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The Effect of Product, Market and Technology Factors on Layout Type Design

(An Applied Field Study on Public Shareholding Manufacturing Companies in Jordan)

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ABSTRACT

This study aimed at identifying the effect of product, market and technology factors on the process of layout type design, and the criteria upon which a specific layout format is adopted in the Public-Shareholding manufacturing firms in Jordan.

Data was collected through a questionnaire designed for the purpose of this study and submitted to production managers in these companies; other used tools were unstructured interviews and researcher's observation.

Statistic analysis tools were discriminant analysis, and Chi-square tests in addition to descriptive statistical measures.

The study resulted in finding that the statistically significant and discriminant layout factors among the three variables groups (product, market and technology variables) are:

1. Product mix among product variables,
2. Production volume and target market's variety's among market variables,
3. Manufacturing processes' type, manufacturing system's type and employee's specialization level among technology variables.

KEYWORDS: Product, Market, Technology, Layout Type Design, Shareholdoing Manufacturing Companies, Jordan.

1. INTRODUCTION

This period is in an extraordinary one of technological change and organizational creativity, firms are anxious to invent better ways of working, more effective forms of organization and more brilliant ways of providing markets with delightful and innovative products and this drives them to look up for all possible means and tools to maximize the benefits that can be gained from resources available for the core business.

Among these means and tools lies an extremely important one, that is layout type design, that concerns the allocation of physical resources to solve immediate as well as long-term accommodation problems-despite uncertainty, inadequate information and shifting goals-for users, customers and society in large to embrace high culture and deep practicality in a skilled and cost effective manner, which makes layout type design decisions correspond to nothing more closely than the highest levels of strategic management.

Designing layout types and creating workspaces is not only a question of corporate identity or health and safety, nor it is only a question of calculations on costs and benefits on building and property; in fact layout type design is the spinal cord that links, coordinates and organizes all organizational elements and resources. It is one of the chief means by which organizational aspirations can be achieved.

But unfortunately, in Jordan, the awareness levels of organizations and the efforts exerted by their

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managements, in the field of layout type design haven't yet reached an effective satisfactory level. This might be due to a number of reasons, but mainly because of the gap that often exists between the designer and the manager, or because layout responsibilities are handled by inappropriate parties, thus inadequate models of design prevail in these organizations hindering organizational performance and effectiveness. That's why; it seems worthwhile to seek a better understanding of the concept of layout type design; and the primary factors that affect the choice of a specific layout type and the relevant series of decisions.

Problem Definition

This study is keen to answer the following questions:

1. What are the different layout types adopted by Public-Shareholding manufacturing firms in Jordan?
2. Which Product, Market and Technology variables are statistically significant and discriminant layout type determinants in the Public-Shareholding manufacturing firms in Jordan?
3. What is the level of importance that production managers attach to each group of these variables in Public-Shareholding manufacturing firms in Jordan?

Research Importance

This study tackles an important topic, successful layout type design has been enabling different organizations all around the globe to use their resources with utility and economy, to achieve and fulfill their targets and objectives and to express and communicate their image and meaning, serving both functionality and aesthetics. In Jordan, both manufacturing and non-manufacturing firms are becoming more and more aware of the roles that layout type design play, yet their awareness didn't reach an effective satisfactory level, which calls for research in this field and from the management's point of view. Still, Findings of this study can be helpful to both managers as well as designers; it can be a beneficial source of information, for future reference.

The most important feature of this study and within our knowledge is attributed to the fact that it's the first to investigate statistically significant and discriminant layout type design parameters, and adopted layouts types in the Public-Shareholding manufacturing firms and in Jordan.

RESEARCH OBJECTIVES

The main objectives of this study are:

1. To examine the most commonly used types of layout designs in manufacturing firms, their design criteria and the ones adopted by the Public-Shareholding manufacturing firms in Jordan.
2. To identify key layout type design determinants with regard to Product, Market and Technology and then to distinguish the statistically significant and discriminant ones in Public-Shareholding manufacturing firms in Jordan.
3. To identify the level of importance that production managers attach to each of these groups of variables in Public-Shareholding manufacturing firms in Jordan.

2. LITERATURE REVIEW

The process of deciding what kind of layout is most appropriate to an organization ruled by a number of key variables that guide to a successful and cost efficient choice, and these are:

Product and Market Variables

Product Mix (Variety), and Production Volume

Lussier (2002), Slack *et al*. (2001) and Fink (1999) agree that layout type design is highly affected by a product's flexibility that is defined through different dimensions especially the volume-variety relationship. Slack *et al*. (2001) states that volume and variety enormously affect flow, when volume is very low and variety is relatively high (process layouts), flow is not a major issue, with a higher volume and lower variety (product layouts) flow becomes an issue. If the variety is still high, however, an entirely flow-dominated arrangement is difficult because there will be different flow patterns, the variety and volume will have substantial effects on layout choice.

It's well-stated in literature that a process layout is more range-flexible than a product layout , still the latter can be more range-flexible if work is reallocated between the various groups Bokhorst (2005).

Product Cost

Several aspects of a manufacturing layout will have impact on a product's manufacturing costs, from the perspective of a production manager the price of a product has to be related to the manufacturing costs, and manufacturing elements that affect cost which are equipment, personnel, material and inventory costs, and several aspects of a manufacturing layout will have impact on these costs Bokhorst (2005) says that.

A survey of 32 U.S. firms involved with cellular manufacturing, and reported by Wemmerlöv and Hyer (1989), showed that new equipment and machine duplication was a major expense category for cell implementation. Specialization in a process layout may lead to a higher production speed, which may reduce equipment and personnel costs. On the other hand, many argue that setup times are usually lower in a product layout and reduce equipment and personnel costs in this type of layout (e.g. Wemmerlöv and Hyer 1989, and Flynn and Jacobs 1986).

All these aspects have to be considered in order to estimate the impact on the equipment and product costs by the various types of layouts. Personnel costs are related to the factors that have impact on equipment costs. Empirical studies show the reduced need for indirect labor where firms convert from a process layout to a cellular layout, they also show reduced costs in general when shifting from the process layout to the cellular (Burbidge 1992, and Wemmerlöv and Hyer 1989). Reductions in throughput time and work-in-process inventory have been reported in surveys of plants that implemented cellular manufacturing (Wemmerlöv and Hyer 1989).

As a conclusion a product's cost, varies from one layout to the other, and yet, these variations may lead to lower costs in certain aspects of one layout, and to higher costs in other aspects for the same layout, in comparison to other layouts.

Product Type (standardized vs. customized)

In a study of flexible manufacturing systems and mass customization manufacturing Qiao *et al.* (2003), argued that the level of standardization in a product will affect the chosen layout type. They define three types of products in terms of the level of standardization or customization required standardized products, configured products, and parameterized products. Their research concluded that cellular layouts are balanced between product and process layouts, and that product layouts are most suitable for highly standardized products while in process layouts customization can be introduced at higher levels with wider varieties and smaller volumes.

Heizer and Render (2005) also identify 4 types of products: *Highly standardized products* (continuous process), *standardized products* (repetitive/assembly processes), *semi-standardized products* where they tend to add customized features, but are mainly produced in a standardized manner, *customized products*, such products are manufactured according to customers' specifications whether in larger or small scales. They state that standardized types of products are associated with product layouts, and higher levels of customization are associated with process and cellular layouts.

Target Market's Variety

The effects that a company's target market have on its layout are many, they can be both direct and indirect, (Bokhorst, 2005) argues that if the company is targeting more than one market and with large differences among them, this will have an impact on the level of variety that the company will produce, on the other hand, the target market also drives new product creations, and product changes, which is reflected on the level of flexibility that the layout has and is willing to offer (Qiao *et al.*, 2003). The target market's size affects volume, variety of tastes, the level of customization to be offered and the speed by which changes can be introduced, which in return affects the type of layout to choose.

Demand

Market demand for a product is an estimation of one of the most difficult problems that companies are usually faced with, because it's not a fixed number, but rather a function of the stated conditions (Kottler, 2003).

Jacob *et al*. (2004) concluded that with regard to demand and its effect on layout type design, two variables arise as extremely important, these are market demand's regularity and level. Demand in product layouts is usually regular, predictable, and thus created on a mass basis, but in fixed-position and often process and cellular layouts demand is usually contract based, and thus predictability is lower (Martinich, 1997). All in all this affects the design requirements of the layout type to be chosen. Requirements for changes in a demand level and regularity increase the appreciation of certain layout features as flexibility in terms of variety, and in terms of mobility (Chiara and Callender, 1990).

Technology Variables

Pride and Ferrell (2000) define technology as the application of knowledge and tools to solve problems and perform tasks more efficiently. Daft (2002) defines it as the knowledge, tools, machines, information, skills and materials used to complete tasks within organizations, as well as to the nature of the outputs of the organization , thus technology refers to both human and machine factors, which both have great impact on layout type design decisions.

