Managing Competitiveness using Production Volumes - Product Variety Model for Automobile Industry

Mirza Jahanzaib, Syed Athar Masood, Khalid Akhtar, Khurram Ali

Industrial Engineering Department, University of Engineering & Technology, Taxila, Pakistan
* jahan.zaib@uettaxila.edu.pk

ABSTRACT: The manufacturing industries can be classified into process industry (PI) and discrete parts manufacturing industry (DPMI). Process industries have dedicated product line with fixed processes, routings and planning, whereas while discrete parts manufacturing industries are more flexible in terms of production volumes and varieties. For economic manufacturing, the optimum combination of Volume – Variety exists i.e. job shop, batch production system or mass production. In this paper, we have looked at the typical production volumes and varieties and have argued that there exist very low variety and low to medium production volumes for this particular sector. This calls for investigating ways and strategies to effectively cope with this situation. By taking a case of automobile part vendors triple strategy approach is adopted. Three strategies are not mutually exclusive – a subsequent strategy assumes that the previous strategy has been executed earlier and its benefits/ results still exist when the subsequent strategy is implemented. Strategies are, Good Governance Strategy (GGS), an Automation Strategy (AS) and an Export Strategy (ES). Using real life data from automobile part manufacturers; attempt is also made to test adopted strategies. The results indicate that a major scope for using techniques likes line balancing, activity based costing and value enhancement, exists. The extent of improvement has been shown by case studies of alternative production lines i.e. comparison of a traditional production line having large number of machines with that of a flexible line involving a much smaller number but versatile machines. Using value analysis in Export Strategy has helped in identifying less rewarding operations/ processes and thus competitiveness is obtained using the proposed model.

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Introduction

Industries can be classified into Process Industries (PI) and Discrete Parts Manufacturing Industries (DPMI). Process industries produce dedicated parts with fixed routing; on the other hand discrete parts manufacturing industries can have many parts with flexible routings. Not much attention has been paid to discrete parts manufacturing sector and it appears that this sector is operating in a sub optimal manner. It is therefore necessary to investigate effective ways for coping with this situation. Annual production figures for major end products of discrete parts manufacturing industries are shown in table 1. These end products depend on different parts manufacturing vendors. These parts manufacturers are the major clients of these end product assemblers. The parts manufacturers can be classified into three major groups i.e. Original Equipment Manufacturer (OEM), independent manufacturers and ancillary industry, which are supplying parts to these end product assemblers. It depends upon the on-time supply of parts from the original equipment manufacturer and other sources.

Table 1. Products data

S.No	Commodities	Quantities	Varieties	S. No	Commodities	Quantities	Varieties
1	Motor tires	90800	50	11	Light vehicles	8491	15
2	Sewing machines	24025	15	12	Jeeps	570	5
3	Electric motors	20330	20	13	Refrigerators	407000	25
4	Televisions	77685	20	14	Diesel engines	839	5
5	Bicycles	553395	10	15	Sugar cane machines	154	5
6	Tractors	24331	10	16	Shuttles	24000	10
7	Motor cycles	133334	10	17	Bobbins	145000	25
8	Buses	1099	10	18	Air Conditioners	648	20
9	Trucks	1141	10	19	Switch gears	6233	8
10	Cars	40601	25	20	Power looms	145000	20
				21	Wheat thrashers	70	5

The major commodities data has been given in Table1. There exists an inverse correlation between production volumes and product variety [1]. The standard feasible diagonal comprises of job shop, batch production and mass production systems as shown in figure 1. Typical ranges for the production volumes and product varieties are:

- Low Volume ~ High Variety (Job Shop): 1~100 Production volumes with up to 800 Product varieties, which make low quantities of specialized and customized products.
- Medium Volume ~ Medium Variety (Batch Production): 100 ~ 10,000 Production volumes with 30 to 100 Product variety. We distinguish between two different types of facility depending on product variety.
- High Volume ~ High Variety (Mass Production): 10,000 ~ Millions of parts with 2 to maximum of 10 Product variety. The situation is characterized by a high demand rate for the product,

And the production facility is dedicated to the manufacture of that product.

These typical ranges have been discussed in different literatures [1, 2]. Production systems shown in figure 1 can be classified using standard Volume-Variety combination.

