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Historical comparison of construction sectors in the United States, Japan, Italy and Finland using input–output tables

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This paper uses the input–output tables compiled since World War II in four advanced industrial countries – United States, Japan, Italy, and Finland – to analyse the role of construction in their economies. Several questions are discussed: How does the construction sector interact with other sectors of the economy? How does this interaction change over time? How does it differ from country to country? The paper first briefly introduces the input–output data and the indicators used for comparative analysis. For reasons of space, the historical values of these indicators are presented only in graphical form. Next, the paper compares the construction sector in the four countries in terms of their shares in gross national product and national income, direct and total backward and forward linkage indicators, and direct and total inputs from manufacturing and service sectors. Special attention is paid to changes in construction technology, that is, changes in the relative shares of manufacturing and service sectors in the input profile of the construction sector. For reasons of space again, the emphasis is placed on international comparisons, rather than on intersectoral comparisons. Finally, the main findings and directions for future research are summarized.

Keywords: Construction technology, international comparisons, input–output analysis

Introduction

How does the construction sector interact with other sectors of the economy? How does this interaction change over time? How does it differ from country to country? As one of us argues in a recent paper, 'despite significant differences in national income accounting conventions, international comparisons of the patterns of change of the construction sector over time are urgently needed today' (Bon, 1988: 69). To the extent that these patterns are universal, the lessons learned in one country may be useful in another.

In this paper we will use the input–output tables compiled since World War II in the US, Japan, Italy, and Finland to analyse the role of construction in these economies. *Nota bene*, there is no compelling reason for selecting these four countries except that they represent a fairly wide range of levels of economic development and that reasonably long series of input–output tables exist for each of them. Rather modestly, we will endeavour to describe the major trends characteristic of this sector in the four countries and to venture explanatory hypotheses for further research. However, although we will confine ourselves to descriptive

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analysis, it will be based on sizeable data sets, as well as on data manipulation of considerable complexity.

This paper is based on several earlier papers, all of which concern the role of the construction sector in the national economy. These papers share the analytical framework of input–output analysis, which is invaluable in the study of economic structure, that is, the interaction among economic sectors. Bon and Minami (1986a) compare the fundamental structure of the US and Japanese economies since World War II, focusing on the construction sector's behaviour over time. Bon and Minami (1986b) use the same data to examine the role of the construction sector in the US and Japanese economies in greater detail, especially regarding changes in construction technology. Bon (1988a) presents an exhaustive review of the US construction sector since World War II based on a large set of economic indicators obtained from input–output data.

We will assume that the reader is familiar with the fundamentals of input–output analysis.[1] Briefly, it is based on Leontief's (1936) insight that commodities are needed in the current production of other commodities. The total output of each sector is therefore divided into intermediate demand and final demand for its goods and services. Also, the total input of each sector is divided into intermediate supply and value added, which represents the supply of primary inputs or factors of production needed by the sector. Leontief (1936) introduced the demand-side input–output model, whereas Ghosh (1958) and Augustinovics (1970) suggested the alternative supply-side input–output model.[2] In this paper we will use economic indicators associated with both types of input–output models. Simply stated, the former model is based on the principle that demand determines output, whereas the latter is based on the complementary principle that supply determines input. As Mizrahi (1989) shows, these two types of models can be understood as special cases of a generalized input–output model that combines the above two principles.

We will first briefly introduce (1) the input–output data and (2) the economic indicators used for comparative analysis. For reasons of space, the historical values of these indicators will be presented only in graphical form. Next, we will compare the construction sector in the four countries in terms of their (1) shares in gross national product and national income, (2) direct and total backward and forward linkage indicators, and (3) direct and total inputs from manufacturing and service sectors. Here, we will pay special attention to changes in construction technology.[3] These three sections represent the core of the paper. For reasons of space again, we will focus on international comparisons and discuss intersectoral comparisons within countries only when these comparisons are essential. Finally, we will briefly summarize the main findings and directions for future research.

Input–output tables used

In this paper we will use the six US input–output tables compiled to date. Our analysis is based on the seven-sector aggregation of 1947, 1958, 1963, 1967, 1972, and 1977 tables presented by Miller and Blair (1985: 420–25). The sectors are: agriculture; mining; construction; manufacturing; trade and transportation; services; and other (the last category is comprised of government enterprises, and scrap and secondhand goods).

For Japan we will use a nine-sector aggregation of five tables compiled in 1960, 1965, 1970, 1975, and 1980. The sectors are: agriculture; mining; construction; manufacturing; utilities; trade and finance; transportation; services; and other (undistributed). In the case of Italy we will use the seven-sector aggregation of 1959, 1965, 1969, 1972, 1978, and 1982 tables. The sectors are the same as for the US; however, the aggregation scheme for the two countries is not identical. For Finland we will use a six-sector aggregation of tables compiled in 1959, 1963, 1965, 1970, 1980, 1982, and 1985. Again, the sectors are the same as in the case of the US, with the exception of the last sector – other. Of course, the aggregation scheme for the two sets of data is not identical either.

The input–output data for Japan, Italy, and Finland were aggregated to conform as closely as possible to the seven-sector aggregation of the US data. Although the aggregation schemes for the four countries contain significant differences – stemming from different income accounting conventions that also change from time to time in each country – there is a high degree of compatibility between them in terms of construction and manufacturing sectors. The income accounting conventions of different countries differ most in the area of services, the last 'newcomer' on the economic scene. Therefore, comparisons of service sectors must remain tentative, as we will repeatedly warn the reader.

