A Linkage analysis of the real estate sector using the hypothetical extraction method

By

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Abstract

Based on the newest Organisation for Economic Co-operation and Development (OECD) input-output database at constant prices, this research aims to measure and compare the total, backward, forward, internal and sectoral linkages of the real estate sector using the hypothetical extraction method over thirty years and explore the role of this sector in national economies and the quantitative interdependence between the real estate sector and the remaining sectors from a new angle. Empirical results show an increasing trend of these linkages, which confirms the increasing role of the real estate sector with economic maturity over the examined period. On the other hand, the significant rank correlations in the linkages imply that, the importance of real estate remained fairly stable among highly developed economies over the examined period. This may supply a tool to signal the maturity of an entire economy. Furthermore, the findings can aid governments making relative policies and businesses choosing strategic partners and location strategies.

1 Introduction

A sector's relationships with the rest of the economy through its direct and indirect intermediate purchases and sales are described as the sector's linkages (Miller and Lahr, 2001). The sectors with the highest linkages should be possible to stimulate a more rapid growth of production, income and employment than with alternative allocations of resources. The importance of linkage lies in its tremendous influence on governments, industries and enterprises. Firstly, information on these linkages is essential to understanding the structure of an economy, which is in turn important in formulating industry policies for government (Cai and Leung, 2004). Governments can interfere in a sector by imposing on other sectors, which have high linkages with this sector, and vice versa. Secondly, linkage is one of the most important factors for gaining competitive advantage for industry. For example, the linkage can affect the sector's location

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strategies because the transport cost can be cut, since locating with sectors that have high linkages. A high linkage between a supplier and a buyer may guarantee on time delivery of inputs and the quality of the inputs. Moreover, when a sector successfully enters a foreign market, it will be relatively easy for sectors that have high linkages with this sector to gain access to the foreign market (Hoen, 2002). Thirdly, the linkage can impact the diversity and investment strategies of enterprises and investors, who may prefer to invest in industries that have high linkages with each other to guarantee profits and avoid risks. More importantly, the linkage can indicate a sector's economic pull and push because the direction and level of such linkages present the potential capacity of each sector to stimulate other sectors (Bon, 2000). Hence, a historical perspective of linkages is necessary and helps to better comprehend the relationship of a sector with other economic sectors and the kind of role it has played at different stages of the economic development.

By displaying all flows of goods and services within an economy, the input-output methodology has been considered in the literature as a main tool to determine, define, measure and assess the linkages between sectors (Miller and Blair, 1985; Lean, 2001; Miller and Lahr, 2001). With the linkage measures, two different countries or regions can be compared and the methods may even be used to analyse productivity, technological and energy linkages (Pietroforte and Gregori, 2003; Su *et al*, 2003; Liu and Song, 2005). Measure methods of the linkages rooted in the input-output table may be classified under two main categories, one refers to the traditional method and the other is the hypothetical extraction method (HEM). The traditional methods mainly focus on the calculations of the demand-driven model (Leontief model) developed by Leontief (1936) and the supply–driven model (Ghosh model) proposed by Ghosh (1958).

The real estate sector in the input-output table refers to the flow of services yielded during any period of time by real estate stock, which is playing an important role in the entire economy (Tse, 1994). The linkage measure using the traditional method has a relatively short history within the field of real estate. Liu and Song (2004) measured real estate productivity using the traditional method. Song et al. (2004) compared the linkages between the construction and real estate sectors and Liu et al. (2005) analyzed the linkages of the real estate sector and formulated a set of indicators to compare the linkages of the real estate sector in seven OECD countries. However, the traditional calculation methods are being gradually ignored because they do not capture much of the inherent complexity of an economy (Miller and Lahr, 2001).

On the other hand, linkage measures based on the HEM become increasingly influential (Miller and Lahr, 2001). The HEM has been applied to the agriculture sector (Cai and Leung, 2004), the water sector (Duarte et al., 2002), the construction sector (Song *et al*., 2006a) and some other sectors (Dietzenbacher and Van der Linden, 1997; Yue and Andreosso-O'Callaghan, 2004). Even though the HEM studies have been applied to many sectors, no real estate linkage research uses the HEM to the best of our knowledge. In the literature, only some real estate research using the traditional method can be found (Song and Liu, 2005; Song *et al*., 2005; Song *et al*., 2006b). It is therefore necessary to fill this gap. Using the newest OECD input-output database[1] at constant prices, this research aims to measure and compare the linkages of the real estate

sector using the HEM and explore the role of this sector in national economies and the quantitative interdependence between the real estate sector and the remaining sectors from a new angle. The rest of this paper comprises an introduction of the HEM, a data description, an analysis of the empirical results, testing, discussion and finally the conclusions of the research.

2 Hypothetical extraction method

The original idea of the HEM was to extract a sector hypothetically from an economic system and examine the influence of this extraction on other sectors in the economy (Cella, 1984; Clements, 1990). Mathematically, the idea was to quantify how much an economy's total output would decrease if the sector were extracted. Thus, by comparing the output levels for each of the remaining sectors before and after the hypothetical extraction, the impact of the extracted sector can be assessed. The difference between the output in the reduced case and in the original situation reflects the linkages between the extracted sector and all other sectors in the economy. The linkage can be decomposed into total, backward, forward and internal linkage indicators according to different transformations.

Nevertheless, one main shortcoming exists in the previous HEM research, namely, the internal linkage and sectoral linkages are not investigated well because the method is used only to analyze the linkages between a specific sector and all other sectors. Most of HEM research has focused on the effect of each sector on the economic system as a whole, which is not suited well for answering questions as to how the linkages operate within a sector and between two specific sectors (Hoen, 2002). In this research, using the input-output tables of 36-sectors in seven OECD counties, four extraction structures are adopted to formulate the total, backward, forward and internal linkage indicators according to Miller and Lahr (2001) and one structure is developed further to formulate the sectoral linkage indicator of the real estate sector, which shows the linkage between the real estate sector and a specific sector. Thus, linkages of the real estate sector can be measured from all directions.

