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EXPLORING INTERSECTORAL LINKAGES BETWEEN REAL ESTATE AND CONSTRUCTION

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Abstract

Even though linkages have attracted a lot of research interest, few researchers focus on the intersectoral linkages between two specific sectors. This research therefore proposes an indirect intersectoral linkage measure model to explore linkages between the real estate and construction sectors using the Hypothetical Extraction Method (HEM). Using the OECD input-output tables, the direct, total intersectoral linkages and the proposed indirect intersectoral linkages are explored and tested respectively for seven OECD countries over twenty years. The findings describe that the intersectoral linkages from construction to real estate are larger than those from real estate to construction. The statistical testing results imply that the proposed indirect intersectoral linkage measure method seems to be appropriate to analyse the intersectoral linkage between the construction and real estate sectors.

Keywords

Input-output analysis, construction sector, real estate, intersectoral linkages, hypothetical extraction method

INTRODUCTION

The linkage concept has been recognized as playing a crucial role and providing substantial contributions towards guiding appropriate strategies for future economic development (Bon, 2000; Sudaryanto, 2003). 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; Cai and Leung, 2004). The concept of linkage explains how the internal structure of an economy behaves, by visualizing it as an interconnected system of sectors that directly and indirectly affect one another (Miller and Lahr, 2001).

Many researchers have stressed the importance of linkages for achieving a healthy economic system. According to Hirschman (1958), linkages play an important role in initiating and transmitting the process of economic development and diversification of the sectoral structure of the economy. Cella (1984) stated that information about linkages and its spreading effects throughout the economy is highly valuable in forecasting and directing the economic activities. Forni and Paba (2001) found that a relatively fast diffusion of knowledge and new technologies always goes with strong linkage effects and concluded that the linkages are an important source of technological externalities. Porter (2004) implicitly denoted that linkage is one of the most important factors for gaining competitive advantages. The sectors with the highest linkages should be able to stimulate a more rapid growth of production, income and employment than with alternative allocations of resources. What is more, linkages are important for the number of innovations developed in a country because there is a positive
relationship between the diversity of the local sector structure and the number of innovations developed by these sectors (Hoen, 2002).

Even though the linkages have attracted a lot of research interest, few researchers focus on the intersectoral linkages between two specific sectors (Hoen, 2002). 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 HEM. Based on traditional methods, research concerning the direct and total intersectoral linkages can be found in literature. However, the traditional methods are being gradually ignored because they do not capture much of the inherent complexity of an economy (Miller and Lahr, 2001). HEM is used to measure the linkages by extracting a sector hypothetically from an economic system. Linkage measures based on the HEM become increasingly influential (Miller and Lahr, 2001). So far, no research focuses on the linkages between two specific sectors using the HEM (Song et al., 2006).

In the construction and real estate discipline, the construction sector is not only the supplier but also the user of the real estate sector in the whole value chain. The real estate sector provides service to the construction sector. Accordingly, most intermediate goods and services produced by the maintenance and repair construction sub-sector pour into the real estate sector (Bon, 2000). It is significant to determine the quantitative correlations between them to investigate their importance and interaction in modern economics. This research therefore aims at proposing a new method to explore the intersectoral linkage between the construction and real estate sectors based on the HEM.

The remainder of this paper reviews the previous intersectoral linkage measure methods including direct and total intersectoral linkages, and then proposes a new intersectoral linkage measure method (termed as indirect intersectoral linkage) based on the HEM. Next, using the latest OECD input-output tables, this research investigates and tests the direct, total and indirect intersectoral linkages between the construction and real estate sectors. Finally, conclusions are drawn.

**LITERATURE REVIEW**

Founded by Wassily Leontief in the late of 1930s, the input-output analysis focuses on how inter-sector trading influences the overall demand for labor and capital within an economy (Leontief, 1936). The input-output technology has been widely used in technology, energy and environment evaluation fields (e.g. Fay et al., 2000; Crawford et al., 2003). By displaying all flows of goods and services within an economy, the input-output technology has been considered in literature as a main tool to determine, define, measure and assess the linkages between sectors (Lean, 2001; Miller and Lahr, 2001).

