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Productivity and Productivity Factors in the Building Industry

Productivité et facteurs de productivité dans l'industrie de la construction

Produktivität und Produktivitätsfaktoren in der Bauindustrie

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SUMMARY

It is said that productivity has not changed for a number of years. This paper gives an exposé of research results of productivity and productivity factors of the Building Industry in the Netherlands. It analyses measures to be considered to improve the productivity, and how to measure productivity in general.

RÉSUMÉ

On dit que la productivité n'a pas considérablement changé depuis plusieurs années. Un résumé des recherches sur la productivité et les facteurs de productivité dans la construction aux Pays-Bas est présenté. Une méthode de mesure de la productivité est présentée, et des propositions sont faites pour améliorer la productivité.

ZUSAMMENFASSUNG

Es wird gesagt, dass die Produktivität sich während mehrerer Jahre verändert hat. Der Beitrag gibt eine Übersicht über Forschungsresultate auf dem Gebiet der Produktivität und Produktivitätsfaktoren in der Niederländischen Bauindustrie. Eine Methode zur Messung der Produktivität und Massnahmen zu deren Verbesserung werden vorgestellt.

1. INTRODUCTION

We often hear that in the Building Industry the development of productivity is lagging when compared with other industries. This opinion is generally based on macro-economic views of the total building industry, whereby the applied definition of productivity exercises an influence on the resulting productivity-figures.

At micro-level, i.e. on the building site, a lot of research has been done during the last 20 years; these research activities particularly deal with the measuring of productive- and improductive-time spent on specific tasks in a job. The ratio between these two time figures did not change for any production task in this period. Is it therefore correct to conclude that productivity has not increased during these years?

However, the improvement of the production-rates for the same production tasks shows a completely different pattern. This implies that there is more to be said about productivity and productivity-improvement.

This paper deals with two subjects:

1. the research on productivity and productivity-factors
2. a proposal for research on the measurement of productivity.

2. RESEARCH ASSIGNMENT

At the request of the Netherlands Ministry of Housing, Physical Planning and Environment, the section of Construction Management of the Department of Architecture of the Eindhoven University of Technology, carried out a research program of productivity and productivity-factors in the Building Industry.[1] Research on both aspects is very relevant, because of the fact that more knowledge may result in improving productivity by affecting productivity-factors. This may result in an improvement of the financial results of projects, contracting organizations and/or a reduction of the construction costs.

The study has been set up as follows:

a. an extensive survey of literature concerning productivity and productivity-factors
b. an enquiry under all kinds of partners in the building process followed by round-table conferences with architects, engineers, consultants, contractors, owners and scientists
c. a prescription of the phenomena of productivity and productivity-factors in the building industry, summarizing the results of a. and b., followed by conclusions and recommendations.

3. RESEARCH RESULTS

3.1 Introduction

The general expression for productivity is laid down in the ratio:

$$P = \frac{\text{output}}{\text{input}}$$

The selection of the factors which prescribe such an output, as well as the input, will be determinating for the type of productivity to speak about and the productivity-ratio of that type of productivity.

The most correct way is to express productivity in terms of units of volume divided by the utilized means for the production. In building practice however

the most common way is to express productivity as a ratio of output volume and construction costs or utilized resources. One of our main problems is the correct coincidence of costs and units of volume. The problems will grow when we compare different output/input ratios.

Our building industry consists of many part-productions and supply services. So productivity-figures will be different, depending on the part of the production-process we are looking at. We note hereby that the building industry consists of a "chain-of-productivities". Therefore a productivity-figure will vary when we take into account more or less activities in any part of that chain. So it may be expected that the more links of the chain are considered, the more complex the productivity-calculation will be.

We suggest to define the following levels of productivity:
for instance:

- at macro-level: the building industry as a totality
- at meso-level: the (design- or construction-) company
- at micro-level: the activity of the operation of the tasks.

Intermediate levels may also be defined.

3.2 Efficiency

Workplans and cost-estimates are based on certain rates; time-rates are used for planning activities and cost-rates for estimating activities. We can distinguish norm-rates (O_n) and actual realised rates (O_r). (In 't Veld [2]) The ratio between these two rates is a measure for the efficiency of the work.

$$\underline{\text{Efficiency}} = \frac{O_{norm}}{O_{real}} = \frac{O_n}{O_r} \quad \text{(input)}$$

For the productivity efficiency is a contributing factor.

3.3 Effectivity

Before starting a production a certain level of result is anticipated (R_n). However during contribution a number of factors may affect this wanted result: Therefore the real result will be different (R_r). The ratio between these two R_n figures is a measure for the effectivity of the organization.

$$\underline{\text{Effectivity}} = \frac{R_{real}}{R_{norm}} = \frac{R_r}{R_n} \quad \text{(output)}$$

For the productivity effectivity is a contributing factor.

