COMPARISON OF MULTIFACTOR PRODUCTIVITY INDICATORS FOR REAL ESTATE SECTORS USING THE OECD INPUT-OUTPUT DATABASE

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ABSTRACT

Research on the international comparison of productivity has gained significant interest throughout several previous decades. Relatively little work has however been done in the real estate sector. This paper aims to develop a new productivity measurement framework for the international comparison of the real estate sector based on the newly-published OECD input-output database. Three multifactor productivity indicators are formulated using the ratio of the sectoral final demand to value added, the intermediate output to intermediate input and the total output to total input effect respectively in the input-output table. Historical analyses and comparisons are also carried out to indicate the differences of productivities of the real estate sectors in seven selected countries. Findings can improve the understanding of how technological, organisational and policy influences combine to affect productivity growth and aid the policy makers, real estate agencies and researchers in evaluating the competitive ability of the real estate sector.

Keywords: Real estate sector, OECD input-output database, multifactor productivity, international comparisons.

INTRODUCTION

Productivity measurement of the real estate sector establishes a connection between the micro and macro levels of the economy and helps answer questions about the contribution of individual industries to productivity growth. Improved international comparisons of the real estate sector productivity levels are also needed in order to achieve a better comprehension of the structural change, technological progress, comparative advantage and competitiveness in this sector in the developed countries (Gullickson and Harper, 1999). On the other hand, a historical comparison on productivity at the industry level will help us understand the nature of long trends in productivity. Nevertheless, relatively little work has been done on the international comparison of real estate productivity. This is partly because the real estate productivity is strongly affected by the institutional organisation, the legal framework and cultural preferences within each country (Ark and Monnikhof, 1999). For instance, the Australian real estate sector contained 6216 agents, 463

property-valuing businesses, 481 conveyancing businesses and 9 government Valuer General organisations with reference to the real estate services industry survey by the Australian Bureau of Statistics in 1999 (ABS, 2000). The complexities of the measurement problems are obvious. On the other hand, the lack of usable data has also hindered empirical research on international comparisons of the productivity of the real estate sector. Recently, however, the availability of international data on the sector has allowed for much more rigorous analysis of this field. The Organisation for Economic Co-operation and Development (OECD) input-output database, which is the most comprehensive database so far, provides appropriate multinational economic data (Pietroforte and Gregori, 2003; Liu and Song, 2004; OECD, 1995).

The multifactor productivity framework based on the input-output table, which measures the changes in output per unit of combined inputs, is well suited to calculate the productivity of the real estate sector, because it allows accounting for capital inputs and for intermediate flows between industries (Gullickson and Harper, 1999). Mathematically, the multifactor productivity is a ratio, which could be used to measure the efficiency in utilization of each of the production inputs. With the multifactor productivity indicator, industry and sectoral productivity trends can be compared and analysed. Multifactor productivity measures can be computed for two different representations of the production process. One is a measure of gross output in relation to primary and intermediate inputs. Another relates value added to primary inputs (OECD, 2001). In this paper, the two representations are combined. In the context of input-output, the gross outputs produced by the real estate services, include selling, letting and acquisition of properties, property rental payments service and other property management and related professional services. These services are mainly provided to the property owners or prospective purchasers or renters and the dollar value of these services is measured in terms of the fees and commission earned. The inputs of the real estate sector include value added and intermediate inputs. The value added represents the utilisation of the factors of production such as labour, capital, land and the incomes of various factors of production; for instance, wages, profit, interest and rent. These resources represent indirect input of the real estate sector. The intermediate inputs are direct input from other sectors. Combining these input and output variables, a series of multifactor productivity indicators are developed in this research.

This paper aims to develop an input-output table perspective for the multifactor productivity measurement of the real estate sector. A series of multifactor productivity indicators are developed and tested based on the newly published OECD input-output database. Historical analyses and comparisons are also carried out to indicate the differences of productivities of the real estate sectors in seven selected countries. The next section provides a review of related literature, followed by a description of the research methodology and data. Then the output and input efficiency indicators are developed and analysed. Next, the input and output

indicators are combined, and a series of productivity indicators are developed to present the productivity measurement of real estate. Meanwhile, these productivity indicators are tested in this section. The last section is a summary of the paper.

LITERATURE REVIEW

Multifactor productivity measurement approaches

Early research efforts formulated productivity measurement in a production function context. Diewert (1976) developed the production theoretical approach to measure productivity and integrated the theory of the firm, index number theory and national accounts. The multifactor productivity concept was adopted and a set of formulae were developed for multifactor productivity, after assuming a competitive input market and constant returns to scale in production. The research led to the publication of multifactor productivity measures by the USA government in 1983. Jorgenson et al. (1987) linked these formulae to the economic growth via investigating the relationship between productivity and post-war USA economic growth. In the area of real estate, Gullickson and Harper (1999) carried out a productivity analysis in the real estate sector and concluded that the multifactor productivity trend is a better indicator of tracing technical change, identifying efficiency and inefficiencies and recognizing economies scale of a sector. Parham (2004) investigated the multifactor productivity of all industries, including real estate, in Australia from 1964 to 1999 and commented that complementary research at the aggregate, industry and micro level is needed. Durand and Vezina (2003) worked out real estate's productivity in Canada from 1961 to 1997. However, no research is based on the input-output tables.

