UNDERSTANDING LONG TERM INTERACTIONS IN FABRICATED METAL MANUFACTURING INDUSTRY : A CASE

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Abstract

The paper describes a system dynamics model of fabricated metal manufacturing industry for Australian economy. Major subsectors considered in the model are: production, customer order, sales and capacity acquisition. The policy runs focus towards understanding of behaviour of capacity, inventory, production and costs.

Introduction

Metal manufacturing industry, specially the fabricated metal manufacturing industry, is one of the matured and established sector of a country. Typically, fabricated metal manufacturing industry is self sufficient with local skills, less dependent on raw material imports and low- medium capital intensive. This industry seems to contain all the necessary inputs for viable and sustained growth. Yet analysis of ups and downs in economy have shown that this sector of the economy suffers greatly when disturbances occur in the national economy. Both new product demands and quality variations exert a great pressure on the capacity and finished goods stock problem of fabricated metal manufacturing industry.

Over the last decade manufacturing industry in Australia showed high unutilised capacity, low productivity, high costs, and technological obsolescence. Generally, manufacturing industry could not compete successfully in the world markets due to high costs and low quality of its products. To many experts, poor quality, high costs, excess stock, excess capacity, etc. are the causes of poor recovery of fabricated metal manufacturing sector. The authors argue that the causes mentioned above are really the results of past managerial decisions and strategic policies followed in the fabricated metal manufacturing sector. The real or root cause of the present situation is poor understanding of the internal mechanisms through which this sector operates. It serves no purpose simply to say that the costs are high and/or the quality is low. It will be useful to know what are the policies that contributed to higher costs or low quality. How the present situation could have been avoided. To be effective in the future, can we design a policy or a set of policies to avoid excess capacity, higher costs, etc.? This paper attempts to provide a deeper understanding of the internal mechanisms which shape the overall dynamic behaviour of fabricated metal manufacturing industry.

Model Description

Based on the understanding of the operations and changes in the Australian manufacturing industry a systems model for the fabricated metal manufacturing sector has been developed. The major constituents ie. subsectors of the model and external factors are shown in Figure 1. While developing the model due considerations have been given to the steps in system dynamics modelling as noted in Mohapatra, Mandal and Bora (1994).

A greater attention is given in modelling the details of internal mechanisms for planning and managing capacity, production, customer order and sales which reflect the major subsectors of fabricated metal manufacturing sector. The subsectors affect each other. For example, a decision to increase capacity (in capacity subsector) implies more production in future, attracting more orders from customers and making more sales. In the course of time, however, the developments in other subsectors will exert pressures and force to modify the decisions taken initially. The arrows on the lines connecting the subsectors in Figure 1 represent this situation.

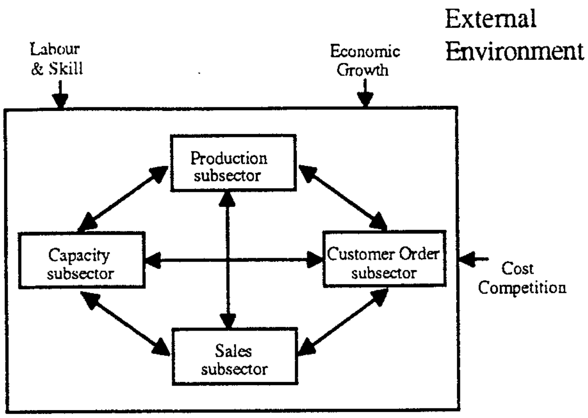

Figure 1: Overview of the Model

The growth of the economy and overseas competition in terms of cost and quality are the major external factors to the fabricated metal manufacturing sector. The model assumes a constant value for the growth rate, competitor's cost and quality. The availability of labour and skills though a major external factor for the manufacturing industry in Australia, is not an important constraint for fabricated metal manufacturing. It has been assumed that the labour can be hired easily from the labour market but their skills need to be upgraded by training.

A. Production

A decision on how much to produce must consider both the market requirements and the feasible production rate (Figure 2). The feasible production rate depends on the available capacity, availability of labour and skills of the labour force. The skills and labour availability scenario is modified through the mechanism of recruitment and training.

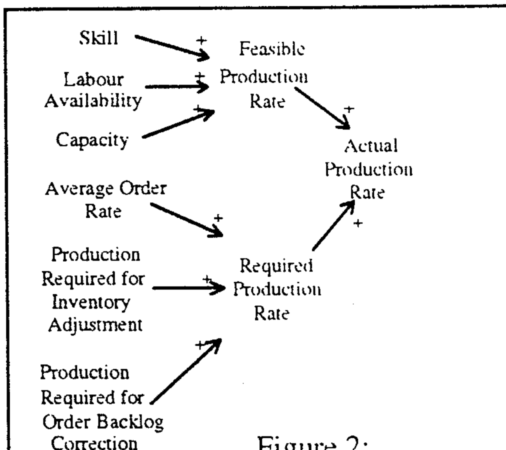

Figure 2: Mechanism of Production Decision

B. Order for Goods

Industry produces goods to meet the demands from the market place. Demand is greatly influenced by the overall growth of the economy. For the metal manufacturing industry, the demand is forecasted on the basis of past history of sales and the expected growth rate of the economy (Figure 3).