Based on the input-output technology, there are two main methods that have been developed to measure intersectoral linkages (Cai and Leung, 2004). The direct intersectoral linkage measure method is to obtain the intersectoral linkage from the matrix of technical coefficients. Given the usual input-output system, an economy consists of \( n \) sectors and the output of sector \( i \) is denoted by \( x_i \) (\( i = 1, \ldots, n \)). The basic balance equation of the demand-driven model (Leontief model) can be shown as: \( X = Ax + Y \), where \( X \) denotes vector of gross output and \( Y \) denotes vector of final demand. \( A \) denotes matrix of technical coefficients (\( n \times n \)) and \( A = [a_{ij}] \), where \( a_{ij} = x_j / x_i \) (\( i, j = 1, \ldots, n \)) and \( x_y \) is the direct intersectoral flow from sector \( i \) to sector \( j \). A
technical matrix $A$ is formed by dividing the flow from one industry to another by the total input into the latter industry. Here, $a_{ij}$ can be used as the direct intersectoral linkage (Chenery and Watanabe, 1958). An alternative, the so-called total intersectoral linkage measure method, aims to measure the intersectoral linkage from the Leontief inverse matrix. Rasmussen (1956) adopted the inverse matrix to measure the linkage. The Leontief model can be rearranged as: $X = LY$, where, $L = (I - A)^{-1}$ denotes the Leontief inverse matrix and $I$ denotes the identity matrix. So, $L_{ij}$ can be considered as the indirect intersectoral linkage, which represents the total intersectoral flow from sector $i$ to sector $j$.

Using the direct and total linkage measure methods, the intersectoral linkage between the construction sector and other sectors has been discussed in depth in Italy, Japan, Turkey, and the United States (Bon, 2000). Such research concluded that the decreasing manufacturing input and increasing services input are the main trends of the construction sector in highly developed economies. Recent studies on construction intersectoral linkages using the above method can still be found. Pietroforte et al. (2000) discussed the role of the construction sector in the economy of Italy's North and South over a period of more than 30 years. Pietroforte and Gregori (2003) first used the OECD input-output tables to conduct an input-output analysis of the construction sector in highly developed economies — namely Australia, Canada, Denmark, France, Germany, Netherlands, Japan and the United States. Their research confirmed the steady decline of manufacturing input and claimed that the increasing share of service input to construction showed changes in the composition of assets. Moreover, Su et al. (2003) examined the intersectoral linkage of the Taiwanese construction section using 12 input-output tables compiled between 1964 and 1999. Wu and Zhang (2005) analyzed the Chinese construction sector using the input-output technology. Song et al. (2006) investigated the construction linkages using the OECD input-output tables.

However, the calculation method based on the matrix of technical coefficients has been gradually discarded because it just reflects the first round of effects generated by the inter-relationships between sectors and ignores the indirect effect of intersectoral linkages in the production process (Miller and Lahr, 2001). The method based on the Leontief inverse matrix is mainly used to analyze the linkages between a specific sector and all other sectors which is not well suited for answering questions as to how the linkages operate between two specific sectors (Hoen, 2002). Moreover, both methods do not take into account all attributes that characterize the propulsive sectors in an interconnected economy (Hirschman, 1958). Hence, a new intersectoral linkage measure method is needed.

**A PROPOSED INDIRECT INTERSECTORAL LINKAGE MEASURE METHOD**

The proposed method is based on the HEM. The original idea of HEM was that it tried to extract a sector hypothetically from an economic system and examine the influence of this extraction on other sectors in the economy (Miller and Lahr, 2001). In light of the basic idea of HEM, it was assumed that the $n$-sector input-output technical coefficient $A$ had been partitioned into two groups: group one ($g_1$) being a sector that was to be extracted from the economy; and group two ($g_2$, $g_1 + g_2 = n$) was all the remaining sectors of the economy. Now, if $g_1$ was extracted hypothetically from the economy, using the same final demand vector, the Leontief model can be rewritten as $X^* = (I - A^*)^{-1}Y$, where $X^*$ is the output after extraction and $A^*$ is a reduced technical coefficients matrix ($(n - 1) \times (n - 1)$). The reduction in output can
be expressed as $X - X^*$ which reflects the linkage between $g_1$ and $g_2$ given that the technical production process is held constant.

