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An enlarged Product - Process Matrix for industrial organisations

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Les typologies existantes des organisations industrielles sont de type, soit uni, soit bi-dimensionnel. Dans cet article, on propose, à partir de la classification de Hayes et Wheelwright, basée sur la nature du processus de production et le cycle de vie du produit, une typologie pluridimensionnelle, centrée sur la nature du processus de production et la position de l'organisation dans la filière industrielle.

Conformément aux dimensions de cette typologie, on étudie les organisations industrielles dans l'optique de l'analyse de l'organisation de la production et des décisions de contrôle de celle-ci. De plus, on envisage les secteurs de la matrice au sein desquels les petites entreprises ont davantage de chances de prédominer, et les risques de dépendance à l'égard des groupes industriels.

On espère que cet article ouvrira des voies nouvelles pour des études comparatives des relations entre grandes et petites organisations, au sein de systèmes culturels différents.

Most typologies of industrial organisations are either single or two-dimensional. In this article, the authors propose a multi-dimensional typology, going beyond the classification of industrial organisations presented by Hayes and Wheelwright, which is based on the nature of the production process and product life cycle.

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Our multi-dimensional typology focuses on the degree of standardization of the product line and the position of the organisation along the industrial column. According to the dimensions of this typology, industrial organisations are studied with the objective of gaining insights for production organisation and production control decisions. Furthermore, the article explores in which sectors of the matrix small firms are predominant, and whether or not they are dependant upon the bigger concerns.

It is hoped that this article will open new avenues for cross-cultural comparisons of the relations between small and large industrial organisations.

La tipologías existentes de organizaciones industriales son de tipo ya sea uni, ya sea bi-dimensional. En este artículo, se propone a partir de la clasificación de Hayes y de Wheelwright, fundamentada en la naturaleza del proceso de producción y el ciclo de vida del producto, una tipología pluridimensional, centrada en la naturaleza del proceso de producción y la posición de la organización en la rama industrial.

Conforme a las dimensiones de esta tipología, se estudian las organizaciones industriales por el enfoque del análisis de la organización de la producción y de la decisiones de control de la misma. Además, se consideran los sectores de la matriz dentro de los cuales las pequeñas empresas tienen más oportunidades para predominar, y los riesgos de dependencia con respecto a las agrupaciones industriales.

Se confía que este artículo abrirá nuevos caminos para estudios comparativos de la relaciones entre grandes y pequeñas organizaciones, en sistemas culturales diferentes.

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Contrary to the argument that the organisations are unique and can only be understood by careful consideration of their specific tasks and environments, many classifications and typologies of organisations are developed to enable better understanding of their processes, structures and common problems. Classifications and typologies are used to consider similarities and differences of phenomena, such as organisations, in order to benefit more from the experiences of others in comparable situations (Hrebniak, 1978).

Most classifications and typologies of organisations are defined in terms of their goals and functions, output, power and involvement relationships of the organisational participants (Gibson, 1979). Size, environment, technology of the

transformation processes and type of production control are also examples of characteristics used in classifying and typifying organisations.

The purpose of this article is to present a typology of industrial organisations which can provide insights for production organisation and production control decisions. It is also aimed at assisting managers in foreseeing the possible consequences of their decisions to:

- alter the structure of existing product lines;
- change the degree of forward or backward vertical integration in the production process;
- acquire independent small firms and to
- select adequate production control systems.

Furthermore this typology may also be used to explain the hierarchical nature of the industrial system by describing the exchange flows in the industrial column, and pointing out the links between the technological process and the product-market at each level of this industrial or business column.

The first section of the manuscript deals, from a synthetic and a critical point of view, with the existing typologies of industrial organisations. In the second part, a pragmatic typology focusing on the degree of standardisation of the product line and on the position of the organisations along the industrial column is given.

Finally the distinctive characteristics of industrial organisations in the several process - product sectors are described.

1. CURRENT TYPOLOGIES OF INDUSTRIAL ORGANISATIONS

Studies of the existing typologies of the industrial organisations indicate that a large span of characteristics are used to classify them. But, most generally, these characteristics are presented in a unidimensional way. A good exception is the typology presented in a recent HBR article by Hayes and Wheelwright (1979). In this article the authors link the technological process to the type of product. Unfortunately their matrix does not seem to be realistic,

since it is based on the many assumptions of the product-life cycle model.

1.1. *Unidimensional typologies*

There have been many pragmatic typologies constructed to provide better insights into industrial organisations.

The following is representative of the characteristics or dimensions used in the typologies encountered in literature (Botter, 1979).

1. The type of the production control systems.

Production organisations based on stock control rules (as for standard parts), based on manufacturing programs (as in steel/automobile manufacturing) or based on customer orders and specifications (such as different installations or projects).

2. The nature of economical dominance in the production process.

Capital intensive, labour intensive, material intensive or energy intensive manufacturing structures.

3. The degree of standardisation of the existing product line.

Production of standard versus specific products.

4. The pattern of the flow of goods and position in the industrial column.

Converging, sequential or diverging flows of the materials during the manufacturing process in the total industrial or business column.

5. The degree of innovation.

The influence of the number of products and technological changes over the last (e.g. five) years on the stability of the manufacturing processes.