2.1 Total linkage indicator

In light of the basic ideal of HEM, it is assumed that the n-sector input–output technical coefficient A has been partitioned into two groups: group one (g_1) is the sectors that are to be extracted from the economy and group two (g_2, $g_1+g_2=n$) consists of all the remaining sectors of the economy. Now, g_1 has been extracted hypothetically from the economy, using the same final demand vector Y, the Leontief model $X=(I-A)^{-1}Y$, and can be rewritten as $X'=(I-A')^{-1}Y$, where X and X' are the output before and after extraction, A is the technical coefficients matrix (n×n) and A' is a reduced technical

[1] The newest OECD database 2002 edition is unpublished publicly and can be obtained on request from OECD.

coefficient matrix ((n − 1)×(n − 1)), i.e. $A' = \begin{bmatrix} 0 & 0 \\ 0 & A_{22} \end{bmatrix}$. The reduction in output can be expressed as $X - X'$, which reflects the linkage between g_1 and g_2, given the technical production process is held constant. Assuming $g_1=1$ and g_1 (sector 1) is hypothetically extracted entirely from the economy, then using the Leontief model, the total linkage (TL), can be expressed as:

$$TL = [\lambda_1 (H - I) + \lambda_2 L_{22} A_{21} H] \times Y_1 + [\lambda_1 H A_{12} L_{22} + \lambda_2 L_{22} A_{21} H A_{12} L_{22}] \times Y_2 \quad (1)$$

where λ_1 and λ_2 are column summation vectors for sector 1 and sector 2 respectively. A_{12}, A_{21} and A_{22} are the partitioned matrixes of the technical coefficient matrix A. H equals $(I - A_{11} - A_{12} L_{22} A_{21})^{-1}$. I denotes the identity matrix. L_{ij} is the ijth element of the Leontief inverse matrix and Y_1 and Y_2 are the final demand of sector 1 and sector 2 respectively. Thus, the total linkage indicator can be obtained as:

$$\text{Total linkage indicator} = \frac{TL}{\lambda X} \times 100\% \quad (2)$$

where λ is a summation column vector.

2.2 Backward linkage indicator

By assuming that sector 1 purchases import goods only to substitute completely for the local inputs, i.e. $A' = \begin{bmatrix} 0 & A_{12} \\ 0 & A_{22} \end{bmatrix}$, the backward linkage ($BL$) can be decided.

$$BL = [\lambda_1 (H - I) + \lambda_2 L_{22} A_{21} H] \times Y_1 + [\lambda_1 (H - I) A_{12} L_{22} + \lambda_2 L_{22} A_{21} H A_{12} L_{22}] \times Y_2 \quad (3)$$

The backward linkage indicator can be obtained as:

$$\text{Backward linkage indicator} = \frac{BL}{\lambda X} \times 100\% \quad (4)$$

2.3 Forward linkage indicator

The measures of forward linkage are based on the extraction of the Ghosh model. The corresponding forward linkage can be similarly obtained. It is assumed that sector 1 is hypothetically extracted, i.e. $A' = \begin{bmatrix} A_{11} & 0 \\ A_{21} & A_{22} \end{bmatrix}$, the forward linkage ($FL$), can be obtained as:

$$FL = V_1 \times [(K - G_{11}) \lambda_1' + K B_{12} G_{22} \lambda_2'] + V_2 \times [G_{22} B_{21} (K - G_{11}) \lambda_1' + G_{22} B_{21} K B_{12} G_{22} \lambda_2'] \quad (5)$$

where λ_1' and λ_2' are row summation vectors for sector 1 and sector 2 respectively. B_{12}, B_{21} and B_{22} are the partitioned matrixes of allocation coefficients matrix B. G_{ij} is the ijth element of the Ghosh inverse matrix. K equals $(I - B_{11} - B_{12} G_{22} B_{21})^{-1}$ and V_1 and V_2 are the value added of sector 1 and sector 2 respectively. The forward linkage indicator can be obtained as:

$$\text{Forward linkage indicator} = \frac{FL}{\lambda' X} \times 100\% \tag{6}$$

where λ' is a summation row vector.

2.4 Internal linkage indicator

The internal linkage indicator reflects the internal effects within a sector. Relative to horizontal linkage, this indicator mirrors the vertical flows among sub-sectors of a sector. Just extracting the internal effect of sector 1, i.e. $A' = \begin{bmatrix} 0 & A_{21} \\ A_{21} & A_{22} \end{bmatrix}$, the internal linkage (*IL*), can be obtained as:

$$IL=[\lambda_1 (H-\theta) +\lambda_2 L_{22} A_{21}(H-\theta)] \times Y_1 + [\lambda_1(H-\theta) A_{12} L_{22}+\lambda_2 L_{22} A_{21}(H-\theta) A_{12} L_{22}] \times Y_2 \tag{7}$$

where $\theta = (I - A_{12} L_{22} A_{21})^{-1}$. So, the internal linkage indicator can be shown as:

$$\text{Internal linkage indicator} = \frac{IL}{\lambda X} \times 100\% \tag{8}$$

2.5 Sectoral linkage indicator

The sectoral linkage indicator represents the linkage between any two sectors. Two questions must be resolved here: one is how to measure this linkage. The other is how to distinguish the directions of the linkage, from sector *i* to sector *j* or from sector *j* to sector *i*.

(1) Sectoral linkage indicators I (from sector i to j)

It is assumed that the *n*–sector input–output technical coefficient matrix *A* has been partitioned into two groups: group 1 ($\hat{g}_1$) and group 2 ($\hat{g}_2$). The symbol $\hat{g}_1$ is a group that consists of two sectors: sector *i* and *j*, which are to be extracted from the economy and sector *i* has relationship with sector *j*. The symbol $\hat{g}_2$ consists of all the remaining sectors of the economy. By extracting $\hat{g}_1$ hypothetically from the economy, the first question mentioned above can be resolved. Theoretically, in the Leontief model, the technical coefficient matrix *A* is also called direct input coefficient matrix. All column elements of the matrix *A* represent the direct input from sector *i* to *j*, that is, the purchases of the *j* sector from the *i* sector per monetary unit. Moreover, all column elements of the total input coefficient matrix *L* represent both direct and indirect flows from sector *i* to *j*, that is, the effect of one monetary unit change in final demand of the *j* sector on total output of the *i* sector. Hence, using the Leontief model to measure the sectoral linkage, the linkage direction (from sector *i* to *j*) can be stated. According to the analysis above, the Leontief model can be shown as

$$\begin{bmatrix} \hat{X}_1 \\ \hat{X}_2 \end{bmatrix} = \begin{bmatrix} \hat{A}_{11} & \hat{A}_{12} \\ \hat{A}_{21} & \hat{A}_{22} \end{bmatrix} \times \begin{bmatrix} \hat{X}_1 \\ \hat{X}_2 \end{bmatrix} + \begin{bmatrix} \hat{Y}_1 \\ \hat{Y}_2 \end{bmatrix} \tag{9}$$

where sub-matrices $\hat{A}_{12}$ and $\hat{A}_{21}$ show the relationships between $\hat{g}_1$ and $\hat{g}_2$ in production. $\hat{A}_{11}$ and $\hat{A}_{22}$ indicate the intra-sectoral connections of $\hat{g}_1$ and $\hat{g}_2$, $\hat{X}_1$ and $\hat{X}_2$ denote the

outputs of $\hat{g}_1$ and $\hat{g}_2$, and $\hat{Y}_1$ and $\hat{Y}_2$ denote the final demand of $\hat{g}_1$ and $\hat{g}_2$ respectively. Now, let $\hat{A}_{11}$= 0, then

$$\begin{bmatrix} \hat{X}'_1 \\ \hat{X}'_2 \end{bmatrix} = \begin{bmatrix} 0 & \hat{A}_{12} \\ \hat{A}_{21} & \hat{A}_{22} \end{bmatrix} \times \begin{bmatrix} \hat{X}'_1 \\ \hat{X}'_2 \end{bmatrix} + \begin{bmatrix} \hat{Y}_1 \\ \hat{Y}_2 \end{bmatrix} \tag{10}$$

