to be the subject of business modelling and reengineering.

The Customer Orders Flow considers the logistics chain from the customer's request to the delivery of the product. It involves and cuts across the Sales, Costing,

Product Development, Production Planning, Materials Management and Shipping functions of both Pilot Industrial Users. The two Pilots are absolutely complementary across the value chain in the specific user sector of semi-processing of non-ferrous metals (see Table 1 for their typological attributes). ELVAL (GR) is a producer and supplier of semi-processed aluminium products, while TUBUSMETALL (D) is a wholesaler of non-ferrous products and a producer of components using semi-processed raw materials. For both of them the Customer Order Flow is of utter importance due to the vast number of product varieties according to customer requirements.

Table 1. Typological attributes of the industrial pilots

ATTRIBUTES	ELVAL	TUBUS
1. PRODUCT STANDARDISATION	Products to customers' specifications	Products to customers' specifications
2. PRODUCT STRUCTURE	Implosion industry	Implosion industry
3. PRODUCT TYPE	Industrial Goods	Industrial Goods
4. PRODUCTION TRIGGER	Make to Order (MTO)	Finish to Order
5. PROCUREMENT STRUCTURE	Vertical production	Extensive outsourcing
6. PROCESS FLOW (TIME DIMENSION)	Batch production	Batch Production
7. PROCESS LAYOUT (SPACE DIMENSION)	Flow shop	Job shop
8. LOGISTICS STRUCTURE	Single plant/single warehouse system	Production/ Distribution system
9. SIZE (P=Personnel)	Large firm (P>500)	Medium-sized firm (50<P<500)

2 APPROACH

The approach used in the REALMS project for building the Benchmarking Model combines three methodologies coming from different science fields, i.e. the *systems analysis* field (ECOGRAI performance modelling), the *cost accounting* field (Activity Based Costing) and the *engineering economics* field (productivity-driven approach):

1. As an overall methodology the GIM (GRAI Integrated Methodology, Doumeingts, 1984) and in particular the ECOGRAI component of GIM (Doumeingts *et al*, 1995) is used for building systems of performance indicators associated to the objectives and decision variables of business processes.

2. The Activity Based Costing (ABC) methodology (Berliner, 1989, Innes & Mitchell, 1990, Cooper and Kaplan, 1991, Theeuwes and Adriaansen, 1994) is a well known cost accounting approach. The REALMS project included a proposed framework for using ABC in business process reengineering projects by connecting to defined cost drivers and overhead allocation to business process modelling (Tatsiopoulous *et al*, 1996).

3. The productivity-driven NTUA approach is a short-term profitability-based modelling approach to evaluate changes in output and in productivity (Cosmetatos, 1996).

In applying the three above methodologies for benchmarking the following basic steps are needed:

Step 1 compares the business practices used for performing the customer order flow process and its critical activities by ELVAL and TUBUSMETALL. The process activities have been previously analysed (REALMS Consortium - WP2, 1996).

Step 2 develops a Performance Model for the selected Business Process. The performance measurement tool used is the ECOGRAI methodology to define performance drivers (time, quality, cost/productivity) in relation to the objectives and the decision variables of the business process.

Step 3 validates the activities of step 1 through collecting performance measurement data. Those data are based on the benchmarking model of performance indicators and are collected with the help of the Benchmarking Questionnaires.

2.1. Comparison of business practices

The critical activities of the two pilots are next described, i.e. of ELVAL (GR), a producer and supplier of semi-processed aluminium products and TUBUSMETALL (D), a wholesaler of non-ferrous products and a producer of components using semi-processed raw materials (Figure 1).

Critical activities of TUBUSMETALL

- What is the right price? To define the lowest permissible price and the earliest possible delivery date
- To find ways to satisfy the customer request. Important is to keep the customer. If they cannot produce or trade they outsource manufacturing or trade.
- To know from which Customer Order they earn money and from which they loose money
- To decide if enough quantity of raw material is available.
- To combine customer orders into production orders. This influences production costs (e.g. setup cost).
- To minimize scrap through solving the cutting stock problem
- Service center: to produce products that are not in the market.

- To outsource special products means to release more capacity for standard products with lower cost.