6. The influence of the markets on production stability.

Operating in stable or fluctuating markets (both in purchasing and selling markets).

7. The size of the batches manufactured.

Unit, small and large batch, mass production process (Joan Woodward's well known pragmatic typology).

Each pragmatic typology presented above uses only one underlying input, throughput, output or environmental characteristic. However, the problem with unidimensional pragmatic typologies is their oversimplification of the phenomena under observation. They often add to more confusion than clarity. The number of unidimensional typologies can be expanded indefinitely as some new factor is seized upon to indicate an additional division (Hall, 1972).

A partial breakthrough in pragmatically typifying organisations came with Joan Woodward's (1965) work and more recently with Hayes and Wheelwright's (1979) twodimensional typology. Both typologies have certain shortcomings. The weakness with Woodward's typology is its unidimensionality. Hayes and Wheelwright's typology implied that a change in the volume of the output of the products in a product line and/or a change in the degree of standardisation necessitate a corresponding change in the manufacturing process. This paper challenges this implication. It is not always true that the sales volume of a specific product, as expressed by Hayes and Wheelwright, will necessitate a change in the manufacturing process.

1.2. A two-dimensional typology

Hayes and Wheelwright position manufacturing companies on a two-dimensional matrix as shown in figure 1.

The columns of this matrix represent the life cycle phases of a product and the rows represent major stages through which a production process tends to pass. In the upper left corner position (1.1) each job is unique (specific) and therefore the equipment tends to be relatively general purpose. In the bottom right corner (4.4) the product is a commodity and the process is continuous. The equipment and operations are therefore highly specialised, capital intensive, and tend to be inflexible. According to Hayes and Wheelwright, in the diagonal cases of figure 1, the "product structure" is ideally matched with its "natural" process structure. "A company that allows itself to drift from this diagonal without understanding the likely implications of such a shift is asking

for trouble". In their opinion, the diagonal is the natural and most advantageous situation.

process structure/ process life cycle stage	product life cycle stage/product structure			
	1 low standardization	2 multiple products	3 few major products	4 high standardization
1 job shop	1.1 commercial printer			
2 batch production		2.2 heavy equipment		
3 assembly line			3.3 automobile assembly	
4 continuous flow				4.4 sugar refinery

FIGURE 1

The Hayes-Wheelwright product-process life cycle stages matrix

In cases of growth in the sales volume of an existing product line, cost reductions can be attained by an ongoing product and technological redesigning and simplification over the years. Companies that choose to follow a path below the diagonal of the matrix may achieve even greater cost reductions for a given level of product standardisation than those pursuing a path on the diagonal of the diagonal of the matrix. The concept of movement along the diagonal is primarily drawn from the product model and therefore has certain flows.

The product life cycle model as illustrated in figure 2 is a rather realistic model for many "fashion" brands, products

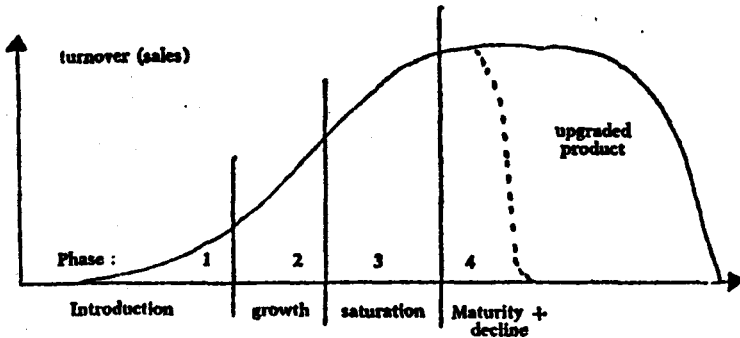


FIGURE 2

Product life cycle model

and product lines. However, for quite a few products and product lines (e.g. for sugar) it is not. The demand for sugar has been stable for many years and we can hardly imagine producing sugar in a job shop or on an assembly line (see figure 3). Along the same lines, although there is a relationship between the degree of standardisation of a product line, the sales volume, and the manufacturing process, it is difficult to visualise how a commercial printer with a job shop manufacturing structure and general purpose equipment (as a result of getting into the phases 2, 3 and 4 of the product life cycle) could adopt a continuous flow process or even an assembly line process for one or more of its products. The only possibility would be to change its product market and begin to print newspapers.

The diagonal movement of a company on the matrix as it changes its degree of product standardisation within the existing product line is questionable. The characteristics of the process industry (sugar, oil, metals, milk, chemicals, glass, vitamins, yarns, drinks) are and will be completely different from that of the assembly industry (cars, household appliances, TV, radio, measuring equipment).