Manufacturing Processes

Hayes and Wheelwright (1979) introduced the concept of a "product-process matrix"; companies match their product structure with the appropriate process structure. As volume and standardization increase and the number of product types decreases, more specialized equipment will be used in a more continuous flow. The choice of a process structure directs the choice of a basic layout (Bokhorst, 2005, Stevenson, 2005, Jacob *et al*., 2004, Slack *et al.*, 2001).

Heizer and Render (2005) defined 3 kinds of processes, their characteristics and what layouts to use with each process, that are presented in Table (1).

Table (1): Heizer and Render's Classification of Manufacturing Processes.

Processing Type Matched with layout type	**Production Volume**	**Unit Costs**	**Labor & equipment utilization**	**skill requirements**	**Flexibility level**
Repetitive [Assembly & Continuous] Product layouts	High with highly standardized products.	Low	High	Low	Inflexible
Intermittent [Job Shop and Batch] Process Layouts	Lower with more customization	Higher	Lower utilization	Skilled or semi-skilled workers	More flexible
Projects [Non repetitive and unique activities] Fixed-position Layouts	Low, and customized	Higher	Lower utilization	Very high skill requirement	Highly flexible to fit each project
Source: Concluded from Heizer, J., and Render, B. (2005). Operations Management, (7^{th} ed.). London: Prentice Hall of Pearson.					

Manufacturing Technology Type

Joan Woodward's 1960's study of more than 100 British manufacturing companies developed a three category scheme for classifying manufacturing technology: unit or small batch production, mass or large batch production and continuous process or flow. By moving from small batch to continuous process the technical complexity increases.

Adler (1988), and Port (1994) have added in to Joan Woodward's customized (unit production), mass production and continuous production the Computer Aided Manufacturing CAM (flexible manufacturing).

Skill and Quality of Labor

The skill and quality of labor can be investigated in several ways. A well-known approach concerns the job characteristics model of (Hackman and Oldham, 1980). This model was used by Shafer *et al. (*1995) to investigate human issues in cellular manufacturing. The job characteristics model distinguishes five task characteristics that have impact on quality of labor: skill variety, task identity, task significance, autonomy and feedback.

As Bokhorst (2005) explains that a process layout is likely supports a higher/better skill variety, more autonomy and a better feedback mechanism, where workers can perform a variety of tasks, they are responsible of the internal organization of the group, and they get a quick feedback on their activities. The task identity and task significance in a product layout is probably better, where the tasks to be performed are clear for all workers and they will be respected because of their specialization.

3. THEORETICAL FRAMEWORK

The Definition of Layout Type Design

Stevenson (2005) defines layout type design as the configuration of departments, work centers and equipment, with particular emphasis on movement of work (customers or materials) through the system.

Francis *et al.* (1998) state that layout type design is defined as the spatial relationships in a facility that material move through over time. It defines the methods and resources (i.e. – people, fork trucks, cranes, AGV's…etc.), associated costs of resources, and unit loads for moving the material from location to location in the layout.

Layout Design Types

Product Layout

A product layout (also called as a flow shop layout) is one in which equipment; machines, workers and work processes are arranged according to progressive steps by which the product is made. In other words, in this layout the machines and/or workers are arranged in accordance with the sequence of operations for a given product or service (Jacobs *et al.* 2004 and Martinich, 1997).The basic difference between this layout and other layouts lies in the pattern of workflow, in this layout the facility is organized around the product, special-purpose equipment are used (this layout is capital intensive), material handling equipments are usually fixed, and processes are repetitive and/or continuous; because the use of standardized processing operations achieves smooth, rapid and high-volume flow (Stevenson, 2005, and Heizer and Render, 2005).

Heizer and Render (2005), Gaither and Frazier (2001), Fink (1999) and Martinich (1997), agree that the requirements to use this kind of layout usually exist when there are standardized products, small product mix, high production volumes, stable production quantities and uniform quality and adequate supplies of raw materials and components.

Process Layout

A process layout is also known as a job-shop layout or a functional Layout because it's used with process-focused processes. Simply it means that similar equipments or functions are grouped together (Stevenson, 2005 and Henry, 2004). The most common approach in developing a process layout is to arrange departments consisting of like processes in a way that provides a satisfactory level of their relative placement. In many installations, a satisfactory placement often means placing departments with large amounts of inter-department traffic adjacent, so that they lie nearby, to one another (Stevenson, 2005, and Martinich, 1997). A part being worked on then travels, according to the established sequence of operations, from area to area, where the proper machines are located for each operation.

This type of layout is usually used when the operations system must handle a wide variety of products in relatively small volumes and where flexibility is necessary to produce customized or semi-standardized products and to adapt to variable production quantities (Heizer and Render, 2005, Gaither and Frazier, 2001), it's suitable for intermittent -job shop or batch- processing (Stevenson, 2005), where general-purpose equipment is used, changeover is rapid, material handling equipment is flexible, operators are highly skilled, technical supervision is required, planning, scheduling and controlling functions are challenging, that's why higher specialization levels are required.

Cellular Layouts

In this layout machines are grouped into a cell that can process items that have similar processing requirements, so that products that undergo the same processing in the same sequence can be produced more efficiently by using cells (Heizer and Render, 2005 and Martinich, 1997). So a cellular layout groups dissimilar machines into work centers (or cells) to work on products that have similar shapes and processing requirements Cellular layout is sometimes called as Group Technology layout (GT), which is the grouping into part families of items with similar design or manufacturing characteristics, group technology also refers to the parts classification and coding system used to specify machine types that go into a cell (Jacobs *et al.,* 2004).

Henry (2004) states that the concept in this layout is that many problems are similar, and by grouping similar problems, a single solution can be found to a set of problems, thus saving time and effort, he says that a cellular layout is a manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in design and manufacturing and a technique for identifying and bringing together related or similar components in order to take advantage of their similarities in the production process.

Fixed Position Layout

In this layout a product or a project remains stationary, and workers, materials and equipment are moved as needed to the site, and products normally remain in one location for the entire manufacturing period (Heizer and Render, 2005, Gaither and Frazier, 2001 and Martinich, 1997). This Layout is dictated by the nature of the product, and it's usually used when the product is very bulky, large, heavy and fragile or has some other factors that make it undesirable or extremely difficult to move the product.

- Fixed-position layout is characterized by a relatively low number of production units in comparison with the previously mentioned layout formats. In developing a fixed position layout, there has to be a visualization of the product as the hub of a wheel with materials and equipment arranged concentrically around the production point in their order of use and movement difficulty. Slack *et al.* (2001) state that this layout needs highly skilled employees because some of the problems that arise, need deep and high skills and knowledge.

Hybrid Layouts

Organizations tend sometimes to use a mixture of two or more of the previously mentioned layout types in order to make use of their collective advantages and avoid the weaknesses of a single layout, in order to achieve enhanced outcomes and fulfilling results.

4. RESEARCH METHODOLOGY

Nature of the study

Trying to answer the previous questions, this study seeks to develop a body of knowledge about the factors that play a major role in choosing a specific layout type, in the public shareholding manufacturing Jordanian companies; that‘s why this research is classified as a basic (fundamental) research. The type of investigation pursued is an analytical correlational one, the type of study can be classified as a field study taking place in a non-contrived setting (the natural workplace setting of these companies), and the time frame is a cross-sectional one.

The Study Model

This study includes two sets of variables:

1. The dependent variable which is the choice of a specific layout type, this type has to be one of the five formats used by manufacturing firms (product layout, process layout, cellular layout, fixed-position layout, and hybrid layout).
2. The independent variables, these variables were grouped in three categories product variables, market variables and technology variables. Figure (1) illustrates these variables in detail.

