Construction Management & Economics

ISSN: 0144-6193 (Print) 1466-433X (Online) Journal homepage: https://www.tandfonline.com/loi/rcme20

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To cite this article: Chan Swee Lean (2001) Empirical tests to discern linkages between construction and other economic sectors in Singapore, Construction Management & Economics, 19:4, 355-363, DOI: 10.1080/01446190010022686

To link to this article: https://doi.org/10.1080/01446190010022686

Construction Management and Economics (2001) **19**, 355–363

Empirical tests to discern linkages between construction and other economic sectors in Singapore

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Received 27 August 1999; accepted 16 November 2000

The construction industry makes significant contributions to the socio-economic development process in most countries. Its importance in the economy is due largely to the direct and indirect impact it has on the national economy. It stimulates the growth of other sectors through a complex system of linkages. Interest in multi-sectoral linkages was generated following Hirschman's work that investigated the relationship between unbalanced sectoral growth and economic development. Most of the past research work had used Leontief's input–output analysis to gauge the backward and forward linkages between industries. This paper proposes an econometric procedure that can be used for determining the construction output linkages. This involves unit-root testing and Granger causality testing. The main purpose is to determine the impact of a fluctuation in construction output on the sectoral production and the economy of Singapore. This helps to assess the role of the construction industry and how it is affected by the changes in the other economic sectors.

Keywords: Construction linkages, economic sectors, Granger causality

Introduction

Construction makes a noticeable contribution to the economic output of a country; it generates employment and incomes (Field and Ofori, 1988) for the people. The effects of changes in the construction industry on the economy occur at all levels (Hillebrandt, 2000, p. 27) and in virtually all aspects of life (Hillebrandt, 1985, p. 12). This implies that construction has a strong linkage (Bon *et al.*, 1999; Pietroforte and Bon, 1999; Bon, 2000, p. 175; Pietroforte *et al.*, 2000) with many economic activities, and whatever happens to the industry will directly and indirectly influence other industries and, ultimately, the wealth of a country. Hence, the construction industry is regarded as an essential and highly visible contributor to the process of growth (Field and Ofori, 1988).

The importance of the construction industry stems from its strong linkages with other sectors of the economy (World Bank, 1984). Construction activities generate demand for raw, semi-processed and processed materials. There exists a close association between construction, the manufacturing sector and the commerce sector that supplies the materials and equipment required by the construction sector. As most construction projects are dependent upon loan financing (Punwani, 1997), there is a close linkage between construction and the financial operations within the economy. The construction industry also generates income through the sale of its products, the purchase of its inputs and the creation of jobs.

Studies have shown that the interdependence between the construction sector and other economic sectors is not static but changes as the nation's economy grows and develops (Bon, 1988, 1992). A secular decline in the manufacturing sector (Bon, 1988) and a growth of services will alter the state of the relationship as the industry depends less on the supply of inputs from the manufacturing sector, the old engine of growth, and channels more of its intermediate output to the service sector, the new engine of growth (Bon, 1992). In an advanced economy, due

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Construction Management and Economics
ISSN 0144–6193 print/ISSN 1466-433X online
http://www.tandf.co.uk/journals
DOI: 10.1080/01446190010022686

to the accumulation of older stock of constructed facilities, the maintenance and repair segment of the industry assumes growing importance, and the construction sector is expected to have a stronger relationship with the service sector (Bon, 1988).

Research objectives

Since its invention by Wassily Leontief in 1957, input–output analysis has been a useful modelling technique which can be used to determine, define, measure and assess the linkages between sectors. However, due to the substantial numbers of trade accounts that are needed to construct the input–output data, such tables are not compiled and published regularly in most countries. Recently, the Institute of Developing Economics, Japan, and several institutions of collaborating countries such as Korea, Thailand, Philippines and Indonesia, have launched joint research projects on the compilation of input–output tables. This helps in making input–output tables more available for use in the developing countries. In Singapore, for example, four sets of input–output tables have been produced for reference years 1973, 1978, 1983 and 1988. An interim table was compiled for 1990 and it remains the most recent. The application of input–output analysis is hampered by the unavailability and unreliability of data that seem to be common problems in developing countries (Miller *et al.*, 1989, p. 222). This hinders attempts to understand and monitor the changing economic structure of a country and the interactions among economic sectors. Thus, it is necessary to explore alternative methodology to input–output analysis.