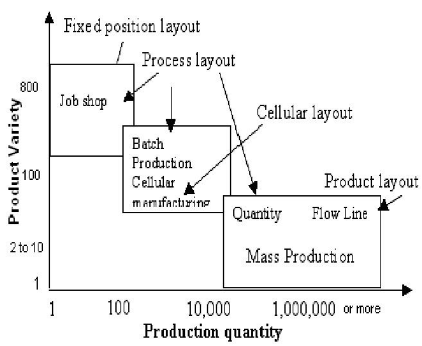

Figure 1. Volume -Variety Combination

The performance of job shop, batch production and mass production systems depends on the annual production and different models offered by the company (variety). Petty [3] suggested different planning and control issues related with production volume and product variety combination. These authors suggested different manufacturing systems based on Volume-Variety combination and then devise strategies suitable for their own environment. Most of discrete parts manufacturing organizations are working in low volume- low variety environment shown in figure 2. But the discrete parts manufacturing industries working above this typical range (in the diagonal) and vertically upward on the right are considered to be economical [1, 2, 4]. This is a challenging task and needs investigating ways and strategies to cope with this low volume -low variety situation. Location of Volume-Variety combination of our OEMs is plotted on the standard Volume-Variety model.

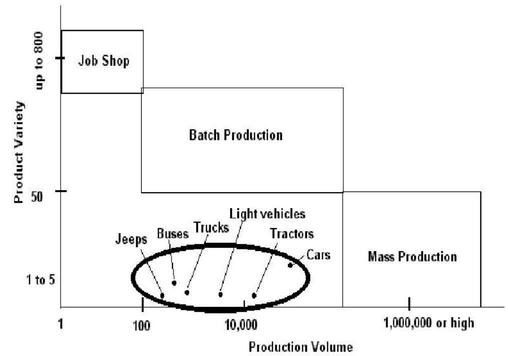

Figure 2. Cluster of the OEM Manufacturers

This is evident from figure 2 that major automobile manufacturers fall in the range of low volume – low variety region. One logical solution would be to invite major changes in the national policies that rationalize taxes / tariff structure on the one hand, while increasing the size of the middle class on the other so that a larger demand of the products would be created. This would allow greater volumes thus making production economical and this approach, however does not allow a major role for the manufacturer. Therefore, an alternative course of action is adopted, which suggests concrete actions on the part of local manufacturers. By taking the case of automobile parts vendors (this being a growing sector), a triple strategy approach is suggested (using traditional techniques for justification of our proposed strategies) and to become competitive in the marketplace.

Strategies as Normative Model

A normative way for coping with this low volume – low variety environment comprise of increasing production volumes on one hand and variety on the other. It is the novel use of traditional approaches in three stage strategies which addresses major changes in their business and leads them to become competetive and adds value to their product. The three strategies are described:

a) Good Governance Startegy (GGS)

The object is to obtain increase on system being more effective and overcoming losses. The key performance indicators for any production systems are utilization, efficiency, uptime of the line and balanced production. For more utilization, the line must be balanced to ensure smooth production. The effect of these tools will result in more utilization of the resources (volumes) and represented in suggested path on Volume-Variety Model as shown in figure 3.

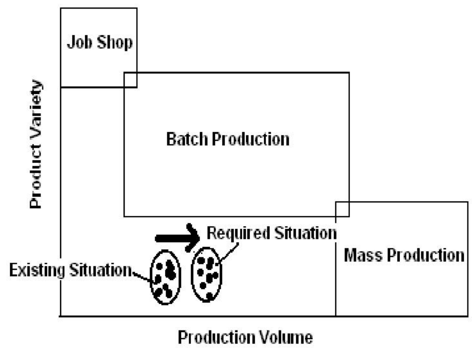

Figure 3. Good Governance Strategy (GGS)

The tools for Good Governance startegy can be any tradional approach like line balancing technique [5], stream lining of operations, reducing set-up times etc which will help to reduce operational loss and hence allow production to increase and reducing the costs.

b) Automation strategy

The changeover between production runs takes time called the setup time or changeover time. It is the time to change tooling and to set up and reprogram the machinery. This is lost production time, which is a shortcoming of manual or traditional systems (machines). The Automation strategy will work here. This strategy will increase volumes and varieties by the acquisition of the automated manufacturing systems and past work of author will help to implement the Technology Driven Strategy (TDS) in this phase [6]. Automation strategy will result in comparatively larger volumes and variety since we are reducing the set up and other non-productive times. The major role of Automation strategy is the flexibility of the system with more volumes [7]. The effect of Automation strategy is to achieve higher flexibility with increased volumes as shown in figure 4.