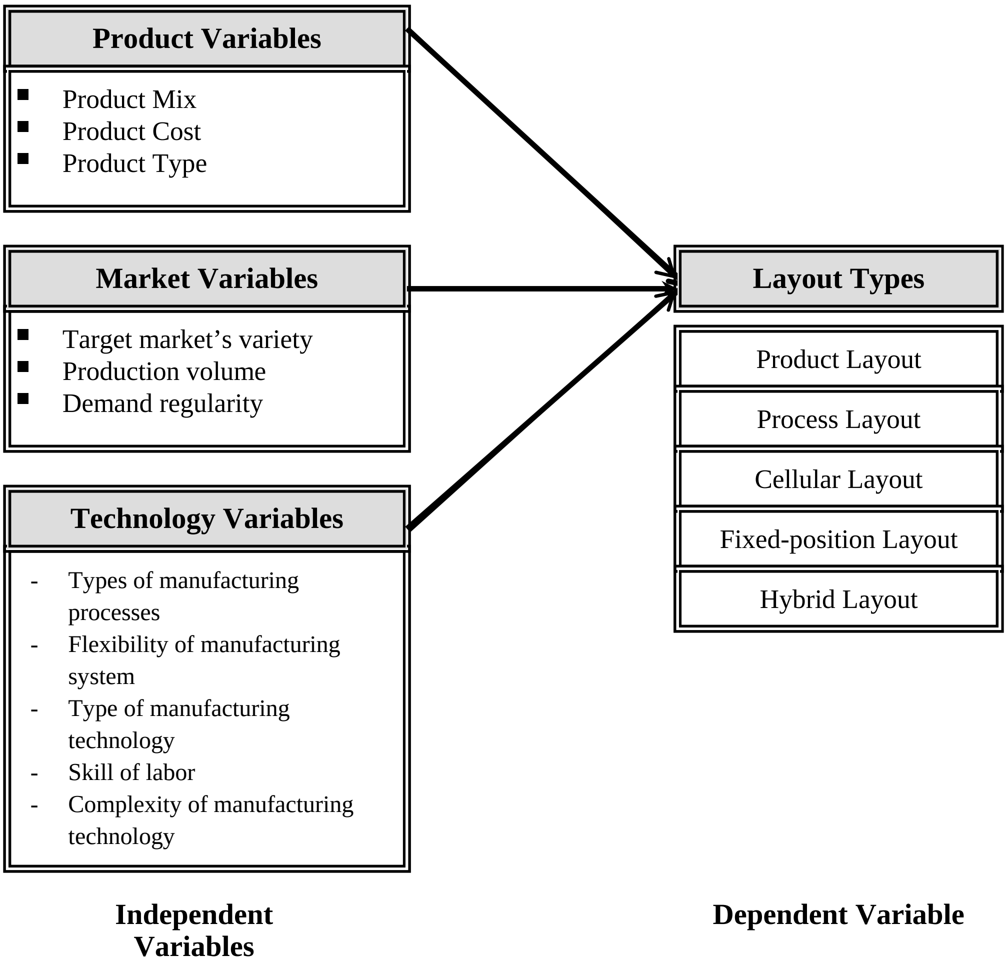

Figure (1): Exhibit The Study Model.

Theoretical and Operational Definitions

<u>Layout Type Design</u>: Refers to layout type used by a manufacturing firm according to one of the following classifications: *1) Product Layout 2) Process Layout 3) Cellular Layout 4) Fixed Position Layout 5) Hybrid Layout.*

<u>Product Variables</u>: Refer to the following group of variables:

Product mix: Refers to the set of all products and items that a particular manufacturer offers (Kottler, 2003).

Product cost: Refers to direct and indirect costs incurred in producing a product, this includes direct product costs (direct materials and direct labor costs) plus indirect manufacturing costs (Tomkins, 1997).

Product type: Refers to the classification of a product according to its manufacturing nature: highly standardized, standardized, semi- standardized and customized (Heizer and Render, 2005).

Market Variables: Refer to the following group of variables:

Target market's variety: The variety of customer groups that the company deals with, which can fall in one or more of these categories: business customers (another manufacturer, wholesaler or retailer) consumer customers (end users), or a mixture (Kottler, 2003).

Production volume: Refers to the total number of produced (output) units a company produces annually from each item (Martinich, 1977).

Demand regularity: Refers to the degree to which the demand pattern (regular, seasonal, cyclical or oscillatory), takes place on a regular and predictable basis (Kottler, 2003).

Technology Variables: Refer to the following group of variables:

Types of manufacturing processes: Refers to the nature of processes: job shop, batch, repetitive/ assembly, continuous, projects or a mixture, this grade is dependent on both the level of variety (customization) and volume produced, for example in a job shop volume is too low and the product is customized, while in a continuous production the production volume is very high and the product is a standardized one (Martinich, 1997).

Flexibility of manufacturing system: Refers to the ability of the manufacturing system to control production volumes, to produce new products and to provide modifications to current ones.

Type of manufacturing technology: Refers to the overall setup of the manufacturing system, according to the following grade: continuous production, mass production, flexible manufacturing, customization, and mass customization which are chosen according to the needed requirements in both product type and production volume.

Skill of labor: Refers to the specialization level of an employee, that can come as a resultant of academic education, and collective qualities of certain factors as knowledge, abilities, aptitudes, training and experiences that make him/her desirable to a certain industry labor market or firm (Noa *et al.*, 2003).

Complexity of manufacturing technology: Refers to the degree to which the used machines are difficult to operate and maintain over time. Table (2) presents the measurement tools for research variables.

Research Hypotheses

The following Hypotheses are developed and tested:

First Hypotheses Group (Related to Product Variables and Layout Type Design):

This group contains the following 3 hypotheses:

H01.1 There is no relationship between product mix and layout type design.

H01.2 There is no relationship between product type (standardized vs. customized) and layout type design.

H01.3 There is no relationship between product cost and layout type design.

Second Hypotheses Group (Related to Market Variables and Layout Type Design):

This group contains the following 3 hypotheses:

H02.1 There is no relationship between target market's variety and layout type design.

H02.2 There is no relationship between production volume and layout type design.

H02.3 There is no relationship between demand regularity and layout type design.

Third Hypotheses Group (Related to Technology Variables and Layout Type Design):

This group contains the following 5 hypotheses:

H03.1: There is no relationship between manufacturing processes type and layout type design.

H03.2: There is no relationship between manufacturing system's type and layout type design.

H03.3: There is no relationship between manufacturing system's flexibility and layout type design.

H03.4: There is no relationship between manufacturing system's complexity and layout type design.

H03.5: There is no relationship between labor skill and layout type design.

Table (2): Measurements of Research Variables and Dimensions.

Variable	Dimensions	Measurement Tool
Layout Design	Layout Type	Question A6, and the researcher's follow-up
General	Scale of Operations	Question A.2
	Industrial Sector	Question A.3
	Buildings' Age	Question A.4
Product Variables	Product Mix	Question B1, B2, B3
	Product Cost	Question B.4
	Product Type	Question B.5
Market Variables	Production Volume	Question C.1
	Demand's Regularity	Question C.2
	Target Market's Variety	Question C.3, C.4
Technology Variables	Manufacturing System's Flexibility	Question D2, D3
	Manufacturing Technology's Complexity	Question D4
	Labor Skill (Specialization Level)	Question D5
	Manufacturing Processes Type	Question D6
	Manufacturing Technology Type	Question D7

Data Collection Methods

Data for this study has been collected as follow:

Secondary Data: secondary data was drawn from both electronic and print sources that varied between books, periodicals, institutions publications, proceedings, abstracts and presentations.

Primary Data: following the extensive literature review, and interviews with a number of professionals, a questionnaire was designed for the purpose of this study (which was the main tool for primary data gathering), it was submitted to production managers in these companies, this was supported by the researchers follow-up, observations and unstructured interviews (face-to-face and telephone ones according to convenience).

The Goodness of Data

The goodness of the questionnaire was tested, examining both reliability and validity. The reliability of the measurement tool was checked for both consistency and stability, first Cronbach Alpha's coefficient was used to test consistency where it was critical, this included the suitability and management variables where inter-item consistency was pursued, second test retest method was used to check stability, and the results are shown in the Table (3).

To ensure the validity of the questionnaire, logical (content) validity was tested using face validity; where the questionnaire was examined by a number of expert judges, who gave their notes and recommendations.

Table (3): Reliability of Questionnaire.

Variables	Reliability
Product Variables	0.937
Market Variables	0.863
Technology Variables	0.902

Population and Sample

The Population of this research consists of all of the production managers working for the public shareholding manufacturing Jordanian companies, the sample included the whole population that consisted of 67companies, of which 55 companies responded, which presents a response rate of 82.10%, that is considered as an acceptable rate.

Research Limitations

The major limitations that were faced while conducting this research can be summarized as follows:

1. The small size of the population and sample.
2. The exclusivity of the research because it was only applied to public shareholding manufacturing companies.
3. Lack of previous Arabic or Jordanian studies in this field.
4. The scope of previous international literature, which was usually specialized and focused on one or more types, and toward a specific group of variables.
5. The tendency of some of the respondents to evaluate some specific issues in a positive manner, and to hide specific information (especially that relevant to financial aspects).
6. The technicality of the studied subject that required a level of respondents' subject literacy.

Data Analysis and Interpretation Methods

SPSS and Excel software's were used for statistical data analysis. The statistical measures that were used are:

1. Descriptive statistic measures: (cross tabulation, mean values, standard deviations frequency distributions, percentages), those measures were used in order to describe the data and arrange the findings according to their importance depending on their means.
2. Inferential statistic measures: in the first part discriminant analysis, Chi-square and one-way ANOVA tests were used to interpret the findings and explain the variance in the layout type (dependent variable) according to the effect of layout determinants (independent variables).

5. DATA INTERPRETATION, RESULTS, DISCUSSION AND CONCLUSIONS

Adopted Layout Types

Data collected through questionnaire, the researchers' observation and follow-up revealed that the layouts adopted by the Public-Shareholding manufacturing firms in Jordan were distributed as shown in Table (4).

It's obvious that the majority of these companies use (49%) Hybrid layouts with hybrid features; where they can take advantage of the combined features of two or more types.

Factors affecting Layout Type Design

Hypotheses Testing

Discriminant analysis, and Chi-square tests were used to testing each of the 11 research hypotheses belonging to the three different hypotheses groups (Product, Market and Technology), and the results are exhibited in Table (5).

Table (4): Layout Types Used by the Sample's Companies.

Layout Type	Total No. of Companies Using this Layout	Percentage %
Product	14	25.5%
Process	5	9.2%
Cellular	7	12.7%
Fixed-position	2	3.4%
Hybrid	27	49.2%
Total	55	100%

Table (5): Hypotheses Testing Results.