Productivity measurement in international comparisons

Many different methods of productivity measurement, calculation and interpretation were adopted in previous international comparisons (Kravis, 1976; Diewert, 1976; Islam, 1999). Kravis (1976) surveyed the majority of research based on the international comparisons of productivity up to 1976 and compared the differences of productivity of agriculture, mining and manufacturing sectors. Diewert (1976) reviewed ten classes of multilateral methods from both the viewpoint of the axiomatic approach and the economic approach in order to make aggregate price and quantity comparisons between different countries and regions. Islam (1999) reviewed the time-series approach, the panel approach and the cross-section approach in the international comparison of total factor productivity and concluded that the choice of productivity measures depends on the purpose of productivity measurement and, in many instances, on the availability of data.

Previous research about international measurement of productivity has also been fulfilled by many researchers. The productivity and economic growth in Japan and USA from 1960-1973 are compared by Jorgenson (1988). Ark et al (1993) explored the comparative productivity performance in manufacturing of three countries-

Germany, Japan and the United States since 1950 using detailed information from censuses of manufacturers for each country. Bernard and Jones (1996) examined the multifactor productivity convergence for 14 OECD countries during 1970-1987. Their research just focused on the productivity convergence; and the real estate sector was not stated individually. The major finding is that manufacturing shows little evidence of either labor productivity or multifactor productivity convergence, while other sectors, especially services, are driving the aggregate convergence result. Moreover, Ark and Monnikhof (1999) dealt with measurement of productivity differentials in manufacturing for five countries: namely Canada, France, Germany, the Netherlands and the US. Gu and Ho (2000) finished a consistent international productivity comparison of the patterns of growth in Canadian and USA manufacturing sectors over the period 1961-1995. This research focused on the manufacturing sector rather than the real estate sector.

RESEARCH METHODS

OECD input-output database

As mentioned above, the OECD input-output database used in this research is the latest version published by OECD and the most comprehensive source for comparing structural productivities in industries internationally. In this database, due to limited comparable and available data in the real estate sector, Germany, Italy and the United Kingdom are not considered, the data from France are discarded before 1980 and the data from Australia are unavailable before the mid-1980s. It is noticed that the OECD input-output database does not provide the data for all countries constantly. Generally, an input-output table is available about every five years. In order to avoid the effect of non-uniform inflation rises in the 1970s and 1980s, the data are adopted at constant prices. The examined period is divided into five comparative periods as shown in Table 1: early-1970s (1970-1972), mid/late-1970s (1975-1978), early-1980s (1980-1982), mid-1980s (1985-1986) and late-1980s (1989-1990).

According to the OECD classification, the 36 industries (sectors) in the input-output table are divided into seven sections as shown in Appendix 1. This research just focuses on Section 3 and Section 4. All sectors in Section 3 are related to the manufacturing industry and are referred to the manufacturing sector in the following sections of this paper. In Section 4, the data of construction sector, real estate and service sector are adopted correspondingly. In this paper, the service sector consists of restaurants and hotels, finance and insurance, real estate and business services, and community, social and personal services. Some other sectors in Section 4, such as electricity, gas and water, wholesale and retail trade and transport and storage, will be discussed individually in this paper.

Table 1: OECD input-output database coverage of the real estate sector

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

For the convenience of research, the data in the OECD database are grouped and symbolised. The symbols and fundamental structure of the OECD input-output database are illustrated in Figure 1.

Figure 1: Fundamental structure of the OECD input-output database

		Domestic Intermediate output					**Total intermediate output**	**Final demand**	**Total output**
		Sector 1	…	Sector j (Real estate)	…	Sector 36			
Domestic intermediate inputs	Sector 1								
	…								
	Sector i (Real estate)			X_{ij}			$X_{i.}$	Y_i	X_i
	…								
	Sector 36								
Total intermediate input				$X_{.j}$					
Value added				V_j				Y=V	
Total input				X_j					

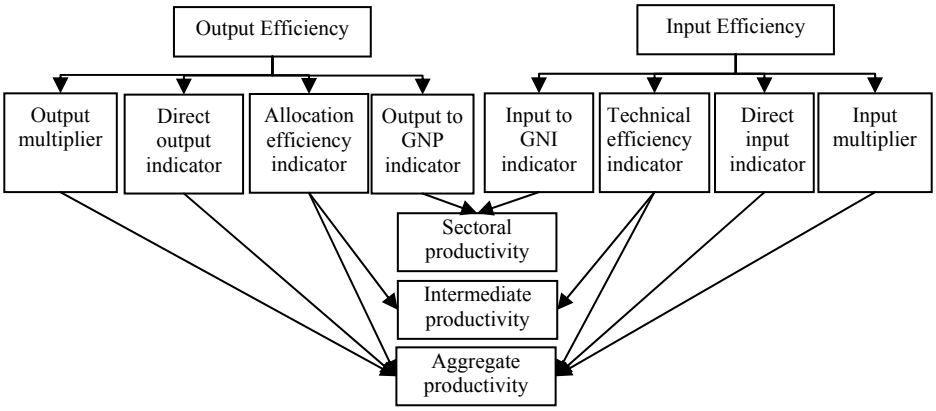
In the OECD input-output database, the symbol X_{ij} represents the intermediate flow from sector i to sector j. The total output of the sector is divided into intermediate output $X_{i.}$ and final demand Y_i for its goods and services (consumption, investment, government expenditures, etc.). The total input of the sector is divided into intermediate input $X_{.j}$ and value added V_j, which represents the supply of primary inputs or factors of production needed by the sector (labour, capital, land, etc.). The total output X_i equals total intermediate output plus final demand, and the total

input X_j equals total intermediate input plus value added. In terms of national product and income accounting conventions, the total final demand represents gross national product (GNP) and the total value added represents gross national income (GNI).