This study proposes an econometric method based on Granger causality in a dynamic multivariate context to discern the linkages between construction and other sectors of the economy. The main aims of the study are to determine the causal-chain effects among sectoral output changes, and to unveil the underlying mechanism that channels the effects from a change in output in the construction sector through a network of dependent industries to the national output as a whole. The study seeks to determine the direct and indirect impact of the construction output change on the economy of Singapore and to find out if this relationship is reversible.

The literature

Hirschman (1958) first defined the concept of 'linkage' in his work *The Strategy of Economic Development*. He emphasized the significance of 'unbalanced' growth among supporting sectors of the economy as opposed to a balanced development of all interrelated economic activities. With this, he means that an economic activity that has the ability to stimulate and propel others in the growth process should be given greater attention than those that have not. He believes that there is 'a structure that can hold together those interrelated activities' in the economy. He describes it as 'hidden, scattered or badly utilized' (Hirschman, 1958, p. 5). This hidden element can transmit and multiply the effects on the economy. Hence, in considering the feasibility of an investment, it should be based not only on its direct contribution to output but also on the larger or smaller impulses that it can impart to further investment and output. This concept sparked off numerous studies to investigate the linkages and linkage effects among economic activities.

Several authors conclude that the construction industry has strong linkages with other industrial sectors. Ofori (1990, p. 59) notes the important role of the construction industry in the national economy and attributes it to the high linkage of construction with the rest of the economy by a complex set of input and output inter-relationships. Many studies (Fox, 1976; Bon and Pietroforte, 1993; Pietroforte and Bon, 1995) use the strong direct and total linkage indicator to explain the leading role of the construction sector in the national economy.

The forward and backward linkages of the construction sector are well discussed in the literature. Bon (1988) comments that the construction industry's need for a large amount of national resources through direct purchases from other sectors makes it an industry that has the highest backward linkages. Other studies also observe the high backward linkage of the construction sector in many countries, especially the following: Italy (Pietroforte *et al.*, 2000), Japan (Bon and Yashiro, 1996), Turkey (Bon *et al.*, 1999) and almost all the Pacific Basin economies that include Indonesia, Malaysia, Philippines, Singapore, Thailand, South Korea, Japan and the USA (Park, 1989). The large quantity of intermediate inputs demanded by the construction industry and the nature of the industry's operations involving the assembly of the many different products purchased from a large number of industries (Pietroforte, 2000) is the cause of a high backward linkage for the construction industry.

Some writers also compare the construction linkages between different countries. Bon and Minami (1986) conducted studies for the USA between 1947 and 1977 and for Japan between 1960 and 1980 using 6 and 5 input–output tables, respectively. They found great similarity in the economic structures of the two economies and they also found that the construction sector is stable and mature. Polenske and Sitivanides (1990) examined the construction industry's backward and forward linkages of 15 countries, both developed and developing, between 1947 and 1982. They found differences in the backward linkages over time among countries due to differences in product mix, relative prices and technology. They found that strong backward linkage of construction exists in countries regardless of their stage of economic development, and deduced that the economic impact of construction activities is relatively evenly dispersed over the sectors from which they obtained their inputs. Park (1989) conducted a study among countries in the Pacific basin and confirmed that the construction industry generates one of the highest multiplier effects through its extensive backward and forward linkages with other sectors of the economy.

Analytical tools are available for measuring the strength of the linkage. Most of the research works applied Leontief's (1936) input–output analysis to gauge the backward and forward linkages between the sectors of the economy. There is not much research work that focuses on the linkages of the construction sector. Bon (1988) is one of the few researchers who applied the concept to the construction industry. He considered the input–output technique to be ideal, for it provides a framework with which to study both direct and indirect resource utilization in the construction sector and industrial interdependence. He also found that the input–output tool can be used for studies of the construction sector in three broad aspects: employment creation potential, role in the economy, and identification of major suppliers to the construction industry. Ganesan (1979) analysed employment creation and material requirement issues. Fox (1976) examined the economic structure and relationship between the construction industry and other sectors.