The proposed method tries to hypothetically extract two specific sectors in order to investigate the potential linkage between them. The loss of the economy due to this extraction reflects the internal effects between the two extracted sectors. This internal effect is termed as the “indirect” intersectoral linkage in this paper due to this hypothetical scenario. 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 $i$.

**Indirect intersectoral linkages 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

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

(1)

where sub-matrices $\hat{A}_{13}$ and $\hat{A}_{23}$ show the relationships between $\hat{g}_1$ and $\hat{g}_2$ in production. $\hat{A}_{1i}$ and $\hat{A}_{2i}$ indicate the inter-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

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

(2)

The difference between Eq. (1) and Eq. (2) can be expressed as

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

(3)

where $\hat{H} = (I - \hat{A}_{11})^{-1} \hat{A}_{12} \hat{L}_{22} \hat{A}_{21}$, and $\hat{L}_{22} = (I - \hat{A}_{22})^{-1}$. Then the indirect intersectoral linkage from sector $i$ to $j$ (intersectoral linkage I) can be expressed as:
Indirect intersectoral linkage \((i \rightarrow j) = \frac{SL_{ij}}{\lambda X} \times 100\% \) (4)

where,

\[
SL_{ij} = \left[ \lambda_1 \left( \hat{H} - (I - \hat{A}_{12} \hat{L}_{22} \hat{A}_{21})^{T} \right) + \lambda_2 \hat{L}_{22} \hat{A}_{21} \left( \hat{H} - (I - \hat{A}_{12} \hat{L}_{22} \hat{A}_{21})^{T} \right) \right] y_i^T + \\
\left[ \lambda_1 \left( \hat{H} - (I - \hat{A}_{12} \hat{L}_{22} \hat{A}_{21})^{T} \right) \hat{A}_{12} \hat{L}_{22} + \lambda_2 \hat{L}_{22} \hat{A}_{21} \left( \hat{H} - (I - \hat{A}_{12} \hat{L}_{22} \hat{A}_{21})^{T} \right) \hat{A}_{12} \hat{L}_{22} \right] y_j
\]

Indirect intersectoral linkage from sector \(j\) to \(i\)

Similarly, using the Ghosh model (Ghosh, 1958) to measure the intersectoral 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:

\[
\begin{bmatrix}
\hat{X}_1 \\
\hat{X}_2
\end{bmatrix} = 
\begin{bmatrix}
\hat{X}_1 \\
\hat{X}_2
\end{bmatrix} 
\times 
\begin{bmatrix}
\hat{B}_{11} & \hat{B}_{12} \\
\hat{B}_{21} & \hat{B}_{22}
\end{bmatrix} 
+ 
\begin{bmatrix}
\hat{V}_1 \\
\hat{V}_2
\end{bmatrix} \quad (5)
\]

where, \(\hat{V}_1\) and \(\hat{V}_2\) denote the value added of \(\hat{g}_1\) and \(\hat{g}_2\) respectively. \(\hat{B}_{11}, \hat{B}_{12}, \hat{B}_{21}\), and \(\hat{B}_{22}\) are the partitioned matrixes of the allocation coefficient matrix \(B\).

From the supply-side model, it is assumed that \(\hat{g}_1\) is hypothetically extracted, so let \(\hat{B}_{11} = 0\). Thus, Eq. (5) can be rewritten as:

\[
\begin{bmatrix}
\hat{X}_1' \\
\hat{X}_2'
\end{bmatrix} = 
\begin{bmatrix}
\hat{X}_1' \\
\hat{X}_2'
\end{bmatrix} 
\times 
\begin{bmatrix}
0 & \hat{B}_{12} \\
\hat{B}_{21} & \hat{B}_{22}
\end{bmatrix} 
+ 
\begin{bmatrix}
\hat{V}_1 \\
\hat{V}_2
\end{bmatrix} \quad (6)
\]