Formulation of the multifactor productivity

The multifactor productivity indicators are developed in this section. The indicators are divided into three groups: the output efficiency indicators, the input efficiency indicators and the multifactor productivity indicators. The multifactor productivity indicators are formulated based the output and input efficiency indicators. The basic framework of the multifactor productivity measurement is shown in Figure 2.

Figure 2: Basic framework of the multifactor productivity measurement



The output efficiency indicators

The output efficiency indicators represent the output levels given limited inputs and describe the contributions of the real estate sector in the whole national economy, including the output to GNP indicator, the allocation efficiency indicator, the direct output indicator and the output multiplier.

The output to GNP indicator	$= Y_i / Y$	(1a)
The allocation efficiency indicator	$= X_i. / X_i$	(1b)
The direct output indicator	$= X_{ij} / X_i$	(1c)
The output multiplier	$= \sum (I-A)^{-1}$	(1d)

where the symbol I refers to the identity matrix and the symbol A stands for the matrix of direct-input technical coefficients.

The input efficiency indicators

The input efficiency indicators are defined to represent the input levels from other sectors to the real estate sector and describe the strength of the real estate sector's economic pull, including the input to GNI, the technical efficiency indicator, the direct input indicator and the input multiplier.

The input to GNI indicator	$= V_j / V$	(2a)
The technical efficiency indicator	$= X_{.j} / X_j$	(2b)
The direct input indicator	$= X_{ij} / X_j$	(2c)
The input multiplier	$= \sum (I-B)^{-1}$	(2d)

where the symbol B stands for the matrix of direct-output allocation coefficients.

The multifactor productivity indicators

The input and output efficiency are combined and the multifactor productivity indicators are developed to represent the mutual effect between the real estate sector and other sectors, including the sectoral productivity, the intermediate sectoral productivity and the aggregate productivity.

Sectoral Productivity	$= Y_i / V_j$	(3a)
Intermediate Productivity	$= X_{i.}/X_{.j}$	(3b)
Aggregate Productivity	$=[\sum(I-A)^{-1}Y_i)]/[\sum(I-B)^{-1}*V_j]$	(3c)

OUTPUT EFFICIENCY ANALYSIS

The output efficiency indicators are developed to analysis the outputs of the real estate sector to gross national product, and reflect the allocation efficiency and economic importance of the real estate sector in the entire economy. It is a measure of intermediate output and gross output in relation to primary and intermediate inputs in the multifactor productivity measurement field. Generally, a higher value implies a larger output efficiency of the real estate sector.

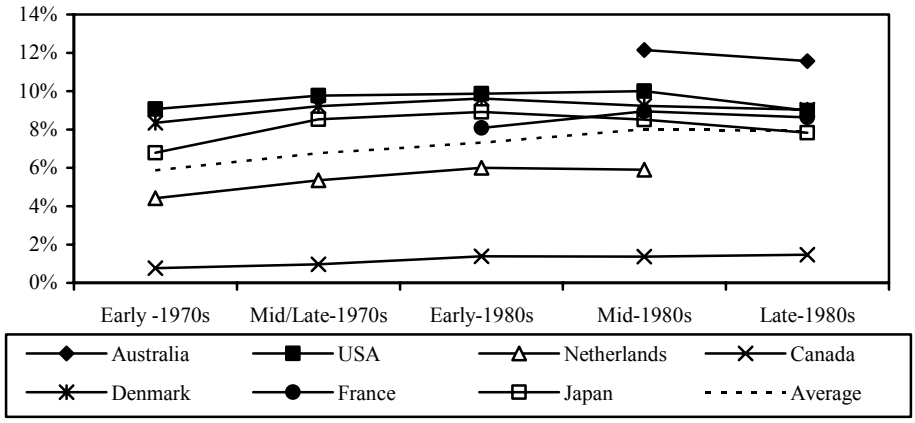
Output of the real estate sector to gross national product indicator

The outputs to GNP indicators are calculated from Eq. (1a) as plotted in Figure 3. With the exception of Canada and the Netherlands, the indicator is stabilising at a value between 6 and 12 percent. The different values represent the different output levels of the real estate sector in different countries. It seems that the Canadian real estate sector experienced low output with the indicator lower than the average level because the import of the real estate sector contributes a large proportion in the final demand. In the Netherlands, the output to GNP of the real estate sector is far lower

than those of manufacturing, construction, trade and agriculture, forestry and fishery sectors. Conversely, the value is just lower than those of trade and agriculture, forestry and fishery sectors and even higher than the construction sector in Demark. Also in Australia, USA, France and Japan, the real estate sectors contribute a larger output rate than most of sectors in the whole national economy. With a higher output value in GNP, the real estate sector seems to be a relatively important engine for economic development in these countries.

In order to reflect the entire trend and average level, the arithmetic means of the values are calculated and then plotted in Figure 3. Starting with a low value, the output to GNP indicator of the real estate sector peaks in the mid-1980s, and then the pace of growth is reversed in all countries. Obviously, this trend of the output to GNP indicators follows the national economic growth cycle during the period studied. Theoretically, this is due to the fact that there is high correlation between economic cycles and real estate performance (Pyhrr et al., 1999). With an ending recession in 1972-1975, the real estate sector recovered and upsurged during the mid/late 1970s and the early 1980s, and peaked in the mid-1980s. Subsequently, real estate declined in the late 1980s. The trend is a result of the economy, housing demand, construction, property values, volume of transactions, capital for real estate, investor interest and tax climate factors (Roulac, 1996; Birch and Sunderman, 2003). Compared with the construction sector, the output to GNP of the real estate sector is relatively low (Bon, 2000). However, compared to the downward trend in the construction sector, the time profile of the indicators shows a slightly upward-waved trend from the early-1970s to the late-1980s. This represents the increasing importance of the real estate sector in national economies.