The difference between Eq. (10) and (9) can be expressed as

$$\begin{bmatrix} \hat{X}_1 - \hat{X}'_1 \\ \hat{X}_2 - \hat{X}'_2 \end{bmatrix} = \begin{bmatrix} \hat{H} - (I - \hat{A}_{12}\hat{L}_{22}\hat{A}_{21})^{-1} & [\hat{H} - (I - \hat{A}_{12}\hat{L}_{22}\hat{A}_{21})^{-1}]\, \hat{A}_{12}\hat{L}_{22} \\ \hat{L}_{22}\hat{A}_{21}[\hat{H} - (I - \hat{A}_{12}\hat{L}_{22}\hat{A}_{21})^{-1}] & \hat{L}_{22}\hat{A}_{21}[\hat{H} - (I - \hat{A}_{12}\hat{L}_{22}\hat{A}_{21})^{-1}]\, \hat{A}_{12}\hat{L}_{22} \end{bmatrix} \times \begin{bmatrix} \hat{Y}_1 \\ \hat{Y}_2 \end{bmatrix} \tag{11}$$

where $\hat{H} = (\mathrm{I} - \hat{A}_{11} - \hat{A}_{12}\hat{L}_{22}\hat{A}_{21})^{-1}$, and $L_{22} = (I - \hat{A}_{22})^{-1}$. Then the sectoral linkage from sector i to j (SL_{ij}) can be expressed as

$$\begin{aligned} SL_{ij} = {} & [\lambda_1 (\hat{H} - (\mathrm{I} - \hat{A}_{12}\hat{L}_{22}\hat{A}_{21})^{-1} + \lambda_2 \hat{L}_{22}\hat{A}_{21} (\hat{H} - (\mathrm{I} - \hat{A}_{12}\hat{L}_{22}\hat{A}_{21})^{-1})] \times \hat{Y}_1 + \\ & [\lambda_1 (\hat{H} - (\mathrm{I} - \hat{A}_{12}\hat{L}_{22}\hat{A}_{21})^{-1})\, \hat{A}_{12}\hat{L}_{22} + \lambda_2 L_{22}\hat{A}_{21})^{-1})\, \hat{A}_{12}\hat{L}_{22}] \times \hat{Y}_2 \end{aligned} \tag{12}$$

So, the sectoral linkage indicator I (from the sector i to sector j) can be shown as

$$\text{Sectoral linkage indicator I} = \frac{SL_{ij}}{\lambda X} \times 100\% \tag{13}$$

(2) Sectoral linkage indicators II (from sector j to i)

Similarly, using the Ghosh model to measure the sectoral linkage, the linkage direction (from sector j to i) can be confirmed. In the Ghosh model, the allocation coefficient matrix B is also called direct output coefficient matrix. All row elements of the matrix B represent the direct output from sector j to sector i, that is, the sales of the j sector to the i sector per monetary unit. Moreover, all row elements of the total output coefficient matrix G represent both direct and indirect flows from sector j to i, that is, the effect of one monetary unit change in value added of the i sector on total output of the j sector. So, the Ghosh model can be expressed as:

$$[\hat{X}_1 \;\; \hat{X}_2] = [\hat{X}_1 \;\; \hat{X}_2] \times \begin{bmatrix} \hat{B}_{11} & \hat{B}_{12} \\ \hat{B}_{21} & \hat{B}_{22} \end{bmatrix} + [\hat{V}_1 \;\; \hat{V}_2] \tag{14}$$

where, $\hat{V}_1$ and $\hat{V}_2$ denote the value added of $\hat{g}_1$ and $\hat{g}_2$ respectively.

From the supply-side model, it is assumed that $\hat{g}_1$ is hypothetically extracted, so let $\hat{B}_{11}$ = 0. Thus, Eq. (14) can be rewritten as:

$$[\hat{X}'_1 \;\; \hat{X}'_2] = [\hat{X}'_1 \;\; \hat{X}'_2] \times \begin{bmatrix} 0 & \hat{B}_{12} \\ \hat{B}_{21} & \hat{B}_{22} \end{bmatrix} + [\hat{V}_1 \;\; \hat{V}_2] \tag{15}$$

The difference between Eq. (15) and Eq. (14) can be shown as:

$$[\hat{X}_1 - \hat{X}'_1 \;\; \hat{X}_2 - \hat{X}'_2] = [\hat{V}_1 \;\; \hat{V}_2] \times \begin{bmatrix} \hat{K} - (I - \hat{B}_{12}G_{22}\hat{B}_{21})^{-1} & [\hat{K} - (I - \hat{B}_{12}G_{22}\hat{B}_{21})^{-1}]\, \hat{B}_{12}G_{22} \\ \hat{G}_{22}\hat{B}_{21}[\hat{K} - (I - \hat{B}_{12}G_{22}\hat{B}_{21})^{-1}] & \hat{G}_{22}\hat{B}_{21}[\hat{K} - (I - \hat{B}_{12}G_{22}\hat{B}_{21})^{-1}]\, \hat{B}_{12}G_{22} \end{bmatrix} \tag{16}$$

where $\hat{K} - (I - \hat{B}_{11} - \hat{B}_{12}G_{22}\hat{B}_{21})^{-1}$, $\hat{G}_{11} = (I - \hat{B}_{11})^{-1}$ and $\hat{G}_{22} = (I - \hat{B}_{22})^{-1}$. Consequently, the sectoral linkage from sector j to i (SL_{ji}) can be expressed as

$$SL_{ji} = \hat{V}_1 \times [(\hat{K}-(I-\hat{B}_{12}G_{22}\hat{B}_{21})^{-1}\lambda'_1 + (\hat{K}-(I-\hat{B}_{12}G_{22}\hat{B}_{21})^{-1})\hat{B}_{12}\hat{G}_{22}\lambda'_2]$$
$$+ \hat{V}_2 [\hat{G}_{22}\hat{B}_{21}(\hat{K}-(I-\hat{B}_{12}G_{22}\hat{B}_{21})^{-1})\lambda'_1 + \hat{G}_{22}\hat{B}_{21}(\hat{K}-(I-\hat{B}_{12}G_{22}\hat{B}_{21})^{-1})\hat{B}_{12}\hat{G}_{22}\lambda'_2] \quad (17)$$

So, the sectoral linkage indicator II (from the sector j to sector i) can be shown as

$$\text{Sectoral linkage indicator II} = \frac{SL_{ij}}{\lambda' X} \times 100\% \quad (18)$$

3 Date description

The OECD input-output database, which is published by the Economic Analysis and Statistics Division of the OECD, is a very useful empirical tool for economic research and structural analysis at international level (OECD, 2004). Moreover, this is the most comprehensive database for comparing the real estate and construction sectors internationally so far (Pietroforte and Gregori, 2003; Liu and Song, 2005). The early edition of OECD input output database (1995 edition) covered ten highly developed countries (Australia, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, United Kingdom, and United States), five year points from the early 1970s through to the early 1990s. These were produced using an earlier system of national accounts (SNA68) and industrial classification system (ISIC Revision 2), including 36 sectors. The newest edition (2002 edition) is unpublished publicly and can be obtained on request from OECD and covered one or more years around the mid/late 1990s for eighteen OECD countries (Australia, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Japan, Korea, Netherlands, Norway, Poland, Spain, United Kingdom) and two non-member OECD countries (Brazil and China). The tables are based on ISIC Revision 3 industrial classifications, including 42 sectors.

