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Building Construction vs. Stationary Production:
a Comparison

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Abstract

Production, whether of goods or services, is a process of transforming multiple inputs into a single output of higher value. This article compares production in two types of industries: building construction, which employs mobile inputs to produce immobile outputs at exterior locations, and industries that produce transportable products in-house in factories. Drawing upon earlier studies, we compare and discuss the characteristics of these two types of production. We conclude by setting our findings against the backdrop of lean management that is commonplace in industries with stationary factories, but rare and in the construction industry.

Keywords

Production types, construction, site production, stationary industry.

Production

General

Goods and services are produced by processes that transform inputs into outputs of higher value. For example, a pre-casting plant uses tools, machinery, labour, aggregate, cement and water (inputs) to produce curbstones (output). Alongside desired goods and services, productive transformation produces undesirable scrap, waste and emissions [5, p. 3]. Although earlier studies establish other concepts such as the transformation–flow–value theory [14, p 89], we focus on the concept of transformation to compare the construction industry and industries that involve stationary production.

The concept of productive transformation also applies to administrative functions. Sales, human resources and accounting departments employ workers, equipment and information (inputs) to prepare reports and documents (outputs) ([6, p. 2] quotes Kern: Handwörterbuch für Produktionswirtschaft, Stuttgart: Poeschel, 1979. Column: 1652). We examine production and transformation as outgrowths of a company’s core competency in generating saleable products and services.

Categorising Production

There are multiple ways of categorising the elements of productive transformation. One approach is to delineate production by the number of products, fabrication organisation and dependence on location [22, p. 337]. A second approach differentiates between the *product mix* (one-of-a-kind, low-volume, batched or mass-produced commodity goods) and the *process pattern* (goods can be fabricated in a job shop by a group or by inflow production) [19]. Ballard and Howell introduce a third approach: *“The division of production types between those in which flow is governed primarily by the alignment of machines, and those in which flow is governed primarily by directives”* [1, p. 4].

Definitions

* We use the term *construction* to mean a building or its constituent parts erected or modified at a location outside the company. Inputs - machines, workers and materials - must be mobile and transported to the location. In this sense, construction is a peripatetic factory.
* *Stationary production* refers to all types of production in which inputs need not be mobile because goods and services are produced in one location although final products are distributed. Conventional factory production is the standard example of stationary production. A possible alternative definition, which considers production output u to be stationary when, and only when, its acceleration u with respect to time is equal to 0 [4, p. 51], will not be paid attention to.

Comparison of Categories

Project Teams

Building construction involves producing a one-of-a-kind product preceded by a prototype*.* As Forbes [11, p. 7] puts it, *“no two projects are alike”*. Therefore, *“a construction project organisation is usually a temporary organisation designed and assembled for the purpose of the particular project. It is made up by [sic] different companies and practices, which have not necessarily worked together before, and which are tied to the project by means of varying contractual arrangements. […] Its [the organisation’s] temporary nature extends to the workforce, which may be employed for a particular project, rather than permanently”* [13, p. 47].

The composition of project teams changes during the project. For example, earthworks specialists initiate construction, welders erect structures and carpenters mount the roof structure. At this point, the colleagues for earthworks are already working on a new project with a new project team.

Construction companies are usually *all-rounders* that are able to create multiple categories of structures rather than specialists in one category. Thus, they construct varying types of buildings. In an analogy to the learning curve, however, workers lose their skills when there are delays between repetitions of operations (unlearning)*:* *“It takes time for the worker to re-learn how to do the task. The same effect will be noted after personnel changes are made, as the new workers must learn what to do”* [9, p. 23].

Client Influence

Unlike in mass production, where the client may influence the results of a production process, a construction company’s client can alter the design (and therefore the production itself) of its building after construction starts. Keeping this mechanism in mind, public sector clients sometimes use their leeway to whitewash projects in order to secure approvals from legislatures or the electorate. Flyvbjerg recognises a strategic goal behind this approach:

*“[P]romoters […] strategically overestimate benefits and underestimate costs when forecasting the outcomes of projects. They do this in order to increase the likelihood that it is their projects, and not the competition's, that gain approval and funding.”* [10, p. 10]*.*

The leeway to make changes after the start of construction may explain cost overruns and missed deadlines, particularly in public projects. However, even when the motive to deceive is absent, simple errors in bidding tenders or missing information during the offer phase can lead to additional costs after construction starts. *“The often-incomplete planning inevitably leads to constant additions and modifications after construction has already started. Private home builders know how expensive this can be”* [7]. Costs rise because drawings must be changed, material orders adjusted and schedules revised.

Design

Traditionally, customers hire a consultant (architect, engineer, design agency) to plan and design their building [9, p. 41]: design-bid-build model. In other cases, contractors provide the design, giving the client the advantage of their experience and expertise. [11, p. 9].

Property developers work in a comparable way. A developer designs and constructs a building at his own risk (often on his own land) and sells it when completed. The buyer acquires an off-the-shelf structure, not one tailor-made. Because the final product is individually produced (prototype production), planning is usually less intensive than in mass production (where prototypes are used to optimise the final product and rarely sold to the customer for his usage). As Trudgeon notes:

*“A totally new Japanese car requires 1.7 million hours of research and development time […] a new office building […] has the benefit of only 10,000 hours of design thought. The […] three-bedroom architect-designed family home […] has only 1,750 hours of design thought.”* [20].