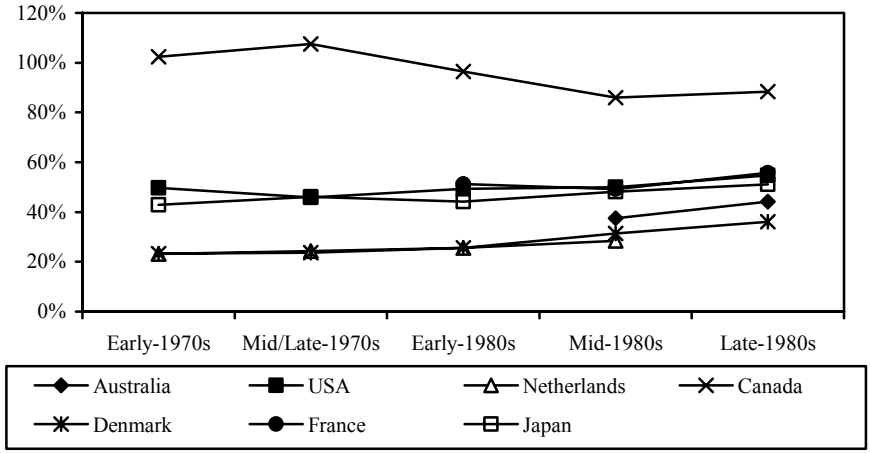
Figure 3: The outputs to GNP indicator



The allocation efficiency of the real estate sector

The allocation efficiency indicator shows the allocation efficiency of the output of the real estate sector and the push strength to the national economy. It represents the intermediate demand to total output ratio of the real estate sector as shown in Eq. (1b). The results are plotted in Figure 4.

Figure 4: Allocation efficiencies of the real estate sectors



The higher value implies that the allocation efficiency of the real estate sector is higher and the push strength is larger. It can be noticed that the allocation efficiencies have a medium value between 20 and 55 percent compared with the construction sector (Bon, 2000). Their time profiles show stability during the observed period (with the exception of Canada). 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. Furthermore, it represents medium push strength to economic development from another angle.

Figure 4 also shows two distinct groups of countries: Australia, Denmark and the Netherlands, with relatively lower allocation efficiency from 23.13% to 44.2% and the remaining countries with higher ones from 42.92% to 107.5%. These differences can be explained in terms of the level of the intermediate demand in different countries. In Australia, Denmark and the Netherlands, the levels of intermediate demand are very low. The allocation efficiency and strength of push of the real estate sector in these countries are comparatively weak over the study period. In addition, most of the output of real estate flows into the final demands; that is, private domestic consumption and government consumption. For France, USA and Japan, the proportion between intermediate demand and final demand

tends to be equal. These countries' allocation efficiency and push strength to economic growth is relatively strong. Compared to other countries, the value of the allocation efficiency in Canada is extremely high, and over 70% of the products of the real estate are contributed to intermediate demand. In this regard, the push economic growth of the real estate sector mainly relies on the push to the construction sector in Canada.

Table 2 plotted with Eq. (1c) represent the allocation efficiencies of the real estate sector to service, construction and manufacturing sectors respectively.

Table 2: Allocation efficiencies to the service, construction and manufacturing sectors

From the real estate sector to:		Early-1970s	Mid/Late-1970s	Early-1980s	Mid-1980s	Late-1980s
		%	%	%	%	%
Australia	Service	N/A	N/A	N/A	13.13	18.12
	Construction	N/A	N/A	N/A	1.39	1.69
	Manufacturing	N/A	N/A	N/A	7.89	4.79
USA	Service	19.13	17.66	20.47	21.58	26.75
	Construction	3.82	3.56	4.41	4.25	3.69
	Manufacturing	12.24	9.31	8.79	9.12	9.83
Netherlands	Service	3.91	4.44	5.00	5.49	N/A
	Construction	2.03	1.87	1.67	1.66	N/A
	Manufacturing	10.95	11.66	12.53	13.98	N/A
Canada	Service	16.39	19.10	20.95	23.92	26.20
	Construction	19.28	19.27	18.63	14.00	15.22
	Manufacturing	17.00	16.71	15.04	14.87	10.18
Denmark	Service	5.13	5.89	6.79	9.89	12.43
	Construction	8.11	6.24	6.24	7.67	9.35
	Manufacturing	5.04	5.84	6.53	6.88	7.45
France	Service	N/A	N/A	16.54	16.65	19.55
	Construction	N/A	N/A	9.15	7.34	8.71
	Manufacturing	N/A	N/A	17.37	17.31	18.83
Japan	Service	9.51	14.90	11.70	15.49	17.14
	Construction	4.28	3.95	4.92	4.71	6.50
	Manufacturing	13.45	10.65	10.64	10.48	11.73

The allocation efficiencies to manufacturing tend to stabilise at an extremely low value and the allocation efficiencies to construction are stabilising at a relatively lower value. The low value suggests that the construction and manufacturing sectors do not have a high attractiveness to the real estate sector. The allocation efficiencies to service is at a relatively large scale compared with other sectors, and

a trend of growth is clearly apparent in the examined period. The high value implies the increasing economic importance of the service sector.