All the difficulties with data notwithstanding, it is worth emphasizing that input–output tables offer the most reliable data available for the analysis undertaken here. The main reason for this is that the rules of double-entry accounting used in their construction ensure the consistency of the data relating to production and consumption – both intermediate and final – of goods and services.

Economic indicators used for comparative analysis

To compare the construction sectors of the US, Japan, Italy, and Finland, we need a set of economic indicators that can be obtained from input–output tables. These indicators can be classified in two groups: first, indicators taken directly from input–output tables ($X=[x_{ij}]$), as well as direct-input ($A=[a_{ij}]$) or direct-output ($B=[b_{ij}]$) and total-input ($L=[l_{ij}]$) or total-output ($G=[g_{ij}]$) coefficient matrices; and second, ratios formed from the above 'raw' data.[4] The two groups will be defined in turn. The basic building blocks of economic indicators used for comparative analysis of the four countries are defined as follows:

x_{ij} = flow of goods and services from sector i to sector j;
x_i = total output of sector i;
x_j = total input of sector j;
$x_{i.}$ = total intermediate output of sector i;
$x_{.j}$ = total intermediate input of sector j;
y_i = final demand for goods and services of sector i;
y = total final demand (gross national product);
v_j = value added by sector j;
v = total value added (national income);
a_{ij} = direct-input or technical coefficient (x_{ij}/x_j), respresenting the purchases of sector j from sector i per monetary unit (US dollar, yen, lira, or Finnish mark) of the total input of sector j;
l_{ij} = total-input coefficient, representing the effect of one monetary unit change in final demand of sector j on total output of sector i;
$l_{.j}$ = column sum of total-input coefficients for sector j, representing the effect of one monetary unit change in final demand of sector j on total output of all other sectors (output or demand multiplier, or total-backward linkage indicator);

b_{ij} = direct-output or allocation coefficient (x_{ij}/x_i), representing the sales of sector i to sector j per monetary unit of the total output of sector i;

g_{ij} = total-output coefficient, representing the effect of one monetary change in value added by sector i on total input of sector j;

$g_{i.}$ = raw sum of total-output coefficients for sector i, representing the effect of one monetary unit change in value added by sector i on total input of all other sectors (input or supply multiplier, or total-forward linkage indicator).

The derived indicators used in this study are as follows, on the basis of the indicators presented above:

$x_{.j}/x_j$ = intermediate to total input ratio for sector j (direct-backward linkage indicator);

$x_{i.}/x_i$ = intermediate to total output ratio for sector i (direct-forward linkage indicator);

y_i/y = final demand of sector i to total final demand ratio (the share of sector i in gross national product);

v_j/v = value added by sector j to total value added ratio (the share of sector j in national income).

Note that $v_j/x_j + x_{.j}/x_j = 1$, and $y_i/x_i + x_{i.}/x_i = 1$. Also note that $y = v$. It follows that the backward linkage indicator $(x_{.j}/x_j)$ offers the same information as the value added to total input ratio (v_j/x_j, not shown above), as the two indicators add to one. Obviously, the same pertains to the relationship between the forward linkage indicator $(x_{i.}/x)$ and the final demand to total output ratio (y_i/x_i, not shown above).

It should be borne in mind throughout this paper that input–output tables provide information on the intersectoral flows of goods and services in terms of *value* (current price times quantity). A change in a particular intersectoral flow may be attributed to a change in price, a change in quantity, or a combination of these changes. Similarly, an intersectoral flow showing little or no change may in fact conceal important changes in the product mix. Therefore, special care should be taken in the interpretation of the data.

Shares in gross national product and national income

Figures 1 and 2 show the shares in gross national product (y_i/y) and national income (v_j/v) of the construction sector in the four economies. With the exception of Japan, the contribution of each construction sector to the respective gross national product tends to decline over time; it tends to stabilize at a value between 10 and 12%. The same holds for the contribution of each construction sector to the respective national income, but the values of national income shares are approximately one half of the values of gross national product shares. They tend to stabilize at a value between 5 and 7%. Again, Japan is the only exception.

The fact that the construction sector's share in national income is lower than its share in the gross national product is characteristic of sectors that produce mainly for final demand. As a capital-producing sector, the construction sector produces very little for intermediate use. In fact, the intermediate goods and services are produced only by the maintenance and repair (M&R) construction subsector, whereas the new construction subsector produces only final demand goods. Furthermore, the relationship between the two shares depicted in Figs 1 and 2 can be explained in terms of the fact that construction technology is one of assembly, rather than production in the strict sense of the word. The production of materials and components that are assembled in the construction process takes place mainly in the manufacturing sector, as we will see presently.

It can be hypothesized that the decline of the construction sector sets in with economic maturity: the more developed an economy, the smaller the construction sector. This is especially evident in Fig. 1, where the US 'example' is followed by Italy and Finland, but it is also evident in Fig. 2. By the same token, the behaviour of the Japanese construction sector in both cases suggests that the Japanese economy is still in 'early' stages of development.[5]

Direct and total backward and forward linkage indicators

Figures 3 and 4 show backward linkage indicators ($x_{.j}/x_j$) and output multipliers ($l_{.j}$) – that is, direct and total backward linkage indicators – for each construction sector. The former represents the intermediate to total input ratio of the construction sector; the latter represents the effect of one monetary unit (US dollar, yen, lira, or Finnish mark) change in final demand of the construction sector on total output of all other sectors. It should be noted that the construction sectors of all countries studied rank very highly in terms of both indicators; in fact, only the manufacturing sectors tend to rank higher.