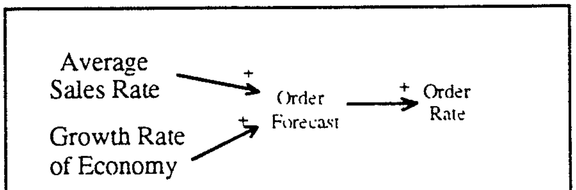

Figure 3: Mechanism of Order Decision

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C. Sales

Figure 4 shows how the mechanism estimates sales rate. Future sales rate depends on the past history of sales, a price multiplier and an inventory multiplier. Price multiplier is related to capacity utilisation which is a ratio of average production rate and capacity. It is assumed that if capacity utilisation decreases, unit cost of production will increase and the product in the market will be costlier. If this happens, the sales will decrease.

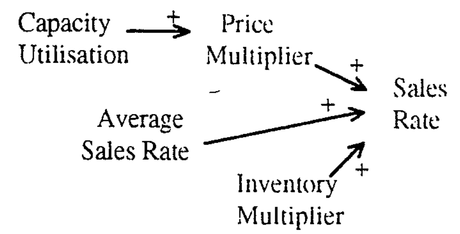

Figure 4: Mechanism of Sales Rate

D. Capacity

The decision on additional capacity is made based on investment availability and capacity gap from consideration of long term forecast and existing capacity. The stages through which a decision on additional capacity culminate into actual capacity are: capacity under decision, capacity on order, capacity on delivery and installed capacity (Figure 5).

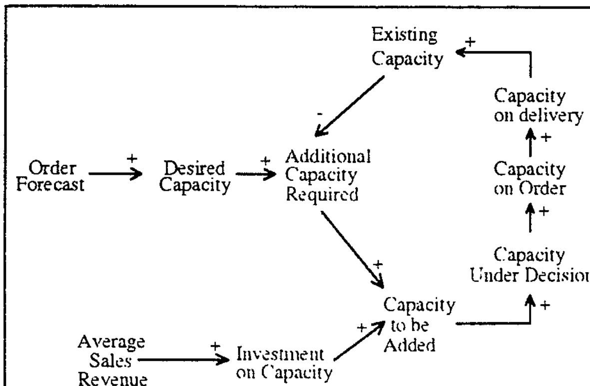

Figure 5: Mechanism of Sales Decision

Model Results

A computer model has been developed for the situation and the model is simulated in a personal computer using a FORTRAN based software package (Mohapatra and Bora,76). The model is used to simulate the behaviour for inventory, capacity and other important variables for a period of ten years. The following what-if type of tests have been carried out with the model.

1. What happens if present situation continues in the future?

This is perhaps the obvious question in the mind of policy makers. After 72 months (6 years) of the simulation, the inventory level keeps on rising; production capacity also increases. The sales are lower than the production rate, which contributes to building up of inventory. The system become unstable during the later part of the simulation period.

The analysis shows that the sales suffer primarily due to high cost of production which increases due to poor capacity utilisation. The capacity has increased but the production rate has fallen (excess inventory forced production down). This behaviour is a plausibility as higher capacity leads to lower capacity utilisation which in turn reduces cost advantage. Reduced cost advantage forces reduction in sales which in the long run forces capacity utilisation down further.

2. What happens if we change capacity acquisition policy?

Two policies directly aimed at affecting capacity have been formulated. In the first policy, capacity acquisition has been made quicker by reducing delays in capacity decision, delivery and installation. In the second policy, a decision is implemented not to invest any capital in capacity creation after five years of operation. By reducing the delays associated in capacity decision, it has been possible to maintain capacity at a constant level. This stabilises production and sales. By not investing in capacity after the fifth year of operation it has become possible to reduce the capacity gradually and gain in cost competitiveness. Through this policy it is possible to get rid off of excess inventory.

3. What happens if we change the production policy?

Five test runs are performed with different weightage to feasible production rate and desired production rate to decide the actual production. The behaviour of the model with respect to cost per unit output (ratio) and capacity utilisation are analysed for the five test runs. The analysis shows, by taking decision based on only on requirement (100% weightage to required production, and ignoring the feasibility of production) it might be possible to obtain a lower value for cost per unit output ratio and a high capacity utilisation.

4. What happens if we change investment policy?

Five sets of computer runs are conducted with different weightages to available and required investments. The investment decision based on only the requirement leads to very high capital stock and consequently to very high level of inventory. On the contrary, the investment decision based on only the availability shows no growth in capital stock and leads to stock out situation. It seems that to achieve growth in capital stock and avoid stock out the investment decision must give a proper weightage to investment availability and requirement.

5. What happens if the market demand changes?

To a 20 percent increase in demand at year 5 the system responds by gradually decreasing inventory. It took almost two years to show an increasing trend in production, until then the extra demand was met from the built up inventory. Towards the end of the simulation period, however, inventory increased to an alarming level, production fell below its original level, costs showed an increasing trend, so also the capital stock.

With a sudden drop in market demand at year 5, inventory increased immediately. The level of inventory at the end of the simulation period was, however, much higher than the previous case.

Discussions

The paper describes the major influences in metal manufacturing industries from a systems perspective. The model considers the mechanisms associated with the dynamic behaviour of production, customer orders, sales and capacity in great detail. Policy tests carried out with the model provides a better understanding of the internal mechanisms and delays in system responses.

References

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Mohapatra, P.K.J., Mandal, P. and Bora, M.C., Introduction to System Dynamics Modelling, Universities Press, Hyderabad, 1994.