Based on the 1995 edition database, the 2002 edition database has been aggregated into 36 sectors in order to facilitate comparisons over time in this study. The 36 sectors used in the OECD input-output table are shown in Appendix 1. For the same reason, the countries which are not involving in the 1995 edition database are ignored. Moreover, due to limited comparable and available data in the real estate sector, Germany, Italy and United Kingdom are not considered. The data of France are unavailable before the early 1980s. The data from Australia are unavailable before mid-1980s and the data from Netherlands is not available in the early-1990s. In addition, the examined period is divided into six comparative periods as shown in Appendix 2: early-1970s (1968–1972), mid/late-1970s (1975–1978), early-1980s (1980–1982), mid-1980s (1985–1986), early-1990s (1989–1990) and mid/late-1990s (1995–1998).

4 Empirical results

Assuming that the real estate sector has been extracted hypothetically from the economic system, the total, backward, forward, internal and sectoral linkages of the real

estate sector are calculated, analyzed and compared in sequence. Thus, the importance of the real estate sector and the quantities relationship between the real estate sector and other sectors can be measured. The developing trends of the real estate sector in different countries can be compared. Based on a good understanding on these linkages, government and businesses can develop their policies and strategies and create a favorable competitive position in the modern economy.

4.1 Total linkage indicators of the real estate sector

Total linkage indicator is one comprehensive measure of the real estate sector's importance to the economy because all connections (forward, backward and internal effects) have been extracted completely. With the "disappearance" of the real estate sector, the remaining sectors in the economy would have to purchase real estate service from overseas and the real estate sector's final demand would have to be satisfied by imports as well. The difference between the outputs before and after the extraction just reflects the importance of the real estate sector. In other words, the total linkage indicator is an integration of the forward, backward and internal effects. The total linkage indicators of the real estate sector for the seven selected countries are generated from Eq. (2) and reported in Table 1, which shows the changes of the total real estate linkage relative to each national economy.

Table 1: Total linkage indicators and ranks of real estate in each country

		Early–1970s	Mid/Late–1970s	Early–1980s	Mid–1980s	Early–1990s	Mid/Late–1990s
Australia	Linkage	N/A	N/A	N/A	6.73%	7.26%	5.96%
	Rank	N/A	N/A	N/A	2	2	6
Canada	Linkage	2.05%	2.33%	3.13%	3.36%	3.99%	5.92%
	Rank	20	19	14	13	13	7
Denmark	Linkage	4.11%	4.81%	5.31%	6.00%	6.82%	8.71%
	Rank	10	9	9	6	5	3
France	Linkage	N/A	N/A	6.75%	7.22%	9.95%	8.82%
	Rank	N/A	N/A	3	1	1	1
Japan	Linkage	4.17%	5.39%	5.26%	5.46%	6.36%	4.69%
	Rank	12	8	9	5	4	3
Netherlands	Linkage	1.86%	2.56%	2.85%	3.21%	N/A	3.34%
	Rank	18	18	16	13	N/A	25
USA	Linkage	5.40%	5.28%	5.79%	6.38%	7.09%	7.53%
	Rank	2	4	2	1	1	1
Average		3.52%	4.08%	4.85%	5.48%	6.91%	6.42%

The total linkage indicators show two distinct groups of countries: Netherlands and Canada with a lower total linkage indicator and the remaining countries with higher ones. In economic development, the real estate sector seems to play a more important role in Australia, Denmark, France, Japan and USA than in Netherlands and Canada. It can be observed that the average values tend to increase over the examined period. In

the 1990s the pace of increase is significant in most of the countries. The reason may be due to the increase in the price of real estate in these countries. However, it has to be noted that the volumes of real estate service are still underestimated because some private brokage are only partially captured by official statistics.

According to Eq. (2), the total linkages of 36 sectors are calculated and ranked for all seven countries, and the rankings of the real estate sector of these countries are reported in Table 1. Except for Canada and Netherlands and Japan, all values of the total linkage of the real estate sector are ranked in the top ten over the examined period. Specifically, the values ranked France and USA in the top five over the whole examined period. Moreover, a trend of increase in the rankings is apparent and all rankings are increasing between the initial and final stages of the examined period. The ranking differences may be contributed by different industrial structures, relative prices, technology changes and government policies in different countries.

4.2 Backward linkage indicators of the real estate sector

Assuming that all local product inputs of the real estate sector are extracted and all inputs will depend on imports (the forward and internal effects will remain), the backward linkage of a sector reflects this sector's dependence on local inputs that are produced within the production process of the economy. A weak backward linkage suggests a strong sectoral independence. On the other hand, a lower value represents a weak economic pull of the real estate sector to the remaining sectors. The backward linkage induces growth through the process of derived demand because the remaining sectors would have to face the losses without the purchase of the real estate sector. More importantly, the backward linkage indicator is a measure of the degree of industrialization of the real estate production process and the national technology difference in terms of intermediate and valued added inputs composition (Pietroforte and Gregori, 2003), because it is generally agreed that input–output tables reflect a general equilibrium model of the economy where inputs are allocated according to technological availability.

The backward linkage indicators of the real estate sector for the seven selected countries are calculated from Eq. (4) and presented in Table 2. The values are scattered at a low value between 0.5% and 4% over the examined period. The low backward linkage indicator suggests a strong sectoral independence and a weak economic pull of real estate. The relatively lower value is reasonable for the real estate sector because this sector plays a fundamental connecting role in the value chain (Roulac, 1999). Moreover, with a lower backward linkage indicator, the real estate sector represents low industrialization and technology levels. However, a slightly upward trend over the entire study period can be seen. In any industry, the progress of technology cannot be stopped. Compared with Canada and Netherlands, the Australian, Danish, French, Japanese and American real estate sectors show relatively weak economic independences, strong pull effects to the remaining sectors of the economy and higher technology levels.

Like the total linkages, the backward linkage ranks of the real estate sector are listed in Table 2. Except for Australia and USA, most of countries have a relative lower ranking. However, most of ranks have experienced a significant rise except for Austra-

lia and Netherlands. For example the rankings of Canada, Denmark, France and Japan rose from 25 to 16, 11 to 4, 9 to 5 and from 14 to 6 respectively between the initial and final stages of the examined period. The increasing trend represents a decreasing sectoral independence of the real estate sector and means the real estate sector needs support more and more from other sectors. On the other hand, it means that the real estate sector's ability to pull the rest of the economy was increasing over the examined period.