Dependence on Weather

Construction of new buildings is highly dependent on weather. At low temperatures, pouring concrete requires special procedures. Assembly of large-format glass panels is limited by wind velocity. Excavated trenches may be filled with groundwater or rain and delay laying pipes. Excessive precipitation may weaken the subsoil and require repeating pre-construction tests for suitability. Ice and snow create dangerous conditions for workers.

Seasonality

Construction projects are influenced by seasonality and seasonal events. Both tropical and continental locales have rainy or windy seasons. People take holiday trips by car, making it inadvisable to close traffic lanes and renovate highways. Schools are more easily renovated during holidays when they are empty. Shopping centres must be finished in time to open for high-sales periods like Christmas.

Seasonality also affects stationary production, primarily through consumer demand. In general, summer-weight textiles are less in demand during winter. Chocolate factories make and sell different confections at Christmas and Easter. Fireworks are manufactured year-long but are sold almost exclusively during the brief period preceding New Year or national celebrations.

Cost Estimation

In the past, methods for determining unit prices were developed depending on the number of goods produced [18, p. 158]. The appropriate procedure used by industries that mass-produce goods is to divide total production costs by the quantity of goods produced. This procedure, which is works with similar goods (or output), is inapplicable to construction because, in this case, output (individual structures) is singular and distinct. In construction, special methods to estimate prices, which are comparable to those calculation methods of other single-item productions (e.g. ship building), are applied.

Estimation must be complete before erecting the building because clients must know the costs before organising the financing. Precise information is often unavailable when a project is conceived, and estimators must work with assumptions while assessing risks that may occur during construction. Weather and soil conditions, traffic, accidents and other logistics can complicate construction, delay completion and multiply costs.

Productivity

Non-farm labour productivity in the United States has increased over the last 50 years, while construction productivity has stagnated ([11], p. 25, quoting Teichholz: *‘*US Productivity Gap (1964–2003)’, US Department of Commerce, Bureau of Labor Statistics). Increased productivity in construction is mainly attributable to improved machine technology (e.g. power saws replacing hand saws) (Forbes 2011, p 1). Productivity in the construction industry is largely unmeasured, and extant measures are contradictory and conflicting [11, p. 3]. A well-known study from the UK, the *Egan Report* of 1998, concludes that *“up to 30 per cent of construction is rework, labour is used at only 40-60 per cent of potential efficiency”* [21, p. 17].

Forbes [11, p. 28] lists 13 reasons why productivity in construction is weak, including ineffective management, slow adoption of innovation, project uniqueness and inadequate training. Issues of competency and qualifications arise, as the construction industry is a large market for Illegal employment and do-it-yourself work [21, p. 15]. The construction site itself is not an optimal workplace. *“Work is often done in sub-optimal conditions with lessened productivity”* [15, p. 249]. On building sites, vandalism and loss from theft drain productivity and profits [2, p. 826].

Low productivity is inherent in the peripatetic factory nature of construction. Equipment and facilities (cranes, machinery and containers) must be dismantled at the completed site and moved. During this time, the equipment can’t be used productively and does not create any value for the customer.

Moreover, contractors must use currently available equipment that might be incompatible with the current job. To minimise downtime, contractors try to acquire more fungible equipment and tools, but doing so is a compromise. Lower productivity is inherent in this type of production.

Logistics

As with stationary factories, inputs (workers, material and equipment) must be procured and distributed at the production site. Distribution of finished goods is not an issue, however, because the completed structure is immobile. Nevertheless, construction necessitates post-production logistics to remove waste and residual materials from the construction site. There is a big difference from stationary production, in particular pertaining to the delivery of required inputs (material, labour, equipment, etc.). In stationary industries, each distinct product (building) requires separate logistical considerations that are generally worked out only once, with small adjustments possible over the time. Allocating resources on the worksite is challenging because it changes daily. Where yesterday there was a passage, tomorrow there will be a wall; today’s staircase or lift was a hole in the floor yesterday.

Management

Projects can be defined by their singular character, targets, temporal limitations and resources such as personnel or finances [8]. Such definitions generally apply to construction because it involves one-time projects with clear goals created within a limited timeframe by multiple parties. Implementation entails multiple project management methods. Projects are also commonplace in stationary production, e.g. shipbuilding. The types of production that involve similar operations, however, are less in need of project management and more in need of operations management or process management.

Language

Language differences exist between stationary production and construction sites. Köster [16, p. 16] compares terms common to construction with terms from general business administration and presents a table of different terms that have identical meanings in their respective fields. Therefore, people in the construction industry and stationary industries can speak about the same thing using different terms.

Conclusion

This study has defined production in the construction industry and industries involving stationary production according to the number of products, organisation of flow and location, as indicated in earlier literature. Subsequently, we examined their effects on production in the two types of industries compared. These categories emerge almost as effects and the dimensions of production as causes. Initially, there appear to be large differences between construction and stationary production, but further comparison shows many similarities. For example, shipbuilders make individual products. Nonetheless, difficulties remain linked to what we describe as the wandering nature of construction.

Despite a quarter-century of implementation in stationary production, concepts and tools from lean management have not become widespread in construction since industrial differences make crossover difficult. However, we have shown that production in stationary industries presents challenges similar, albeit less concentrated, to construction. The construction industry involves one-of-a-kind production based on prototypes; but it also involves repetitive processes inherent in stationary industries. The crossover of lean management concepts into construction should therefore be manageable as successful historical examples prove.

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