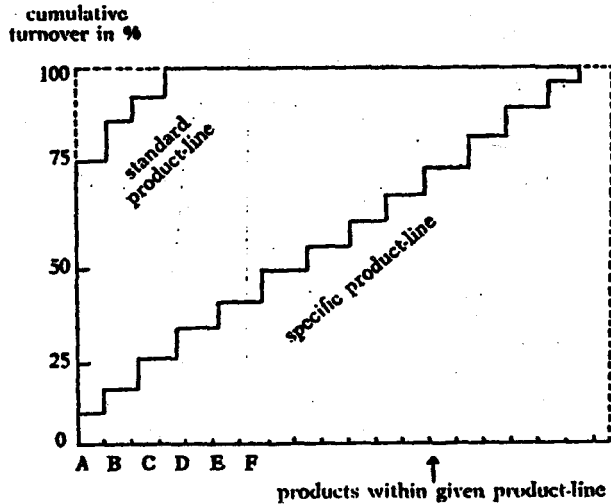


FIGURE 3

Cumulative turnover patterns of a standardised and specific product line

2. PROPOSITIONS FOR A NEW TYPOLOGY: AN ENLARGED PRODUCT/PROCESS MATRIX

2.1. Product line standardisation and business column defined

In this paper, similarities and differences in manufacturing process are identified by an enlarged product/process matrix. Two characteristics or dimensions to typify industrial organisations are used in this matrix.

1. The degree of standardisation of a more or less homogeneous product line of a manufacturing unit.
2. The position of the manufacturing unit in the industrial or business column.

2.1.1. Degree of standardisation of the product line

A homogeneous product line is considered standardised if the total revenue generated by this product line is obtained

through the sale of only *one* or a small number of product (s) such as iron. On the other hand a homogeneous product line is considered specific if the total revenue is from the sale of many different items such as for communication systems.

Cumulative turnover data in industrial organisations will point out the degree of standardisation of a product line. Figure 3 illustrates the concept of cumulative turnover or sales. In one case (upper left hand corner) 75% of the total revenue in a product-line comes from one product and the remaining 25% from the sale of additional products.

In the second case (represented by the diagonal in figure 3) we have an instance of specificity of a product line. Here the total revenue is obtained from the sale of many specific products perhaps none contributing to more than 5% of the total sales. We will elaborate on both variables of our typology.

2.1.2. *Position in business or industrial column*

The concept of the position of the firm's output in the industrial column as a determining factor of the manufacturing process is introduced. The industrial column is defined as the phases goods flow through from the raw material stage to the consumer and durable goods users stages.

All industrial activity can then be classified into product groups depending upon its outputs' location on the flow of goods continuum. In this sense product groups form a sequence representing the number of times the output of an industrial activity has become the input for another set of industrial activity, until the output ultimately reaches its final user, either in the form of a consumer good (e.g. a washing machine or bread) or a producer durable good (e.g. a punch press, a hydro-electric plant or a nuclear turbine).

The product groups positioned in a descending order from top to bottom in the industrial column are:

Materials. This is the immediate transformation of raw materials into usable form. This group includes products

Business column	Degree of standardisation of a product line	
	standardised product-line	specific product-line
1. materials ↓	iron flat glass	integrated circuits
2. single products ↓		electronic parts
3. assembled products ↓	motors cars	furniture large engines
4. installations and projects		defense systems

FIGURE 4

The two-dimensional typology of industrial organisations

such as chemicals, metals, paper, plastic powders, glass and yarns.

Single products. This group covers such products as drawn thick wires, nuts and bolts, enmalled wires, pressed products and parts for professional and fashion sensitive products.

Assembled products. These products are manufactured by assembling several items. They could be simple or complex assembled products such as lamps, tubes, small motors, furniture, cables, clothing, TV receivers, passenger vehicles, large engines, goods vehicles, specific machines and prototypes.

Installations and projects. The main characteristic of the products in this group is in most cases their uniqueness, complexity and interrelatedness of many divergent activities. They include such outputs as vessels, large construction works, defense systems and factory installations.

Each group occupies a unique position in the industrial column which correlates the degree of complexity of the products produced. Companies producing different outputs but positioned in the same level of the business column will have striking similarities in types of problems and alter-

native solutions. These similarities result from the fact that each output, although the machines and the manufacturing equipment are different, is produced following the same manufacturing process. (The manufacture of raw material requires a certain kind of manufacturing process, and control of the production of chemicals and metals is in principle the same). (Woodward, 1965; Hayes and Wheelwright, 1979).

By considering the *position of a company in the business column* and the corresponding *degree of standardisation of the product line* (which is correlated with the volume of turnover and the batch sizes in the manufacturing process) a twodimensional matrix is built.

In figure 5 some manufacturing industries are given as examples of the typology proposed in this article.

Structural characteristics of the representative firms found in each cell block or sector of the matrix is described in the next section with the purpose of identifying similarities in problems and alternative solutions. For example, managers of firms contemplating increasing or decreasing the degree of vertical integration in their operations will be able to look ahead to the structural characteristics of the majority of the firms already in the position they are considering.

2.2. Basic considerations

Many manufacturing industries may have vertical integration in some of their manufacturing and/or commercial operations. In these cases their internal production organisation is structured in such a way that each of the manufacturing departments is specialised to produce an output which corresponds to one of the four categories in the business column.

Example 1: machine factories nearly always manufacture the parts as single products, which are later used in the assembly operations.

