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MACROMODEL OF BUILDING PRODUCTION
Changes in the building industry and their technological and economic impact

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KEY WORDS

Construction economics, forecasting, systems analysis, input-output analysis, building construction, production mix, production technology, employment

SYNOPSIS

The paper is based on the input-output method which is an excellent tool in analyzing the effects of construction on the industries and enterprises of the economy.

In the construction sector the utilization of the input-output method has been quite limited, because in the input-output tables the information concerning the inputs of construction is usually quite unreliable and its upgrading is very laborious or even impossible.

The paper introduces one suggestion on how to improve the input information by developing a so-called input model, which calculates the inputs of building construction and analyzes the impact of the changes in the production mix, quality standard and technology of building.

Then using the input-output method the author examines, how the the changes in the inputs affect the demand for the production of other industries and their use of primary inputs.

This so-called Macro-Model of Building Production has been succesfully used in estimating the impact of construction on employment, energy consumption and the use of other primary inputs.

UN MACROMODÈLE POUR L'INDUSTRIE DU BÂTIMENT
Les changements dans l'industrie du Bâtiment et
leur impact technologique et économique

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Mots-clés

Économie du Bâtiment, prévisions, analyse des systèmes, industries du Bâtiment,
analyse entrée/sortie, répartition de la production, technologie de production, emploi

Sommaire

Cet article se base sur la méthode d'entrée et de sortie, excellent outil permettant d'analyser l'impact de Bâtiment sur les industries et les entreprises de l'Économie du pays. Dans le secteur du Bâtiment l'utilisation de la méthode d'entrée et de sortie a été limitée par le fait que l'information relative aux entrées contenue dans les tables d'entrée et de sortie est d'une fiabilité assez faible. En outre leur amélioration est une opération extrêmement laborieuse, voire impossible.

L'article suggère une possibilité d'améliorer l'information d'entrée en développant un modèle dit d'entrée qui calcule les entrées de la construction et analyse l'impact des changements survenant dans la répartition de la production, des standards de qualité et dans la technologie de la construction.

Utilisant la méthode entrée/sortie l'auteur étudie comment des changements survenant dans les entrées influencent la demande de production des industries annexes et leur utilisation des entrées primaires.

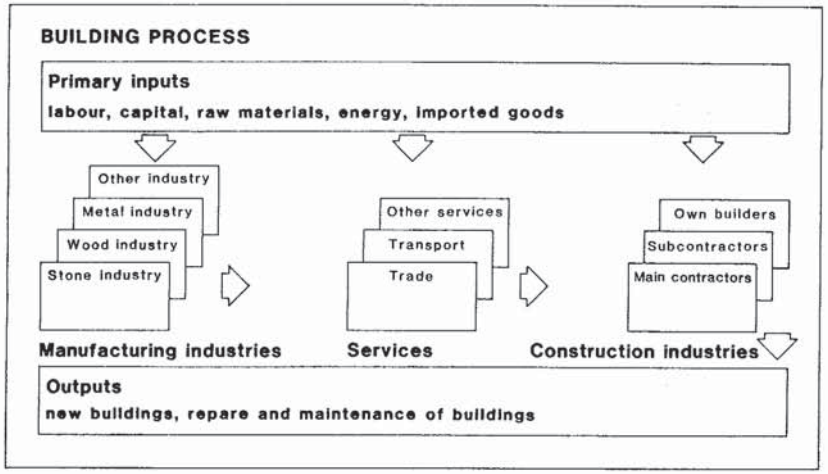
Ce Macro-Modèle pour la Production de Bâtiment a été utilisé avec succès dans l'estimation des effets de la construction sur l'emploi, la consommation énergétique et l'utilisation des autres entrées primaires.

MACROMODEL OF BUILDING PRODUCTION

**Changes in the building industry and
their technological and economic impact**

1 INTRODUCTION

Building production is the cooperation of several industries. At the beginning of the production process the different sectors of the manufacturing industries produce the building materials which the building services supply for sites. At the end of the production process the construction companies and private homebuilders construct various types of buildings using the materials and components delivered to the sites. Each industry utilizes its own primary inputs (labor, capital, raw materials and imported goods) and intermediate inputs acquired from other industries (semifinished products and related services) (Ill. 1).



Ill. 1.
Building production requires the cooperation of many industries, whereby stone, wood, metal and other raw materials are transformed into various types of buildings using labor, capital and energy.

Changes in the building industry and their impact. The Finnish building industry entered a period of turbulence with the first energy crisis in the early 1970's. This caused radical changes in inputs, outputs and the production process of buildings (see Ill. 1).

The major changes in outputs are the significant decrease in the growth rate of new production and a noticeable fall in some sectors (e.g. apartment buildings), greatly improved quality standard and brisk repair and maintenance work. These changes have had a significant impact on the demand of building-related industries and their use of labor, capital and other primary inputs.