Two distinct groups of indicators are shown in Fig. 3: Japan and the US with higher indicator values, and Italy and Finland with lower values. These differences can be explained in terms of different levels of industrialization of the construction process in the two groups of countries, that is, different degrees to which the construction and manufacturing sectors are interconnected. We will return to this issue shortly.

This interpretation changes in Fig. 4, where the Italian construction sector is shown to be closer to those of Japan and the US than that of Finland. The output multiplier values for the Finnish construction sector are comparatively low over the entire study period. As we will see below, this is related to the nature of the Finnish manufacturing sector.

Figures 5 and 6 show forward linkage indicators ($x_{i.}/x_i$) and input multipliers ($g_{i.}$) – that is, direct and total forward linkage indicators – for each construction sector. The former represents the intermediate to total output ratio of the construction sector; the latter represents the effect of one monetary unit change in value added by the construction sector on total input of all other sectors. It should be noted that the construction sectors rank lowest of all sectors in terms of both indicators.

Figures 5 and 6 do not differ significantly in terms of the basic pattern of relationships between the four economies. The low values of both direct and total forward linkage indicators reflect the fact that the construction sector produces intermediate goods and services only through its M&R construction subsector. Most of these intermediate goods and services go to the real estate subsector of services. All other construction goods and services are included in various components of final demand by income accounting conventions. Therefore, Figs 5 and 6 suggest that the importance of M&R construction grows with economic maturity.[6] In this regard, the relative positions of the four countries are roughly the opposite of those in Figs 1 and 2.

Direct and total inputs from manufacturing and services

Figures 7 and 8 show direct input (a_{ij}) and total input (l_{ij}) from the manufacturing of each construction sector. The former represents the purchases of the construction sector from the

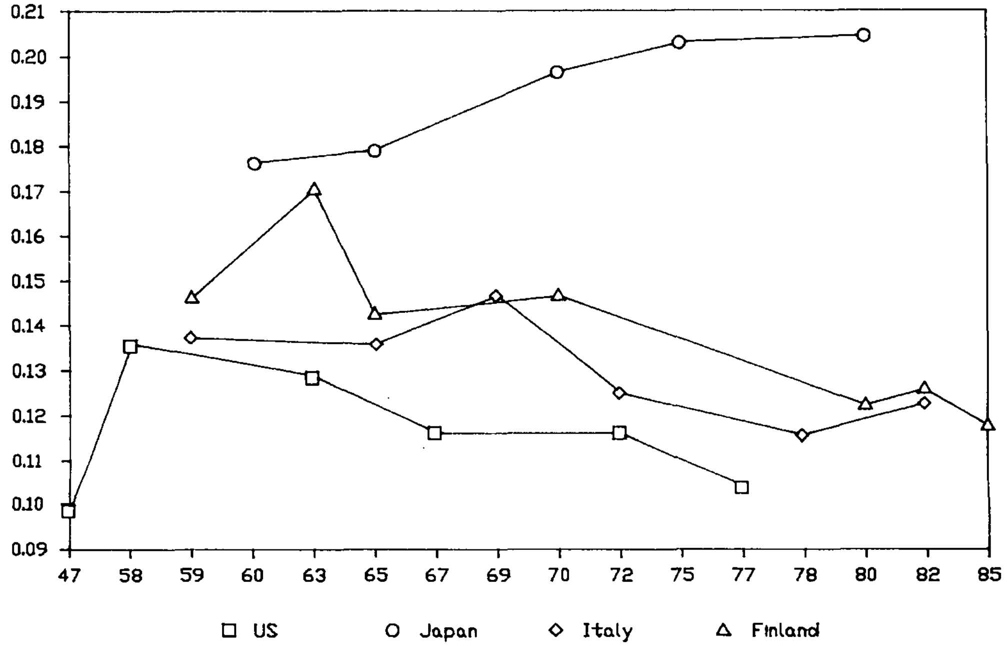

Fig. 1. Shares in gross national product (y_i/y)

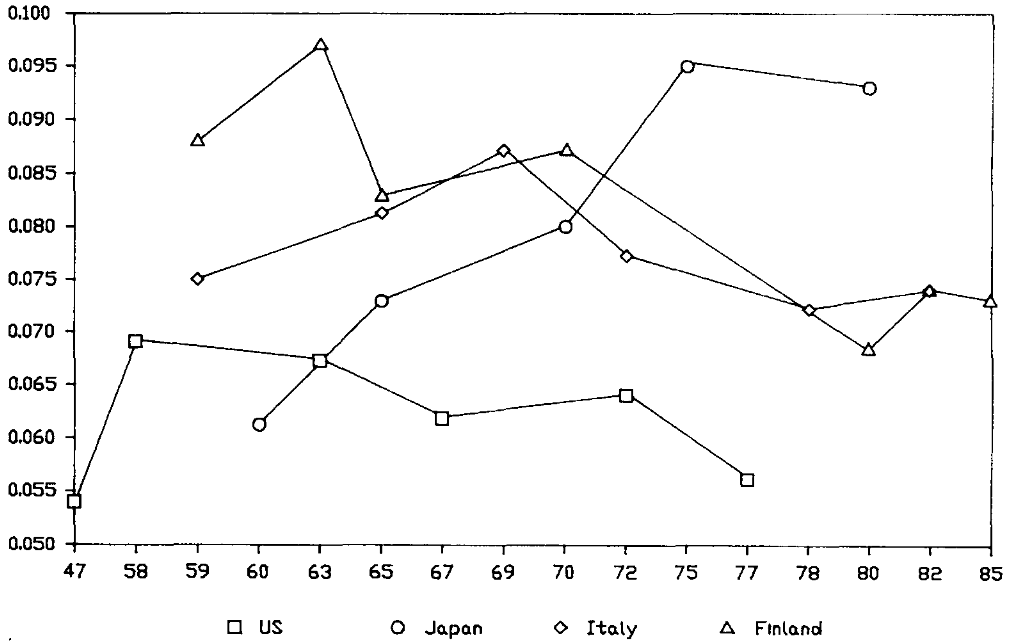

Fig. 2. Shares in national income (v_j/v)