The logistics chain

Figure 1. The logistics chain of the two pilot users

Critical activities of ELVAL

- What is the right delivery date? Delivery date assignment strategies.
- The least expensive way to produce an alloy
- To allocate raw material. That is to take make or buy decisions for the aluminum slabs that feed the hot rolling unit. Either to make them in the casting unit or to buy them from external suppliers.
- Where to stock in the logistics chain? (raw materials, intermediate products, ex-factory finished products, finished stock in distribution centres near the customer?
- To process internal packing lists. A “blocking factor” is measured, i.e. if all the batches ordered by a customer are ready for shipment. This is similar to the final assembly problem in discrete manufacturing and serious time losses may occur.
- Detailed cost estimation

Comparison of ELVAL and TUBUSMETALL customer order flow processes

A comparison of the Customer Order Flow activities in the two companies (Table 1) has shown that the activity “A2. to manage stock” of TUBUS is included in the activity “A2. to process the C.O.” of ELVAL. The activity “A3. to process the C.O.” of TUBUS includes the activity “A3. to produce & pack” of ELVAL. The activity “A4. to prepare the delivery” of TUBUS includes the activity “to pack”. The rest of differences and similarities is shown in Table 2.

Table 2. Comparison of business processes

ELVAL	TUBUSMETALL
A1. To create C.O.	A1. To create C.O.
• Existence of blanket orders	• No blanket orders • If they cannot produce

• If they cannot produce they refuse the customer request • Price assignment is based on detailed standard cost estimation • Importance of the Delivery Lead Time assignment strategy • Separate processes in ELVAL “to study the technical feasibility” (Engineering design and tooling of special products.	• or trade they outsource trading or production • Price assignment is heavily customer-oriented (need for Activity Based Costing) • Importance of the reliability of delivery due date, not the lead time (too short) • In Tubusmetall it is included in “to precise inquiry”
<i>A2. To process C.O.</i>	<i>A2. To manage stock</i>
<i>A3. To produce & pack</i> - Manufacturing centre	<i>A3. To process the C.O.</i> - Service centre
<i>A4. To prepare the delivery</i>	<i>A4. To prepare the delivery</i>

2.2. Performance model for the selected business process

The performance model includes a system of key indicators:

1. Operational indicators concerning time-based and process quality performance measurement (Zuelch *et al*, 1995). For the business process and its critical activities chosen in this project (customer order flow and delivery date/price assignment decisions) this translates into indicators having to do with *delivery lead times (time-based)* and their *deviations (process quality)*. Another class of quality indicators is the *reliability of cost and price estimations* used to respond to customer requests.
2. Cost drivers and their reciprocal cost rates developed using the Activity Based Costing technique (ABC). The activities of ABC coincide to the activities of the activity model developed with GIM, thus making easier communication and integration of the key indicators model (Tatsiopoulos *et al*, 1996). For the Customer Order Flow process, the ABC technique leads to a more fair distribution of *overhead costs* to customer orders that either require *special products/customers* or *small batch quantities*, compared to whatever is considered a standard product or a normal batch quantity ordered. This permits a better assignment of product prices.
3. Productivity-driven indices of the Customer Order Flow process help to evaluate changes in sales output caused by accepted customer orders and changes in

productivity caused by the treatment of those customer orders (e.g. manufacturing or outsourcing) using a profitability-based modelling approach. Those indices are based on *variable cost* calculations, that help to define product profit contributions and profitable customer orders, and therefore they are complementary to the ABC cost drivers that deal with the distribution of fixed costs in pricing decisions (Eilon & Cosmetatos 1977, Cosmetatos & Eilon 1981, 1983, Cosmetatos in REALMS-WP3 (1996).

3 THE ECOGRAI BENCHMARKING MODEL

The following objectives, decision variables and performance indicators have come out of the Synthesis Group of ELVAL users.