The difference between Eq. (5) and Eq. (6) can be shown as:

\[
\begin{bmatrix}
\hat{X}_1 - \hat{X}_1' \\
\hat{X}_2 - \hat{X}_2'
\end{bmatrix} = 
\begin{bmatrix}
\hat{V}_1 \\
\hat{V}_2
\end{bmatrix} 
\times 
\begin{bmatrix}
\hat{K} - (I - \hat{B}_{12} \hat{G}_{22} \hat{B}_{21})^{T} \\
\hat{G}_{22} \hat{B}_{21} \hat{K} - (I - \hat{B}_{12} \hat{G}_{22} \hat{B}_{21})^{T} \hat{B}_{12} \hat{G}_{22}
\end{bmatrix} \quad (7)
\]

where \(\hat{K} = (I - \hat{B}_{11} \hat{B}_{12} \hat{G}_{22} \hat{B}_{21})^{T}\) and \(\hat{G}_{11} = (I - \hat{B}_{11})^{T}\) and \(\hat{G}_{22} = (I - \hat{B}_{22})^{T}\). Consequently, the indirect intersectoral linkage from sector \(j\) to sector \(i\) (intersectoral linkage \(\Pi\)) can be shown as

\[
\text{Indirect intersectoral linkage } \Pi = \frac{SL_{ji}}{\lambda X} \times 100\% \quad (8)
\]
where,

\[ SL_{ji} = \hat{V}_1 x [(\hat{K} - (I - \hat{B}_{12}\hat{G}_{22}\hat{B}_{21})^{-1}) \hat{z}_1 + (\hat{K} - (I - \hat{B}_{12}\hat{G}_{22}\hat{B}_{21})^{-1})\hat{B}_{12}\hat{G}_{22}\hat{z}_2] + \\
\hat{V}_2(\hat{G}_{22}\hat{B}_{21}(\hat{K} - (I - \hat{B}_{12}\hat{G}_{22}\hat{B}_{21})^{-1}) \hat{z}_1 + \hat{G}_{22}\hat{B}_{21}(\hat{K} - (I - \hat{B}_{12}\hat{G}_{22}\hat{B}_{21})^{-1})\hat{B}_{12}\hat{G}_{22}\hat{z}_2]
\]

**DIRECT AND TOTAL INTERSECTORAL LINKAGE MEASURES OF OECD COUNTRIES**

The OECD input-output database, which is published by the Economic Analysis and Statistics Division of the OECD, provides appropriate multinational economic data (OECD, 1995). This is the most comprehensive database so far for comparing the construction and real estate sectors worldwide (Liu et al., 2003; Liu et al., 2005; Pietroforte and Gregori, 2003). Using the OECD input-output table, the direct, total and indirect intersectoral linkages are applied to the construction and real estate sectors of Australia, Canada, Denmark, France, Japan, Netherlands, and United States over 20 years.

**Direct and total intersectoral linkage measures from construction to real estate**

The direct sectoral linkages from the construction sector to the real estate sector are shown in Figure 1. With values between 0.004 and 0.11, the purchases of the real estate sector from the construction sector per monetary unit are reflected. The construction sector of Denmark has the greatest direct input to the real estate sector, and the French construction sector has the lowest direct input. A trend of decline in the above figure is clearly apparent during the examined period for most countries. The total intersectoral linkage from the construction sector to the real estate sector is shown in Figure 2. The values vary between 0.01 and 0.16. It indicates the strength of the interconnection between the construction and the real estate sectors from the construction point of view. The construction sectors of Denmark and France have the highest and lowest total effect on the real estate sector respectively. Moreover, the varying ranges of both the total and direct input between the construction and the real estate sectors are almost at the same level. This means that the interactions between two sectors stabilize at the same range in all selected countries during the study period.

**Direct and total intersectoral linkage measures from real estate to construction**

Direct intersectoral linkages from the real estate sector to the construction sector are calculated and presented in Figure 3. The direct input reflects the purchases of the construction sector from the real estate sector per monetary unit. The values stabilize between 0.01 and 0.1 except for Canada, and indicates the strength of the interconnection between the construction and the real estate sectors. In most years, France and Denmark have high indicator values over 0.06, and the remaining countries have low indicator values below 0.06. The real estate sector of Denmark has the greatest direct effect on the construction sector, and the Australian real estate sector has the lowest direct effect.