Example 2: large lamp factories produce their own materials such as gasses, tungsten and glass bulbs. They manufacture the metal components as single product. They assemble the lamps with a high sales volume in assembly

		sales volume				
		high ←————→ low				
		degree of standardisation		standardised product line ←————→ specific product line		
		process structure				
		continuous flow process	larger series (dis-) assembly line	medium series functional layout	small and unit job shop	
		1.	2.	3.	4.	
degree of complexity	low ↑ high	1. materials	1-1 .chemicals .metals .paper .glass	1-2 .meat (slaughter house) .milk	1-3	1-4
		2. single products	2-1 .copper wires	2-2 .nuts and bolts .electronic parts	2-3 plastic pressed products	2-4 test products
		3. assembled products	3-1 .motorcar tires	3-2 lamps small motors TV receivers	3-3 large engines furniture	3-4 special tools proto-types
		4. installations and projects	4-1	4-2 .military aircrafts	4-3 .civil aircrafts	4-4 .defense systems unique projects

FIGURE 5

Product-process matrix (sixteen types of manufacturing industries)

lines, and those with a low sales volume as batches in departments with a functional lay out.

Example 3: Detergent companies produce some of the chemicals (as materials) in separate departments, while the detergents are made in a continuous flow process in another factory.

Another consideration is that not all goods pass through the various phases in the flow process before they are utilized as consumer products or producer durables as illustrated in figure 6. Some products are immediately suitable for consumption as "material" without the need for transformation into single or assembled products, and are found in short industrial columns. Sugar and salt are excellent illustrations.

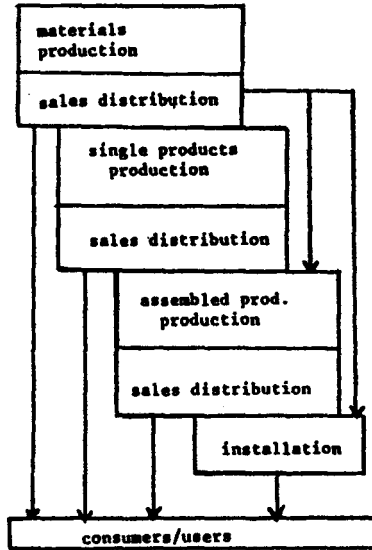


FIGURE 6

Goods flow patterns in the business column

A third observation is that the manufacturing process can be divergent, sequential or convergent. The manufacture of materials is characterised by a diverging process. Many products are made from iron, milk, flour, wood and alcohol. The production of single products has nearly always a sequential character (e.g. meta components) with a weak diverging and/or converging material flow. Assembled products and installations are on the other hand characterised by a strong convergence as shown in figure 7.

2.3. Assumptions

As is illustrated in figure 3, some product lines are composed of only specific products made to order as in ship building and plant construction. In other situations (espe-

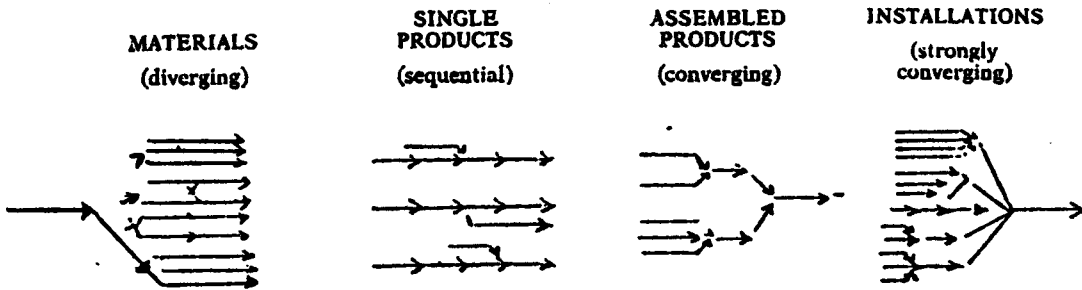


FIGURE 7

Diverging, sequential and converging flows in the industrial column

cially in the material and single products sector) only one or a few (standardised) products of the existing product line are the big money makers on the market. In these cases, it is not exceptional that 90% of the turnover is contributed by one or two products of the product range.

If all products of a product line are ranked in order of their diminishing contribution to turnover volume, starting with the product with the highest contribution to turnover, we can visualise the different degrees of standardisation of the several product lines as illustrated in figure 8. This figure represents the composition of cumulative turnovers in industrial organisations positioned along the diagonal of our product-process matrix. The curves in figure 8 are obviously just approximations for the purpose of giving a general impression.

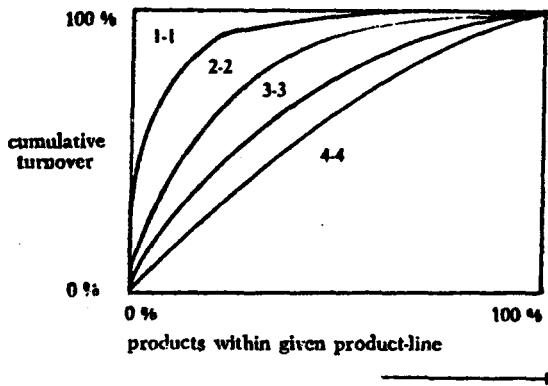


FIGURE 8

Composition of cumulative turnovers of given product-lines in industrial organisations positioned on the diagonal of the product-process matrix

2.4. Degree of dependency

In describing the characteristics of industrial organisations in each sector of the typology, we will also explore the degree of dependency which may exist between organi-

sations in the production and marketing of goods and services. Dependency is viewed as the relationship which may exist between a small and a large industrial organisation. Dependency is considered as a one way relationship, that of the small firm upon the large, and not vice-versa.