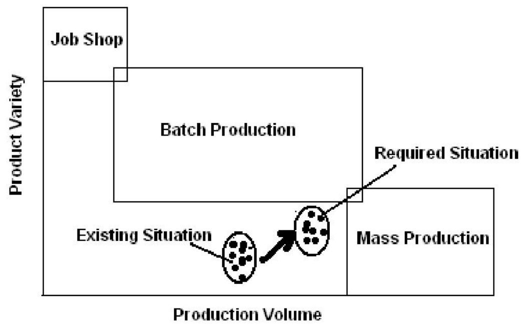

Figure 4. Automation Strategy (AS)

c) Export strategy

In the competitive environment the significance of Cost – Importance relationship plays a challenging role. In Export strategy, those processes (manufacturing or business) are eliminated which do not contribute higher value to the product i.e. more costly and less importance. The Export strategy works in a way that it will check the Cost vs. Importance relationship. Business process value analysis is still a relatively new concept in the developed world and it will improve the export and our manufacturers can be benefited by fully adopting these techniques. Recent literature shows work related to organizational actions [8]. The effect of this strategy is shown in figure 5 and allows even higher volumes and variety due to the additional purchase power of the customer in the developed world.

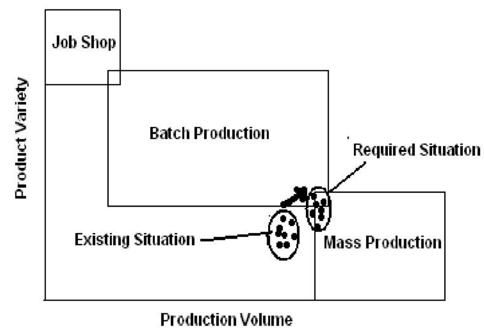

Figure 5. Export Strategy (ES)

The three strategies are not mutually exclusive rather a subsequent strategy assumes that the previous strategy has been executed earlier and its benefits/ results still exist when the subsequent strategy is implemented. The strategic route for the three strategies is shown in figure 6.

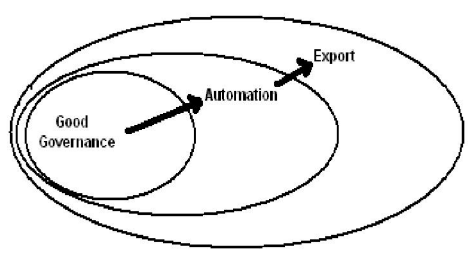

Figure 6. Three Strategies path (Normative way) [9]

Testing of Strategies for Competitiveness

The case company is located in industrial area Islamabad. It is supplying parts to the local and international automobile industry. The installed capacity is 120,000 parts per annum. There are more than 120 parts types for which the company is working. At one time the company can only manage a maximum of 10 different models (depending upon the order). The per annum production of parts is 45,000 to 60,000 with very limited variety. The company receives an order from the assembler Y. Total number of items produced per year would be 60,000 to 62,000 parts per year. There are fair chances for the company that it will take orders from other companies too. At present there are manual and flexible CNC's machines for satisfying the demand. The following two options are studied i.e. 1) Manual Lines, 2) Flexible Lines.

Good Governance Strategy (GGS) using Manual Lines:

The Good Governance strategy has been tested for the manual line. The cycle time and sequence of operations data collected for manual line system is shown in figure 7 and is summarized in table 2.

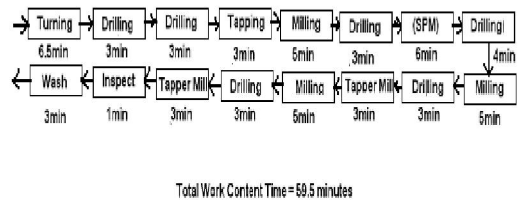

Figure 7. Processing Line

Sixteen machines are used for the manufacturing of the auto part operating with a cycle time of 6.5 min (bottleneck station time). The total work content time for the line is 59.5 minutes. The line problem has been solved analytically using the approach as given in [1], however we also use [5] heuristics to balance the line.

Table 2. Base Data (GGS)

Option No	Process Time	Work Elements	Work Stations	Balance Efficiency	Balance Delay
Analytical Approach					
1.	7.316 min	16	12	67.77%	32.33%
1(a)	7.316 min	16	12	70.60%	29.40%
1(b)	6.5 min (company's assessment)	16	14	65.38%	34.61%
Helgeson & Birnie Approach					
1.	6.5min	16	12	76.28%	23.72%
2.	6.25min	18	12	79.00%	21.00%

The results for the manual operating line with the different number of stations and balanced efficiencies are given in Table 2. This shows that the line using manual machines cannot be balanced from 65.38% to 79and is evident that utilization of the resources increase by effectively balanced the line with more volumes thus reducing costs and hence tested Good Governance Strategy (GGS).