Table 2: Backward linkage indicators and ranks of real estate in each country

		Early–1970s	Mid/Late–1970s	Early–1980s	Mid–1980s	Early–1990s	Mid/Late–1990s
Australia	Linkage	N/A	N/A	N/A	3.50%	3.17%	3.04%
	Rank	N/A	N/A	N/A	4	5	5
Canada	Linkage	0.80%	0.78%	0.95%	1.08%	1.31%	2.35%
	Rank	25	23	23	21	21	16
Denmark	Linkage	2.39%	2.91%	3.13%	3.39%	3.64%	3.90%
	Rank	11	10	8	7	7	4
France	Linkage	N/A	N/A	2.59%	2.87%	4.05%	2.84%
	Rank	N/A	N/A	9	6	3	5
Japan	Linkage	2.24%	2.57%	2.53%	2.51%	3.16%	2.02%
	Rank	14	10	11	6	6	6
Netherlands	Linkage	0.90%	1.22%	1.29%	1.33%	N/A	2.11%
	Rank	20	17	15	17	N/A	23
USA	Linkage	2.08%	2.04%	1.95%	2.44%	2.60%	2.48%
	Rank	6	8	8	5	5	5
Average		1.68%	1.90%	2.07%	2.45%	2.99%	2.68%

4.3 Forward linkage indicators of the real estate sector

Assuming that the real estate sector just sells for export, except for deliveries to itself, the difference between the outputs in the reduced case and in the original situation reflects the economic losses of the remaining sectors of the economy without the supply of the local real estate sector. The forward linkage of a sector reflects the dependence of the remaining sectors in the economy on this sector's supplies that are produced within the production process. The forward linkage indicators of the real estate sector for the seven selected countries are calculated from Eq. (6) and depicted in Table 3.

The value of the forward linkage indicators are stabilising at a higher value compared with the backward linkage. A strong forward linkage shows a weak sectoral independence and a strong economic push of the real estate sector. Moreover, the value of the indicator reflects that the proportion of final demand of the real estate sector is larger than its intermediate demand in most selected countries. The main reason seems to be that real estate has a major role in creating demand and attracting the buyer to the distribution system. The arithmetic means of the forward linkage indicators divides these countries into two distinct groups of countries: Denmark, Canada and Nether-

lands, with a lower forward linkage indicator and the remaining countries with higher ones. These differences can be explained in terms of the level of the intermediate demand in different countries. In Denmark, Canada and the Netherlands, the economic push of real estate was weaker with a lower level of intermediate demand over the study period. The reason seems to be most of the output of real estate flows into final demand, that is, private domestic consumption and government consumption. For Australia, France, Japan and USA, the proportion between intermediate demand and final demand tends to be equal. These countries' push strength to economic growth was relatively stronger.

Table 3 Forward linkage indicators and ranks of real estate in each country

		Early–1970s	Mid/Late–1970s	Early–1980s	Mid–1980s	Early–1990s	Mid/Late–1990s
Australia	Linkage	N/A	N/A	N/A	4.75%	5.56%	3.13%
	Rank	N/A	N/A	N/A	1	1	5
Canada	Linkage	1.68%	2.08%	2.87%	2.89%	3.50%	4.26%
	Rank	14	12	7	7	6	3
Denmark	Linkage	2.34%	2.57%	3.00%	3.49%	4.09%	5.80%
	Rank	8	8	7	3	3	1
France	Linkage	N/A	N/A	5.73%	5.93%	7.89%	5.93%
	Rank	N/A	N/A	1	1	1	1
Japan	Linkage	3.64%	5.23%	5.13%	5.19%	5.20%	4.05%
	Rank	7	4	4	1	1	2
Netherlands	Linkage	1.20%	1.61%	1.93%	2.20%	N/A	1.49%
	Rank	13	10	9	7	N/A	16
USA	Linkage	5.21%	4.99%	5.92%	4.51%	5.94%	6.56%
	Rank	2	2	1	1	1	1
Average		2.81%	3.30%	4.10%	4.14%	5.37%	4.46%

The forward linkage indicator's rankings of the real estate sector for these countries are also presented in Table 3. The forward linkages have the highest ranking compared with the backward linkages. It seems that the higher rankings in the forward linkage are the main reasons for the higher rankings in the total linkage. Except for Canada and Netherlands in the early-1970s and the mid/late-1970s, all values of the forward linkage of the real estate sector were ranked in the top ten. Especially, the values ranked Denmark, France and USA first in the mid/late-1990s. Compared with the backward linkage indicators, the higher rankings reflect the strength of the push to economic growth is larger than that of the pull in the real estate sector. It also demonstrates that developing a national economy by promoting the real estate industry is not as effective as developing real estate through promoting the national economy (Liu et al., 2005).

4.4 Internal linkage indicators of the real estate sector

Assuming that the real estate sector's intra-sectoral shipments are eliminated, the internal linkage of a sector reflects the interrelationship of sub-sectors. According to Eq. (8), the internal linkage indicators are described in Table 4, which displays three characteristics. Firstly, the real estate sectors have low internal linkage indicators, which are all under 1.6% relative to the entire economy. The real estate sector is usually divided into two sub-sectors, namely residential and commercial real estate services. The residential real estate sub-sector supplies living accommodation for the commercial subsector, whereas the commercial sub-sector supplies few services for the residential real estate sub-sector. The relationships between these two sectors are relatively loose with a lower internal linkage indicator.

Secondly, all values present an increasing pattern, which may be due to increasing prices over the examined period. Thirdly, the differences among countries are enormous. For example, France had an extremely high value whereas Netherlands had a very low value. The differences may be attributed to different economic development levels, relative prices and government policies in different countries. The relative prices and government policies differences in different economic developing stages definitely affects the interflow between the residential and commercial real estate sub-sectors. Obviously, the internal flows between the sub-sectors are weak even relative to this sector in seven countries. However, in some developing countries, the internal linkage indicator may be higher than in developed countries. One reason is the dramatically increasing commercial real estate market in developing countries may need more residential services than in developed countries. As expected, the internal linkages have a low ranking as reported in Table 4. Compared with other sectors, the low ranking just reflects the industry characteristics of the real estate sector in developed countries.