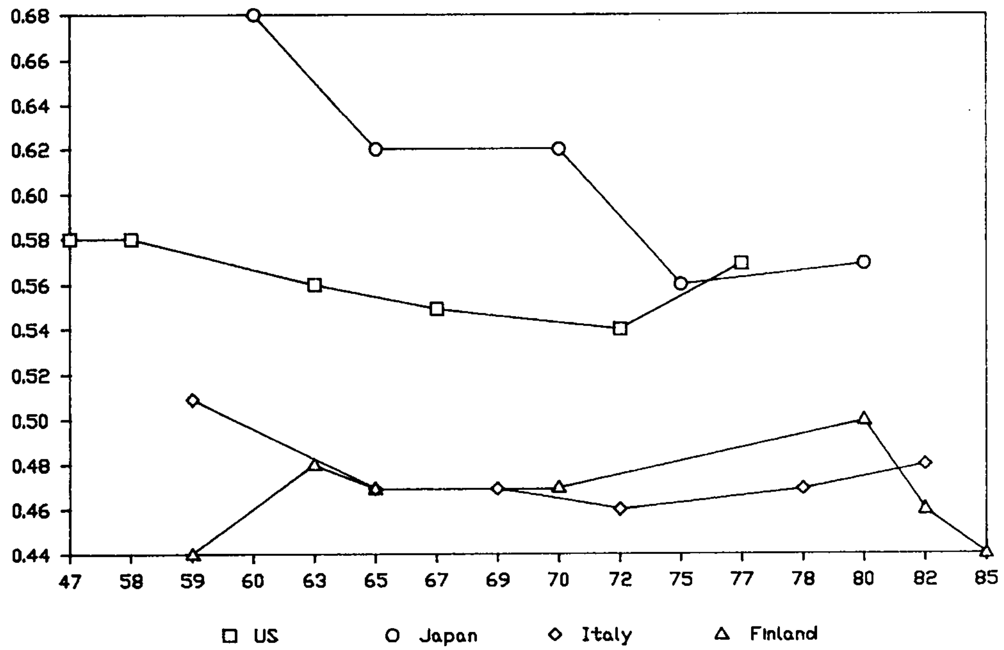

Fig. 3. Backward linkage indicators ($x_{.j}/x_j$)

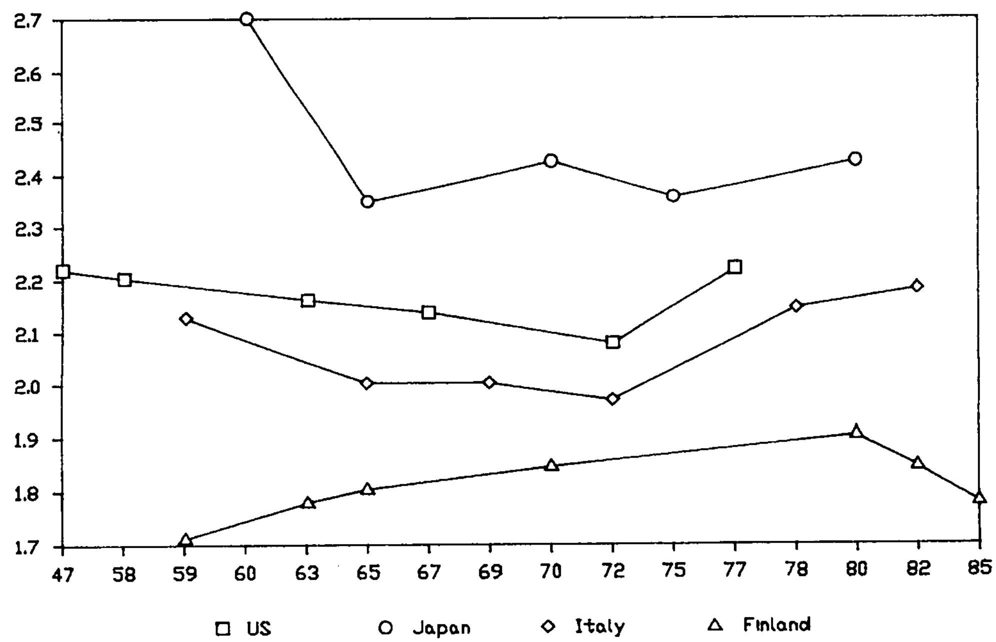

Fig. 4. Output multipliers ($l_{.j}$)