3.4 Real productivity

The production starts with a certain expectation of the productivity, that we call the 'norm-productivity' (P_n).

This P_{norm} can be defined as:

$$P_{norm} = P_n = \frac{R_{norm}}{O_{norm}} = \frac{R_n}{O_n}$$

The real productivity is now: P_r.

$$P_r = \frac{\text{real result}}{\text{realized rates}} = \frac{R_r}{O_r}$$

When we manipulate this formula, we see

$$P_r = \frac{R_r}{O_r} = \frac{R_n}{O_n} \times \frac{R_r}{R_n} \times \frac{O_n}{O_r}$$

Which shows: the real productivity P_r

$$P_r = P_{norm} \times \text{effectivity} \times \text{efficiency}$$

3.5 Conclusions

Productivity will grow through:

a. increase of the effectivity, i.e. improvement of the real result: improvement of the organization

b. increase of the efficiency, i.e. improvement of the real rates, lowering of the real sacrifices expressed in terms of: money, labour hours or fixed investment: improvement of the work-performance.

4. PRODUCTION BY LABOURER

4.1 Labour productivity

Considering productivity in terms of production by labourer during a certain period, Malotaux [3] gives the following relation:

$$P = \frac{W}{lab} = \frac{T}{lab} \times \frac{I}{T} \times \frac{P_C}{I} \times \frac{W}{P_C}$$

In which: T = manhours per year

I = total labour costs per year

P_C = costs of production per year

W = production value per year

lab = the number of labourers used in this production

In addition this means that:

$\frac{T}{lab}$: stands for manhours per labourer

$\frac{I}{T}$: stands for labourcosts per manhour

$\frac{P_C}{I}$: stands for production costs per total labourcosts

$\frac{W}{P_C}$: stands for production value per production costs

By rearranging this formula we see

$$P = \frac{W}{lab} = \frac{T}{P_C} \times \frac{I}{lab} \times \frac{P_C}{T} \times \frac{W}{I} = \frac{I}{lab} \times \frac{W}{I}$$

TABLE 1 PRODUCTIVITY AND PRODUCTIVITY FACTORS IN THE BUILDING INDUSTRY [4]

TOTAL TIME OF OPERATION UNDER EXISTING CONDITIONS

TOTAL WORK CONTENT

TOTAL INEFFECTIVE TIME

	BASIC WORK CONTENT	SHORTCOMINGS		MEASURES	MANAGEMENT TECHNIQUES	
A						A
B	WORK CONTENT ADDED by defects in DESIGN or specification of the PRODUCT	bad design	1	product development and value analysis	TO ELIMINATE excess work focused on the PRODUCT	B
		lack of standardization	2	specialization and standardization		
		incorrect quality standards	3	market and product research		
		design implies use of too much material	4	product development		
C	WORK CONTENT ADDED by inefficient METHODS of CONSTRUCTION OPERATIONS	wrong plant and equipment used	1	process planning	TO ELIMINATE excess work focused on the PROCESS	C
		construction process insufficient controlled	2	process planning		
		wrong tools used	3	process planning		
		bad lay out of building site	4	method study		
		bad working methods used	5	method study		
D	INEFFECTIVE TIME due to shortcomings of MANAGEMENT	excessive product variety	1	marketing and specialization	TO ELIMINATE excess work focused on better MANAGEMENT	D
		lack of standardization	2	standardardization		
		design changes	3	product development		
		bad planning	4	production control based on work measurement		
		lack of materials	5	material control		
		equipment break downs	6	maintenance and instruction		
		building site in bad condition	7	orderliness		
		bad working conditions	8	improved working conditions		
		incidents and accidents	9	health and safety programmes		
E	INEFFECTIVE TIME due to shortcomings of WORKERS	absence lateness and idleness of men	1	personnel policy and incentives	TO ELIMINATE excess work for better functioning of WORKERS	E
		careless workmanship	2	personnel policy and operating training		
		incidents and accidents	3	safety training		

The different ratios have the following meaning:

$\frac{T}{P_c}$ = evaluation of norms. (= cost-recording)

$\frac{I}{lab}$ = average labour costs per manyear

$\frac{P_c}{T}$ = production costs per manhour

$\frac{W}{I}$ = production value per year-labour costs (financial productivity)

4.2 Cost-ratios

In these examples productivity is now expressed in cost-ratios. From these formulae we may understand now that it may occur that the labourproductivity increases, while the financial productivity per labourer decreases.

It is therefore impossible to speak about increase or decrease of 'productivity', without mentioning which factors have been considered.