Automation Strategy (AS) using Flexible Lines:

The Automation strategy is tested using the above algorithm for the flexible system. There are six machines required with the processing times and sequences of operations as shown in figure8.

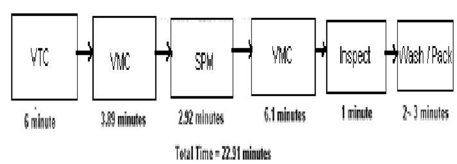

Figure 8. Flexible Line Sequnce of Operations and Cycle times

Flexible systems (technology driven) offer higher volumes as summarized in table 3. This means that Automation would increase morevolumes and offer greater variety in the systems by reducing setup time. There is definite opportunity of flexible systems applicability in our scenario.

Table 3 Flexible Lines

Option No	Process Time	Work Elements	Work Stations	Balance Efficiency	Balance Delay
Analytical Approach					
1.	7.023 min	6	4	78.28%	21.72%
Helgeson & Birnie Approach					
1.	6.81min	6	4	84.10%	15.90%
2.	6.405min	10	4	89.42%	10.58%
3.	6.05min	9	4	94.66%	5.34%

There is a large bandwidth of systems available from the manual systems – digital read out – semi automatic – fully automatic – and transfer machines, but fully automated system are not justifiable because of very high initial cost, maintenance cost, training of workers on specialized machines and definitely the demand. Break-even concepts at this stage for validating the base values obtained from the company and incorporating these concepts for the stage wise cost of the machine is also likely solution. At this stage we are comparing the cost of producing a part. It is obvious that the initial cost of flexible line is more than manual systems and base values given in table 4.

Table.4. Base Values of Flexible and Manual Lines

Title	Flexible Line Cost	Manual System Cost
Machine Cost per part	Rs. 180.024	Rs. 52.345
Labor Cost per part	Rs. 5.4375	Rs. 1.89
Material Cost per part	Rs. 350	Rs. 350
Energy Cost per part	Rs. 19.21	Rs. 41.26
Tooling Cost per part	Rs. 12.284	Rs. 6.2
Fixture Cost per part	Rs. 3.265	Rs. 6.19
Admin. Cost per part	Rs. 13.44	Rs. 13.44
Building Cost	Rs. 19.21	Rs. 19.21
Taxes	@ 15% per part	@ 15 % per part
Total	Rs. 704.85	Rs. 564.11

(1 Us$ = 95.5 Pak Rs.)

There is a difference between the cost of producing parts on manual and flexible line since the flexible line costs more. The reason for selecting the flexible system is discussed briefly as: a) the variable cost in manual systems would be more, due to energy cost, wastage due to lack of quality, labor cost (14 workers would be required per shift). b) Reliability of the system is more in flexible lines as compared with manual system. c) the flexible lines offers more flexibility and can handle variety of orders by changing the program of instructions, whereas the manual system need extra fixtures and can increase the set up time and learning of the operators. This will definitely increase the cycle time of the line and fewer parts would be produced and d) it is a challenging task to achieve the balanced efficiency even on an automated system. The greater involvement of the labor in manual system makes it even more risky. It is difficult to obtain the accuracy and precision on manual lines. Therefore, the flexible system would work better with low variable cost, good quality of parts, greater flexibility and high reliability. The comparison and justification for the advanced manufacturing systems shows that the Automation strategy results in higher flexibility (product variety) at affordable cost and improved quality/ repeatability. At this stage, the export markets can be explored due to better responsiveness and competitive edge.

Export Strategy (ES) using Value Analysis:

The Export strategy is tested using value analysis. Value Analysis is the systematic application of techniques, which identify the function of a product or service, establish a monetary value for the function and provide the necessary function reliably at the lowest cost. Value can be increased either by increasing the importance for the same cost or by decreasing the cost for the same utility. It is very difficult to compute the Importance – Cost on judgment basis and to identify the importance of one operation over other operation. Analytical Hieratical Process (AHP) [10, 11], decision making technique can be used. Let; I = Importance; C = Cost;

$$Value = {}^{I}\!/_{C}$$

The information collected from the company is on the basis of importance versus cost out of one. Importance at operation 1, 2, ..,6 is I_1, I_2,…, I_6 respectively**.** Similarly the related cost at operation 1, 2, …, 6 is C_1, C_2,… C_6 respectively. The weights are given in percentage and the process information is plotted between Cost – Importance as shown in figure.9.