We will discuss three possible forms of dependency:

1. dependency of inputs;
2. dependency of outputs;
3. dependency by investment.

We can assume that a production organisation (A) is highly dependent upon another production organisation (B) when:

— organisation B is the dominant or the only organisation in: 1. supplying inputs for the manufacturing process in A; 2. for buying A's output; and 3. for providing the capital and technology for the manufacturing process;

— there is no or low substitution possibility of organisation B by organisation A;

— organisation B is essential for organisation A to produce its goods or services. To stop the exchange between A and B would entail the stopping of the manufacturing process, and even the cessation of all business activities.

Fortunately, total dependency of a production organisation upon another is unfrequent. Empirical studies and observations indicate that dependency should be considered in relative rather than absolute terms (Marchesnay 1979). There are degrees of dependency and they vary significantly among the different sectors of the industrial column.

The emergence of dependency of a production organisation to another organisation can be explained by several economic and sociotechnical factors. First, the degree of technological complexity involved in manufacturing a product plays a significant role in increasing the degree of dependency of a production organisation upon another. Process complexity, product complexity, and task complexity alone or in combination determine the degree of technological complexity.

Technological turbulence, defined as: the rate of innovation; the diversification in process, product and tasks; and the discontinuity of the environment (such as sudden and drastic technological changes) is the second indicator of the emergence of dependency.

Finally, the profitability influences the dependency of a production organisation upon another. If we assume that profitability is determined by such factors as: conditions of entry (investment costs, economies of scale, differentiation) and the concentration rate (number of existing firms and potential entrants), then dependency would be greater in cases where profitability is low. Various degrees of profitability will be found in different sectors of the matrix.

Dependency can explain the existence and the concentration of small firms in certain sectors of the matrix. We may assume that at any given sector of the matrix the small firm can exist if the following conditions prevail:

- there is complexity;
- there is turbulence;
- there is low profitability.

When these three conditions exist, the big concerns will not directly invest in the manufacturing process, but preferably disengage and maintain links of high dependency upon the whole set of small production organisation. The big corporations will invest at the point where, at best, the technology is well-known, stabilized, and highly profitable. But, unfortunately (or fortunately?), except for the monopolies, we may expect that the profitability falls as the product-markets are stabilizing and the technology is well known.

One of the objectives of this paper is to investigate, by means of the enlarged process-product matrix, the conditions of low or high dependency, at the various sectors of this matrix, to predict the survival profitability of small firms in the given sectors and the nature of the links between the "independent" small firms and the firms integrated in a big concern.

3. SECTORIAL CHARACTERISTICS OF THE PROCESS-PRODUCT MATRIX

3.1. *Characteristics of the process industry sector (classes 1-1 and 1-2).*

3.1.1. *Acquiring natural raw materials*

The inputs of the enterprises in this sector are natural raw materials. They are therefore highly dependent upon political developments, harvests and the uncertainties of nature. Compared to manufacturing enterprises in the other sectors of the industrial column, these firms operate in an environment characterized by a high rate of change. Even, if the company is operating in a relatively stable environment, in processing natural raw materials it must adjust its primary manufacturing processes as required by the changes in the quality and composition of the loads bought in. Such adjustments are not always possible. For instance an oil refinery in which the primary manufacturing process is geared to Iranian crude cannot switch in less than six months to process Venezulean crude.

Companies processing agricultural raw materials such as hides, tobacco, tea, vegetables and fruit are also dependent upon their purchasing ability to provide competitive end products of high quality. Often, purchasing is done in future markets.

3.1.2. *Manufacturing*

Due to the large quantities of raw materials or end products that need to be shipped in and out, enterprises in the materials sector prefer to be located near the raw materials and transportation centers.

The manufacturing process is characterized by the divergence of the material flows. It begins with the transformation of one main raw material into several series of end products. The main raw material is processed continuously.

Due to the continuity of the manufacturing process the equipment is highly specialized, single purpose, self contained

and used to transform only one raw material. Examples may include glass mills, blast furnaces, kilns, etc.

If more than one production operation is required, then connecting transportation equipment is designed. The output of one machine becomes the input of the other. The machines must match each other with little or no tolerance limits on quality. The machines are arranged sequentially to follow the natural flow process, as is in the cases of a brewery or a refinery.

The equipment used is expensive and often will work for more than 20 years. This is a high capital intensive industry. Since changes and adjustments are rather difficult to make, it requires extensive planning of the manufacturing process. Continuity of the operation lends itself to the use of automatic control systems.

Investments of capital per employee is high, often leading to the introduction of multi-shift production systems. Due to its high cost, equipment will not be kept idle. When fluctuations in sales occur, rather than adjusting capacity, an attempt is first made to adjust the sales price of the product.

Operating cost is closely tied to the size of the batch produced: the larger the batch size, the smaller the unit cost. The tendency therefore is a constant desire to increase the scale of production and the standardisation of the product line.