Variables Group	Variable	Hypothesis	Result
Product Variables	Product Mix	H0 1.1	Rejected
	Product Type	H0 1.2	Accepted
	Product Cost	H0 1.3	Accepted
Market Variables	Target Market's Variety	H0 2.1	Rejected
	Production Volume	H0 2.2	Rejected
	Demand's Regularity	H0 2.3	Accepted
Technology Variables	Manufacturing processes type	H0 3.1	Rejected
	Manufacturing system's type	H0 3.2	Rejected
	Manufacturing system's Flexibility	H0 3.3	Accepted
	Manufacturing system's Complexity	H0 3.4	Accepted
	labor skill (specialization) level	H0 3.5	Rejected

Results Discussion and Conclusions

First Hypotheses Group (Product Variables):

H0 1.1 There is no relationship between product mix and layout type design.

This hypothesis was rejected, as previously mentioned. Product mix was statistically proved to have an effect on the design of a specific layout type with statistically different values at different layout types. Discriminant analysis Table (7) at the appendix demonstrates that product mix has a big F value of (5.037), and a statistically significant value equal to (0.002) that is < (0 .05), which proves that product mix has the ability to discriminate between the different five layout types. This significance was due to the differences evident in mean values of product mixes at different layout types, shown in Table (6) at the appendix.

This is also substantiated by the standardized canonical discriminant function coefficients values shown in Table (8) at the appendix where product mix has the highest coefficient (1.255) contributing to the first discriminant function, and this as Table (9) at the appendix illustrates explains (86.2%) of the variance among the two other functions, which means that product mix has the highest possibility among all other product variables to discriminate between different layout types. Chi-square tests results shown in Table (10) at the appendix also proved product mix to be significant. These findings are consistent with the findings of Heizer and Render, (2005), Lussier, (2002) and Fink, (1999).

Cross tabulation Table (11) at the appendix provides a detailed look of different product mixes at each of the five different layout types. It's demonstrated that (71.4%) of the companies that use a product layout, had low to very low product mixes (few to very few numbers of products), (100%) of the companies that used both process or cellular layouts, had high and very high product mixes, in the fixed position the two companies that were placed in this category had very low product mix, in hybrid layouts the scores varied, but this followed a pattern, the layouts that were with dominant product layout features had a low and very low product mixes (e.g. Jordan Magnesia, Arab Potash), and those that had dominant process layout features, had high mixes.

H0 1.2 There is no relationship between product type (standardized vs. customized), and layout type design.

With regard to product type (degree of standardization vs. customization), the relevant hypothesis was accepted. This means that product type had close values at different layout types, and as a resultant it does not enormously affect the design of a specific layout type. Table (7) at the appendix demonstrates that product's type (standardization level) has a small F value of (.945), and a statistically insignificance value of (.446) that is > (0.05), which indicates that it isn't able to discriminate between different layout types. Reviewing Table (6) at the appendix of group means shows that this insignificance is caused by the closeness in mean values of product type at different layout types.

In the first discriminant function, product type has moderate abilities to discriminate between different layout types with a coefficient of (0.721), and in the second function that explains (11.9%) of the variance, product type has the highest coefficient (1.005), which implies that this variable has a limited ability to discriminate. Chi-Square tests results, shown in Table (10) at the appendix, also support this result. These findings are actually inconsistent with all of the previously reviewed literature, including the findings of Heizer and Render (2005), Slack *et al.* (2001) and Fink (1999).

This can be attributed to a number of reasons: first of all the concept of customization can be achieved at three different categories according to the different stages within which it can be introduced in the value-chain:

1) Form customization, where customization can be introduced in the delivery stage.
2) Optional customization, where it can be introduced at the manufacturing stage, where a large number of pre-designed, standard options are provided to customers, and this produces configured products where customers can only select options from a pre-determined list and request them to be assembled.
3) Core customization, where customers are integrated with the design process, and accordingly manufacturing processes and delivery are customized too.

In the sample, companies tend to avoid the second and third forms because they are associated with higher levels of risk, ambiguity and vulnerability. The majority of companies use the first form of customization, because it's the simplest form and with the least requirements, looking at their ratings it can be seen that the majority of these companies didn't actually rate their products as highly customized ones, because they often added customized features to the package and not the content. And for those companies that use the second and third forms, customization was not an option; it was a must, due to the nature of the industry within which these companies operate, examples of these are companies operating in the printing industry (Al-Ekbal Printing and Packaging, Union Advanced Industries, Arab Paper Converting and Trading), and those companies in the gourmet industry (The Jordan Worsted Mills, International Textile Manufacturing, Woolen Industries, El-Zay Ready Wear Manufacturing and Jordan Tanning).

Another reason that was noticed through observation, and data collection; was that the samples' companies are interested in achieving economies of scale, and they regard customization as an impediment to this concept, the majority of these companies are oriented toward achieving profits through producing high volumes of standardized products, and they lack the strategic vision of being able to generate profits by building a long-term base of satisfied and loyal customers.

In a product layout it can be seen that products are highly standardized, because on average, sales take place on a massive scale, but in the fixed-position and some process, for example: cellular and hybrid layouts, many of the sales are contract based.

Yet in both cases, customization can be introduced and in efficient manners, that can help build a long-term base of loyal and satisfied customers, which will add to the long-term profitability of the company, but unfortunately many of these companies view customization as a burden and aren't well-educated or oriented toward the concepts of customer satisfaction, and customer relationship management.

Another important factor that has to be taken into consideration is that many of the region's companies are either reluctant to or not interested in the new concepts of mass customization and customerization-where companies can enjoy the opportunities to produce customized products quickly while keeping costs at the production level of manufacturing – such concepts are still new and are difficult to apply in our region, this is due to many reasons that extend beyond the scope of this research, but some of them include high investment costs, lack of resources and capabilities (e.g. know-how) that are needed to operate and maintain such systems, the overall orientation of business and culture, change resistance, risk aversion, the small market size and the retarded industrial and technological development levels…etc.

In the sample, and based on Qiao *et al.'s* (2003) classification, we can find that the majority of these companies provide customers with either standardized or configured products, but not parameterized products. Taking a look at the cross tabulation Table (11) at the appendix will provide a clearer view of the previous discussion.

<u>H0 1.3 There is no relationship between product cost and layout type design.</u>

Regarding the product cost variable, the above hypothesis was also accepted, because in our sample cost wasn't strong enough to discriminate between different types of layouts, and as a resultant it doesn't enormously affect the decisions incorporated in the design of a specific layout type and choosing between alternative layout formats. Looking at Table (6) at the appendix demonstrates that the mean values for this variable at the five layout types are close to each other. And in Table (7) at the appendix, product cost has a small F value of (0.219), and a statistically insignificant value equals to (0.927) that is > (0.05). This is also an evident in Table (8) at the appendix where product cost has the lowest coefficient value (-0.065) in the first discriminant function. Chi-square test results shown in Table (10) at the appendix also supported these findings. To support these results, cross tabulation was conducted and the findings are presented in Table (11) at the appendix.

One of the reasons why product cost was unable to discriminate between different layout types, is that the process of cost calculation is a very complex one that incorporates a wide range of variables. Another reason is due to the fact that the sample's companies are scattered across different industries, and as known cost calculation varies enormously from one industry to the other, this affected the respondents' ratings, because they evaluated their costs according to companies operating in the same field. Another factor that might have affected the results, is the tendency of the respondents to treat financial information as confidential, and thus not to declare it in the right rate, this was obvious since none of these companies rated their costs as very low.

Although product cost wasn't statistically significant in affecting the design of layout type, this doesn't mean that layout type design doesn't affect product costs.

Second Hypotheses Group (Market Variables):

<u>H0 2.1 There is no relationship between target market's variety and layout type design.</u>

As previously mentioned, this hypothesis was rejected. This means that target market's variety had different values at different layout types, and in return it affects the design of a specific layout type. Table (7) at the appendix demonstrates that target market's variety had a big F value of (4.482) and a statistically significant value of (0.004) that is < (0.05), which means that this variable has a discriminant ability. Looking at Table (6) at the appendix, this was due to the differences in mean value of target market's variety at different layout types. Reviewing Tables (8 and 9), shows that in the first discriminant function that explains (54.3%) of the variance, target market's variety has the highest coefficient value, which indicates its significance in discriminating layout types. Chi-Square test results presented in Table (10) at the appendix also support the above results.

To develop a deeper understanding, cross tabulation associating target market's variety levels and each layout type was conducted and the findings are presented at Table (11) at the appendix.

In our sample, target market's variety was the highest in cellular and product layouts.

The choice to adopt a cellular layout usually takes place after using other layout formats, and deciding to switch to more efficient ones, thus this layout benefits to a great deal from an organization's learning curve and accumulation of organizational experiences , because it's usually designed with a deep understanding of both organizational and target market's needs. Wemmerlöv and Hyer (1989) reported that when designed-well, cellular layout can increase organizational benefits; it provides the organization with increased abilities to satisfy wider varieties of markets simultaneously and in an effective manner. This was the case with Rum Aladdin Company that has been in the market for about 22 years, when the company decided to shift from a process to a cellular layout, this choice as their production manager states, came after a long period, and after a deeper understanding of organizational and customer needs, now the company can operate more efficiently while satisfying a wider group of customers.