On the input side, for instance the changes in the price of energy have considerably affected building costs. An example of a change in the production process is the industrialization of building which has continually transferred work from sites into factories thereby increasing the cost share of building materials and decreasing the role of the building site.

Analyzation of the impact of changes. The impact of the changes in the building production on the economy are many and significant. Their direction and magnitude can be analyzed by many different methods. One of the best is the input-output method which considers the flow of goods and services between various industries of the economy. Thus the input-output method makes it possible to calculate the effects of the changes in the inputs of building construction on the demand for other industries.

However, the utilization of the input-output method in analyzing building production is very troublesome, because in the input-output tables the inputs of building construction are unreliable and the estimation of their changes is almost impossible.

2 OBJECTIVES AND LIMITATIONS OF THE STUDY

On the basis of the above, the following major objectives have been set:
1. to build a model that analyzes the impact of the changes in the building production on the inputs of building construction
2. to take advantage of the analyzation possibilities of the input-output method in building production.

The attainment of these objectives has required the development of two separate submodels: the input model and the input-output model, known together as the Macro Model of the Building Industry.

The study **does not aim** to forecast changes, **but** to create a so-called deterministic causal model that is valuable in estimating the effects of known or forecasted changes in the building production on the Finnish economy.

3 INPUT MODEL

The function of the input model is to determine, for the later input-output analysis, how the changes in the volume of total production, production mix, quality standard, choice of material, degree of prefabrication etc. affect the inputs of building construction i.e.
- the amount of building materials and services that building construction buys from domestic industries and
- the amount of its own inputs, such as labor and capital.

For the purposes of the later input-output analysis, the building materials and services bought from domestic industries are called intermediate inputs and constructions own inputs primary inputs. Intermediate inputs are divided into 31 groups by supplying industries. The primary inputs are divided into five groups: labor, depreciation, operating surplus, import goods and indirect taxes minus subsidies.

Calculation method. The input model rests on the following assumptions:
* If we know various industries share of the cost of major building materials, labor and services, it is possible to calculate the breakdown of costs of total building production for each industry by combining building materials first into components, components into buildings and buildings into construction sectors etc.

The input model and its ADP-files have, on the basis of the above, been divided into five levels:
1. Material level
2. Building component level
3. Building level
4. Construction sector level and
5. Total building construction level.

The mathematical expression of the input model is as follows:

$$X(i) = X1(i,k) \cdot Q2(k,l) \cdot Q3(l,m) \cdot Q4(m,n) \cdot I(n) \quad (1)$$

where

$X(i)$ = inputs of total building construction: intermediate inputs (i=1...31) and primary inputs (i=32...36),

$X1(i,k)$ = inputs (i=1...36) of building materials, labor and services (k=1...1000),

$Q2(k,l)$ = quantities of the building materials, labor and services (k=1...1000) in building components (l=1...500)

$Q3(l,m)$ = quantities of the building components (l=1...500) in buildings (n=1...81) produced in various ways

$Q4(m,n)$ = volume of the buildings (m=1...81) in building sectors (n=1...9)

$I(n)$ = unit vector (n=9)

Changes in the building production have an impact on the matrices of the levels. By adjusting these matrices according to developments one can analyze the effect of these changes on the inputs of building construction (Ill. 2).

TABLE 2.
CHANGES IN THE PRODUCTION MIX OF BUILDING CONSTRUCTION AND THEIR EFFECTS ON THE INPUTS.

	THE INPUTS OF BUILDING CONSTRUCTION SECTORS (thousands)									CHANGES IN THE INPUTS OF BUILDING CONSTRUCTION (thousands)			
	1 Single family houses	2 Row houses	3 Blocks of flats	4 Indus-trial houses	5 Commer-cial bldgs	6 Public bldgs	7 Farm bldgs	8 Other bldgs	9 Repair &main-tenance	1970	1980	1990	2000
01 Stone Industries	85	133	182	141	105	126	132	96	48	122	103	102	97
02 Wood Industries	209	134	103	81	91	80	115	217	188	131	146	146	147
03 Metal Industries	93	99	126	183	204	176	85	51	36	132	120	122	123
04 Chemical Industries	12	11	10	17	16	16	14	22	34	15	18	17	20
05 Other Manufacturing	5	2	5	0	0	0	6	5	17	4	5	5	6
06 Energy Production	11	17	15	14	13	10	4	12	5	11	10	11	10
07 Building Construction	0	0	0	6	0	0	0	0	0	0	0	0	0
08 Other Construction	31	41	20	22	37	32	31	0	0	24	23	21	19
09 Trade	64	61	42	41	42	44	60	75	83	55	62	60	61
10 Transport	25	27	28	27	22	26	45	31	21	26	26	25	25
11 Services	57	59	72	69	83	91	34	41	9	58	50	51	47
01-11 Total	583	599	603	586	616	601	520	570	482	579	563	560	555
12 Labour	238	237	223	230	268	229	324	272	368	254	274	276	280
13 Depreciation	18	18	32	27	27	29	25	19	0	23	18	18	18
14 Operating Surplus	0	6	0	0	0	0	0	0	0	0	0	0	0
15 Imported Goods	36	40	40	50	49	45	33	32	49	44	42	44	46
16 Indirect Taxes	103	102	102	107	100	96	98	107	101	101	103	102	101
12-16 Total	417	401	397	414	384	399	480	430	518	422	437	440	445
01-16 Total	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
PRODUCTION MIX OF BUILDING CONSTR. IN 1979, 1985, 1995 AND 2000													
- 1970	187	43	225	156	85	111	23	40	130	1000			
- 1980	233	78	86	119	80	101	23	41	239		1000		
- 1990	214	73	70	169	92	128	23	47	244			1000	
- 2000	172	83	69	136	72	110	21	36	308				1000