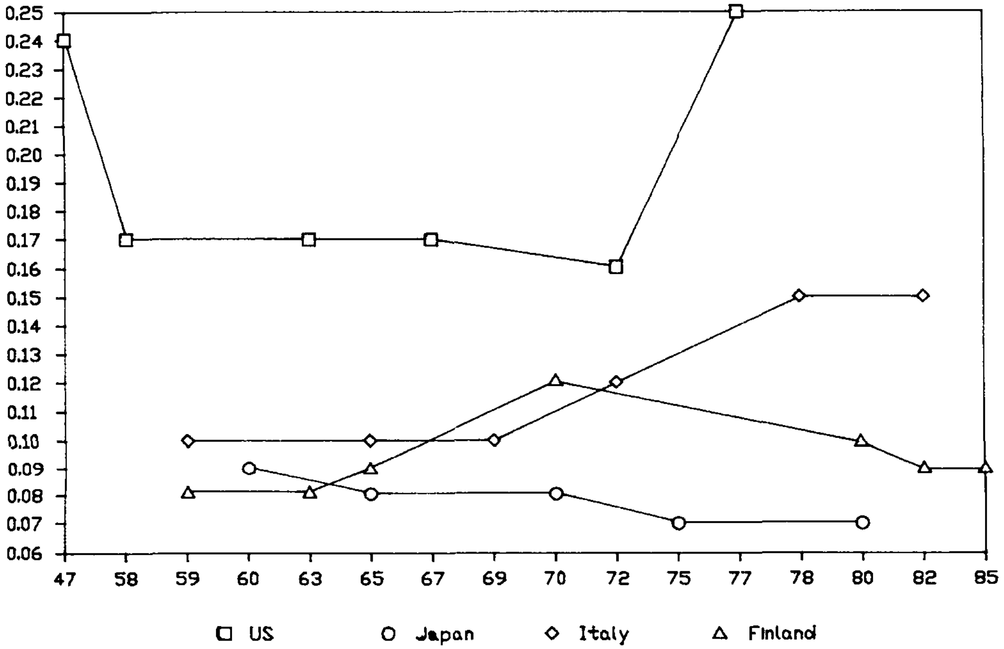

Fig. 5. Forward linkage indicators ($x_{i.}/x_i$)

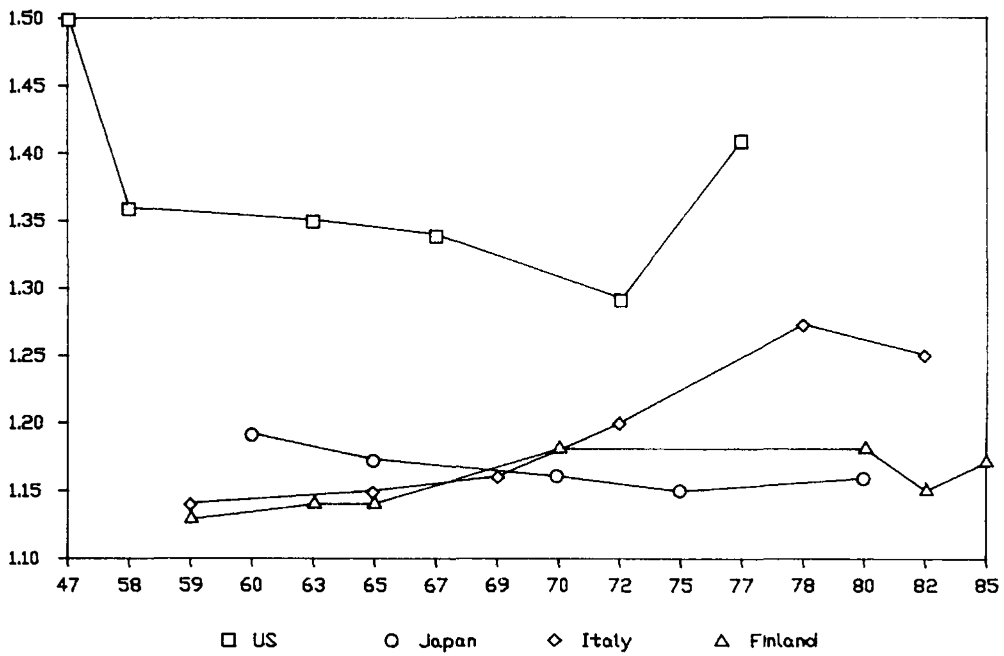

Fig. 6. Input multipliers ($g_{i.}$)

manufacturing sector per monetry unit (US dollar, yen, lira, or Finnish mark); the latter represents the effect of one monetary unit change in final demand of the construction sector on total output of the manufacturing sector. Figure 7 suggests that the construction sectors in the four countries are converging in terms of their input structures. With the exception of Finland in the early 1980s, direct input from manufacturing is stabilizing at a value between 34 and 36%.