The total input from the real estate sector to the construction sector (total intersectional linkage indicator) represents the effect of one monetary unit change in final demand of the construction sector on total output of the real estate sector. The indicators are presented in Figure 4. With values between 0.04 and 0.15, the indicators also show the strength of the interconnection between the construction and the real estate sectors. In most observed periods, France, Denmark, and Japan show a high value over 0.08, and the United States, Germany, and
Australia have low values below 0.08. The French real estate sector has the highest total effect on the construction sector, and the Australian real estate sector has the lowest total effect. The average values of the total input linkage indicators from the real estate sector to construction also present a significant waveform trend.

In addition, the average values of indicators show a significant waveform trend. In other words, there is an apparent cycle in the economic performance of real estate (Pyhrr et al., 1999). Historically, with recession ending in 1972-1975 in most developed countries, the real estate sector recovered and upsurged during the mid/late 1970s and the early 1980s, and peaked in
the mid-1980s with the very strong market demand, extraordinary boom of construction and very brisk volume of transactions. Later, real estate declined in the late 1980s with a sharp drop in market demand, lower property prices and a substantial reduction in the volume of transactions. The trend is a result of the economy, market demand, construction, property values, volume of transactions, capital for real estate, investor interest and tax climate factors (Roulac, 1999). Obviously, given the wave of the real estate sector’s performance, contributions to the construction sector are wavelike as well.

Figure 3  Direct intersectoral linkages from real estate to construction

Figure 4  Total intersectoral linkage from real estate to construction
INDIRECT INTERSECTORAL LINKAGE MEASURES OF OECD COUNTRIES

Considering the directions, the indirect intersectoral linkage can be divided into two groups: one is the linkage from the construction sector to the real estate sector (intersectoral linkage I), which is calculated from Eq. (4) and described in Figure 5. The other is the linkage from the real estate sector to the construction sector (intersectoral linkage II), which is from Eq. (8) and illustrated in Figure 6. As expected, the average indirect intersectoral linkages from construction to real estate are larger than those from real estate to construction.
One of the main assignments of the real estate sector is to make decisions about plant location of construction businesses concerning the country, region, submarket and site. Another concern is size of facility, layout, lease or buy decision and brokerage. What is more, the real estate sector also influences construction manufacturers’ access, including the location of the manufacturer’s showrooms, access to shows that display 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 (Roulac, 1999). On the other hand, the construction sector is the one of largest suppliers of the real estate sector and most intermediate goods and services produced by the maintenance and repair construction sub-sector go to the real estate sector (Bon, 2000). This explains why linkages from construction to real estate are larger than those from real estate to construction.

**DISCUSSION**

Some issues raised from the proposed indirect intersectoral linkage should also be discussed. Since the internal flow has been kept in the linkage measures, the magnitude of construction and real estate internal effects should be investigated further. Assuming that the construction sector’s intra-sectoral shipments are eliminated, the internal effects of the construction sector are shown in Table 1. To some extent, the internal effect of construction represents the sector’s self-supply and use. As can be seen in Table 1, the internal effect of construction is very small. Except for the Netherlands and Canada, all values are less than 0.1 percent. The magnitude of this internal linkage effect depends in part on the level of aggregation in the input-output model (Miller and Lahr, 2001). It would seem that construction has a small aggregation level in the input-output model. In other words, the internal effect of construction has a limited influence when measuring the indirect intersectoral linkages.