According to the allocation efficiencies of the real estate sector, the detailed sectors are ranked based on their ranking in Australia. The top 10 sectors of Australia are compared with those of the other countries. In Australia, wholesale and retail trade (14.04%), real estate and business services (7.10%), finance and insurance (4.89%), community, social and personal services (4.60%) and transport and storage (2.80%) are ranked as the top five. The rank in other countries is quite different owing to different economic agents. The different ranks are presented in Table 3. The wholesale and retail trade sector is ranked first in Australia, second in USA (9.80%), third in Canada and fourth in Denmark and France. The real estate sector is ranked first in USA (11.46%) and France (12.07%). For construction, Canada (17.75%) and Denmark (9.40%) can both be ranked first with different percentages. Basically, the allocation efficiencies of the real estate sector to wholesale and retail trade, real estate and business services and finance and insurance sectors are ranked higher in almost all selected countries.

Table 3: Ranked sectors of allocation efficiencies of the real estate sector in the late-1980s

	Australia 1989	USA 1990	Netherlands 1986	Canada 1990	Denmark 1990	France 1990	Japan 1990
Wholesale and retail trade	1	2	1	3	4	4	1
Real estate and business services	2	1	11	5	2	1	2
Finance and insurance	3	4	3	2	3	3	5
Community, social and personal services	4	3	8	7	5	14	4
Transport and storage	5	8	6	9	7	7	6
Construction	6	5	7	1	1	2	3
Restaurants and hotels	7	6	13	10	11	17	9
Mining and quarrying	8	9	25	8	25	20	34
Food, beverages and tobacco	9	7	2	13	6	5	7
Agriculture, forestry and fishing	10	12	16	15	9	25	32

INPUT EFFICIENCY ANALYSIS

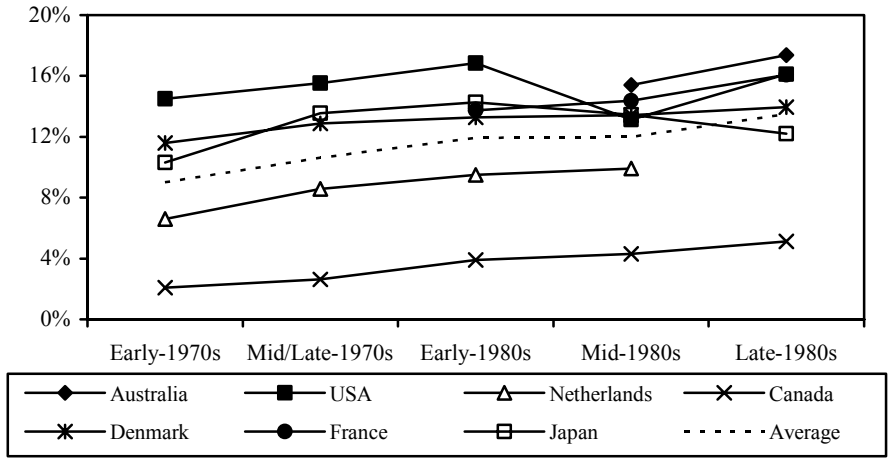
The input efficiency analysis of the real estate sector is a measure of value in relation to intermediate and total inputs in the multifactor productivity measurement

category. This section includes the input analysis of the real estate sectors to GNI and the technical efficiency analysis.

Input of the real estate sector to gross national income indicator

The input of real estate sector to GNI indicators for the seven selected countries are generated from Eq. (2a) and presented in Figure 5. The indicators tend to stabilise at a value between 10 and 20 percent with the exception of Canada and the Netherlands. The higher value indicates a higher proportion of the sectoral value added in total value added, and reflects the importance of the real estate sector from an input point of view. Compared with the lower value in the construction sector (Bon, 2000), the real estate sector has a higher value added than the intermediate output in most selected countries. As a service sector, the input of the real estate sector derives mainly from the input of the value added components (wages, profit and interest, rent, etc.) due to the fact that real estate has a major role in creating demand (Roulac, 1999).

Figure 5: The input to GNI indicator

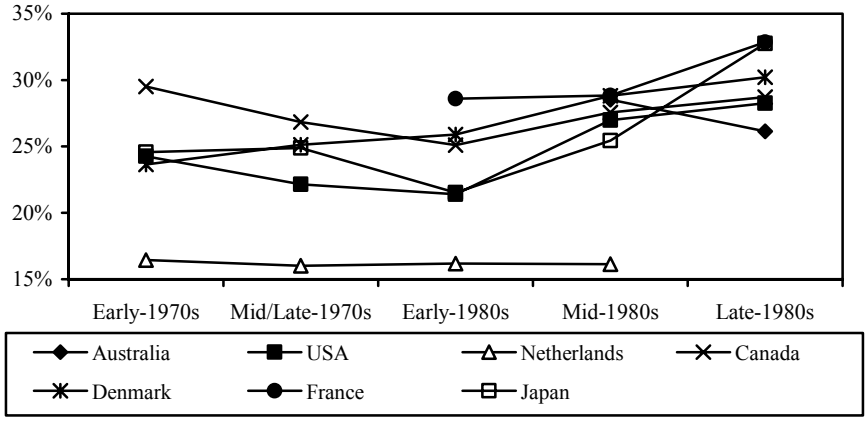


In order to reflect the whole trend, the average value of the input to GNI indicators is plotted in Figure 5 as well. During the study period, the value shows a constantly increasing trend. The reason may be due to the price elasticity of the value added components being less than that of the final demand, and the wave varies less with the economic cycle. It is noticed that the variations are significant during the middle-late term of the 1980s. The main reason is that the real estate bubble rose during the mid 1980s, and the demand declined sharply (Zhu, 2002). The low input to GNI of Canada is due to small final demand and large imports. The whole industry is monopolised by the import service businesses in Canada.