Table 4: Internal linkage indicators and ranks of real estate in each country

		Early–1970s	Mid/Late–1970s	Early–1980s	Mid–1980s	Early–1990s	Mid/Late–1990s
Australia	Linkage	N/A	N/A	N/A	0.48%	0.75%	1.46%
	Rank	N/A	N/A	N/A	9	6	1
Canada	Linkage	0.12%	0.16%	0.22%	0.25%	0.32%	0.38%
	Rank	25	22	17	17	17	17
Denmark	Linkage	0.15%	0.21%	0.27%	0.49%	0.63%	0.68%
	Rank	20	18	15	11	11	9
France	Linkage	N/A	N/A	0.96%	1.02%	1.58%	2.00%
	Rank	N/A	N/A	9	8	4	1
Japan	Linkage	0.13%	0.56%	0.29%	0.48%	0.58%	0.33%
	Rank	23	11	17	12	12	13
Netherlands	Linkage	0.03%	0.04%	0.05%	0.06%	N/A	0.08%
	Rank	27	27	28	29	N/A	34
USA	Linkage	0.68%	0.61%	0.75%	0.97%	1.07%	1.24%
	Rank	8	8	8	3	2	3
Average		0.22%	0.32%	0.42%	0.54%	0.82%	0.88%

4.5 Sectoral linkage indicator between the real estate and construction sector

Assuming that the flows between the real estate sector and a specific sector are eliminated, the sectoral linkage indicator reflects the interrelationship of the real estate sector and the specific sector in an economy. The real estate sector has a very tight relationship with the construction sector. The construction sectors mainly consist of new construction and maintenance and repair construction, whereas real estate plays a fundamental connecting role in the value chain (Roulac 1999). The real estate sectors provide services for the construction sectors. Accordingly, most of intermediate goods and services produced by the maintenance and repair construction sub-sector pour into the real estate sector (Bon 2000). The construction sector is not only the supplier but also the user of the real estate sector in the whole value chain. Moreover, both the construction and real estate sectors have been considered vital productive drivers for the economic development. As one of the largest consumers of the construction sector, the inter-sectoral flows between real estate and construction sectors are varied and complex and it is difficult to determine the quantitative relationships between them in modern economics. Considering the directions, the sectoral linkage indicator can be divided into two groups: one is the linkage from the construction sector to the real estate sector, which is calculated from Eq. (13) and described in Table 5. The other is the linkage from the real estate sector to the construction sector, which is from Eq. (18) and illustrated in Table 6.

Table 5: Sectoral linkage indicator I from construction to real estate in each country

		Early–1970s	Mid/Late–1970s	Early–1980s	Mid–1980s	Early–1990s	Mid/Late–1990s
Australia	Linkage	N/A	N/A	N/A	1.02%	1.09%	2.05%
	Rank	N/A	N/A	N/A	12	17	14
Canada	Linkage	0.70%	0.85%	1.38%	1.11%	1.20%	1.30%
	Rank	13	7	6	8	7	13
Denmark	Linkage	1.57%	1.91%	2.03%	2.34%	2.52%	2.78%
	Rank	5	4	3	3	1	3
France	Linkage	N/A	N/A	1.84%	1.78%	2.65%	3.55%
	Rank	N/A	N/A	11	10	8	5
Japan	Linkage	1.05%	1.56%	1.14%	1.30%	1.46%	1.08%
	Rank	8	5	9	10	11	10
Netherlands	Linkage	2.13%	2.26%	2.18%	2.18%	N/A	3.98%
	Rank	2	2	3	3	N/A	2
USA	Linkage	1.50%	1.49%	1.54%	1.75%	1.93%	2.16%
	Rank	8	9	10	11	8	4
Average		1.39%	1.62%	1.68%	1.64%	1.81%	2.41%

As expected, the linkages from construction to real estate are larger than that from real estate to construction. The real estate sector supplies various kinds of services for the construction sector, such as brokerage, plant location, layout and lease, procurement

decisions, and so on. One of the main assignments of the real estate sector is to make decisions for plant location of construction businesses concerning the country, region, submarket and site. Another is the size of facility, layout, lease or buy decision and brokerage. What is more, the real estate sector also influences construction manufacture access including the location of the manufacturer's showrooms, access to displays of construction merchandise, and catalogues. Generally, the real estate sector as supplier just plays a service delivery role in the value chain of the construction sector. On the other hand, the construction sector is the one of largest suppliers for real estate and most intermediate goods and services produced by the maintenance and repair construction sub–sector go to the real estate sector. This explains why linkages from construction to real estate are larger than that from real estate to construction.

According to the input and output directions of the real estate sector, all sectoral linkages from the other sectors to the real estate sector and from the real estate to the other sectors are calculated and ranked respectively. The rankings of the sectoral linkage between the real estate and construction sectors are also reported in Tables 5 and 6. The sectoral linkage from construction to real estate has a higher ranking than that from real estate to construction. This just reflects that construction contributes more to real estate. However, it can be stated that the economic development in a developed country has been characterized by two main trends: the decreasing economic importance of the construction industry and the progressively increasing services of the real estate sector. Interestingly, the two main trends are just reflected by the rankings of the sectoral linkage indicators in Tables 5 and 6. All rankings of the sectoral linkage indicator II (from real estate to construction) showed an increasing pattern (Australia, Canada, Denmark, France and USA were increasing and Japan and Netherlands kept constant), whereas, only three countries had an increasing ranking of the sectoral linkage indicator I (from construction to real estate).

Table 6: Sectoral linkage indicator II from real estate to construction in each country

		Early–1970s	Mid/Late–1970s	Early–1980s	Mid–1980s	Early–1990s	Mid/Late–1990s
Australia	Linkage	N/A	N/A	N/A	1.07%	1.26%	1.39%
	Rank	N/A	N/A	N/A	15	21	13
Canada	Linkage	0.54%	0.72%	1.16%	0.98%	1.11%	0.94%
	Rank	14	10	6	9	12	8
Denmark	Linkage	1.24%	1.45%	1.62%	1.97%	2.23%	1.75%
	Rank	7	4	4	5	4	4
France	Linkage	N/A	N/A	1.85%	1.79%	2.61%	2.52%
	Rank	N/A	N/A	12	13	11	5
Japan	Linkage	0.90%	1.65%	1.12%	1.37%	1.44%	0.84%
	Rank	9	8	10	10	14	9
Netherlands	Linkage	1.49%	1.54%	1.48%	1.51%	N/A	1.19%
	Rank	3	4	3	4	N/A	3
USA	Linkage	1.82%	1.74%	1.95%	1.55%	2.46%	2.11%
	Rank	11	11	12	11	11	7
Average		1.20%	1.42%	1.53%	1.46%	1.85%	1.53%

According to the data of the early-1990s, a detailed ranking of the sectoral linkage indicators I and II are reported in Appendixes 3 and 4 respectively, which present the rankings of the sectoral linkages both from other sectors to real estate and from real estate to other sectors. As can be seen, in different countries, the rankings of the sectoral linkage indicators vary in the early-1990s. For example, in Australia, the sectoral linkages between the wholesale and retail trade and real estate sectors are ranked first. However, in France, the sectoral linkages between the finance and insurance and real estate sectors are ranked first. In fact, the interrelationship between the real estate sector and other sectors is determined by the characteristics of real estate in different countries. Based on the rankings of the sectoral linkage indicators I and II in the early-1990s, all relative sectors are re-ranked based on the average rankings of every sector. The top ten sectors that have the highest average sectoral linkage with the real estate sector are reported in Table 7. As can be seen, the top ten sectors that have the sectoral linkage with the real estate sector are by and large similar. To some extent this means the constituents of the input/output of real estate are analogous. The finance and insurance, manufacturing, transport and storage, wholesale and retail trade and construction sectors are the main suppliers and users of the real estate sector. Except for the community, social and personal service sectors, the remaining sectors in the national economy are easily affected by the real estate sector, and these sectors have a significant effect on the real estate sector as well for all selected countries. The intrinsic characteristic of linkages can aid the governments in formulating industry policies and businesses in choosing strategic partners and location strategies. Governments can interfere in the real estate sector by imposing on other sectors, which have high linkages with it, and vice versa. The businesses can cut their costs, improve productivities by adopting appropriate integrative and location strategies, and therefore gain competitive advantage.

