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Production Cycle Model for Short Life Cycle Models

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Abstract
Short life cycle products belong to a special segment of manufacturing. Following an empirical investigation into the process of their manufacture, a graphic model of the production cycle divided into four subprocesses was created. The subprocesses were illustrated using the example of garment production. The model and its description were used to confirm the hypothesis that the duration of the production process can be determined and that the subprocesses are separated by constant time intervals.

Key words: *clothing, production cycle, product life cycle, modelling a production process.*

Introduction

New areas of knowledge can only be created based on earlier scientific output. To identify possible cognitive gaps, existing knowledge of management was analysed, which allowed to divide the knowledge hierarchically into three levels of organisational management, enterprise management and production management. The lowest position of the last level in the hierarchy does not make it is less important, especially in the present economic situation in the world, which is struggling with the impact of the global crisis.

Short life cycle products

The investigation concentrated on production management and the theory that management deals with providing scientific solutions to production problems. Concentrating on processes and not jobs, people, structures and functions makes it possible to observe the main purpose of the process and not its components" [4]. A process-based approach was adopted to create a production cycle model for short life cycle products (SLCP). The term "life cycle" wasderived from the natural sciences after an analogy between living organisms and products had been found: 'They are too destined to be born, mature, age and die" [1]. The popularity of the term increased with the European Commission's project of 2005 *'The European Platform on Life Cycle Assessment (LCA)"* [15], which extended the notion of a life cycle to business and politics. These circumstances increasingly justify the search for regular patterns (cycles, loops, or equilibrium points) that systems tend towards [8]. The role of a product life cycle was also commented on by P.F. Drucker [2], who stated that it could be used as a tool for evaluating a firm's position. Furthermore, R. Kleine-Doepke [5] mentioned the life cycle together with an experience curve concept and the results of research conducted under the PIMS (*Profit Impact of Market Strategy*) program as the third of the factors that contributed to the development of portfolio planning methods. All these circumstances provided inspiration for focusing the study on the management of the production of short life cycle products. Such products have one of the characteristics below:

- the length of the selling period depends on the product design, and fashion shows cyclical changes,
- the end of the production period is determined by objective constraints on sales (e.g. alternating seasons in the case of clothing),
- the length of the production cycle is incommensurate with the selling period.

Typical products whose life cycle is decided by their design are clothing and footwear. Their selling time is correlated with the passing of seasons, which, together with the seasonal character of fashion trends, subject production management to strict discipline. Products manufactured for too long become unsaleable. Manufacturers of durable goods use the positive aspect of fashion to stimulate demand (motor vehicles, interior design articles, etc.).

Formulation of the research hypothesis
According to M. Marchesnay [11], a theory is constructed via a process consisting of the following stages: formulation of a hypothesis, construction of a hypothesis confirmation procedure, confirmation by means of an empirical test or mathematical-logical evidence, assessment of the confirmation success rate, and formulation of conclusions (theoretical/practical). This sequence has been criticised by persons advocating the

phenomenological approach, who believe that understanding the phenomena examined is more important than measuring them. This approach is justified in the case of heuristic research and scientific procedure. However, M. Marchesnay's procedures are appropriate when the researcher's reasoning is linear. With these reservations in mind, the following hypothesis was formulated:

Management of the production of short life cycle products is a process of a determined duration, consisting of four cyclical subprocesses. The cycles are staggered with respect to each other by fixed time intervals.

For the hypothesis to be confirmed, an appropriate investigation had to be conducted and its results analysed. In this case management science proposes a three-stage model of analysis comprising decomposition (into building blocks), description and integration [13]. The algorithm presented was used at later stages of the investigation.

Process decomposition and a description of its components

The process applied to produce garments was divided into four main subprocesses: product development, preparation of production, production and sales. As far as short life cycle products are concerned, separating product development from all other actions related to the production preparation process is justified. An example of the SLCP is fashion articles, whose production is determined by the seasonality of sales. Two fashion collections are usually created, i.e. for the spring-summer and autumn-winter seasons.