Recent studies on industrial linkages and their role in inducing economic development using the input-output tables can still be found (Polenske and Sivitanides, 1990). With the popularity of the new econometric methodology, pioneered by Engle and Granger, many modelling studies related to economic and financial issues have applied this new technique to analyse economic relationships. Odedokun (1996) analysed the role of the financial sector in economic growth using data from 71 least developed countries (LDCs) and found that the financial sector promotes economic growth in 85% of the countries, and that its growth-promoting effects are more predominant in low income than high income LDCs. Green (1997) applied the Granger causality test to determine the relationship between GDP and residential and non-residential investment, using quarterly national income and gross domestic product data for the period 1959–1992. His results showed that residential investment causes, but is not caused by GDP, while non-residential investment does not cause, but is caused by GDP. He concluded that housing leads and other types of investment lag the business cycle. The results also suggest that policies designed to funnel capital away from housing into plant and equipment could produce severe short-term dislocations.

Among the very few, Tse and Ganesan (1997) attempted to determine the causal relationship between construction flows and GDP using quarterly Hong Kong data from 1983 to 1989. They did not use input–output data but time series data instead. Their work applied the same econometric technique (causality test) as that used in this paper, except that it was done in a bivariate form. They found that the GDP leads the construction flow and not vice versa. This view contradicts other researchers' conclusions: the construction sector is a main buyer from other sectors, it determines the demand for their produce, and their output activities feed back to the economy (Briscoe, 1988; Ofori, 1990).

There are research studies that examine the relationship between output and other macroeconomic variables such as money, interest rates, prices and exchange rate (Masih and Masih, 1996). A model that attempts to represent the multi-sectoral output relationship is due to Long and Plosser (1983). This is a form of real business cycle (RBC) model. It attributes aggregate economic fluctuations to some periodic or randomly occurring real disturbances that can be propagated to the economy. Real disturbances referred to by most RBC theorists such as Kydland and Prescott (1990) refer to changes in technology or constraints, such as fiscal policies. Monetary disturbances are not commonly accepted as real disturbances, although some may regard the impact of credit supply and other monetary aspects to be important causes of business fluctuations. RBC theorists, on the whole, contend that real disturbances can account for most, if not all, of the observed fluctuations in output.

Construction is a sector that is sensitive to changes in both fiscal and monetary disturbances. This is because most construction projects involve large sums of money and need to be financed through loan facilities. Changes in interest rate, money supply or credit availability will affect the cost and ease of borrowing, hence affecting construction output. The multi-sectoral linkages (Long and Plosser, 1987; Engle and Issler, 1993) that the construction industry depicts imply that reactions to the change in the level of construction activity are spontaneous among other sectors. Although little is known, there is an 'intersectoral transmission mechanism' that exists between construction and the aggregate output. The effect of the fluctuation in the construction output on the economy is channelled and amplified through this hidden mechanism.

Singapore's economy and the construction sector

Singapore attained self-government in 1959. After forty years of nation building, despite its city-state size and lack of natural resources, Singapore has emerged as one of the richest nations in the world. In 1996, the OECD reclassified Singapore as a 'more advanced developing country' because of the great progress reflected in its economic growth compared with her contemporaries. The country's per-capita GNP in 1998 was about US$22 800, which is relatively high by international standards and surpasses those of many developed countries.

Many sectors of the economy have contributed to Singapore's economic progress. The major sectors delineated in the Singapore Standard Industrial Classification (SSIC) 1990 are manufacturing, utility, construction, commerce, transport and communications, finance and business services, and other services. The real estate sub-sector, which is an important client of construction, is included under the broad category of 'finance and business services'. The finance and business services sector is expected to have a close relationship with the construction sector because of the need for loan facilities in the building process, and the dependence of the construction on the real estate sub-sector for the marketing and sales of its construction products.

Table 1 presents the contributions to the GDP by various sectors. Evidently, industries like manufacturing and finance and business are the most important, contributing 22% and 26%, respectively, to the overall economy of Singapore in 1998. The construction sector's share of GDP averaged 8% between 1975 and 1998 and reached a high of 14% in 1984, quarter 2, just before a national economic recession in 1985.

Sectoral interdependence

In Singapore, the level of dependence of a sector can be observed based on the input and output relationship among the sectors. Table 2 shows how a million dollar increase in the final demand of the output of a sector would affect the total economy. The construction sector has a relatively high output multiplier effect (1.847) compared with the others. Its ability to create employment is ranked second after 'other services'.

Economic sectors in the economy depend on each other's produce as inputs for their own production. The commerce and construction sectors depend heavily on other sectors for the supply of their inputs; hence they have the highest backward linkage coefficients of 1.145 and 1.048, respectively (Table 3). Their own outputs are less demanded by other sectors, so that their forward linkage coefficients of 0.787 and 0.934 are among the lowest.