Target market's variety was also high (3.92) in product layouts. Reviewing Table (11) at the appendix demonstrates that production volumes are the highest in a product layout, the logic that lies behind producing large amounts of products, lies in market demand, where there are expectations for large consumption volumes, because of existing needs for that product (and in some of the cases a monopoly), that justifies producing large volumes.

To sell these large volumes, the company can target one, few or many markets. In the sample and among the 14 companies using a product layout, only one company targeted one market, which is the Jordan Industrial Resources- it was established as a manufacturer of specific chemical raw materials for another company that manufactures soap and detergents- the rest of these companies targeted more than one market, and the majority operated with the privilege of a monopoly, or an oligopoly in the Jordanian market, which means that a wide variety of markets are obliged to deal with these companies in one way or another, examples of these are the Jordan Petroleum Refinery, Jordan Industries and Match (JIMCO), International Chemical Industries and International Silica Industries.

In the case of process layouts, target market's variety was moderate in the majority of the sample's companies (3.00), where product mix is moderate to high (3.8), and production volumes are low to moderate (2.6), which means that these companies produce relatively high mixes, with moderate volumes , targeted toward moderate numbers of markets. Comparing between this layout and the cellular layout, these results are consistent with the findings and ideas of Heizer and Render (2005), Wemmerlöv and Hyer (1989) and Flynn and Jacobs (1986), who state that a cellular layout is more efficient than a process layout.

Looking at the fixed-position layouts results illustrate that they had the lowest levels of target market's variety, these findings are consistent with literature, where it's stated that in many cases the fixed-position layout is used in temporary projects or manufacturing efforts that only target a specific customer, or a specific group of customers. In our sample both companies that used this layout excavated raw-materials, and sold them only to other manufacturers in the value-chain, for example the National Petroleum Company excavated only gas (far from its name), and sold it to the Jordan Electricity Company, and the Public Mining Company, excavated raw materials needed in the manufacturing of cement, pottery, and porcelains, and sold them to a few number of manufacturers.

H02.2 There is no relationship between production volume and layout type design.

As mentioned earlier, this hypothesis was rejected. This means that production volume scored different values at different layout types, and that it was able to stand as discriminant variable, which means that it affects the design of a specific layout type. Looking at discriminant analysis Table (7) at the appendix shows the results that proves production volumes to be significant with a big F value of (4.583) and a significant value of (0.003) that is < (0.05). Reviewing Table (6) at the appendix demonstrates that this significance resulted from the differences in mean values at different layout types. These findings are also supported by Chi-square test results presented in Table (10) at the appendix. The significance of this variable is also evident through its high coefficient values in both the first and second functions, which are presented in Tables (8) and (9) at the appendix.

These results are consistent with the findings of Fink (1999), and Martinich (1997). Reviewing the findings presented at the appendix in Table (6) and at the cross tabs in Table (11) its demonstrated that the highest production volumes exist in product layouts with a mean value of (4.14), then fixed position and hybrid layouts with mean values of (3.0), followed by process layouts with a mean value of (2.6) and finally cellular layouts with a mean value of (2.28).

H02.3 There is no relationship between demand regularity and layout type design.

With regard to demand's regularity, discriminant analysis results in Table (7) at the appendix show that it doesn't have an ability to discriminate between one layout and the other, with a small F value of (0.839), and a significant value of (0.507) that is > (0.05), which proves its insignificance, as shown in Table (6) at the appendix this resulted because of the closeness in mean values at these different layouts. Chi-square tests results in Table (10) at the appendix also supported these findings. All in all, this means that this hypothesis is accepted, and that demand's regularity doesn't enormously affect the design of a specific layout type.

The meaning that lies underneath indicates that demand was rated by the majority of these companies as regular (in other words predictable), this might be attributed to the nature of the products produced by these companies, where it was found out earlier that the majority of these companies produced standardized products and only few produced customized ones, (customization results in lower capabilities to anticipate and predict future demand levels), or it can be an indication that many of these companies lack the long-term strategic vision, because no matter how predictable demand is, changes will take place and flexibility is a must for adaptability. The Iraqi war, is a good example of this, because as a result of this war many of these companies fell in deep financial problems, they reduced their production levels to a great deal, and faced serious problems in selling the inventories, but others benefited a lot, and increased their production levels, their shifts, and are looking for ways to expand (specially in the construction industry).

To take a deeper look, at the results, cross tabulation was conducted to see the details of demand regularity at each layout type, were findings are presented in Table (11) at the appendix. This table shows demand's regularity had high to very high levels at different layout types. where the highest levels were associated with the product and fixed-position layouts, in a product layout 92.8 % had high to very high levels of regular demands, in a fixed position 100% (both companies) had high to very high levels, followed by hybrid layouts (88% had high to very high levels), process layouts (80% had high demand levels), and cellular layouts (71.6 %) that had high to very high levels.

Third Hypotheses Group (Technology Variables)

H03.1: There is no relationship between manufacturing processes type and layout type design.

As previously mentioned, this hypothesis was rejected. This means that the type of manufacturing processes is one of the factors that affect the design of a specific layout type. Looking at discriminant analysis Table (7) at the appendix that presents the tests of equality of group means proves the statistical significance of manufacturing processes type with a big F value of (5.421), and a value equal to (0.001) that is < (0.05). This resulted from the differences in mean values of manufacturing processes types used at different layout types shown in Table (6) at the appendix. Chi-square test results presented in Table (10) at the appendix also support these findings.

To develop a deeper understanding, cross tabulation was conducted associating each type of processes with different layout types, and the findings are presented at Table (11) at the appendix. Reviewing this Table demonstrates that product layouts which are (35.8%) of the sample's companies, use repetitive and assembly processes, and (42.8%) of them use continuous processes, with process layouts (100%) of the companies use batch processes, with cellular layouts (71.4%) of the companies use mixed processes, and (28.6%) of them use batch processes, with fixed position layouts (100%) of the companies that use project processes, and with hybrid layouts the majority (44.04%) use mixed processes. These results are consistent with the findings of Heizer and Render (2005), Slack *et al.* (2001) and Fink (1999).

H03.2: There is no relationship between manufacturing system's type and layout type design.

Table (7) at the appendix that tests the equality of group means proves that the manufacturing system's type has a relatively moderate F value of (2.922), and a statistically significant value equals to (0.003) that is < (0.05).

Chi-square test findings presented in Table (10) at the appendix also prove this significance. This indicates that the null hypothesis (H03.2) is rejected. This means that the type of used manufacturing system is one of the factors that affect the design of a specific layout type.

Cross tabulation is conducted to provide a deeper comprehension of theses results, and findings demonstrate that in product layout (42.85%) of the companies use continuous production systems, and (21.43%) of them use mass production systems, while only one company uses a mass customization system, and one uses a customized system.

In the process layout (80 %) of the companies use flexible manufacturing systems, in the fixed-position both companies used mass production systems, because of the nature of the products produced in these companies. Yet results related to this part can't be considered generalizable because of the small sample size. With regard to hybrid layouts the majority used flexible manufacturing systems, and the rest use various manufacturing systems, (this choice is highly influenced by the dominant layout feature).

The process of choosing a manufacturing system is determined by two main variables; batch size and product type (customized vs. standardized). It was found out earlier that only few of these companies manufacture customized products, which explains the small usage of customized manufacturing systems.

Through our findings, it was obvious that the majority of these companies needed flexible systems that can enable them to control volume, variety and type in ways that match their own requirements; this proves that our findings are consistent with the ideas of Meredith (1987), Adler (1988), Port (1994), and Qiao *et al.* (2003). Still, it's important to keep in mind that using flexible manufacturing systems doesn't necessarily mean that these companies are using them in a flexible manner.

H03.3: There is no relationship between manufacturing system's flexibility and layout type design.

A manufacturing system's flexibility was measured in this paper in terms of volume and variety. In discriminant analysis the results in Tables (6) and (7) at the appendix showed that flexibility wasn't able to discriminate between different layout types with an F value of (0.950), and a significant value of (0.443) that is > (0.05), because of the closeness in mean values at different layout types, ranging from a minimum value of (2.80) in product layouts, and a maximum value of (3.5) in cellular layouts. In Chi-Square test shown in Table (10) at the appendix, the level of significance of Pearson's Chi-square value for the association was (0.182) that is > (0.05), which also proves the association to be insignificant, and so hypothesis (H03.3) was accepted.

In part this might be due to the fact that the majority of these companies use flexible systems that enable them to control volumes and in some cases variety, and regardless to the layout type, but as previously seen, mix flexibility is highly appreciated at process and cellular layouts, while volume flexibility is highly appreciated at product layouts, and so the systems of these companies have close mean values of flexibility, but difference in these areas exist where this flexibility is needed, and where it's currently oriented.