**Table 1** The internal linkage effects of construction

<table>
<thead>
<tr>
<th></th>
<th>Early-1970s</th>
<th>Mid/Late-1970s</th>
<th>Early-1980s</th>
<th>Mid-1980s</th>
<th>Late-1980s</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0.00006</td>
<td>0.00007</td>
<td>0.00096</td>
</tr>
<tr>
<td>Canada</td>
<td>0.00080</td>
<td>0.00104</td>
<td>0.000279</td>
<td>0.00191</td>
<td>0.00139</td>
<td>0.00080</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.00010</td>
<td>0.00006</td>
<td>0.00005</td>
<td>0.00037</td>
<td>0.00017</td>
<td>0.00010</td>
</tr>
<tr>
<td>France</td>
<td>N/A</td>
<td>N/A</td>
<td>0.00003</td>
<td>0.00002</td>
<td>0.00002</td>
<td>0.00004</td>
</tr>
<tr>
<td>Japan</td>
<td>0.00010</td>
<td>0.00002</td>
<td>0.00007</td>
<td>0.00010</td>
<td>0.00024</td>
<td>0.00010</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.00943</td>
<td>0.00898</td>
<td>0.00859</td>
<td>0.00864</td>
<td>N/A</td>
<td>0.00943</td>
</tr>
<tr>
<td>USA</td>
<td>0.00001</td>
<td>0.00004</td>
<td>0.00004</td>
<td>0.00006</td>
<td>0.00005</td>
<td>0.00001</td>
</tr>
</tbody>
</table>

**Table 2** The internal linkage effects of real estate

<table>
<thead>
<tr>
<th>Forward</th>
<th>Early-1970s</th>
<th>Mid/Late-1970s</th>
<th>Early-1980s</th>
<th>Mid-1980s</th>
<th>Late-1980s</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0.00048</td>
<td>0.000075</td>
<td>0.00062</td>
</tr>
<tr>
<td>Canada</td>
<td>0.000012</td>
<td>0.000016</td>
<td>0.000022</td>
<td>0.000025</td>
<td>0.000032</td>
<td>0.000021</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.000015</td>
<td>0.000021</td>
<td>0.000027</td>
<td>0.000049</td>
<td>0.000063</td>
<td>0.000035</td>
</tr>
<tr>
<td>France</td>
<td>N/A</td>
<td>N/A</td>
<td>0.000096</td>
<td>0.000102</td>
<td>0.000158</td>
<td>0.000119</td>
</tr>
<tr>
<td>Japan</td>
<td>0.000013</td>
<td>0.000056</td>
<td>0.000029</td>
<td>0.000048</td>
<td>0.000058</td>
<td>0.000041</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.000003</td>
<td>0.000004</td>
<td>0.000005</td>
<td>0.000006</td>
<td>N/A</td>
<td>0.000004</td>
</tr>
<tr>
<td>USA</td>
<td>0.000068</td>
<td>0.000061</td>
<td>0.000075</td>
<td>0.000097</td>
<td>0.000107</td>
<td>0.000081</td>
</tr>
</tbody>
</table>
Similarly, assuming that the real estate sector's intra-sectoral shipments are eliminated, the internal effects of the real estate sector are shown in Table 2. A similar conclusion can be drawn: the internal effect of real estate is also very small and the internal effect of real estate has a limited influence when measuring the indirect intersectoral linkages. The real estate sector is generally divided into two sub-sectors in the national accounts, namely residential and commercial real estate services. The residential real estate sub-sector supplies living accommodation for the commercial sub-sector, whereas the commercial sub-sector supplies few services for the residential real estate sub-sector. The relationships between these two sectors are relatively loose (Song et al., 2005). However, in some developing countries, the internal effect of real estate may be higher than that in developed countries. One reason is that the increasing commercial real estate market in the developing countries may need more residential services than the developed countries (Song et al., 2005).

Moreover, the direct, total and indirect intersectoral linkage differences amongst countries are worth investigating statistically and further discussion. Firstly, a descriptive statistic is conducted to enumerate the differences over the examined period. Table 3 reports the sample numbers, mean, standard deviations and mean ranks of the direct, total and indirect intersectoral linkages respectively. Obviously, some discrepancies can be observed in different study periods.

Furthermore, in order to investigate the stability and consistency of the proposed indirect intersectoral linkage implemented between the construction and real estate sectors, the Kendall's coefficient of concordance \((W)\) has been tested statistically over the examined period. The three linkages are ranked respectively and the Kendall's \(W\) is worked out for the three linkages. Table 4 presents the Kendall's \(W\) of the direct, total and indirect intersectoral linkages. As expected, comparison results suggest that there are positive agreements over the five study periods for the three linkages. The results imply that the proposed indirect intersectoral linkage measure method seems to be appropriate to analyse the intersectoral linkage between the construction and real estate sectors.