The garment development subprocess

This subprocess is carried out between the 1st of February (of the year preceding product release) and 1st of August for the spring-summer collection and between the 1st of August and 1st of February of the next year for the autumn-winter collection.

New product designs are created based on external and internal sources of information. The latter usually account for more than 55% [7]. This rate, however, does not apply to fashion articles. Their originality is assessed by means of criteria laid out in the copyrights. For a season's collection to be created, information has to be collected from several sources:

- design guidelines formulated by fashion creators,
- data provided by a survey of a market segment targeted by the enterprise,
- information about relevant garment constructions and manufacturing technologies that will be used subject to the availability of appropriate equipment.

A talented designer and a person with an ability to assimilate design guidelines, whose new informative contents alter knowledge of trends in fashion development, are a prerequisite for starting work on a collection. Relevant guidelines can be sought in Paris, Milan, etc., at international fashion shows. As observed, some fashion elements are recurrent but never copied, as they are introduced after some modifications. This justifies the statement that all models of a season's collection are new. Products that are attractive for buyers (because of their design, quality and price) involve interaction with customers. Data offered by market surveys are an important source of information, allowing the manufacturer to look at a product from a broader perspective [10]. However, a design that is attractive but priced against the expectations of the market segment targeted will render sales unsuccessful. Responsibility for setting prices rests on an authorised group of persons who take account of design manufacturing data (material and labour costs, etc.). Design attractiveness is the main criterion affecting the level of prices. A market failure is certain when a season's collection is released too late. This fact demonstrates the importance of time in the production cycle of seasonal products.

The production preparation subprocess

This subprocess is carried out between the 1st of June and the 1st of December for the spring-summer collection and between the 1st of December and the 1st of June of the next year for the autumn-winter collection.

The production preparation subprocess consists of:

- the preparation of technical and technological documentation,
- the procurement of necessary materials,
- planning and organising the product manufacturing subprocess.

From the standpoint of the operations to be carried out within the production preparation subprocess, it is not important whether the team of workers responsible for the subprocess will be based in their parent company or at the service provider's site [3]. The technology to be used must correspond to the materials selected and machines available (either owned or belonging to another party). Modern enterprises prepare necessary documentation using Computer Aided Manufacturing systems (CAD), which are common in Polish medium and large-sized manufacturing companies today. The author pioneered the implementation of the first of such systems in Poland in 1987. Other activities related to the preparation of documentation include:

- sequencing the technological operations,
- selecting the machines and pieces of equipment necessary to perform the operations,
- calculating the times necessary to complete each operation.

These documents allow to set up a product manufacturing subprocess, estimating wages to be paid to piece-rate workers, direct production costs, etc.

Material procurement, which is a separate activity, is equally important. The domestic clothing industry buys its materials from suppliers based in the EU (the high end of the apparel market) and in Asian countries (the remaining segments). The geography of the suppliers usually has a bearing on fabric quality, wearability and price, the latter being a key factor shaping the final price of a product. Fabric patterns are picked by designers, who take into account the designs to be produced, while procurement personnel are responsible for analysing offers submitted and making choices that are optimal for the firm. All procurement, despite the contract signing process being exposed to time pressure, must be carried out prudently. The type of payment (advance payment, pay on delivery, deferred payment) is an important aspect of negotiations concerning the terms of supply. Optimisation of the procurement process is vital for the functioning of an enterprise.

The organisational setup of a product manufacturing process must integrate the following areas:
- human (the necessary number of workers with the skills required, who are available at the right time and place),
- technical (the availability of machines and equipment),
- material (the optimal quantity of materials stored in working areas and available when needed).

The above areas decide on the type of manufacturing system that will be used: an assembly line, an assembly line with sections, sections with synchronised working teams, a flow system or an arrhythmic system [17]. Other factors that influence the production preparation process include the size of an order, the possibility of making several models simultaneously, etc. Organisational efforts must optimise manufacturing times and costs, as well as provide a product of expected quality (in relation to manufacturers' expenses and target buyers' preferences).