Ill. 2.
Exemplary calculation of the impact of changes in the production mix of building construction on inputs (level 5). The number of intermediate inputs have been reduced from 31 industries to 11.

4 INPUT-OUTPUT MODEL

The input-output model is the core of the Macro Model of Building Production. The input-output model calculates how the changes in inputs of building construction affect the production of building-related industries and their demand for labor and other inputs directly and indirectly. The input-output model utilizes the input-output tables of the Finnish economy and Leontief's inverse matrices calculated with their help.

The input-output tables are a form of national economic accounting showing the flow of goods and services between various industries of the economy. The input-output tables are presented in matrix-form so that the columns of the matrix show inputs of industries and the rows show sales of outputs.

Leontief's inverse matrix is calculated from the input-output table as follows

$$(I-A)^{-1}, \qquad (2)$$

where
I = unit matrix
A = input coefficient matrix, derived from the input-output table by dividing each flow by the column sum.

Each column of the inverse matrix shows, how much production is needed in various industries, if the industry indicated by the column produces one unit of output and, if all direct and indirect effects of the production are taken into account.

Results of input-output analysis. With the help of the input-output model we can calculate e.g. the following tables and analyze their variation on the basis of the changes in the inputs of building construction:
- primary inputs of building production
- employment impacts of construction (table 3)
- domestic share of building production.

Table 3

THE EMPLOYMENT EFFECTS OF CONSTRUCTION FROM 1970 TO 2000 (100 man years) /5/.

	BUILDING CONSTRUCTION				OTHER CONSTRUCTION				EXPORT RELATED CONSTRUCTION ABROAD			
	1970	1980	1990	2000	1970	1980	1990	2000	1970	1980	1990	2000
01 Stone industries	167	163	136	114	37	17	12	7	3	14	47	49
02 Wood industries	268	269	213	174	17	12	8	5	167	519	453	379
03 Metal industries	235	256	217	181	109	82	54	34	19	102	111	120
04 Chemical industries	40	53	39	38	14	10	8	5	5	26	25	28
05 Other manufacturing	51	47	40	34	18	12	7	5	6	19	23	22
06 Energy production	15	17	16	15	6	4	3	3	2	9	10	10
07 Building construction	1602	1220	1115	1023	1	1	1	0	0	2	2	2
08 Other construction	3	5	3	3	723	539	420	309	0	2	2	2
09 Trade	167	136	165	145	52	40	28	19	4	19	21	22
10 Transport	121	123	113	103	125	79	57	39	7	34	42	44
11 Services	99	155	175	180	47	47	42	33	4	51	86	122
01-11 Total	2768	2494	2232	2010	1149	843	640	459	217	797	822	800

5 APPLICATIONS OF MODEL

The application possibilities of the model are the following:
- primary input studies
- industry studies
- others

The most important primary input-related studies deal with building cost development /4/, employment impact /5/, energy consumption /2, 6/ and import /7/.

Of industry studies we may mention the impact of the building industry on the development of Finnish metal industry 1985 to 1995 /8/.

Other applications are, e.g. the effects of incomes of different economic units of building production /9/ and the analysis of the effects of industrialization of building /3/.

6 CONCLUSIONS

The central aim of the macro model of the building industry is to utilize the opportunities derived from the input-output method in analyzing the effects of building production on the Finnish economy. Previously the use of the input-output analysis in studies of this kind has not been practical since the inputs of building construction had to be calculated by the fairly uncertain residual method (one first determines what is known and allocates the rest in an intelligent manner). The macro model has done away with this problem through the input model since by it one may calculate in detail the effect of changes in building production on inputs. This makes the use of the input-output method in analyzing the building industry much more meaningful.

The extensive files of the macro model of the building industry may be used also in other countries since the quantity information on different levels of the input model is similar in various countries requiring only limited adjustments.

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