The technical efficiencies of the real estate sectors

The technical efficiency indicator demonstrates the industrialisation of the real estate sector and the proportion of the intermediate input to total input of the real estate sector. It also represents the strength of the real estate sector's economic pull. The larger the value, the higher is the national technologies level of the intermediate inputs and the stronger is the pull of the real estate sector. Figure 6 shows the results generated by Eq. (2b). The value of technical efficiency is stabilising at a value between 20% and 35% (with the exception of the Netherlands). Compared with the technical efficiency of the construction sector, the value suggests a relatively lower industrialisation level of the real estate sector than the construction sector, or in other words, the real estate sector's ability to pull the rest of the economy is weaker than is the construction sector's. Due to the fact that real estate plays a fundamental connecting role in the value chain (Roulac, 1999), the relatively lower technologies level is reasonable for the real estate sector. Evidence of a low technological level in Australia is that only 2040 (27%) of real estate business use buyer/seller matching computer packages according to the Real Estate Services Industry Survey in 1999 (ABS, 2000). However, a slightly upward trend over the entire study period in all selected countries can be seen. In any industry, the progress of technology cannot be stopped.

Figure 6: Technical efficiencies of the real estate sectors



As shown in Eq. (2c), Table 4 represents the input's technical efficiency from the service, construction and manufacturing sectors to the real estate sector respectively. On the other hand, these figures also demonstrate the consumption structure of the real estate sector. Not surprisingly, a strong upward trend of input's technical efficiency of service is in evidence for almost all the countries, as Maddison (1987) states that the growing service is one of three broad trends that characterise the last hundred years of economic development. In fact, modern real

estate really needs an increasing number of knowledge-based services. The downward trend of the input's technical efficiency of the construction sector supports that one of the main historical trends is the decreasing economic importance of the construction industry itself (Bon, 2000). The input's technical efficiency from manufacturing to the real estate sector is scattered between 1% and 7% depending on different countries. It represents the manufacturing sector's limited role in the real estate sector.

Table 4: The input from the service, construction and manufacturing sectors to real estate sectors

		Early-1970s	Mid/Late-1970s	Early-1980s	Mid-1980s	Late-1980s
		%	%	%	%	%
Australia	Service	N/A	N/A	N/A	13.12	12.74
	Construction	N/A	N/A	N/A	3.09	1.09
	Manufacturing	N/A	N/A	N/A	4.44	4.32
USA	Service	12.26	11.90	13.11	16.67	15.62
	Construction	5.21	5.37	3.57	3.37	4.65
	Manufacturing	3.54	1.94	2.31	2.74	3.37
Netherlands	Service	5.27	5.89	7.05	7.01	N/A
	Construction	6.38	5.36	4.81	4.47	N/A
	Manufacturing	2.79	2.76	2.41	2.44	N/A
Canada	Service	13.21	14.02	14.04	15.25	16.01
	Construction	0.51	0.34	0.17	0.23	0.23
	Manufacturing	1.75	1.42	0.89	1.07	0.98
Denmark	Service	7.97	8.29	8.74	11.44	12.64
	Construction	8.80	10.36	10.43	9.41	8.56
	Manufacturing	4.90	4.47	4.65	5.09	4.91
France	Service	N/A	N/A	17.01	17.15	19.56
	Construction	N/A	N/A	0.50	0.47	0.41
	Manufacturing	N/A	N/A	6.28	6.00	6.63
Japan	Service	8.23	10.86	9.48	13.10	17.38
	Construction	7.35	7.02	4.25	4.19	2.82
	Manufacturing	5.84	3.63	4.17	5.21	5.64

In accordance with the method mentioned in the last section, the detailed sectors are also ranked according to the technical efficiencies to the real estate sector from other sectors as shown in Table 5. The top 10 sectors of Australia are compared with that of the other countries. In Australia, real estate and business services (7.10%), electricity, gas and water (4.61%), finance and insurance (4.41%), communication (1.52%), and community, social and personal service (1.23%) are ranked as the top five. The different rank in other countries is presented in Table 5 for the late 1980s period. Among these countries, the real estate and business

services sector is ranked first in Australia, USA (11.46%) and France (12.07%). The finance and insurance sector is ranked first in the Netherlands (4.71%). For construction, Denmark (8.62%) is ranked first. Essentially, the real estate sector is ranked first in most countries, and the finance and insurance sector is ranked higher in almost all selected countries.