Table 1 Sectoral distribution of GDP ($ million), 1998[a]

	1960	1965	1970	1975	1980	1985	1990	1995	1998
Manufacturing	985	1 523	3 545	5 859	9 968	10 769	19 393	28 529	28 398
Utility	90	115	244	373	601	827	1 250	1 741	2 171
Construction	326	780	1 411	2 107	2 517	5 113	3 724	7 586	11 040
Commerce	1 538	1 769	3 315	4 961	6 737	8 209	12 764	18 714	22 520
Transport and communications	475	513	946	1 856	3 683	5 591	8 716	13 414	16 828
Finance and business services	824	1 293	2 398	4 503	6 881	12 382	17 835	27 634	34 326
Others	1 135	1 461	2 074	2 989	3 814	5 239	7 359	10 626	13 060

[a]Source: Department of Statistics, Singapore.

Table 2 Multipliers by industrial sector (per $m of change in final demand)[a]

Industrial sector	Output ($ million)	Value added	Income	Import	Employment number
Manufacturing	1.320	0.316	0.121	0.774	6.6
Utilities	1.390	0.822	0.167	0.303	6.9
Construction	1.847	0.902	0.428	0.417	24.9
Commerce	1.995	1.062	0.445	0.270	24.9
Transport and communications	1.617	0.834	0.304	0.393	15.9
Financial and business services	1.725	1.076	0.345	0.182	14.4
Other services	2.044	1.078	0.630	0.392	34.5

[a]Source: Input–output Tables, 1990, Department of Statistics, Singapore (1998).

Table 3 Backward and forward linkage[a]

Industrial sector	Forward linkage	Backward linkage
Manufacturing	0.880	0.773
Utilities	0.910	1.364
Construction	1.048	0.787
Commerce	1.145	0.934
Transport and communications	0.973	1.063
Financial and business services	1.022	1.150
Other services	1.037	0.908

[a]Source: Input–output Tables, 1990, Department of Statistics, Singapore (1998)

Econometric methodology used

New versus old

This study uses time series data to demonstrate the sectoral linkages in Singapore. This is different from the static data that all input–output linkage methods use. A time series is a sequence of values or readings ordered by a time parameter, such as hourly and yearly readings. Since the order of the data is of considerable importance, most of the classical statistical techniques are no longer relevant and a new technique has to be devised (Granger and Newbold, 1986, p. 1). The new cointegration technique is a breakthrough in the field of econometrics, and it changes the way that analysts handle and model time series data. In essence, the technique requires the assumption of a constant mean and variance or stationarity in the data that can be checked using unit root tests discussed below. If the data are non-stationary, then frequently stationarity can be achieved by first differencing (Granger and Newbold, 1986, p. 206), that is, obtaining the differences between the current value and that of the previous period. Once stationarity is determined, structural modelling of the variables or testing for causality can take place. The causality test aims to verify whether historical variations of the construction data follow or precede those of other sectors and the GDP.

The econometric approach models the linkages between sectors over a long period of time to see if there is a systematic pattern. The input–output linkage method describes the relationship at a particular time only. The question of whether this relationship persists over time cannot be addressed by the input–output procedure. The input–output linkage method assumes an instantaneous relationship between the sectors and the economy, whereas the new econometric approach provides an estimate of the time lag by which precedence of an event occurs, and hence it is more useful for prediction and policy making.

Unit root test

The econometric methodology employed in this study involves several procedures. The first procedure is to test for unit root or to check if the data are stationary. A series is said to be stationary if it displays the tendency of returning to its mean value and fluctuates around it within a more-or-less constant range: i.e. it has a finite variance (Harris, 1995). This step is very important because if non-stationary variables are not identified and used in the model, it will lead to a problem of spurious regression (Granger and Newbold, 1974), whereby the results suggest that there are statistically significant relationships between the variables in the regression model when in fact all that is evidence of contemporaneous correlation rather than meaningful causal relations (Granger and Newbold, 1974; Harris, 1995). The number of times the data have to be differenced to become stationary is the order of integration. If a series is differenced d times to become stationary, it is said to be integrated of order $I(d)$.