3.1. Activity Index for the Customer Order Flow Process in ELVAL

- A0 Customer Order Flow Process
- A1 To create a customer order (C.O)
- A11 To precise the request
  - A111 Identification of basic technical information
- A12 To study the technical feasibility
  - A121 To check if the specs correspond to a standard product.
- A13 To define the price and the delivery date
  - A131 To define a production date and calculate cost
  - A132 To check the acceptability of the date
  - A133 To calculate a delivery date and price
  - A134 To negotiate date and price with the customer
  - A135 To negotiate date inside the company
- A14 To confirm the customer order
- A15 To process blanket orders
- A2 To process the C.O. in the production dept.
  - A21 To release production orders
  - A22 To produce work sheets
  - A23 To allocate raw material
  - A24 To order raw material for the casting unit
  - A25 To order raw material for the rolling unit
- A3 To produce and pack
- A4 To manage the delivery
  - A41 To process internal packing lists
  - A42 To prepare delivery documents
  - A43 To prepare the transportation
  - A44 To deliver ex-factory

3.2. Objectives Index and Coherence Analysis for the ELVAL case

Global objectives of A0 (“Customer Order Flow Process”)

- GO1: To increase the profitability
 GO2: To keep (or to lower) the cost and to keep at least the estimated cost
 GO3: To reduce the delivery time and gain a time-based competitive edge
 GO4: To deliver the agreed quality and to maximise the quality level
 GO5: To deliver the order on time promised and to keep at least the estimated lead time

Objectives of activity A1 (“to create a customer order”)

- O1.1: To fill the the capacity
 O1.2: To sell with the highest possible price
 O1.3: To satisfy the customer requirements in terms of delivery time
 O1.4: To reduce the time to create the Customer Order (C.O.)
 O1.5: To have the right estimation in terms of cost & delivery time
 O1.6: To identify the right customer specifications
 O1.7: To make the deal

Objectives of activity A13 (“to define price and delivery date”)

- O1.3.2.1 Not to overload (internal agreement)
 O1.3.3.1 To calculate the right Delivery Date
 O1.3.3.2 To calculate the right price
 O1.3.3.3 To perform the calculation in minimum time
 O1.3.4.1 To negotiate the difference between the proposals & the negotiated results on price and Delivery Date
 O1.3.4.2 To reduce the negotiation time
 O1.3.5.1 To negotiate the feasibility of the production
 O1.3.5.2 To propose an alternative delivery date
 O1.3.5.3 To fill the capacity
 O1.3.5.4 To reduce the negotiation time

Figure 2. Coherence analysis of objectives

Decision Variables of A0 (Customer Order Flow)

DV1: *Customer Order Promising decisions that affect the monetary value (turnover) and the profitability of the Sales Plan and the Master Production Schedule (output mix) in three kinds of ways: (a) Increase or decrease sales/production volume (change in its size only) keeping the product mix and technical specifications unchanged, (b) Change in the product mix only, (c) Change in product specifications only (e.g. produce more advanced products).*

DV2: *Decisions that affect the input mix of production factors (material, labour, capital, energy) and/or specifications of the inputs (e.g., to buy slabs for hot rolling instead of using the labour and capital of the casting unit).*

DV3: *Decisions that increase the productivity of some inputs without adversely affecting the productivity of other inputs (e.g. to accelerate customer order flow through better production planning & control or to shorten lead times through elimination of non-value adding activities).*

Performance Indicators of A0 (Customer Order Flow)

PI1: P/D Ratio, where P=(total supply chain lead time) and D = (delivery time requested by the customers)

PI2: Index on the effect of master plan changes on the sales turnover

PI3: Index on the effect of master plan changes on the cost

PI4: Index on the effect of master plan changes on the profit

PI5: Index on the effect of input mix changes on input usage levels

PI6: Index on the effect of input mix changes on the cost

PI7: Index on the effect of input mix changes on the profit

PI8: Value Added Ratio = (Total supply chain value-adding time) - (Total supply chain lead time)

GO1	+							+
GO2			++		+	++		+
GO3								
GO4		+		++			++	+
GO5	++							++
	PI1	PI2	PI3	PI4	PI5	PI6	PI7	PI8
DV1		++	++	++				
DV2	++				++	++	++	
DV3	+				++	++	++	++

Table 3. Coherence panel of performance indicators

4 RESULTS ON LEAD TIMES

Here follows the presentation of benchmarking results in the two industrial pilots, ELVAL and TUBUSMETALL concerning the performance indicators **PI1 (P/D**

Ratio) and **PI8 (Value Added Ratio)** of global activity A0 (Customer Order Flow). According to the coherence panel of Table 3, these important time-based indicators have a profound influence on global objectives **GO5** (PI1 and PI8)) and decision variables **DV2** (PI1) and **DV3** (PI8).