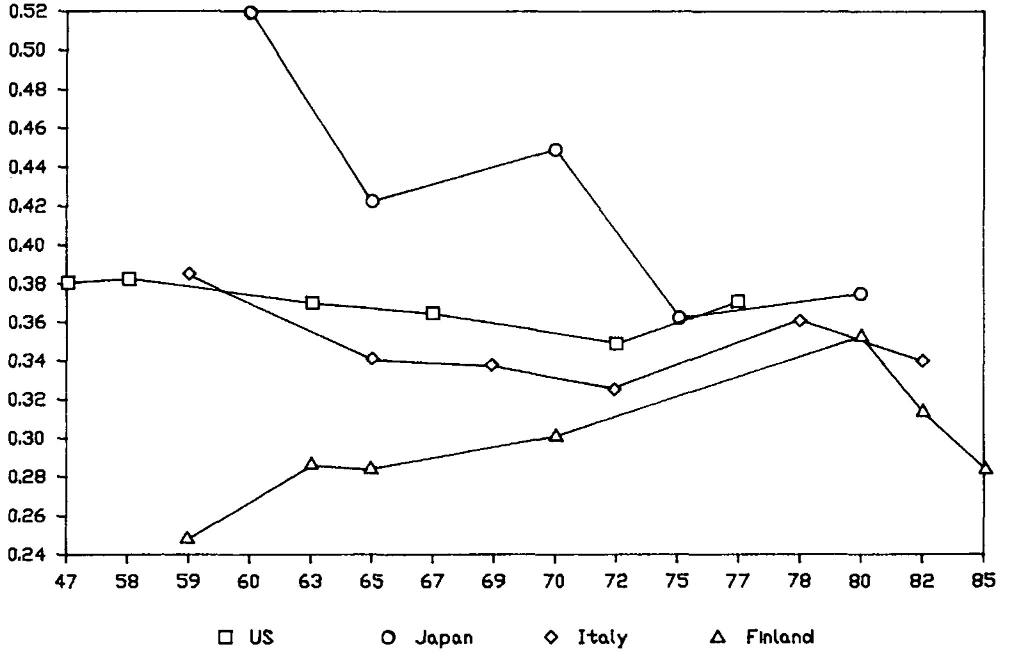

Fig. 7. Direct inputs from manufacturing (a_{ij})

However, Fig. 8 offers a somewhat different picture, suggesting three 'parallel', rather than convergent, paths. The similarity with Fig. 4 is striking, indicating the strength of the interconnection between the construction and manufacturing sectors. The Japanese construction sector has the greatest total effect on the manufacturing sector; the US and Italian construction sectors are nearly identical in this regard; and the Finnish construction sector has the smallest total effect on the manufacturing sector. We will return shortly to this issue.

In general, we can hypothesize that the decline of the construction sector follows the decline of the manufacturing sector. This can be explained both in terms of the output of the construction sector, the capital goods needed for the production of goods and services, and in terms of the input of the construction sector. In fact, the share of the manufacturing sector in gross national product has been declining in all the countries under study except Italy, where it has been stagnating.

The case of Finland is surprising in view of our discussion of Figs 1 and 2, but not in view of our discussion of Fig. 4. Namely, our argument about the relationship between the construction sector and economic maturity would suggest that the Finnish construction

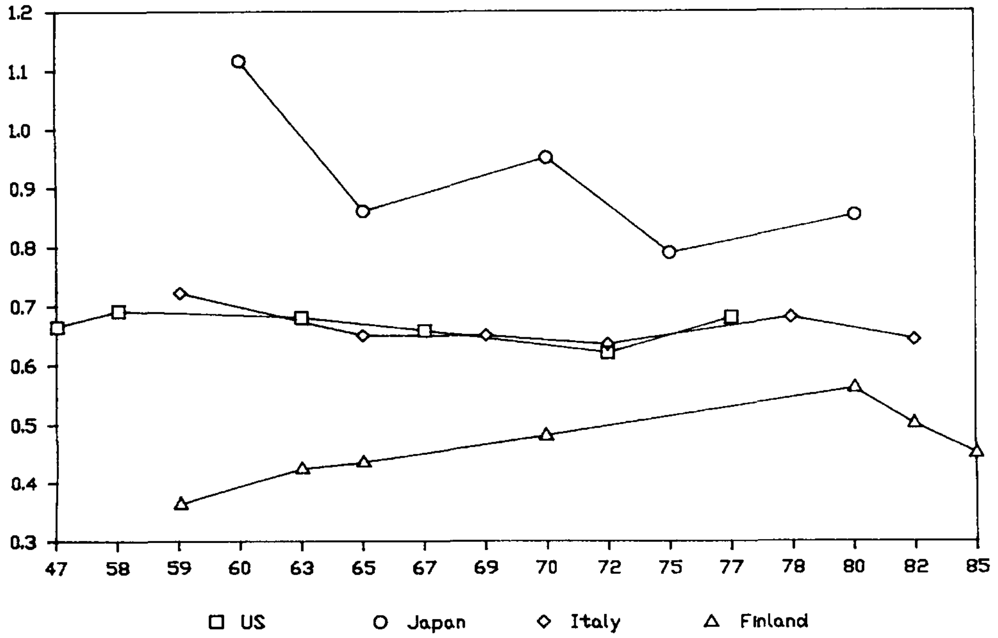

Fig. 8. Total inputs from manufacturing (l_{ij})

sector should fall someplace between the Japanese, and above the Italian and US construction sectors. In fact, it falls beneath the latter two, as well. Figures 7 and 8 show that there is very little difference between the Finnish direct and total inputs from manufacturing, whereas the value of the latter is approximately twice the value of the former in the cases of the US, Japan, and Italy. This suggests that the relationship between the Finnish construction and manufacturing sectors is not 'deep', even though it may be 'wide'. Put differently, although much of Finnish construction work takes place off the construction site, due to adverse weather conditions, these manufacturing facilities appear not to be closely related to the remainder of the manufacturing sector.[7]

Figures 9 and 10 show direct and total input from services of each construction sector.[8] Again, our analysis of these figures is most tentative. Figure 9 suggests divergence in service inputs in the four economies. Although the service input shares are growing in all countries except Italy since the early 1970s, they are growing at different rates. However, Fig. 10 offers a different picture. As in Fig. 8, there is evidence of four 'parallel', rather than divergent, paths.