Several tests are available for testing the order of integration. The study adopted the most common procedures of Dickey Fuller (DF) (Dickey and Fuller, 1979), augmented Dickey Fuller (ADF) and Phillips Perron (PP) (Perron, 1988). The optimal lag lengths are chosen based on the Akaike's (1969) final prediction error (FPE), which has received wide acceptance among time series analysts (McClave, 1978). In the case of the Phillips Perron, the lagged lengths are based on Newey and West's (1987) autocorrelation consistent covariance estimator, which is a standard feature in modern econometric computer programs such as the 'Eview' program used in this study.

Once the variables are integrated of the same order, it implies that the differenced variables can be expressed in a mathematical form. A vector autoregression (VAR) model can be utilized to represent the relationship, and causality among the variables must exist in at least one direction (Granger and Newbold, 1986). This can be tested using the Granger causality procedure.

VAR representation and causality

The kth order autoregression can be expressed as

$$\Delta Y_{it} = \sum_{j=1}^{k} \alpha_j \, \Delta Y_{it-j} + \sum_{i=1}^{n-1} \sum_{j=1}^{k} \beta_j \, \Delta X_{it-j} + \varepsilon_t \tag{1}$$

Where Y_{it} is ith sector at time t; X_{it} are other sectors in the economy at time t, while

ε_t are the disturbances. The parameter α_j if nonzero indicates that its own lagged term precedes the change in Y; and β_j if nonzero indicates that the lagged term of X_i precedes the change in Y. The Granger causality test performs pairwise causality tests between (all possible) pairs of the listed series or a group of series. Here, the causality relationship is determined by testing the hypothesis to check whether the lags of X_i of interest are jointly zero while leaving others at their ordinary least-squares values (Davidson and MacKinnon, 1993, p. 686).

Empirical estimation

The data

There are eight variables in this model: GDP (gdp), manufacturing (mfg), utility (utl), construction (cns), commerce (com), transport and communications (trp), finance and business services (fbz), and other services (oth). They are used in their natural logarithmic forms and are denoted in lower case. The data are obtained from the electronic TREND database maintained by the Department of Statistics, Ministry of Trade and Industry of Singapore. The data are quarterly real figures that span from 1986, quarter 1 to 1999, quarter 2, that is, 54 usable data points. They have been seasonally adjusted to avoid seasonal irregularities that may distort the underlying properties of the time series data.

Test for stationarity

The results of the unit root tests using the augmented Dickey Fuller (ADF), Dickey Fuller (DF) and Phillips Perron (PP) methods are summarized in Table 4. The null hypotheses of non-stationarity are performed at the usual 1%, 5% and 10% significance levels, and the critical values for the tests are presented in Table 5.

The results from the DF tests indicate that all the data series are not stationary at all levels, since the null hypothesis cannot be rejected at 5% significance level. Based on the ADF tests, all the first-differenced data series except ‘oth’ are stationary at the 5% significance level. Results from the PP tests strongly support the conclusion that each of the series is stationary after first differencing at the 1% significance level. This means that only differenced data should be used in the model.

Tests for sectoral interdependence

The Granger causality test is applied to determine whether a change in construction output precedes the other outputs of other sectors within the Singapore economy. This approach is different from Tse and Ganesan’s (1997) study that examines the causal relationship of construction flows with the aggregate output instead of sectoral demand and relationships.

Table 4 Unit root tests: Singapore sectoral output data, seasonally adjusted (1986:3–1999:2)[a]

DF test at levels			ADF test in first difference				PP test in first difference			
Series	No trend	With trend	No trend	Lag	With trend	Lag	No trend	Lag	With trend	Lag
gdp	-1.55	-2.38	-3.52**	3	-3.94**	3	-6.33***	3	-6.48***	3
mfg	-2.79*	-3.00	-3.60***	3	-4.15**	3	-5.68***	3	-5.77***	3
utl	-1.76	-2.91	-4.33***	3	-4.69***	3	-7.51***	3	-7.73***	3
cns	-1.20	-3.15	-4.26 ***	2	-4.11 **	2	-5.39***	2	-5.43***	2
com	-1.68	-0.81	-3.37**	3	-4.31***	3	-7.07***	3	-7.42***	3
trp	-0.81	-1.68	-4.07***	3	-4.24***	3	-5.96***	3	-5.96***	3
fbz	-0.82	-3.26 *	-3.48**	3	-3.57**	3	-10.16***	3	-10.34***	3
oth	-0.75	-2.36	-3.37**	3	-3.44*	3	-9.74***	3	-9.92***	3
CPI	-0.58	-0.23	-3.57***	3	-3.83**	3	-4.36***	3	-4.43***	3

[a]Note: *, ** and *** denote the rejection of the null hypothesis of unit roots at 10%, 5% and 1% significance levels, respectively.