The product manufacturing subprocess

This subprocess is carried out between the 1st of August and the 1st of February of the next year for the spring-summer collection and between the 1st of February and the 1st of August for the autumn-winter collection.

A characteristic feature of garment production is the input of manual labour. In the developed countries, small series of garments involving particularly large inputs of manual labour are produced for high-end market segments. Regardless of the target buyer, garment production consists of two main stages: cutting out garment elements and their assembly. Operations performed at the two stages depend on the organisational plan and technological documentation prepared beforehand.

The first of the two stages comprises the following operations:
- fabric layers are spread along a cutting table to form a stack (in a manual or automated process),
- a layout of the templates to be cut out is transferred onto a stack of fabric,
- garment elements are cut out from the fabric with dies, portable oscillating knives, stationary cutting machines, or automated cutting systems,
- adhesive inserts are bonded with the cut-out elements or sections thereof that need stiffening / strengthening,
- the cut-out elements are numbered/marked,
- the cut-out elements are checked for quality,
- the cut-out elements are bundled up (e.g. 50-piece bundles) and stored.

The cutting room setup is aimed at keeping the cutting machine busy at all times, as the machine is a central piece of equipment that decides the output of semi-finished products. The continuous operation of the cutting machine can be ensured via one of two modes: The first requires the keeping of spare stacks of laid-out fabric, which increases the amount of work in progress; the second method allows to accomplish a steady workflow by feeding into the machine sections of stacked fabric that are prepared simultaneously on two or several tables. Therefore, cutting room operations are mainly determined by the equipment available.

The cut-out elements are then transported to the sewing room so that the finished product can be assembled. The garment assembly process is preceded by the following procedures:
- reorganisation of the working team as required by technical and technological documentation, allowing for the installation of necessary machines and equipment as well as the verification of their reliability,
- cooperation with the Production Preparation Department in making a model ready for production.

All technological operations in the sewing room can be divided into three groups:
- sewing,
- adhesive bonding,
- thermal processing of the product.

Thread joints are the basic technology employed in garment manufacturing. Sewing machines can be divided into three catergories: universal, semi-automated and automated. Automated sewing machines are state-of-the art technology, but garment complexity makes them more appropriate for performing specific jobs or making simple products. Stitching quality is assessed against in-house standards, as it ultimately affects the quality of a finished product.

Adhesive bonding makes use of the diffusion process that takes place between adhesive particles and the substrate. There are three types of adhesive joints: bonded, heated and welded. A popular adhesive bonding method is contact heating. In most cases, two layers of fabric are bonded together with an adhesive. The elements to be bonded are heated on one side and then mechanically pressed together. The bonding process can be applied to a surface (e.g. inserts reinforcing the chest elements of a jacket) linearly (adhesive stitching) or in a dot-like manner. The criterion for the division is the area exposed to bonding. Adhesive bonding is now an important part of the garment manufacturing process, greatly reducing its time.

In terms of technology, the thermal processing of garments can be divided into the following:
- forming, i.e. the shaping of garment elements by applying force, temperature and by moistening, a major process in the production of heavy garments (overcoats), as the shape of their elements also depends on factors other than the construction of particular elements alone;
- product upgrading by pleating, applying a permanent press, as well as the surface or local dyeing of finished products in which the design is transferred from a paper template onto the product by pressing them together;
- steaming, which involves the use of steaming dummies in order to remove minor workmanship defects or to freshen up a product after it has been stored for a long time or cleaned;
- the interim pressing operations performed at different stages of the assembly process; they have a strong effect on the quality of final pressing and are carried out immediately after the cut-out elements have been joined together as after attaching the lining, such joints become inaccessible;
- final pressing, which determines the final product quality; the operation can be performed with a whole range of specialist machines and pieces of equipment.

Smart clothes are different from other types of clothing not because of their construction (which can be copied) but due to the fabric quality, quality of the assembly process and thermal processing.

