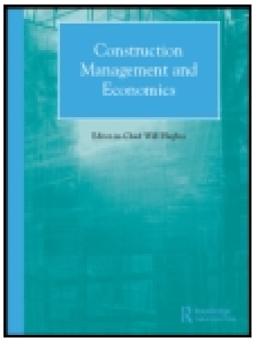

Construction Management & Economics

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

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To cite this article: Raymond Y.C. Tse & Sivaguru Ganesan IV (1997) Causal relationship between construction flows and GDP: evidence from Hong Kong, Construction Management & Economics, 15:4, 371-376, DOI: 10.1080/014461997372926

To link to this article: https://doi.org/10.1080/014461997372926

Construction Management and Economics (1997) **15**, 371–376

NOTE

Causal relationship between construction flows and GDP: evidence from Hong Kong

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Received 12 April 1996; revised 17 October 1996

Granger causality methodology is used to investigate lead–lag relationships between construction activity and aggregate economy. Using data from Hong Kong, the results of this paper suggest strongly that the GDP tends to lead the construction flow not vice versa. Our finding is contrary to the view that construction is more volatile than the GDP. However, our results show that the construction volatility after 1990 is smaller than that in the period 1983–1989, a result that is particularly important for policymakers in that it is the macroeconomic policy of government that affects output, and influences the construction activity, and not vice versa.

Keywords: GDP; unit root test; causality; Hong Kong

Introduction

At first sight, construction output is an integral part of national output. It is possible that expansion of construction activity is preceded by an increase in economic output, with the initial effect felt largely within the construction sector and only subsequently on the aggregate economy. Akintoye and Skitmore (1994) suggest that construction investment is a derived demand which is growth dependent. However, the results of the econometric models used by Akintoye and Skitmore (1994), who tested the relationship between national output and construction demand, are mixed. If markets are interdependent, disturbances in one market will be transmitted to other markets. However, there have been few empirical studies of relationships between the construction sector and the aggregate economy. The issue of concern here is whether the construction sector and the aggregate economy are segmented or interdependent, and whether construction activity contributes to economic growth and/or vice versa. The purpose of the present paper is to examine the specific lead–lag relationships between construction flow and gross domestic product (GDP). Granger causality methodology is commonly applied to investigations on the relationships among money supply, stock prices and inflation, but no-one has tested the linkages between the construction sector and the aggregate economy using this method. In addition, we will make use of the most recent innovations in the literature of unit root tests.

The following section presents the results of the unit root analysis to study the stationarity of GDP and construction flow. Accordingly, we employ Granger causality methodology to investigate the lead–lag relationships between the construction flow and the GDP. We will also examine whether volatilities in the construction sector are excessive relative to the volatilities in the output.

Unit root tests

The casual tests of Granger (1969) are essentially tests of the predictive ability of time-series models. However, Granger causality tests require the use of stationary time-series data (Granger and Newbold, 1974; Ong, 1994; Huang, 1995). Under current practice, developing such data requires the observed data series be tested for unit roots. The tests for unit roots are known also as Dickey–Fuller (DF) and augmented Dickey–Fuller (ADF) tests. Typically, the ADF test is based on the following formulation:

$$\Delta Y_t = \mu + \delta T + \alpha Y_{t-1} + \sum_{i=1}^{n} \beta_i \Delta Y_{t-i} + u_t \qquad (1)$$

where $\Delta Y_t = Y_t - Y_{ti}$, μ is a drift term and T is the time trend with the null hypothesis H_0: $\alpha = 0$ and its alternative hypothesis H_1: $\alpha \neq 0$, n is the number of lags necessary to obtain white noise and u_t is the error term. The simpler Dickey–Fuller (DF) test removes the summation term. However, the implied t statistic is not the Student t distribution, but instead is generated from Monte Carlo simulations (Engle and Granger, 1987, 1991). Note that failing to reject H_0 implies the time series is non-stationary.