Table 7: Re-ranked sectors of the sectoral linkage indicators I and II in the early-1990s

	Sectoral linkage indicator I		Sectoral linkage indicator II	
Rank	**Sector No.**	**Sector**	**Sector No.**	**Sector**
1	31	Finance and insurance	7*	Industrial chemicals
2	7*	Industrial chemicals	3*	Food, beverages and tobacco
3	6*	Paper, paper products and printing	31	Finance and insurance
4	29	Transport and storage	6*	Paper, paper products and printing
5	27	Wholesale and retail trade	4*	Textiles, apparel and leather
6	3*	Food, beverages and tobacco	21*	Motor vehicles
7	26	Construction	29	Transport and storage
8	1	Agriculture, forestry and fishery	27	Wholesale and retail trade
9	33	Community, social and personal service	1	Agriculture, forestry and fishery
10	12*	Iron and steel	26	Construction

* *Sectors 3 to 24 are categorized into the manufacturing sector according to the OECD classification.*

Table 8: Descriptive statistics of the real estate linkages

Linkages	Periods	N	Range	Minimum	Maximum	Mean	Std. Deviation
Total	Early–1970s	5	0.0354	0.0186	0.0540	0.0352	0.0152
linkage	Mid/Late–1970s	5	0.0306	0.0233	0.0539	0.0408	0.0151
indicator	Early–1980s	6	0.0390	0.0285	0.0675	0.0485	0.0154
	Mid–1980s	7	0.0401	0.0321	0.0722	0.0548	0.0160
	Early–1990s	6	0.0596	0.0399	0.0995	0.0691	0.0191
	Mid/Late–1990s	7	0.0548	0.0334	0.0882	0.0642	0.0205
Backward	Early–1970s	5	0.0160	0.0080	0.0239	0.0168	0.0077
linkage	Mid/Late–1970s	5	0.0213	0.0078	0.0291	0.0190	0.0089
indicator	Early–1980s	6	0.0219	0.0095	0.0313	0.0207	0.0084
	Mid–1980s	7	0.0242	0.0108	0.0350	0.0245	0.0094
	Early–1990s	6	0.0274	0.0131	0.0405	0.0299	0.0096
	Mid/Late–1990s	7	0.0188	0.0202	0.0390	0.0268	0.0065
Forward	Early–1970s	5	0.0401	0.0120	0.0521	0.0281	0.0162
linkage	Mid/Late–1970s	5	0.0362	0.0161	0.0523	0.0330	0.0169
indicator	Early–1980s	6	0.0399	0.0193	0.0592	0.0410	0.0170
	Mid–1980s	7	0.0373	0.0220	0.0593	0.0414	0.0133
	Early–1990s	6	0.0438	0.0350	0.0789	0.0537	0.0154
	Mid/Late–1990s	7	0.0507	0.0149	0.0656	0.0446	0.0179
Internal	Early–1970s	5	0.0065	0.0003	0.0068	0.0022	0.0026
linkage	Mid/Late–1970s	5	0.0057	0.0004	0.0061	0.0032	0.0025
indicator	Early–1980s	6	0.0091	0.0005	0.0096	0.0042	0.0035
	Mid–1980s	7	0.0096	0.0006	0.0102	0.0054	0.0035
	Early–1990s	6	0.0126	0.0032	0.0158	0.0082	0.0045
	Mid/Late–1990s	7	0.0192	0.0008	0.0200	0.0088	0.0070
Sectoral	Early–1970s	5	0.0143	0.0070	0.0213	0.0139	0.0054
linkage	Mid/Late–1970s	5	0.0141	0.0085	0.0226	0.0162	0.0052
indicator I	Early–1980s	6	0.0105	0.0114	0.0218	0.0168	0.0040
	Mid–1980s	7	0.0131	0.0102	0.0234	0.0164	0.0051
	Early–1990s	6	0.0156	0.0109	0.0265	0.0181	0.0067
	Mid/Late–1990s	7	0.0290	0.0108	0.0398	0.0241	0.0109
sectoral	Early–1970s	5	0.0127	0.0054	0.0182	0.0120	0.0050
linkage	Mid/Late–1970s	5	0.0102	0.0072	0.0174	0.0142	0.0041
indicator II	Early–1980s	6	0.0083	0.0112	0.0195	0.0153	0.0034
	Mid–1980s	7	0.0099	0.0098	0.0197	0.0146	0.0036
	Early–1990s	6	0.0150	0.0111	0.0261	0.0185	0.0066
	Mid/Late–1990s	7	0.0168	0.0084	0.0252	0.0153	0.0062

5 statistical testing

The linkage characteristics are worthy to be tested statistically. A descriptive statistic is conducted over the examined period. Table 8 reports the sample numbers, ranges, minimum and maximum values, mean, and standard deviations of the linkages respectively. As expected, all mean of linkages show an increasing trend, which confirms the increasing role of the real estate sector with economic maturity in all selected country over the examined period. Furthermore, in order to investigate the consistency of all

linkage indicators of the real estate sector among all selected countries over the examined period, the Spearman Rank Correlation Coefficient (*Rs*) is used to test if there are any notable differences in rankings of total, backward, forward, internal and sectoral indicators among all selected countries.

These indicators are ranked according to the studying periods respectively and the *Rs* of every two periods are worked out. If the *Rs* is significant at the level of *probability*<0.05, the consistency of these linkages between the two periods being compared is evidenced. A two-tailed test is adopted due to the small sample. As seen in Table 9, the significant rank correlations imply that the economic pull and push and internal effects of real estate keep constant amongst the seven OECD countries. In other words, the importance of real estate remained fairly stable among highly developed economies over the examined period. This may supply a tool to signal the maturity of an entire economy.

Table 9: Spearman rank correlation coefficients

	Early–1970s	Mid/Late–1970s	Early–1980s	Mid–1980s	Early–1990s	Mid/Late–1990s
Early–1970s	1.000					
Mid/Late–1970s	.974(**)	1.000				
Early–1980s	.963(**)	.957(**)	1.000			
Mid–1980s	.962(**)	.967(**)	.982(**)	1.000		
Early–1990s	.979(**)	.972(**)	.970(**)	.979(**)	1.000	
Mid/Late–1990s	.842(**)	.818(**)	.857(**)	.826(**)	.825(**)	1.000

** *Correlation is significant at the 0.01 level (2–tailed).*

6 Conclusions

This research has measured and compared the linkages of the real estate sector using the hypothetical extraction method based on the OECD input-output database. Four extraction structures are adopted to formulate the total, backward, forward and internal linkage indicators. One structure is developed further to formulate the sectoral linkage indicator of the real estate sector, which indicates the linkage between the real estate and construction sectors.