The labor cost is not as important. Labor cost is included, as an allowance, either in the hourly rate of the equipment or in the materials used.

3.1.3. *Marketing*

Products of this sector are sold in industrial markets (metals, chemicals, glass, paper and plastic powders) as well as on consumer markets (especially food). Industrial markets are characterized by a relatively small number of well-informed professional customers. They are experts in their fields with access to industry wide technical information on the quality and the price of the products delivered.

Customers' demand on quality and reliability of supply is high.

Purchases and sales in this sector are often based on long term or yearly contracts. Management will try to adapt to fluctuations in the markets, not by decreasing or increasing the utilisation of the existing capacities, but by price changes.

3.1.4. Innovation orientation and organisation

Strategic orientation of the enterprises in this sector is not primarily toward sales but toward the basic materials. In other words they are input rather than output oriented. Diversification in this sector does not easily occur in terms of the inputs but rather there is a tendency to diversify the output. Dairy-factories may produce such diversified products as butter, cheese, yoghurt, icecreams, etc.

Product innovation is not too intensive. The main attention is directed toward technological innovation with the purposes of assuring high product quality, low production cost, and high production reliability. To create optimal production processes, it is worth while for these enterprises to engage in intensive process studies and explore the feasibility of further automation.

The organisation structure in the process industry on the operational level is primarily enforced by the technical equipment. Technology dictates the organisational structure. Departmentalization at the higher organisation levels is along functional lines. The structure is bureaucratic and mechanistic with relatively long chains of command, many specialist groups and a large number of indirect labor (Harvey, 1968).

3.1.5. Dependency

In the process industry sector we can find primarily two different types of firms, operating under different conditions and environmental characteristics.

The first set of conditions characterized by well-known, stable technologies with no major technological discontinuities expected from the environment.

The profitability of the firms operating under these conditions is dependent on the availability of large amounts of technical capital, the free access to inputs, and the achievement of economies of scale. The output of one production unit becomes the input of the process at a lower point in the industrial column where effective capital valorisation can take place, such as in the case of petroleum for the petrochemical industry. Consequently, the production units are in these situations integrated in a big concern, leaving no room for "independent" firms. Most of the firms are here affiliates of large multinational corporations.

A second set of conditions exists primarily in the agro-industrial column. In this segment, technology is also stabilized and well-known. However, there are less restrictive technical conditions of entry. This is because the required initial investment is substantially lower and profitability is not so much a factor of economies of scale as is the case for instance in the petroleum and petrochemical industries.

High transportation costs create the necessity to locate production units near consumption centers such as in the case of dairies and breweries. Many small independent firms with a potential for growth exist in this segment of the process industry sector.

Most of these small enterprises are quite independent of the furnishers of inputs (such as farmers and agricultural cooperatives). However, they are often far less independent from the retailers.

As has been observed there may exist a strong dependency of the small enterprises upon special machinery producers. But in practice this dependency is restricted.

Due to profitability which correlates with easiness of entry there is a lack of interest and willingness of the large industrial concerns to integrate with small firms. Another reason for this lack of interest of the large industrial concerns to integrate by manufacturing the products directly is the vulnerability in the face of technological turbulences such as the discovery of new manufacturing machinery. When product differentiation sharply increases profitability, the big industrial concerns will attempt to integrate through

external growth, while big commercial concerns (wholesale-retail) will reinforce the dependency of the small enterprise by use of "hard purchasing" policies.

3.2. Characteristics of single products sector (classes 2-1 and 2-2)

3.2.1. Purchasing materials

Manufacturing enterprises using the output of the materials sector as an input and converting it into single products are grouped under the single products sector. Industries in this sector are not as dependent on their environment. They operate in industrial markets. In the non-agricultural sector their suppliers are often large companies with even better information about the market conditions than the enterprise itself. These companies often have to buy internationally standardized products.

3.2.2. Manufacturing

The primary manufacturing process of these enterprises is characterized by sequential operations in weakly convergent or divergent linear flows. Rolling mills, wire drawing mills, pressing shops and turning mills are examples of weakly divergent production flows.

Manufacturing enterprises as spinning mills, twinning mills, paint shops, and enamelling shops have weakly convergent production processes. These firms transfer, restructure or finish single products.

The machines used to transfer the inputs are small in scale, transportable and have broad applicability. The tools used in the transformation process, however, are usually order-bound. Change over costs are relatively high due to the need to replace tools and to the relatively high speed of the production. These companies attempt to increase production by manufacturing related families of products.

The capital investment per employee is lower than in the previous sector. In determining the factory price of the product, labor and machine costs are separately calculated

and are equally important. The level of the output does not have as much influence in determining the operating cost. Therefore, the tendency to increase the scale of operations is not very high. Growth of the company can take place in many geographically scattered locations. There is no real economic necessity to concentrate operations in one location.

3.2.3. *Marketing*

Sales of the single products is primarily in industrial markets for assembly industries. If a company producing single products is a subsidiary of a large assembly firm, their marketing plans are derived from the overall company plans.

Some independent firms produce their standard products in "optimal" quantities and deliver from stock with short delivery time. Specific items are produced on customer order and require longer delivery time.