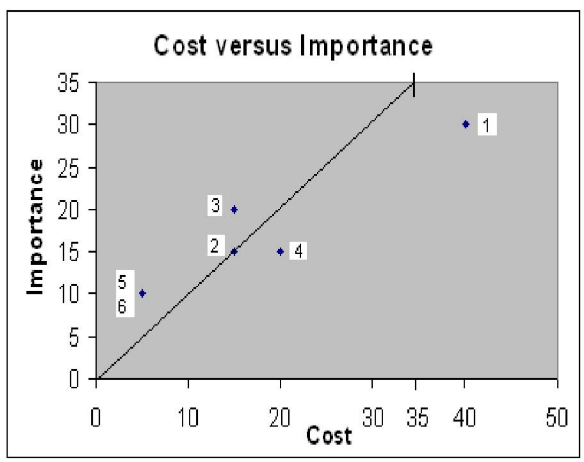

Figure 9. Cost – Importance (Value)

It is evident that Operation 1 and Operation 4 are more costly and have comparatively less importance. There are likely to add value so that these points move above the diagonal line in Cost-Importance plot. The diagonal line showing that the cost and importance is equal. Some innovative methods can also be adopted to reduce costs of these operations. This usually requires change of product / process design. Some of them are pointed in our study. This is given in table 5

Table 5.Importance and Cost data Table

Importance	I_1	I_2	I_3	I_4	I_5	I_6
Weights in percent	30%	15%	20%	15%	10%	10%
Cost	C_1	C_2	C_3	C_4	C_5	C_6
Weights in percent	40%	15%	15%	20%	5%	5%
Value	0.75	1.0	1.334	0.75	2.0	2.0

Operation 1: Cost of machine producing per part is more (as manual machines requires variety of additional tooling and fixtures for such arrangement); Chances of rejection are more in this stage; Tool worn out is rapid and due to some other quality related problems at this stage. **Operation 4:** Machine and tooling for producing the parts are expensive; Due to some quality problems at this stage; and more care for the operations is required since this is the last operational stage. These problems can be handled if we appreciate the stage wise quality levels. The cost of machines is at initial phase of the project; rest of the problem is related with the ongoing quality of the shop. Pareto analysis and cause and effect practices are required for identifying the quality issues at operation 1 and 4 respectively. This shows that our Export strategy can work in case company and increase access to high volume, good quality auto parts by eliminating the more costly, less important processes.

Discussion and Conclusion

The three strategies are tested for the case company and it shows that volumes would be increased using the Good Governance strategy. There is an increase of more volumes and flexibility i.e. variety in the system using Automation strategy. The Export strategy would identify the Cost versus Importance relationship and identify the less important, more costly operations. The results would be increased market access to high volume, good quality auto parts. By adopting triple strategy, major chunks of Volumes and Varieties are increased. The three strategies are summarized as: 1) Good Governance (renamed as Cost cutting approach) Strategy (making use of line balancing approach for more utilization of the line), 2) Automation (Technology Driven renamed as flexible) Strategy (making use of higher flexibility systems, offers more volumes and variety) and 3) Export (Value added renamed as value enhancement) Strategy (making use of value analysis concepts to identify the more costly, less important operations at all stages in manufacturing / business). The path for the three strategies is shown in figure.10.

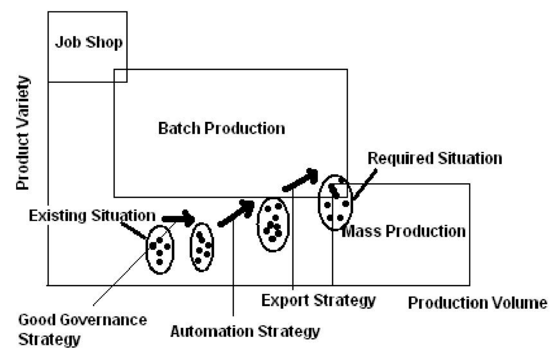

Figure 10 Three strategies Path.

Managing low volume – low variety manufacturing offers a challenge for manufacturers (especially auto parts producers) to become competitive in local as well as international market. This work deals with identifying the discrete parts manufacturing industries lie in low volume - low variety manufacturing region and to cope with this situation needs some corrective actions to be taken by the manufacturers. These strategies have been suggested and are tested using the real life data for automobile industry. These strategies have shown satisfactory result, which allows coming closer to the feasible diagonal. This would need looking more deeply into each strategy (for characterization) and using state of the art tools for more utilization, cost effective manufacturing systems and value enhancement methods for local and international market. The scenario pictured in this work shows that there are chances of change in the existing system making use of these strategies. It is the novel use of existing techniques in this particular order that allows the OEMs to shift from low volume- low variety environment to comparatively high volume- high variety manufacturing. Therefore, the competitive edge can be managed in a systematic manner as suggested in the present study.

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