Table 5 MacKinnon critical values for rejection of hypothesis of a unit root [a]

	DF test at levels		ADF test in first difference		PP test in first difference	
Critical value	No trend	With trend	No trend	With trend	No trend	With trend
1%	-3.56	-4.14	-3.56	-4.15	-3.56	-4.14
5 %	-2.92	-3.50	-2.92	-3.50	-2.92	-3.50
10%	-2.60	-3.18	-2.60	-3.18	-2.60	-3.18

[a]Source: MacKinnon (1991).

Table 6 demonstrates the strong inter-relationship of construction with the other sectors in Singapore. Construction leads 'other services', utility, finance and business services, and commerce sectors by one, two, four and five quarters, respectively. It also leads the manufacturing and transport and communications sectors by six quarters and the GDP by two years. Since construction output represents a form of finished work by the construction industry, this causal linkage can be interpreted as the forward linkages of the construction sector with other sectors over different time frames.

Table 6 shows the short run (within 6 quarters) Granger lead–lag relationship among the various sectors using the value-added series. A six-quarter lag is used so as to confine the analysis to short term responses generated in the multi-sector system. This is also to prevent the network of linkages from becoming too complicated.

Statistical results show that there are multiple links among the sectoral output. Some of these outputs from manufacturing, commerce, transport and communications, finance and business services and utility, in turn, feed back into the construction industry. Individual sectoral outputs have direct causal effects on the GDP at various time lags, as shown in Table 7.

'cns' is affected greatly by changes in all the sectors except 'other services', as shown by the densest convergence of arrows at 'cns' in Figure 1. This is consistent with the common understanding that demand for construction is a derived demand such that the level of construction output depends on the growth or decline of other industrial outputs. Changes in 'com', 'trp' and 'utl' appear to have more immediate influence on 'cns'. Output variation in 'fbz' causes change in 'cns' within 2 quarters, while 'mfg' has a delayed effect on construction. The lag length is estimated to be about a year.

Many of the causal relationships between the economic sectors are bi-directional as indicated by the

Table 6 Causality tests of construction on other economic sectors[a,b]

Direction of causality			Lag length	*F* Statistic	
Δ cns	⇒	Δ com	5	5.09	**
Δ cns	⇒	Δ fbz	4	5.64	**
Δ cns	⇒	Δ oth	1	6.29	**
Δ cns	⇒	Δ utl	2	5.38	**
Δ cns	⇒	Δ mfg	6	4.15	**
Δ cns	⇒	Δ trp	6	4.09	*
Δ mfg	⇒	Δ cns	4	5.44	**
Δ mfg	⇒	Δ com	2	2.94	*
Δ mfg	⇒	Δ oth	4	4.27	**
Δ com	⇒	Δ mfg	1	6.00	**
Δ com	⇒	Δ cns	1	4.18	**
Δ com	⇒	Δ utl	1	5.00	**
Δ com	⇒	Δ oth	2	9.55	**
Δ trp	⇒	Δ cns	1	6.87	**
Δ trp	⇒	Δ utl	1	3.47	*
Δ trp	⇒	Δ com	3	4.36	**
Δ trp	⇒	Δ oth	3	4.03	**
Δ fbz	⇒	Δ cns	2	3.33	*
Δ fbz	⇒	Δ com	1	4.05	**
Δ fbz	⇒	Δ oth	3	9.63	**
Δ utl	⇒	Δ cns	1	5.52	**
Δ utl	⇒	Δ trp	4	3.00	*
Δ oth	⇒	Δ mfg	1	3.78	*
Δ oth	⇒	Δ utl	3	10.83	**
Δ oth	⇒	Δ com	3	8.41	**
Δ oth	⇒	Δ trp	1	3.00	*

[a]Note: * and ** denote rejection of the hypothesis at 5% and 1% significance levels, respectively.

[b]$\Delta x \Rightarrow \Delta y$ represents a change in x will precede a change in y. The critical values at 1% and 5% significance levels are 4.10 and 2.8, respectively.