Empirical results show an increasing trend of these linkages in real estate, which confirms the increasing role of the real estate sector with economic maturity over the examined period. In economic development, the real estate sector seems to play a more important role in Australia, Denmark, France, Japan and USA than in Netherlands and Canada.

The backward linkage indicators are scattered at a low value, which suggests a strong sectoral independence and a weak economic pull of the real estate sector to the remaining sectors. The forward linkage indicators are stabilising at a higher value, which show a weak sectoral independence and a strong economic push of real estate. What is more, a low internal linkage indicator means the relationships between these two sectors are relatively loose and the sectoral linkage indicators from construction to

real estate are larger than that from real estate to construction. The intrinsic characteristic of linkages can aid the governments in formulating industry policies and businesses in choosing strategic partners and location strategies. Governments can interfere in the real estate sector by imposing on other sectors, which have high linkages with it, and vice versa. The businesses can cut their costs, improve productivities by adopting appropriate integrative and location strategies, and therefore gain competitive advantage. Moreover, the significant rank correlations in the linkages imply that the importance of real estate remained fairly stable among highly developed economies over the examined period. This may supply a tool to signal the maturity of an entire economy.

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Appendix 1: OECD sectoral classification

No.	Sector
1	Agriculture, forestry and fishery
2	Mining and quarrying
3	Food, beverages and tobacco
4	Textiles, apparel and leather
5	Wood products and furniture
6	Paper, paper products and printing
7	Industrial chemicals
8	Drugs and medicines
9	Petroleum and coal products
10	Rubber and plastic products
11	Non–metallic mineral products
12	Iron and steel
13	Non–ferrous metals
14	Metal products
15	Non–electrical machinery
16	Office and computing machinery
17	Electric apparatus
18	Radio, TV and communication equipment
19	Shipbuilding and repairing
20	Other transport
21	Motor vehicles
22	Aircraft
23	Professional goods
24	Other manufacturing
25	Electricity, gas and water
26	Construction
27	Wholesale and retail trade
28	Restaurants and hotels
29	Transport and storage
30	Communication
31	Finance and insurance
32	Real estate and business services
33	Community, social and personal service
34	Producers of government services
35	Other producers
36	Statistical discrepancy

(*Source: OECD, 1995*)

Appendix 2: OECD input–output table coverage

	Early −1970s	Mid/Late −1970s	Early −1980s	Mid −1980s	Early −1990s	Mid/Late −1990s
Australia	N/A	N/A	N/A	1986	1989	1995
Canada	1971	1976	1981	1986	1990	1997
Denmark	1972	1977	1980	1985	1990	1997
France	N/A	N/A	1980	1985	1990	1995
Japan	1970	1975	1980	1985	1990	1997
Netherlands	1972	1977	1981	1986	N/A	1998
USA	1972	1977	1982	1985	1990	1997

(*Source: OECD, 1995*)

Appendix 3: Ranks of the sectoral linkage indicator I (from other sectors to real estate) in the early–1990s

Sector No.	Australia 1989	Canada 1990	Denmark 1990	France 1990	Japan 1990	Netherlands 1986	USA 1990
1	11	5	7	7	16	8	6
2	8	19	21	3	25	13	9
3*	9	9	3	9	12	1	11
4*	19	11	13	18	17	9	22
5*	16	17	14	26	21	14	23
6*	6	21	2	2	4	4	5
7*	4	4	5	4	2	2	4
8*	34	32	30	33	33	26	29
9*	22	25	11	20	19	19	19
10*	20	27	19	19	13	17	25
11*	21	26	33	34	34	20	34
12*	10	13	18	10	1	7	15
13*	15	14	22	12	10	32	16
14*	13	15	9	13	22	15	24
15*	25	16	8	21	14	11	20
16*	32	18	32	23	23	23	17
17*	24	23	17	24	15	6	26
18*	18	10	20	17	8	33	13
19*	31	33	24	28	30	24	32
20*	30	28	26	29	29	30	31
21*	14	2	28	14	5	18	10
22*	28	22	34	25	31	22	21
23*	26	30	27	32	27	29	27
24*	27	31	25	27	26	28	28
25	3	24	15	16	18	21	12
26	17	7	1	8	11	3	8
27	1	8	12	6	7	12	2
28	23	29	23	22	20	27	14
29	5	3	4	5	6	16	7
30	12	20	16	15	24	25	18
31	2	1	6	1	3	5	1
33	7	12	10	11	9	10	3
34	29	34	29	30	32	31	30
35	33	6	31	31	28	34	33
36**	–	–	–	–	–	–	–

* *Sectors 3 to 24 are categorized into the manufacturing sector according to the OECD classification.*

** *Sector 36 (the statistical discrepancy sector) is not involved in the rankings.*

Appendix 4: Ranks of the sectoral linkage indicator II (from real estate to other sectors) in the early-1990s

Sector No.	Australia 1989	Canada 1990	Denmark 1990	France 1990	Japan 1990	Netherlands 1986	USA 1990
1	14	8	9	8	18	11	8
2	13	22	30	4	32	19	14
3*	4	5	1	5	7	1	7
4*	7	10	6	9	11	5	10
5*	16	19	11	22	19	12	21
6*	8	6	3	3	6	6	5
7*	5	4	2	2	3	2	6
8*	23	29	22	27	31	23	28
9*	25	25	12	25	23	18	22
10*	20	24	19	23	16	17	26
11*	22	26	23	34	24	22	31
12*	12	16	21	13	2	8	20
13*	17	13	27	12	13	33	17
14*	15	17	8	14	20	14	24
15*	24	14	7	17	10	10	18
16*	34	7	34	18	17	21	16
17*	19	20	15	24	15	3	25
18*	11	3	16	15	5	34	12
19*	32	33	24	30	33	25	33
20*	31	27	17	29	27	27	30
21*	9	1	32	6	1	7	4
22*	27	21	31	16	29	13	15
23*	28	30	25	28	26	30	27
24*	29	31	26	32	28	26	29
25	2	28	18	20	21	24	13
26	21	12	4	11	14	4	11
27	1	15	14	10	9	16	3
28	26	32	28	26	22	28	19
29	10	9	5	7	4	20	9
30	18	23	20	21	25	29	23
31	3	2	10	1	8	9	2
33	6	18	13	19	12	15	1
34	33	34	33	33	34	32	34
35	30	11	29	31	30	31	32
36**	–	–	–	–	–	–	–

* *Sectors 3 to 24 are categorized into the manufacturing sector according to the OECD classification.*

** *Sector 36 (the statistical discrepancy sector) is not involved in the rankings.*