The sales subprocess

The subprocess is carried out between the 1st of February and the 1st of August (one year after the product development process was started) for the spring-summer collection and between the 1st of August and 1st of February for the autumn-winter collection.

The Kotler model [6] applied to the sales subprocess is well known, hence it will not be discussed here to make the article concise. Because the scientific output in this field is considerable, it was decided that repeating it would be pointless.

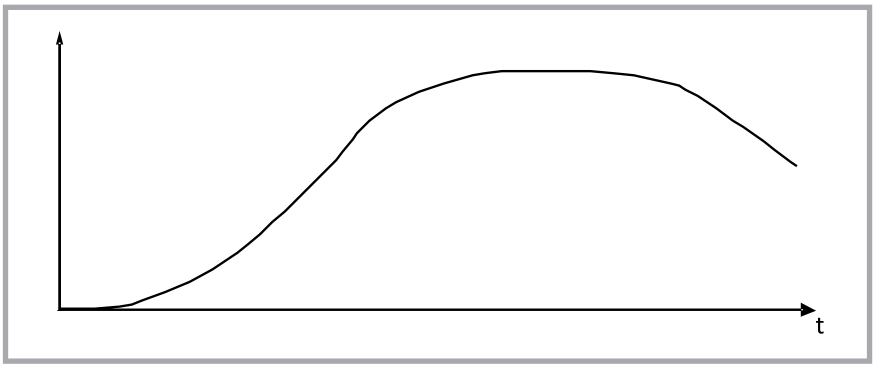

Figure 1. *Product life cycle – Kotler curve;* ***Source****: developed after Ph. Kotler, Marketing Management, 11th ed., Prentice Hall 2003, p. 328.*

Product life cycle and production cycle

The authors quoted earlier suggested that it was possible to present research results as a Kotler curve [6] extended to include earlier subprocesses. The curve describes a product life cycle as sales in time (***Figure 1***).

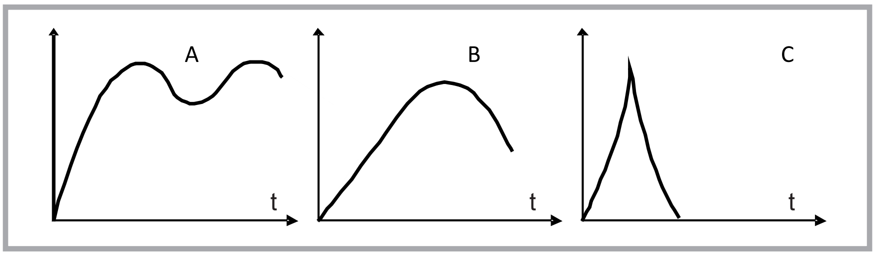

Figure 2*. Life cycles: A – stylish products, B – fashion articles, C – temporarily popular products.* ***Source****: developed after [6].*

According to Kotler [6], the sales curves vary depending on the product (***Figure 2***):

A – stylish products (architecture, furniture, etc.),

B – fashion articles (clothing, footwear etc.),

C – products with temporary popularity (Rubik's cube, yo-yo, etc.).

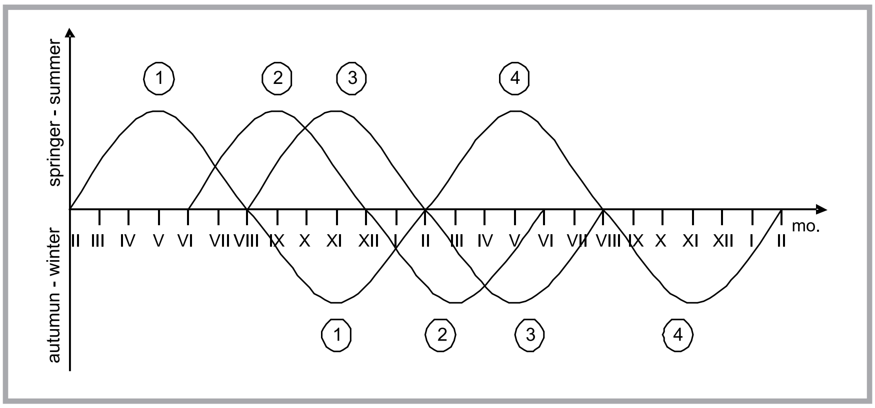

Figure 3. *SLCP production cycle model.* ***Source****: developed by the author; Subprocesses: 1 – product development 2 – preparation of production, 3 – production, 4 – sales.*