Table 7 Granger causality between sectoral outputs and the economy[a]

Direction of causality			Lag length	*F* Statistic	
Δfbz	⇒	Δgdp	3	9.37	
Δcom	⇒	Δgdp	6	8.02	
Δcns	⇒	Δgdp	8	3.92	*
Δtrp	⇒	Δgdp	1	22.47	
Δutl	⇒	Δgdp	2	7.67	
Δoth	⇒	Δgdp	2	5.91	**
Δgdp	⇒	Δcns	3	17.99	

[a]Notes: * and ** denote rejection of the hypothesis at 5% and 1% significance levels, respectively.

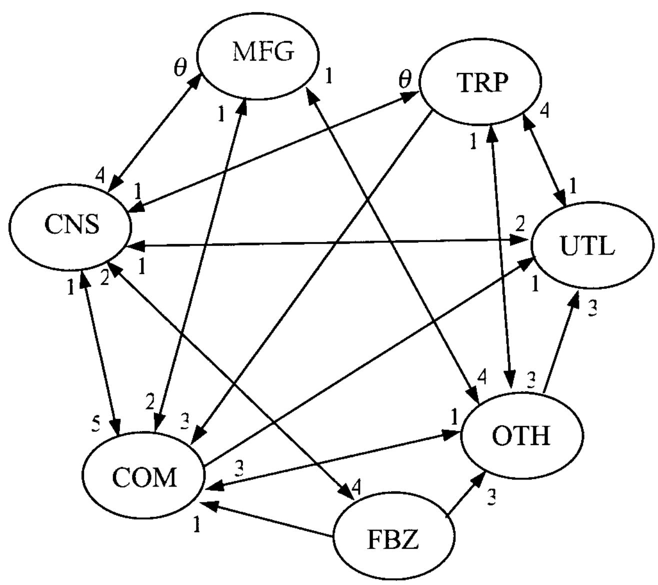

Figure 1 Schematic diagram to show causal relationships among sectoral outputs

double arrowheads connecting pairs of sectors. This implies mutual dependence among some of the economic functions in the system.

Conclusions, implications and future research

This paper has illustrated a new methodology for estimating the output linkages of construction activity and dynamic causal chain effects on other sectors of the economy. The new methodology models the long term association of economic output changes between construction and other industrial sectors as opposed to a static relationship determined by the traditional method. Based on the input–output accounts, the forward linkage effect is computed as an aggregate term, whereas the econometric methodology is able to capture a more specific lead–lag relationship between a pair of activity flows within the economy, and define the sequence of happenings or the chain effects following a disequilibrium change in one sector of the economy. This helps the policy makers, who often apply regulatory measures on construction activity, to understand how the impact on the construction sector is being channelled through other sectors of the economy. Investors in Singapore can benefit from this study by tracking the level of construction output, as it gives them prior knowledge about the general business performance in the near future. The estimated lag times of the causal effects give the industrialists and investors time to plan and strategize their businesses so that they can cope better with the unusual situations caused by the fluctuation in demand.

The study shows that some causal relationships are bi-directional, including those between the construction sector and other sectors; and the construction sector and the GDP. This implies that the causal trends can be reversed by a change in the economic condition in Singapore or technology innovations in certain sectors via the bi-directional linkages. This also shows that the intersectoral linkages are complex, and the construction output change has a multiplied effect on the economy over the short to medium term. Many economic sectors are receptors of the shocks in construction output, and they make short term adjustments endogenously in varying degrees to this shock that has been dissipated within the system. Empirical results have shown that outputs in all industries are susceptible to output shocks in the economy that result in the short term or transitory deviations from their long term common trends. This means that economic sectors have to be adaptable and possess flexible capacity to adjust their output requirements in the shortest possible time. The empirical results affirm the belief that the direction of the relationship between construction flow and the overall economy is two-way, at least in Singapore. This is different from Tse and Ganesan's (1997) finding that Hong Kong's construction flow precedes GDP whereas GDP does not precede construction flow.

Future research should extend the study to cover sectoral interdependence using other measures of construction output, such as contracts awarded and progress payments. The construction value added data used in this study provides an insight into the forward linkages of the construction sector. The lead effects of a change in construction output measured by the value of certificates awarded can be used as a proxy for the backward linkage of the construction sector. Likewise, impact studies of construction output change on the economy, balance of payment and employment level can be conducted using the econometric approach to show the multiplier effects on the economy.

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