4.1. Lead time measures

Lead time or throughput time is a measure of the speed to execute an input through a process into a delivered output and includes all processing, setup, waiting, moving and storage times. Lead time can be measured in a variety of ways for different processes. For the overall supply chain lead time of manufacturing products, the following lead time ratios are particularly suitable.

P:D Ratio. The time extending from the placement of the supply orders through manufacturing to the delivery of finished product to the customer should be aimed to be equal or less than the customer's expected delivery lead time.

P:D Ratio = total supply chain lead time / customer's expected delivery lead time,

where P:D Ratio goal ≤ 1

This definition measures a multiple of internal lead time over customer lead time. The goal of the lead time measure is a value less than one, meaning the production system can supply product to the customer's order without the need for forecasts or excess inventory. For companies that produce custom products to customer orders and therefore quote lead times in weeks or months, the denominator can be modified to be either the customer-desired delivery lead time or the best industry-competitor lead time.

Value added ratio. The value-added measure is an indicator of the effectiveness of a process relative to its potential. Value-added time is the "processing" time where activities are performed on the product that the customer (if it were known they were being done) would be willing to pay for. A lot of time is usually lost quite needlessly, costing visible amounts of money that contribute no value to the process. Setting value-added time in relation to available time is often a highly illustrative way of discovering how time is used in an organization.

Value added ratio = total production system value-added time / total supply chain lead time,

where Value-added ratio goal = 1

4.2. Benchmarking results

The following tables 4 and 5 show the lead-time benchmarking results of the two pilots:

Table 4. Results in TUBUSMETALL

	Min	Avg	Max
1.Customer Order Lead-time (days)	4	8	15
2.Customer Order Estimation Lead-time (days)	1	1	1
3.Production Order Release Lead-time	21	28	35
4.Production Order Lead Time	1	2	3
5.Processing Time (hours)	0.5	2	4
6.Shipment Lead Time	1	1	1
7.Transportation lead-time (days)	1	1	2
8.Supplier Lead-time (days)	28	28	84
P:D Ratio $[(2+3+4+6+7+8)/1]$	13.25	7.62	8.40
Value Added Ratio (Production) $[(5/3+4)]$	0.003	0.066	0.105

These differences in benchmarking data are explained by the fact that ELVAL is a vertically integrated make- to- order manufacturing company while TUBUSMETALL is mainly a trading company servicing customers from semi-finished stock by adding one or two final production stages.

Table 5. Results in ELVAL

	Min	Avg	Max
1.Customer Order Lead-time (days)	90	90	90
2.Customer Order Estimation Lead-time (days)	1	1.5	2
3.Production Order Release Lead-time (days)	28	28	28
4.Production Order Lead Time (days)	32	32	32
5.Processing Time (days)	17	17	17
6.Shipment Lead Time	20	20	20
7.Transportation lead-time (days)	7	15	30
8.Supplier Lead-time (days)	15	21	45
P:D Ratio $[(2+3+4+6+7+8)/1]$	1.14	1.46	1.744
Value Added Ratio (Production) $[(5/3+4)]$	0.283	0.283	0.283

5 CONCLUSIONS

The above results came out from internal benchmarking procedures within the companies of the REALMS consortium. The next steps in order to put the benchmarking model in the service of business reengineering are the following:

1. **Conduct External Benchmarking** based on the performance model developed and the internal benchmarking studies. Identify examples of best practices, compare to the existing performance indicators and set targets to be pursued by the reengineering actions.
2. **Evaluate reengineering targets.** Those targets set in step 1 are usually expressed in the form of operational indicators (e.g. lead times, inventory levels, etc.). Those indicators need to be translated in financial terms, a task which is almost impossible to be handled by traditional cost accounting systems. Activity based Costing (ABC) seems to be here the ideal approach to calculate *Return On Investment (ROI)* coming from the improvement of such operational indicators.
3. **Conduct a simulation study.** The simulation tool FEMOS will be used to evaluate reengineering actions in the two pilots. This tool has been developed by the REALMS partner IFAB (TU Karlsruhe, Zuelch 1995) and is particularly suited for evaluating organizational changes. Thus it is hoped that a combination of *a priori* and *a posteriori* evaluation of business process reengineering will be possible.

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7 BIOGRAPHY

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