Table 5: Ranked sectors of technical efficiencies to the real estate sectors in the late-1980s

	Australia 1989	USA 1990	Netherlands 1986	Canada 1990	Denmark 1990	France 1990	Japan 1990
Real estate and business services	1	1	4	1	2	1	1
Electricity, gas and water	2	10	8	8	8	15	11
Finance and insurance	3	3	1	2	3	2	2
Communication	4	4	9	4	6	4	9
Community, social and personal services	5	6	3	5	5	5	5
Paper, paper products and printing	6	5	6	9	4	3	3
Construction	7	2	2	11	1	12	4
Industrial chemicals	8	16	14	17	16	16	6
Wholesale and retail trade	9	7	10	6	12	7	10
Transport and storage	10	9	12	10	9	6	17

MULTIFACTOR PRODUCTIVITY INDICATORS

Three multifactor productivity indicators are developed in this research, based on the input output table. The sectoral productivity indicator is for measuring the gross influence of the real estate sector, the intermediate productivity indicator measures the efficiency of the intermediate output of real estate and the aggregate productivity indicator presents the total efficiency of the real estate sector production.

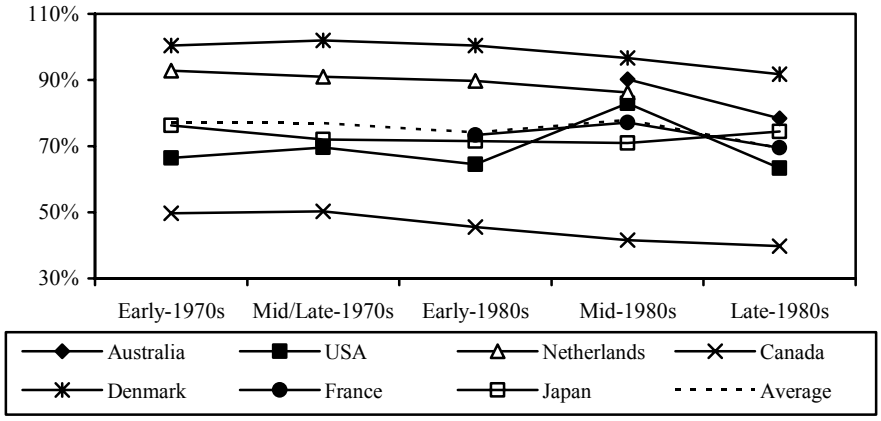
Sectoral productivity indicators

The sectoral productivity is a measure of the gross influence of the real estate sector on all industrial sectors. It indicates the sectoral final demand to value added ratio. The value added consists of salaries, wages, capital consumption allowances, profits, net interest charges and taxes, and the final demand consists of the demands of households and governments and exports demands. The indicator shows the capital employed efficiencies and the productive level of a sector in an economy. A

higher value means a higher capital employed efficiencies and higher productive level. Figure 7 shows the sectoral productivities of seven selected countries over the study period, which are calculated from Eq. (3a).

The productivity illustrates a relationship between primary inputs utilised and final outputs produced by the real estate sectors. The sectoral productivity of every country is comparatively stable until the mid 1980s. Then, due to declining housing demand and property values, reduced volume of transaction and hard to access capital over the late of 1980s, the sectoral productivities of real estate sectors decreased dramatically. The real estate sector of Canada had the lowest sectoral productivity, which was due to small final demand and large imports and the whole real estate sector was monopolised by the import service businesses. Whereas the Danish real estate sector had the largest sectoral productivity with a higher final demand and lower value added.

Figure 7: Sectoral productivity indicators

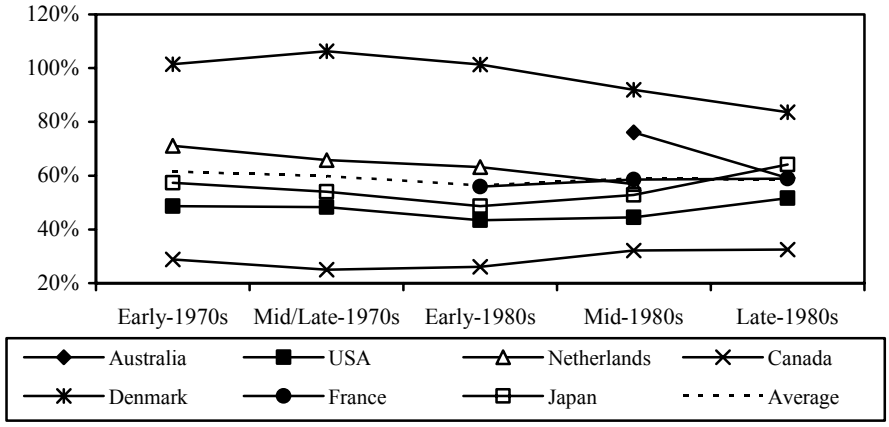


Intermediate productivity indicators

The intermediate productivity indicator denotes the intermediate output to input ratio in the real estate sector. It represents the amount of product created by one unit of a group of factors of production over a stated period as shown in Eq. (3b). Figure 8 shows the intermediate productivities for the real estate sector of seven selected countries. Increases in productivity come from increased efficiency on the part of inputs. From the output perspective, most of the output of real estate flows into the final demands, i.e. private domestic consumption and government consumption. On the other hand, the input of real estate focuses on the capital and labour input with a relatively technical level. Therefore, it is reasonable that the real estate sector has a wholly lower intermediate productivity than sectoral productivity. Over the examined period, except for Denmark and Canada, the intermediate productivity of

other countries located on a narrow band from 40% to 80%. The real estate sector of Denmark had the highest intermediate productivity with a higher intermediate output and lower intermediate input. The real estate sector of Canada had the lowest intermediate productivity with the lower output, smaller final demand and larger imports.