As the service sector of the four countries has been steadily growing since World War II, the construction sector's input from services has also been increasing. However, the service sector cannot replace manufacturing as the main supplier of construction inputs. One again, the fate of the construction sector largely depends on the fate of manufacturing.

Conclusions

The construction sector has attracted much less attention from the economics profession than any other sector of the national economy. The field of construction economics still lacks

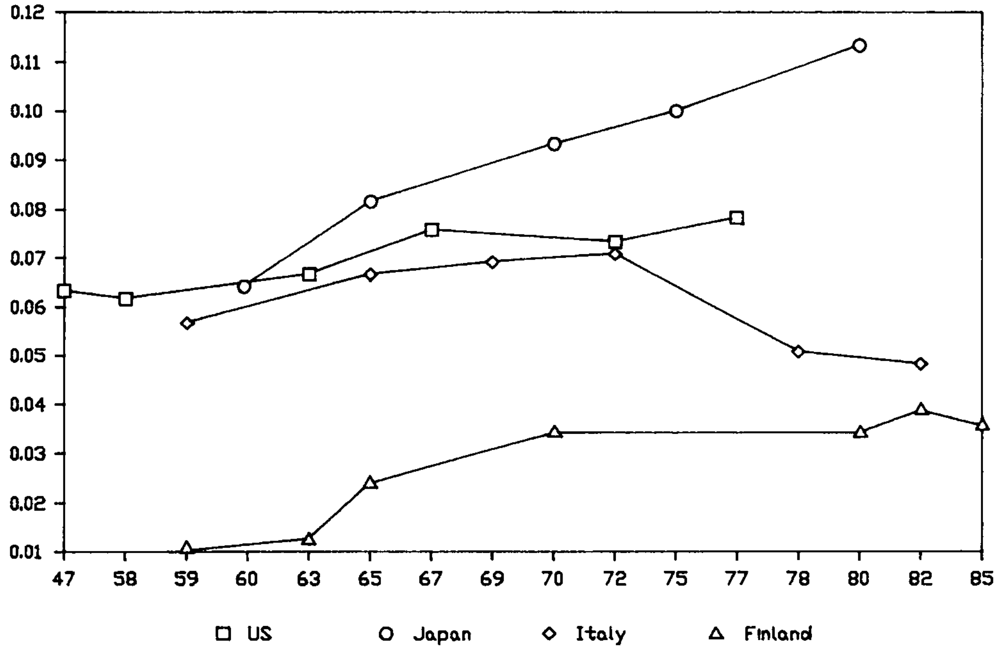

Fig. 9. Direct inputs from services (a_{ij})

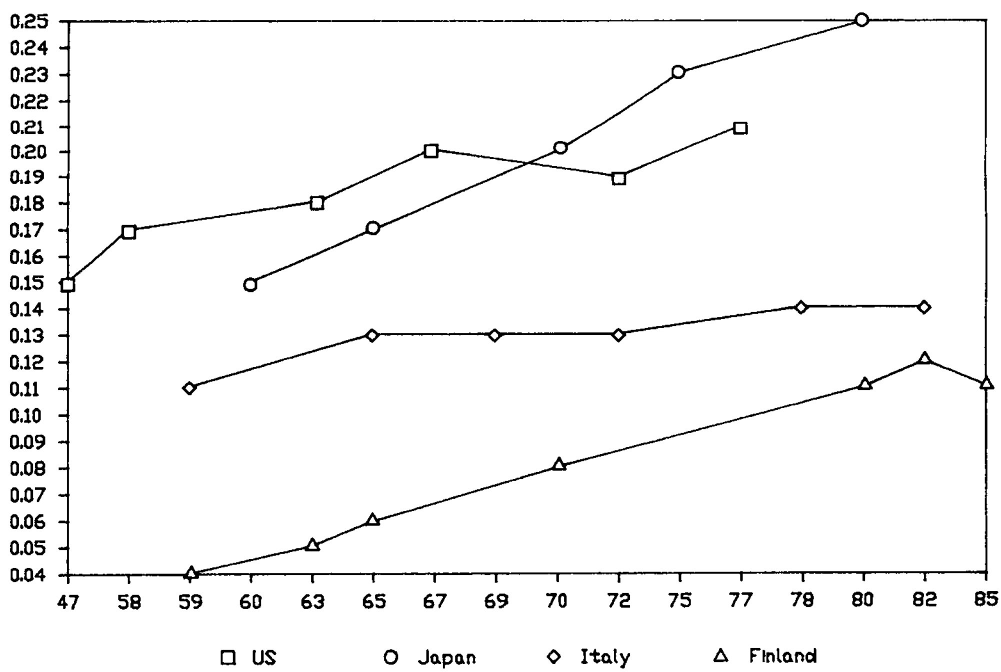

Fig. 10. Total inputs from services (l_{ij})

a solid descriptive substratum upon which a variety of explanatory frameworks might be built. We believe that input–output analysis provides a descriptive cornerstone of great value in understanding the economic role of the construction sector. In particular, it offers an invaluable model of economic interaction between the construction and other sectors of the national economy. As we have shown repeatedly, there is a marked difference between all the direct and total impacts analysed here – both in terms of their absolute and relative magnitudes.[9]

The picture that emerges from our analysis suggests that the construction sector follows the economic destiny of the manufacturing sector, its primary partner in economic growth and development.[10] As Maddison (1987: 666) shows in his study of several advanced industrial economies including the US and Japan, there are three broad trends that characterize the last 100 years of economic development: declining agriculture, growing services, and the 'bell-shaped pattern of relative industrialization and deindustrialization'. These structural changes affecting the manufacturing sector are reflected in the construction sector's bell-shaped performance. It grows and declines *pari passu* with the manufacturing sector.