It was noticed that many of these companies focused at controlling production volumes, and only few focused at taking advantage of the system's flexibility to introduce new products or modify the existing ones.

In general it was noticed that the obstacles that hinder flexibility in terms of variety, aren't always related to the system, because many of the used systems are flexible in terms of both variety and volume, these obstacles were most related to disabilities in the know-how, management style and the potentials to deploy available skills, capabilities and resources in an innovative manner.

With regard to volume's flexibility, the case is also the same because as shown in the findings many of the used systems are flexible, but the ways in which they are utilized, organized and managed, controls their flexibility to a great deal.

H03.4: There is no relationship between manufacturing system's complexity and layout type design.

Results shown in Table (6) and (7) at the appendix revealed that a manufacturing system's complexity doesn't have the ability to discriminate between different layout types with an F value of (1.625), and a significant value of (0.182) that is > (0.05), where differences between mean values, range between a minimum of (2.8) at the process layout and a maximum of (4.00) at the fixed position layout. Chi-Square tests, shown in Table (10) at the appendix, also prove the association to be insignificant. Table (6) at the appendix demonstrates that in the product, process, cellular, fixed-position and hybrid layouts mean values are close to each other. All in all, this means that this hypothesis is accepted, and that a manufacturing system's complexity doesn't enormously affect the design of a specific layout type.

H03.5: There is no relationship between labor skill (specialization) and layout type design.

The results of discriminant analysis presented in Table (7) at the appendix, revealed that labor skill was able to discriminate between different layout types, with an F value of (12.67), and a significant value equals to (0.000) that is < (0.05). Due to the differences between the mean values of this variable at different layout types shown in Table (6) at the appendix, that range between a minimum value of (2.78) at product layout, moving to a value of (3.00) at the process layout, and a value of (3.42) at the cellular layout, then a value of (3.85) at the hybrid layout, and reaching to a maximum of (5.00) at the fixed-position layout.

Looking at functions 1 and 2 that explain (92.6 %) of the variance in Table (8) at the appendix, reveals the importance of this variable, where it has the highest coefficient values in both functions. Looking at Chi-square tests results in Table (10) at the appendix the findings also support the above results. Thus this hypothesis is rejected. Which means the labor skill affects the design of a specific layout type.

These results are consistent with the findings of Stevenson (2005), and Heizer and Render (2005). To take a closer look at these results, Table (11) at the appendix presents a cross tabulation between labor skill (specialization) levels and different layout types, where its presented that among the product, process and cellular layouts, cellular layouts have the highest skill (specialization) levels.

These results are consistent with the findings of Wemmerlöv and Hyer (1989) and Burbidge (1992) who found that moving from a process layout to a cellular layout will have impacts on costs because of the higher utilization levels of employees and machines at these layouts, in cellular layout the deployment of all available resources including employees skills are more sophisticated and efficient. Fixed-position layouts employ highly skilled and specialized labor, which is consistent with the findings of Slack *et al.* (2001), and in hybrid layouts skills were moderate to very high. This might be because these layouts use combined features of two or more layout types, and this is more sophisticated than using only one layout.

The Importance Attached to Product, Market and Technology Factors

Production managers were asked to attach a percentage of importance on a (1 to 5) scale to each of the three variables groups (Product, Market and Technology) in order to evaluate the degree to which each group affects layout type design.

Table (12) demonstrates that the percentages were close to each other, the highest levels were attached to market variables (82.78%), followed by technology variables (81.18%), where these variables were rated as extremely important. Product variables are rated as important (79.84%).

When questioned in a different part about the group of variables that played the first role in determining the company's current layout, 35 companies (63.6%) reported that it was product variables, 7 companies (12.7%) reported that it was market variables, 1 company (1.81%) reported that it was technology variables, and the rest of the companies (21.8%) reported that other variables played the first role in affecting the current layout.

6. CONCLUSIONS

Main Conclusion

The study came up with the following main conclusions:

1. The Layout type design process has to take place after a conscious study and analysis of a company's current and potential target markets, the variety that might exist between them, their sizes and needs, and the company's current and future (anticipated) product mix, in addition to a precise definition of the needed technology by identifying the manufacturing processes' type, the manufacturing system's type and employees specialization level.
2. The Layout type design process is a dynamic and an ongoing process that needs continuous evaluation and improvement.
3. The Layout type design process is strongly related to the ways in which layout is utilized and managed in order to achieve the pursued benefits.
4. Many of the studied companies lack the awareness or the know-how to utilize their layouts to their full potentials.

And based on the previous results and conclusions the following recommendations were proposed:

1. Organizations are recommended to fully understand and analyze their markets before engaging in the process of layout type design by analyzing the needs and the size of their current and potential target markets, the variety between these different markets and the effects that these market variables have on the product mix.
2. Organizations are recommended to study and design their product mix carefully before designing their layouts. And to be aware to the importance that product mix has in the design of a specific layout type.
3. Organizations are recommended to fully comprehend the types of technologies to be adopted (based on their needs) before starting with layout type design, and especially type of manufacturing system, type of manufacturing processes, and employees' skill (specialization) level.
4. Organizations are recommended to pay full attention to the effects that changes and shifts produced in product mix, production volume, target market's variety, manufacturing processes' type, manufacturing system's type or employee's specialization level might have on the functionality of the adopted layout type.
5. Layout development is part of organizational learning, relevant decisions should be considered in an organic and a dynamic manner rather than a static one because time and experience are extremely critical. That's why organizations and designers are recommended to think of layout decisions as strategic ones. Layout design has to take into consideration the current company's markets, products and technologies, and how they will develop in the long-terms.
6. Organizations are recommended to fully comprehend the capabilities of their layouts, and to align them with their resources and competencies in a sophisticated manner. Good layout design can work as an excellent tool and resource if the org. knows how to operate and utilize it to achieve the pursued benefits.

General Conclusions

Specific conclusions related to each of the research variables were discussed earlier during hypotheses testing, in this part the general conclusions that can be drawn from this study are listed as follows:

1. -To design an appropriate layout type, a company has to analyze its market (s). By studying its current and future target markets, the variety that might exist between them, their current sizes and needs, and how they might develop in the future. Along with that the company has to decide its product mix, and how it might develop in the future. After drawing the main product and market requirements it proceeds with the needed technologies (human and machine), by carefully planning the required manufacturing processes, systems and labor skill. And then proceeds with an effective allocation of available resources to solve immediate as well as long-term accommodation problems of people, machines and activities.

2. -Layout type design isn't a static process; it's an ongoing one that needs continuous evaluation, feedback, and improvements when necessary. Successful companies tend to develop their layouts within a learning curve, where experience adds to the maturity of layout design.
3. -Layout's performance is controlled by its design and the ways in which it's utilized and managed. That's why layout type design is affected by an organization's mindset and culture.
4. -Many companies are not fully aware of the potentials that their layouts can offer, this was due to a number of reasons- one of them is getting stuck with routine ways of utilizing this layout-on the other hand other companies -as previously discussed - have that awareness but lack the know-how to utilize their layouts in the best manner, or lack the right education and enthusiasm to adopt new and continuous layout improvements.

7. RECOMMENDATIONS

General Recommendations

1. Organizations are recommended to fully understand and analyze their markets before engaging in the process of layout type design by analyzing the needs and the size of their current and potential target markets, the variety between these different markets and the effects that these market variables have on the product mix.
2. Organizations are recommended to study and design their product mix carefully before designing their layouts. And to be aware to the importance that product mix has in the design of a specific layout type.
3. Organizations are recommended to fully comprehend the types of technologies to be adopted before starting with layout type design, and especially type of manufacturing system, type of manufacturing processes, and employees' skill (specialization) level.
4. Organizations are recommended to pay full attention to the effects that changes and shifts produced in product mix, production volume, target market's variety, manufacturing processes' type, manufacturing system's type or employee's specialization level might have on the functionality of the adopted layout type.
5. Layout development is part of organizational learning, relevant decisions should be considered in an organic and a dynamic manner rather than a static one because time and experience are extremely critical. That's why organizations and designers are recommended to think of layout decisions as strategic ones. Layout design has to take into consideration the current company's markets, products and technologies, and how they will develop in the long-terms.
6. Organizations are recommended to think of layout type design in a collective manner. The adoption of a successful layout starts with careful design that should have inputs from both designers, decision makers in an organization, and those who will be affected by these layouts (employees and sometimes customers).
7. Organizations are recommended to fully comprehend the capabilities of their layouts, and to align them with their resources and competencies in a sophisticated manner. Good layout design can work as an excellent tool, but if the org. doesn't know how to operate it, pursued benefits won't be fully achieved.
8. Layout design decisions have to take into consideration both man and machine, that's why organizations are recommend to pay more attention to human factors.

APPENDIX:

Table (6): Group Statistics for Variables' Discriminant Analysis.