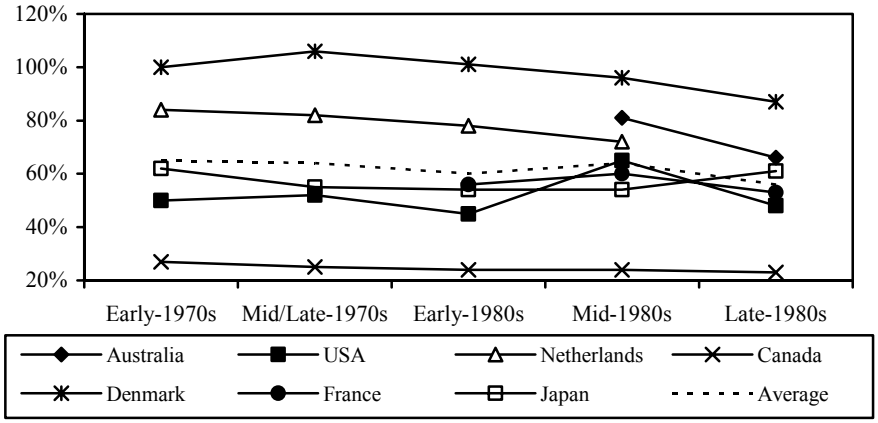
Figure 8: Intermediate productivity indicators



Aggregate productivity indicators

The aggregate productivity indicator represents the ratio of the output multiplier multiplying final demand of the real estate sector to the input multiplier multiplying value added. Figure 9 shows the aggregate productivities of the real estate sectors in seven countries as per Eq. (3c). The output multiplier can be calculated from Eq. (1d) showing the effect of one monetary unit change in final demand of the real estate sector on total output of all other sectors. The output multiplier multiplying final demand shows the total effect of change in final demand of the real estate sector. The input multiplier, which is from Eq. (2d), represents the effect of one monetary unit change in value added by the real estate sector on total input of all other sectors and is a symbol of technical relationships between sectors at a particular moment in time. The input multiplier multiplying value added represents the total effect of change in value added by the real estate sector. The aggregate productivity measures the total efficiency of industry production resulting from all final demand sales by the industry (West, 1999). A higher value means the higher outputs such as reduced cost, improved service and increased volume or lower (efficient) inputs for instant materials, human resources and management systems in the real estate sector (SCRCSP, 1997). Two distinct groups of countries can be observed: Australia, Denmark, and the Netherlands with a relatively higher aggregate productivity from 66% to 106% and the remaining countries with lower ones from 20% to 60%.

Figure 9: Aggregate productivity indicators



Spearman rank correlation coefficient testing

Further, the inter-relationship among the sectoral, intermediate and aggregate productivity indicators should be investigated to decide the reasonableness of the three indicators, because no previous research had investigated these indicators based on the input output table. In order to explore the association relationship, the Spearman rank correlation coefficient is used to measure if there are any notable differences in rankings of these indicators in the following part of this section (Levin and Rubin, 1998). Table 6 presents the results of the ranking of sectoral, intermediate and aggregate productivity indicators.

Table 6: Spearman rank correlation coefficient analysis results

	Early-1970s	Mid/Late-1970s	Early-1980s	Mid-1980s	Late-1980s
Sample number	5	5	6	7	6
Sectoral/Intermediate	1.00	1.00	1.00	0.82	0.94
Intermediate/Aggregate	1.00	1.00	1.00	0.82	0.94
Aggregate/Sectoral	1.00	1.00	1.00	1.00	1.00

As expected, comparison results suggest that there are a perfect association among the three indicators in the early-1970s, mid/late-1970s and early-1980s. Moreover, the correlation coefficients of 0.82 and 0.94 also suggest a substantial positive association between the sectoral, intermediate and aggregate productivity indicators in the mid-1980s and late-1980s. This supports the claim that the three indicators

are coherent and reliable to some extent. On the other hand, the results mean that the developing levels of real estate productivity are stable for every country during the study period and variations of structure of real estate productivity are also relatively stable.

CONCLUSIONS

Based on the newly published OECD input-output database, this research develops a new productivity measurement approach based on the input-output tables for the international comparison of the real estate sector. Input efficiency indicators, output efficiency indicators and three multifactor productivity indicators are developed and tested. The input efficiency analysis of the real estate sector is a measure of value in relation to intermediate and total inputs in the multifactor productivity measurement category. The output efficiency indicators reflect the output efficiency and importance of the real estate sector in the entire economy. Three multifactor productivity indicators are formulated using the ratio of the sectoral final demand to value added, the intermediate output to input and total output to input effect respectively in the input output table. The sectoral productivity measures the gross influence of a sector on all industrial sectors. The intermediate productivity indicator denotes the amount of product created by one unit of a group of factors of production over a stated period. The aggregate productivity denotes the total efficiency of industry production resulting from all final demand sales by the industry. Moreover, rank correlation tests suggest a substantial positive association among the sectoral, intermediate and aggregate productivity indicators over the study period. Additionally, historical analyses and comparisons are also carried out to indicate the differences of productivities of the real estate sectors in seven selected countries over the study period. Findings can improve the understanding of how technological, organisational and policy influences combine to affect productivity growth and aid the policy makers, real estate agencies and researchers in evaluating the competitive ability of the real estate sector.

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Appendix 1: OECD section and sectoral classification

Section	OECD Sector No.	Sector
1	1	Agriculture, forestry and fishery
2	2	Mining and quarrying
3	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
4	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
5	34	Producers of government services
6	35	Other producers
7	36	Statistical discrepancy

(Source: OECD 1995)