Curve B reveals a special character of the fashion articles. The graph is fully adequate when a fashion article is regarded as one model of a product. However, the investigation has confirmed that the classical product life cycle approach can be applied to clothing too (***Figure 1***), if we assume that such products do not represent a single design but a set of designs comprising a seasonal offer, which is in fact the final product of an enterprise. This knowledge encouraged the author to present the investigation's findings graphically as a Kotler curve extended to include earlier production management subprocesses. Consequently, an original production cycle model for the SLCP was created, approximating the temporal work intensity distribution in particular components of the production process. According to Waszczyk and Szczerbicki [16], such approximation is rarely treated as model falsification. It is rather assumed that some developments taking place in the economic reality were omitted from the model. Leśkiewicz [9] accused the approach of being internally inconsistent, i.e. combining unrealistic assumptions and a strongly accentuated previdistic function of the economy. Nevertheless, Waszczyk and Szczerbicki [16] view things differently: a solid description provided at the stage of constructing an explanatory model lends credence to its prognostic value. The long-term research conducted by the author of this article has allowed her to confirm this opinion.

The production cycle model constructed (***Figure 3***) is underpinned by the author's empirical study, the findings of which were verified in the course of her 18 year long business practice. Although changing circumstances impeded correct time measurements, the cyclical character of the production process enabled their verification. For the model to be created, 'the reality had to be appropriately smoothed out" [5]. At present it is justified to state that the model presented sufficiently reflects the actual situation. The author's good knowledge of the research subject is confirmed by the description of the production process attached. All these circumstances together allow to conclude that the evaluation [16] of the model of prognostic properties constructed is fully relevant.

In the production cycle model presented, sales are only one of the subprocesses (curve 4). The *x*-axis separates operations necessary to prepare two clothing collections in a year; those related to the spring-summer season run above the axis, while operations concerning the autumn-winter collection are below it. The curves illustrate the rising and falling intensity of work in the particular subprocesses during the execution of a seasonal collection, as well as determine their acceptable completion times. The curves are shifted with respect to each other by a time interval indicated by research findings. Although it is possible for the interval to show minor variations, the regular occurrence of a constant time interval is a fact. The interval is:

- four months between curves 1 and 2,
- only two months between curves 2 and 3,
- as many as six months between curves 3 and 4.

Because each of the four subprocesses goes on for as long as 6 months, the production process could be spread over 24 months. The possibility of reducing the time by four months (between curves 1 and 2) and two months (between curves 2 and 3), as demonstrated by the research findings, shortens the production process to 18 months. It is also worth noting that start dates for the spring-summer collection (curve 1 above axis x) and the autumn-winter collection (curve 1 below axis x) are shifted against each other by 6 months. Knowledge of this fact allows to optimise management of the production of seasonal products with a determined manufacturing completion time.

Conclusion

The operational algorithm presented allows to conclude that empirical verification of the production model for short life cycle products confirms the hypothesis of the duration of the production process determined. The process consists of four subprocesses that run cyclically and are staggered with respect to each other by constant time intervals. Because the main building block of management science is inductive methods, which enable to draw general conclusions from empirical research [12], the modelling results presented can be assumed to have scientific value. The model of the product manufacturing cycle generated is central to a company's management. Its importance goes beyond the possibility of synchronising subprocesses alone. Prolonged production of the SLCP shortens the selling period available, and in extreme cases it can completely ruin sales, which is caused by the seasonal character of sales, the time of year when a clothing article can be worn, etc.

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