**Table 3** Descriptive statistics of the intersectoral linkages between construction and real estate

<table>
<thead>
<tr>
<th>Period</th>
<th>Linkages</th>
<th>N</th>
<th>From construction to real estate</th>
<th>From real estate to construction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>Std. Deviation</td>
</tr>
<tr>
<td>Early-1970s</td>
<td>Direct</td>
<td>5</td>
<td>0.056</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5</td>
<td>0.047</td>
<td>0.022</td>
</tr>
<tr>
<td></td>
<td>Indirect</td>
<td>5</td>
<td>0.014</td>
<td>0.005</td>
</tr>
<tr>
<td>Mid/Late-1970</td>
<td>Direct</td>
<td>5</td>
<td>0.057</td>
<td>0.036</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5</td>
<td>0.062</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>Indirect</td>
<td>5</td>
<td>0.016</td>
<td>0.005</td>
</tr>
<tr>
<td>Early-1980</td>
<td>Direct</td>
<td>6</td>
<td>0.040</td>
<td>0.037</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6</td>
<td>0.052</td>
<td>0.043</td>
</tr>
<tr>
<td></td>
<td>Indirect</td>
<td>6</td>
<td>0.017</td>
<td>0.004</td>
</tr>
<tr>
<td>Mid-1980</td>
<td>Direct</td>
<td>7</td>
<td>0.036</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>7</td>
<td>0.056</td>
<td>0.043</td>
</tr>
<tr>
<td></td>
<td>Indirect</td>
<td>7</td>
<td>0.016</td>
<td>0.005</td>
</tr>
<tr>
<td>Late-1980</td>
<td>Direct</td>
<td>6</td>
<td>0.030</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6</td>
<td>0.059</td>
<td>0.057</td>
</tr>
<tr>
<td></td>
<td>Indirect</td>
<td>6</td>
<td>0.018</td>
<td>0.007</td>
</tr>
</tbody>
</table>
### Table 4  Kendall's coefficient of concordance

<table>
<thead>
<tr>
<th>Period</th>
<th>From construction to real estate</th>
<th>From real estate to construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kendall's W(a)</td>
<td>0.88</td>
<td>0.84</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>Early-1970</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kendall's W(a)</td>
<td>0.72</td>
<td>0.84</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>Mid/Late-1970</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kendall's W(a)</td>
<td>0.75</td>
<td>0.86</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Early-1980</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kendall's W(a)</td>
<td>0.71</td>
<td>0.88</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>Mid-1980</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kendall's W(a)</td>
<td>0.53</td>
<td>0.86</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>Late-1980</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### CONCLUSIONS

This paper proposed an indirect intersectoral linkage measure model to explore the linkages between the real estate and construction sectors using the HEM. The proposed model hypothetically extracted two specific sectors from the economy, and the loss of economy due to the hypothetical extraction is termed the indirect intersectoral linkage between these two sectors. The Leontief and Ghosh model are adopted in order to distinguish the linkage directions.

Using the OECD input-output tables, the direct, total intersectoral linkages and the proposed indirect intersectoral linkages were investigated respectively. Considering the directions, the indirect intersectoral linkage can be divided into two groups: one is the linkage from the construction sector to the real estate sector. The other is the linkage from the real estate sector to the construction sector. The findings show that the intersectoral linkages from construction to real estate are larger than those from real estate to construction. The real estate sector as supplier plays a service delivery role in the value chain of the construction sector. On the other hand, the construction sector is one of the largest suppliers of real estate and most intermediate goods and services produced by the maintenance and repair construction sub-sector go to the real estate sector. Moreover, the direct, total and indirect intersectoral linkages differences amongst countries were tested statistically and further discussed. The results implied that the proposed indirect intersectoral linkage measure method seems to be appropriate to analyse the intersectoral linkage between the construction and real estate sectors.

### REFERENCES


Exploring intersectoral linkages between real estate and construction