Independent small enterprises in this sector usually have a rather weak approach to marketing. These enterprises try to base their marketing strategies on their reputation as professional craftsmen and well-developed personal relations with their clients. Having no definite sales organisation, they depend primarily on sale agents.

3.2.4. *Innovation, orientation and organisation*

Innovation in this sector is not too intensive and primarily oriented toward the improvement of the manufacturing process rather than the development of new products. This statement is especially valid for the many small independent enterprises with a craftsmanship orientation. Innovation in this sector usually takes place in the machine and tooling industries. Top management's emphasis and orientation is not on materials purchasing or on marketing, but on technology.

3.2.5. *Dependency*

Technological dependency along with the opportunity for survival and development of the small independent firms

in the single products sector can be analyzed as in the previous sector as a function of technological complexity, turbulence, and profitability.

In the case of high complexity, low turbulence and high profitability we may expect that big industrial concerns will integrate primarily via external growth policies. That is, they will buy the independent firms to acquire the patent and property rights as well the manufacturing expertise. The big industrial concern may also choose not to integrate but to increase the dependency of the individual firms upon them by exercising pressure as a seller of inputs or a buyer of outputs. Pressure could be exercised through pricing policies, added financial conditions, quality and delay requirements. By increasing the dependency of the small enterprise in this manner the big industrial concern can actually transfer a substantial part of the profits.

A different picture is observed when there is high turbulence, high complexity, and a big short term profitability. As a general rule large industrial organisations are rather reluctant to invest in the face of discontinuity (turbulence) and prefer to wait for a relative degree of stability. However, they may support small innovative firms through minority investments and parenting practices.

A third situation exists when high complexity, high turbulence and low profitability are observed. When the environment is so characterized, this sector becomes the realm of the small independent firms. This is especially the case in the machine and tooling industry. High complexity entails specific entrepreneurial characteristics and crafts manship; an essential organisational characteristic where small companies possess a built-in advantage (small is efficient). Low profitability implies easiness for entry as a result of low investment costs, no need for economies of scale (low volume orders), and not much product differentiation. Under these circumstances the big industrial concerns find integration undesirable and prefer to receive an added share of the profit by increasing the dependency of the small enterprises upon them.

A fourth situation is presented in this case, when technological complexity, turbulence and profitability are low. We may observe a low degree of dependency of the small enterprise upon the big concern. These segments of this industrial sector are generally in the decline phase. The big concerns have already disinvested here and if there is a merger (concentration process), this is due to the death of the failing firms rather than to marriages, or, *a fortiori*, births. It is possible, that such a segment of this industrial sector could be revitalized by a technological or commercial turbulence. In such a case the short term profitability sharply rises, putting us back into one of the previous situations.

3.3. *Characteristics of the assembled products sector (classes 3-2 and 3-3)*

3.3.1. *Materials and components purchasing*

Enterprises in the assembled products sector are generally linked by long term purchasing contracts for numerous materials and components, with various suppliers. They are extremely dependent on the degree of reliability in the delivery times and consistency in quality of the purchased products. Adequate inventory of component parts, perfect control of the configuration of the final products, and well-documented parts lists are critical to determining future needs for materials and parts.

3.3.2. *Manufacturing*

The enterprises in this sector are characterized by the increasing convergence of the flow of goods. Assemblies can be simple or complex. At various stages of the convergent assemblies, sub-assemblies of single products exist. The manufacturing process is of a mechanical nature.

With the exception of the auto assembly industry, capital investments per employee are usually the lowest among all sectors of the industrial column. Labor costs are more important than the machine or material costs in determining

factory sale price. Some adjustments to market fluctuations are made by changing personnel capacity. Since these enterprises are generally labor intensive, large lay-offs or new hirings occur as business cycles fluctuate. This is possible because assembly industries generally experience a high natural turnover rate (20-30% per year).

Many improvements on the assembly lines since their full-scale introduction around 1920, have resulted in shorter through-put times and lower production and control costs. By-products of more sophisticated and well-organized assembly lines are reduced flexibility for the company and increased worker absenteeism.

3.3.3. Marketing and innovation orientation

The enterprises in this sector, manufacturing consumer products, have the tendency to develop strong and well organized marketing organisations. Innovation is market and product oriented. Technological innovations take place primarily in the specialized machine and tooling manufacturing enterprises. Managers are continuously on the look out for new products for which there is a demand in the market.

The position of the firm takes in the channels of distribution, the need to carry a wide product range, new product development, and marketing are very important factors in the success or failure of these enterprises.

3.3.4. Organisation structure

Carrying a wide product range reduces standardization, requiring more dynamic processes and flexibility in management. Decentralization of operations and horizontal growth of the organisation structure are common.

3.3.5. Dependency

In this assembled products sector, one of the most important features is the preeminence of "hyperfirms". These hyperfirms are the outcome of integration processes, generally using mergers when the product cycle has reached

the maturity stage. They are considered second industrial generation firms (car, chemistry, electricity, etc...) contributing to the making and the continuation of the consumption society. The business policy of the hyperfirms, from a product-process point of view, tends to:

— Reduce, rule out, or dominate the technological complexity, once the product-market has reached its maturity stage. This may be achieved through various means: process and product standardization (e. g. world car) labor reducing skill requirements, search for markets and product innovations. When complexity appears unavoidable, then this complexity is removed outside the hyperfirms by subcontracting (single product processing), and, increasingly nowadays, by acquiring small individual firms.