Of course, this is true of new construction, not of M&R construction, which includes all forms of rebuilding of the existing building stock. The two subsectors differ in terms of inputs – both primary and intermediate. Also, their technologies tend to diverge over time. Finally, their output goes to different destinations – final users in the case of new construction, and intermediate users in the case of M&R construction. The decline of the former and the growth of the latter will thus have a significant impact on the national economy. We believe that the transformation of the construction sector outlined here warrants a more detailed study, for which input–output analysis provides an excellent anaytical framework.

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Last but not least, we are thankful to Olli Niemi from the Construction Economics Laboratory, Tampere University of Technology, for the Finnish data presented here and for his help in the interpretation of the data. His knowledge of the Finnish construction sector was invaluable to us.

Of course, the people whose contributions we gratefully acknowledge cannot be responsible for the form this paper has ultimately taken. In fact, they may disagree with many of our conclusions. We can only hope that we have not misinterpreted their advice.

Notes

1. For the fundamentals of input–output analysis, see Miller and Blair (1985). For applications of input–output analysis to the construction sector, see, for example, Bon with Minami (1986) and Bon (1988a). Bon (1988a) provides an elementary introduction to input–output analysis, as well as an exhaustive review of the construction economics literature, including input–output analyses of the construction sector.
2. For greater detail concerning the supply-side model, see Miller and Blair (1985: 317–22) and Bon (1986, 1988a, 1988b, and 1989). Bon (1988b) presents the most exhaustive and technically rigorous discussion of the supply-side model, both 'national' and multiregional.
3. It should be emphasized that we are not concerned with forecasting of technological change, for which input–output models may not be best suited; rather, we use input–output tools to study historical trends depicted by input–output tables. *Nota bene*, although input–output models are generally considered unable to handle technological change, Hewings *et al.* (1988) argue that the spread of technological change and the resulting competition for inputs can, in fact, be presented in these models by means of a logistic process.
4. It should be noted that matrices A and L are associated with the demand-side model introduced by Leontief (1936), whereas matrices B and G are associated with the supply-side model, first suggested by Ghosh (1958) (see Note 2). As these two types of input–output models are based on different assumptions about economic behaviour, economic indicators based on them must be compared with great care. This applies especially to the so-called backward and forward linkage indicators defined below, which are based on demand-side and supply-side input–output models, respectively.
5. Of course, the difficulty here is in interpreting the term 'early'. This interpretation depends on economic policy. In particular, the Japanese construction sector benefits greatly from abundant government funding of public infrastructure projects. As Aschauer (1988) argues, the steady productivity growth in Japan and its steady decline in the US may be explained in terms of radically different attitudes of the two governments toward public capital. Although more recent data suggest a considerable drop in the relative size of the Japanese construction sector, its share in gross national product is still significantly higher than in the other countries analysed. According to Hasegawa *et al.* (1988: 2–3), for example, the Japanese construction sector's share in the gross national product was 16% in 1985. This is attributed to the relatively underdeveloped infrastructure in Japan.
6. It is important to note that the M&R construction subsector tends to be underestimated in national income accounts because much of the maintenance and repair work is performed directly by owners of constructed facilities on so-called force account. A significant proportion of this work is not reported as construction work.
7. A concrete example may be helpful here. Much of Finnish construction relies on large concrete components, typically produced in manufacturing facilities. One of the most ubiquitous components in Finland is the so-called hollow core slab. According to Niemi (1987: 61), 1000 Finnish marks worth of hollow core slabs included 655 marks worth of intermediate inputs, whereas value added accounted for 345 marks – all expressed in 1980 prices. The intermediate inputs consisted of nonmetal, mineral products such as sand, gravel, and cement (575 marks);

basic metal products such as reinforcement bars (17 marks); and trade (16 marks) and transportation (47 marks). Out of 31 types of intermediate inputs listed, four were in evidence, only two of which come from the manufacturing sector. Most of value added was attributed to labour (230 marks) and indirect taxes (102 marks). It is plain to see that the total effects of this kind of simple manufacturing cannot be very different from its direct effects.

8. The Japanese service sector has been redefined here to include the trade and finance sector. This has been done to improve the comparability with the US service sector, which includes finance, but does not include trade. As trade is very important in the construction sector's input profile, the importance of services in the Japanese construction sector is exaggerated. Without trade, the Japanese service inputs would most likely fall below the US service inputs.
9. On this topic, see also Bon (1988a). Most importantly, the ranking of economic sectors often differs for direct and total economic indicators. This is especially evident in the differences between rankings of economic sectors in the input profile of the construction sector. For example, the US trade and transportation sector is followed by services in terms of direct inputs to the construction sector, whereas this relationship is reversed in terms of total inputs (Bon, 1988a: 65). Of course, this conclusion can be reached only by means of input–output analysis.
10. It should be noted again that the manufacturing sector is not only the primary supplier of construction sector's inputs, but also the key demander of construction sector's goods and services; however, static input–output analysis employed in this paper does not provide a clear picture of sectoral demand for construction goods. Dynamic input–output analysis offers such a picture by means of an additional table showing the flows between capital-producing and capital-consuming sectors of the economy.

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