5. PRODUCTIVITY FACTORS

5.1 Introduction

The different factors which are of influence on the productivity may be grouped into the following five general areas:

1. Society
2. Quality
3. Building Process
4. Technology and Innovations
5. Organization.

The enquiry resulted in a number of factors which have been arranged under these areas. See also Table 1.

5.2 Society

- simplification of the approval procedures will contribute to productivity: it gives more freedom within certain conditions.
- not only the pure cost of construction should be considered, but also the cost of planning and design, the public-services costs, and the costs of officialdom. Private bodies may work cheaper than public bodies.
- knowledge of the building process by all participants.
- method of financing.
- good relations and good cooperation affect also the productivity.

5.3 Quality

- productivity and sense for quality are closely linked.
- the quality of the product is dependent on the designer as well as the contractor; therefore quality is closely related to craftsmanship and expertise.
- design and realization are closely connected; they should learn from each other.
- quality can be improved by the introduction of the contractor already in the design phase.

5.4 Building process

- the structure of the building process requires more research on the role of each participant in the decision process.
- lack of cost-conscience leads to too costly designs, causing delays in the total building process.
- cooperation between partners in design-teams (contractors inclusive), will lead to acceptable quality matched with acceptable cost-consequences.
- when contractors are more involved in the initiative phase, production techniques and production costs will be better reflected in the designs.

5.5 Technology and innovations

- The opinion that the building industry is not innovating is not correct; on the contrary, innovations in a lot of fields, just have slowed down the cost-increase.
- the development of 'open-building-systems' is a good example of such an innovation; which makes it attractive to use the philosophy of support and detachable units.
- innovation in design and construction techniques will lead to changes on the building sites, since there will be a lot more prefabrication and industrialization.
- building metrology (e.g. the theory of design tolerances, measure-deviations during construction and fitting-calculations) is another innovation which improves quality and productivity.

5.6 Organization

- improvement of the organization of the design office as well as the construction firm.
- improvement of the project-organization in design and construction, and of work in offices and on the building sites.
- planning, workpreparation, control, material management, quality-control, production studies and construction techniques, cooperation between organizations and within organizations, toolbox-meetings, motivation of men: All have contributed a lot to productivity increase.

6. PRODUCTIVITY ON BUILDING SITES

A number of the above mentioned factors which influence productivity-figures have been applied to a certain extent in the building industry. There is still the impression that organizations are engaged with their own situation only and do not seek cooperation; however we feel cooperation is one of the key-stones for improving productivity.

Looking at production measuring results, we see that since the sixties a lot of measurements have been carried out on building sites in order to analyse the activities of labourers. The results are figures which give information of the different actions: direct productive, indirect productive, time for rest and personal treatment and improductive actions.

Dutch figures show that the proportions between these actions or activities have not changed dramatically: [5]

direct productive	58%	
indirect productive	18%	
rest + pers. treatment	12%	
		88%
improductive	12%	
		100%

By better organization of all activities the 12% improductive time could be lowered, but a percentage of 0 will never be reached. The percentage direct-productive may increase, indirect-productive and rest and personal treatment may decrease.

The ideal situation should be:

productive - direct	80%
- indirect	10%
rest + pers. treatment	10%
	100%
improductive	0%
	100%

7. DEFINITION OF BUILDING PRODUCTIVITY

We propose a general definition of building-productivity, which reads as follows:

> "Building-productivity is the ratio of that which is produced (= the production = output) and which was required to realize this production (= input)"

Measuring of productivity-ratios will be very useful, a single productivity-figure of a (part-)production is of less importance than information about productivity-changes in due course. The differences between the productivity-figures are relevant, therefore the choice of one definition or another of productivity is of less importance.

8. MEASUREMENT OF PRODUCTIVITY

As a follow-up of this study, we have started research on methods of measuring productivity. This new project is just in its first phase, so we can indicate only the method this research project will be carried out.

The project will be done in cooperation with a contracting firm. In one way or another costs and productivity are related to each other, therefore we try to make use of the ideas of Bela Gold [6], in which he developes a network of productivity relations within a cost-structure.

In this respect we think it possible that an increase in one of the productivity-factors at some level does not always mean an increase at the next level; other productivity-factors may be influenced in a different way.

We try to find answers to the following questions:

- what does such an integrated productivity-network look like for the building industry?
- on what levels will productivity-measurement be useful; why or why not?
- in what way can such productivity-measurement be carried out?

We have started our analysis on one complete building-project; after that we shall split this project into a number of phases and into a number of activity levels. This will give us a more detailed look at all the activities involved, after which the related productivity-factors will be calculated.

By means of sensitivity-analysis we will try to find out which factors are of more importance and which ones may be neglected. For correct conclusions we shall have to do the same investigations on similar projects.

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