Product Variables			
Layout	**Product Variable**	**Mean**	**Std. Deviation**
Product	Cost	3.21	0.80
	Type	4.14	0.80
	Mix	2.78	1.25
Process	Cost	3.00	1.00
	Type	4.00	1.22
	Mix	3.80	0.20
Cellular	Cost	3.00	0.58
	Type	4.14	0.76
	Mix	4.57	0.53
Fixed-position	Cost	3.00	1.41
	Type	4.50	0.70
	Mix	1.50	0.70
Hybrid	Cost	2.92	1.03
	Type	3.48	1.45
	Mix	3.25	1.12
Market variables			
Product	Demand regularity	4.35	1.08
	Target Market variety	3.92	0.73
	Production volume	4.14	0.86
Process	Demand regularity	3.60	0.89
	Target Market variety	3.00	0.71
	Production volume	2.60	0.89
Cellular	Demand regularity	3.86	1.46
	Target Market variety	4.14	0.69
	Production volume	2.28	0.48
Fixed-position	Demand regularity	4.50	0.71
	Target Market variety	1.50	0.71
	Production volume	3.00	0.00
Hybrid	Demand regularity	4.33	0.92
	Target Market variety	3.44	1.05
	Production volume	3.07	1.26
Technology variables			
Product	Manufacturing system's complexity	3.57	0.85
	Labor specialization level	2.78	1.07
	Type of manufacturing processes	4.20	0.70
	Type of manufacturing system	3.85	1.44
	Manufacturing system's flexibility	2.86	0.86

Process	Manufacturing system's complexity	2.80	0.45
	Labor specialization level	3.00	0.45
	Type of manufacturing processes	3.00	0.00
	Type of manufacturing system	2.60	1.34
	Manufacturing system's flexibility	3.40	0.42
Cellular	Manufacturing system's complexity	3.43	0.54
	Labor specialization level	3.42	0.71
	Type of manufacturing processes	2.28	0.71
	Type of manufacturing system	3.00	0.00
	Manufacturing system's flexibility	3.50	0.71
Fixed-position	Manufacturing system's complexity	4.00	1.41
	Labor specialization level	5.00	0.00
	Type of manufacturing processes	1.00	0.00
	Type of manufacturing system	4.00	0.00
	Manufacturing system's flexibility	3.00	1.41
Hybrid	Manufacturing system's complexity	3.85	1.02
	Labor specialization level	3.85	0.60
	Type of manufacturing processes	3.11	1.81
	Type of manufacturing system	3.03	1.27
	Manufacturing system's flexibility	3.33	0.96

Table (7): Tests of Equality of Group Means for:

Product Variables' Discriminant Analysis					
Product Variable	**Wilks' Lambda**	**F**	**df1**	**df2**	**Significance**
Product Cost	0.983	0.219	4	50	0.927
Product Type	0.930	0.945	4	50	0.446
Market Variables' Discriminant Analysis					
Market Variable	**Wilks' Lambda**	**F**	**df1**	**df2**	**Significance**
Demand regularity	0.937	0.839	4	50	0.507
Target Market variety	0.736	4.482	4	50	0.004
Production volume	0.732	4.538	4	50	0.003
Technology Variables' Discriminant Analysis					
Technology Variable	**Wilks' Lambda**	**F**	**df1**	**df2**	**Significance**
1. Manufacturing system's complexity	0.885	1.625	4	50	0.182
2. Labor skill level	0.497	12.67	4	50	0.000
3. Type of manufacturing processes	0.701	5.421	4	50	0.001
4. Type of manufacturing system	0.811	1.922	4	50	0.003
5. Manufacturing system's flexibility	0.929	0.950	4	50	0.443

Table (8): Standardized Canonical Discriminant Function.

Coefficients of Product Variables' Discriminant Analysis				
Product Variable	**Function**			
	1	**2**	**3**	
Product Cost	-0.065	0.277	0.972	
Product Type	0.721	1.005	-0.228	
Product Mix	1.255	0.061	0.041	
Coefficients of Market Variables' Discriminant Analysis				
Market Variable	**Function**			
	1	**2**	**3**	
Demand Regularity	0.093	0.292	0.977	
Target Market Variety	0.071	-0.705	0.129	
Production Volume	0.680	0.687	0.309	
Coefficients of Technology Variables' Discriminant Analysis				
Technology Variable	**Function**			
	1	**2**	**3**	**4**
Manufacturing system's complexity	0.086	0.455	0.329	-0.195
Labor skill level	0.830	0.675	0.055	0.236
Type of manufacturing processes	-0.690	0.519	0.310	0.351
Type of manufacturing system	0.318	-1.162	0.705	0.415
Manufacturing system's flexibility	0.182	-0.438	0.093	1.076

Table (9): Percentage of Variance for the Discriminant Analysis Functions of:

Product Variables		
Function	**Percentage of variance**	**Cumulative percentage**
1	86.2%	86.2%
2	11.9%	98.1%
3	1.9%	100.0%
Market Variables		
Function	**Percentage of variance**	**Cumulative percentage**
1	54.3%	54.3%
2	41.2%	95.5%
3	4.5%	100.0%
Technology Variables		
Function	**Percentage of Variance**	**Cumulative percentage**
1	75.7%	75.7%
2	17.0%	92.6%
3	6.9%	99.5%
4	0.5%	100.0%

Table (10): Chi-square Test Results.

Product Variables			
Product Variable	**X^2 Value**	**df**	**Asymptotic Significance (2-sided)**
Product Cost	10.984	16	0.810
Product Type	23.051	16	0.112
Product Mix	30.672	16	0.015
Market Variables			
Market Variable	**X^2 Value**	**Df**	**Asymptotic Significance (2-sided)**
Demand regularity	19.149	16	0.261
Target Market variety	23.879	8	0.015
Production volume	37.538	16	0.002
Technology Variables			
Technology Variable	**X^2 Value**	**Df**	**Asymptotic Significance (2-sided)**
Manufacturing system's complexity	19.149	16	0.261
Labor skill level	62.247	16	0.000
Type of manufacturing processes	24.205	16	0.017
Type of manufacturing system	20.657	16	0.048
Manufacturing system's flexibility	9.342	16	0.427

Table (11): Cross Tabulation.

Product Mix and Layout Types						
Layout Type	**Product Mix**					
	Very High	**High**	**Moderate**	**Low**	**Very Low**	**Total**
Product	0	2	2	8	2	14
	0	14.3%	14.3%	57.1%	14.3%	100%
Process	1	4	0	0	0	5
	20%	80%	0	0	0	100%
Cellular	4	3	0	0	0	7
	57.1%	42.9%	0	0	0	100%
Fixed-position	0	0	0	0	2	2
	0	0	0	0	100%	100%
Hybrid	1	10	9	5	2	27
	3.7%	37.1%	33.3%	18.5%	7.4%	100%

Product Type and Layout Types (Dependent Variable)						
Layout Type	**Product Type (Standardization Level)**					
	Very Low	**Low**	**Moderate**	**High**	**Very High**	**Total**
Product	0	2	3	4	5	14
	0	14.3%	21.4%	28.6%	35.7%	100%
Process	0	1	0	2	2	5
	0	20%	0	40%	40%	100%
Cellular	0	0	2	2	3	7
	0	0	28.6%	28.6%	42.8%	100%
Fixed-position	0	0	0	1	1	2
	0	0	0	50%	50%	100%
Hybrid	3	3	7	6	8	27
	11.1%	11.1%	25.9%	22.2%	29.6%	100%

Table (11): Cross Tabulation.

Product Cost and Layout Types						
Layout Type	**Product Cost**					**Total**
	Very low	**Low**	**Moderate**	**High**	**Very High**	
Product	0	2	8	3	1	14
	0	14.3%	57.1%	21.4%	7.1%	100%
Process	0	2	1	2	0	5
	0	40%	20%	40%	0	100%
Cellular	1	1	4	1	0	7
	14.3%	14.3%	57.1%	14.3%	0	100%
Fixed-Position	0	1	0	1	0	2
	0	50%	0	50%	0	100%
Hybrid	1	10	8	6	2	27
	3.7%	37%	29.6%	22%	7.4%	100%

Target Market's Variety and Layout Types						
Layout Type	**Target Market's Variety**					
	Very Low	**Low**	**Moderate**	**High**	**Very High**	**Total**
Product	0	0	4	7	3	14
	0	0	28.6%	50.0%	21.4%	100%
Process	0	1	3	1	0	5
	0	20%	60%	20%	0	100%
Cellular	0		1	4	2	7
	0		14.3%	57.1%	28.6%	100%
Fixed-position	1	1	0	0	0	2
	50%	50%	0	0	0	100%
Hybrid	2	2	8	12	3	27
	7.35%	7.35%	29.6%	44.4%	11.3%	100%

Production Volume and Layout Types						
Layout Type	**Production Volume**					
	Very Low	**Low**	**Moderate**	**High**	**Very High**	**Total**
Product	0	1	1	7	5	14
	0	7.1%	7.1%	50.0%	35.7%	100%
Process	1	0	4	0	0	5
	20%	0	80%	0	0	100%
Cellular	0	5	2	0	0	7
	0	71.4%	28.6%	0	0	100%
Fixed-position	0	0	2	0	0	2
	0	0	100%	0	0	100%
Hybrid	3	6	9	4	5	27
	11.1%	22.2%	33.3%	14.8%	18.5%	100%
Demand Regularity Level and Layout Types						
Layout Type	**Demand's Regularity Level**					
	Very Low	**Low**	**Moderate**	**High**	**Very High**	**Total**
Product	1	0	0	5	8	14
	7.1%	0	0	35.7%	57.2%	100%
Process	0	1	0	4	0	5
	0	20%	0	80%	0	100%
Cellular	1	0	1	2	3	7
	14.3%	0	14.3%	28.6%	42.8%	100%
Fixed-position	0	0	0	1	1	2
	0	0	0	50%	50%	100%
Hybrid	1	0	2	10	14	27
	3.7%	0	7.4%	37%	51.9%	100%

Table (11): Cross Tabulation.