— Avoid external turbulence by anticipating or preventing market or demand fluctuations (with product replacement or renewal policies) and by controlling innovations (acquiring or holding patents). During the initial stages of the product life cycle for new products as the turbulence is strong, the hyperfirms will not directly invest in these products but will attempt to control small innovative firms by means of financial support or by acquiring patents.

— Search profit opportunities by using decentralized decisions rules (such as management by objectives) and by giving up the unprofitable (due to non-stabilized technology or saturated demand) product-market areas.

Thus in this sector the small individual firms may only survive when:

(1) technological complexity and environmental turbulence are great, i.e. during the pioneering phase;

(2) profitability is low, i.e. at the pioneering or declining stages.

On the other hand, small individual firms may find expansion possibilities in the product assembled sector when: (1) a well-specified product-market (a "niche") exists and (2) when a special skill in sub-assembling technologically complex assembled products (as in aircraft industry) is required.

3.4. Characteristics of the "installation" sector (classes 4-3 and 4-4)

3.4.1. Purchasing

The purchasing and inventory control in this sector exhibit similar characteristics found in the assembled products sector which has already been reviewed.

3.4.2. Acquisition, project preparation and execution

Acquisition of customer orders, design of the installation, preparation, and execution of projects overlap highly in practice and are aimed at short and reliable delivery times.

The throughput times of projects may be anywhere from several months to several years. The projects are nearly always developed and specified in close cooperation with the customers on a contractual basis.

Matrix and project type of organisational structures are often found in this sector. The workflow on the projects is partly sequential and partly pooled. This characteristic requires more specialized communication patterns than those found in most manufacturing enterprises. The vertical channels of communication are greatly supplemented by horizontal and diagonal communication networks. The traditional authority of the chain of command has difficulty to exact action, and the sources of authority are more professional than hierarchical.

Materials and labor are the critical factors in the cost/price structure. The composition of the labor force is mixed, and is greatly affected by the degree of innovation of the projects. Unique and advanced projects of high cost require large numbers of highly skilled personnel (engineers, managers, accountants, etc...). A space project or a complex electronic defense system will fall under this category. On the other hand, the manufacture of a large hydro electric plant or a suspension bridge will require more unskilled labor than skilled personnel.

3.4.3. *Dependency*

In the more traditional areas of the installation and project sector, big firms systematically use and encourage the creation of a network of small individual firms, by legal subcontracting or, more frequently, by specific and short term purchasing contracts. If the conditions are unstable, the demand for small firms is related to the nature and the amount of the projects. The individual firms may then be strongly dependent on big firms and in a vulnerable position if the big firm is failing. If the technology is simple (or simplified through task differentiation), the environment is relatively stable and profitability is low, the big firm will exert its bargaining power for more profits by way of the dependency links. This can usually be observed in the building industry.

But in new areas of the installation and project sector, big firms expand through the creation of industrial engineering departments. Many multinational firms adopt an expansion strategy via the sale of their technology. For example, sugar producers are selling to developing countries engineering expertise for building sugar refineries. They avoid to invest directly in building their own refineries in those countries. Consequently, the manufacturing activities are steadily (and sometimes sharply) replaced in these countries by "intellectual" or service activities. In new areas we may expect the surging of new networks of small individual firms, highly specialized in technologically sophisticated product-markets and highly dependent on installation or engineering departments of big concerns. These small individual firms will work with complex and turbulent technologies and with a very low pure profit (entrepreneurship work and capital incomes being deduced).

4. *Implications of the product-process matrix*

This two dimensional matrix groups manufacturing organisations into several sectors according their position in the business column and their manufacturing process. The usefulness of this typology does not lie in its consis-

tency in putting organisations into neatly defined groups but rather in its instrumentality in providing a criteria for strategic decisions. This typology can provide some significant assistance in making long term decisions in organisations.

More specifically, it offers an analytical grid for a strategical diagnosis of small individual firms, located at some point of the industrial column. Indeed, it permits to connect the technological (inner and external) data, the level of efficiency that the firm is expected to attain, and its location in the industrial column. Its bargaining power appears related to the nature of the exchange link settled with big firms, or, more accurately, with firms integrated in a big concern.

From a broader point of view, the proposed process-product matrix enlightens the very nature of the power relations between the small and big business in market economies. It gives a further explanation, more, complete and comprehensive than the micro (insulated strategic analysis) or macro systems; for it focuses on the proper structure of the productive system, using a meso-analytic approach centered on the industrial column analysis, to explain the behavior and the intents of the economic partners. From this point of view, this is also an enlarged matrix.

Finally, this analysis should be pursued and developed with empirical investigation in different market economies, more or less decentralized and concentrated, for the same industrial columns. Attempts in the French economy have been made to study the behavior of small firms according their location the industrial column vis-à-vis the dependency originated from firms integrated (affiliated) in big concerns (Marchesnay, 1979). The first results give a strong incentive to enlarge the empirical research, and to make a comparison between American, Dutch and French economies.

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