Type of Manufacturing Processes and Each Layout Type						
Layout Type	**Type of manufacturing processes**					
	Continuous	**Repetitive Assembly**	**Batches**	**Mixture**	**Projects**	**Total**
Product	6	5	3	0	0	14
	42.8%	35.8%	21.4%	0	0	100%
Process	0	0	5	0	0	5
	0	0	100%	0	0	100%
Cellular	0	0	2	5	0	7
	0	0	28.6%	71.4%	0	100%
Fixed-position	0	0	0	0	2	2
	0	0	0	0	100%	100%
Hybrid	7	1	7	12	0	27
	26.0%	3.70%	25.9%	44.4%	0	100%

Type of Manufacturing System and Each Layout Type						
Layout Type	**Type of Manufacturing System**					
	Continuous Production	**Mass Production**	**Flexible Manufacturing**	**Mass Customization**	**Customization**	**Total**
Product	6	3	3	1	1	14
	42.85%	21.43%	21.43%	7.14%	7.14%	100%
Process	0	0	4	0	1	5
	0	0	80%	0	20%	100%
Cellular	0	0	7	0	0	7
	0	0	100%	0	0	100%
Fixed-position	0	2	0	0	0	2
	0	100%	0	0	0	100%
Hybrid	7	3	11	0	6	27
	26.0%	11.1%	40.7%	0	22.2%	100%
Employees Skill (Specialization) and Layout Types						
Layout	**Employees Skill (Specialization) Level**					
	Very Low	**Low**	**Moderate**	**High**	**Very High**	**Total**
	2	9	1	1	1	14
Product	14.3%	64.3%	7.1%	7.1%	7.1%	100%
Process	0	0	4	1	0	5
	0	0	80%	20%	0	100%
Cellular	0	0	3	3	1	7
	0	0	42.85%	42.85%	14.3%	100%
Fixed-position	0	0	0	0	2	2
	0	0	0	0	100%	100%
Hybrid	0	0	7	17	3	27
	0	0	25.9%	63.0%	11.1%	100%

Table (12) Mean Values of the Importance Associated to Each Group of Factors Affecting Layout Type Design.

Group	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Product Variables	30%	100%	79.84%	17.03%
Market Variables	40%	100%	82.78%	12.11%
Technology Variables	40%	100%	81.18%	12.80%

REFERENCES

BOOKS:

Bokhorst, J. A. C. 2005. ***Shop Floor Design: Layout, Investments, Cross-training, and Labor Allocation,*** 1st Ed. The Netherlands: Labyrint Publications.

Chiara, J. D. and Callender, J. 1999. ***Time Saver Standards for Building Types,*** 3rd Ed. New York: McGraw-Hill.

Daft, R. L. 2002. ***Organization Theory and Design,*** 7th Ed. Ohio: South-Western College Publications.

Hackman, J. R. and Oldham, G. R. 1980. ***Work Redesign,*** 1st Ed. MA: Addison-Wesley.

Heizer, J. and Render, B. 2005. ***Operations Management,*** 7th Ed. London: Prentice Hall of Pearson.

Jacobs, F.R., Chase, R. B. and Aquilano, N. 2004. ***Operations Management for Competitive Advantage,*** 11th Ed. New York: McGraw-Hill/Irwin.

Kottler, P. 2004. ***Marketing Management,*** 11th Ed. New Jersey: Prentice Hall.

Lussier, R. N. 2002. ***Management Fundamentals: Concepts, Applications, Skill Development,*** 2nd Ed. Ohio: South-Western College Publications.

Martinich, J. S. 1997. ***Production and Operations Management: An Applied Modern Approach,*** 1st Ed. Canada: John Wiley and Sons.

Pride, W. M. and Ferrell, O. C. 2004. ***Marketing Concepts and Strategies,*** 2000 Ed. Boston: Houghton Mifflin.

Slack, N., Chambers, S. and Johnston, R. 2001. ***Operations Management,*** 3rd Ed. London: FT-Prentice Hall.

Stevenson, W. J. 2005. ***Operations Management,*** 9th Ed. New York: McGraw- Hill/Irwin.

Woodward, J. 1965. ***Industrial Organization: Theory and Practice,*** 1st Ed. London: Oxford University Press.

PERIODICALS:

Adler, P. S. 1988. Managing Flexible Automation. ***California Management Review***, 8, Spring, 34-56.

Burbidge, J. L. 1992. Change to Group Technology: Process Organization is Obsolete. ***International Journal of Production Research,*** 30 (5): 1209-1219.

Flynn, B.B. and Jacobs, F.R. 1986. A Simulation Comparison of Group Technology with Traditional Job Shop Manufacturing. ***International Journal of Production Research***, 24 (5): 1171-1192.

Hayes, R. H., and Wheelwright, S. C. 1979. Link Manufacturing Process and Product Life Cycles. ***Harvard Business Review,*** 57 (1): 133-140.

Huber, V. L. and Hyer, N. L. 1985. The Human Factor in Cellular Manufacturing. ***Journal of Operations Management,*** 5 (2): 213-228.

Shafer, S. M., Tepper, B. J., Meredith, J. R., and Marsh, R. 1995. Comparing the Effects of Cellular and Functional Manufacturing on Employees' Perceptions and Attitudes. ***Journal of Operations and Production Management,*** 16 (8): 81-103.

Wemmerlöv, U. and Hyer, N.L. 1989. Cellular Manufacturing in the U.S. Industry: a Survey of Users. ***International Journal of Production Research***, 27 (9): 1511-1530.

ELECTRONIC RESOURCES:

Qiao, G., Lu, R., and McLean, C. 2003). Flexible Manufacturing System for Mass Customization Manufacturing. Retrieved August 10, 2003, from ***http://www.mel.nist.gov/msidlibrary/doc/flexms.pdf.***

Fink, R. L. 1999. Facility Layout, Retrieved October 11, 2002, from ***http:// bradley. bradley. edu /~rf/ Facility Layout.ppt.***

Tomkins, C.R.T., Madigan, D., May, B. and Steckelmacher, P. 1997. Modern Developments in Cost Management. University of Bath, School of Management Research Papers, ACI/DLV/97/024 (2). Retrieved March 14, 2003, from ***http://www.bath.ac.uk/ management /agile/ publication s/ pdf /public/97.024.200. pdf.***

أثر عوامل المنتج والسوق والتكنولوجيا في تصميم نوع الترتيب الداخلي (دراسة تطبيقية ميدانية في الشركات المساهمة العامة الصناعية في الأردن)

غادة عجور وسليمان عبيدات

ملخص

هدفت هذه الدراسة الى تحديد أثر كل من العوامل المتعلقة بالمنتج، والسوق، والتكنولوجيا في عملية الترتيب الداخلي، والمنهجية التي يتم بموجبها اختيار نموذج تصميم محدد من ضمن النماذج الخمسة المعروفة: ترتيب حسب المنتج، ترتيب حسب الأنشطة، ترتيب خلوي، ترتيب ثابت في نفس المكان، أو مزيج، وذلك في الشركات الصناعية المساهمة العامة في الأردن. وقد تم جمع البيانات من خلال استبانة تم تصميمها لأغراض هذه الدراسة، وتوزيعها على مديري الانتاج في هذه الشركات، ومن خلال المقابلات غير المهيكلة، وملاحظة الباحثة في الفترة بين كانون الثاني ونيسان عام 2005. تم استخدام التحليل التمايزي، واختبارات مربع كاي، وأدوات التحليل الاحصائي المتقدم، اضافة الى الأساليب الاحصائية الوصفية. وخلصت الدراسة الى أن المتغيرات الدالة احصائيا والمؤثرة في التمييز بين الأنواع المختلفة للترتيب الداخلي من بين المجموعات الثلاث للعوامل (المتغيرات المتعلقة بالمنتج، والمتغيرات المتعلقة بالسوق، والمتغيرات المتعلقة بالتكنولوجيا)، هي:

1. المزيج السلعي ضمن مجموعة العوامل المتعلقة بالمنتج.
2. حجم الانتاج وتنوع السوق المستهدف ضمن مجموعة العوامل المتعلقة بالسوق.
3. نوع العمليات الصناعية ونوع نظام الانتاج ودرجة تخصص العمالة ضمن مجموعة العوامل المتعلقة بالتكنولوجيا.

الكلمات الدالـة: المنتج، السوق، التكنولوجيا، تصميم نوع الترتيب الداخلي، الشركات الصناعية المساهمة العامة، الأردن.

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