In this study, GDP is an expenditure-based estimate, compiled using current market prices. The construction flow (CTN), measured at current market prices, refers to: new construction works and renovation and maintenance, including the erection of new buildings and structures and installation of service facilities such as utility fittings and ventilation systems; major alteration and conversion works on existing structures; demolition, site formation, piling and other sub-structure work preceding the actual erection of structures; and the restoration of existing buildings and structures to normal condition. All of the data come from the *Hong Kong Monthly Digest of Statistics* (various issues). Since quarterly data of CTN before 1983 are not available, the study employs data from 1983Q1 to 1995Q1. The quarterly data used in this analysis contain the gross value of construction work put in place by main contractors within and outside construction sites. Each round of the survey covers approximately 1850 construction establishments. All main contractors employing over 100 persons at construction sites, and all other construction establishments engaging 100 persons or more, are fully enumerated. The others are surveyed using rational replicated sampling (Census and Statistics Department, Hong Kong, *Report of the Quarterly Survey of Construction Output*). The value of work put in place is obtained from progress payments received during the reference period, after deducting the value of work done before the reporting period and adding payment received afterwards for work done during the reference period. The procedure adopted is prone to estimating errors. However, the difference between the data compiled for the quarterly estimates and the estimates of construction in the annual GDP figures computed from more detailed information has been shown to be only marginal. It is noteworthy that construc-tion flow data do not include expenditure on investigations, surveys and designs that are incurred before construction work commences. Also it does not include expenses incurred by clients on supervision during construction (Census and Statistics Department, Hong Kong, *Estimates on Gross Domestic Product 1966 to 1992*, March 1993).

Table 1 reports the DF and ADF test statistics on the natural logarithm of the CTN and GDP in regression (1) omitting minus signs for simplicity. In Table 1, the null hypothesis of unit root for GDP, in level form with and without time trend, is rejected at all conventional levels of significance, but not rejected for CTN when the calculated Dickey–Fuller test statistics associated with the numerical coefficients of GDP_{t-1} and CTN_{t-1} are compared with its critical values, as given in Engle and Granger (1987). We will assume the CTN series is non-stationary in level terms. The two series were (log) first-differenced and the unit root tests re-run; in this form, the DF and ADF (with one lag) test statistics reject the hypothesis of a unit root at all conventional levels of significance, suggesting that the variables appear to be first-difference stationary (i.e. $I(1)$). For comparisons, the causality tests were carried out in level form and then in first-differences of the data.

Table 1 Results of unit root tests[a]

		Level		First differences	
Variables		Trend	No trend	Trend	No trend
GDP_{t-1}	DF–0 lag	4.70*	1.02	6.51*	6.55*
	ADF–1 lag	6.46*	0.92	15.8*	15.9*
	ADF–4 lags	4.58**	0.22	3.00	3.06
CTN_{t-1}	DF–0 lag	2.94	0.068	8.21*	8.29*
	ADF–1 lag	2.36	0.047	6.40*	6.47*
	ADF–4 lags	2.22	0.614	2.12	2.30

[a]Note that * and ** indicate significant at the 1% and 5% levels, respectively. The critical values of DF statistics are: 3.5 with trend and 2.93 without trend, and 4.15 with trend and 3.58 without trend at the 5% and 1% levels of significance, respectively.

Causality test results

To test whether construction flow stimulates aggregate economy or aggregate economy leads the construction activity, or if there exist feedback effects between construction flows and the aggregate economy, the Granger causality test is used in the present study, fitted with quarterly data from 1983Q1 to 1995Q1. This is represented by (see Granger, 1969; Ashley *et al.*, 1980; Thornton, 1993; Ng, 1995)

$$GDP_t = \sum_{i=1}^{n} \alpha_{0i}\, CTN_{t-i} + \sum_{i=1}^{n} \beta_{0i}\, GDP_{t-i} + u_t \quad (2)$$

$$CTN_t = \sum_{i=1}^{n} \alpha_{1i}\, GDP_{t-i} + \sum_{i=1}^{n} \beta_{1i}\, CTN_{t-i} + v_i \quad (3)$$

where causality implies CTN is Granger-causing GDP provided that some α_{0i} is not zero in Equation 2. Similarly, GDP is Granger-causing CTN if some α_{1i} is not zero in Equation 3. If both of these events occur, then feedback effects exist. The basic concept of the Granger causality tests is that future values cannot predict past or present values. If past values of CTN do contribute significantly to the explanation of GDP, then CTN is said to Granger-cause GDP. This means that CTN is Granger-causing GDP when past values of CTN have predictive power of the current value of GDP even if the past values of GDP are taken into consideration. Conversely, if GDP is Granger-causing CTN, it would be expected that GDP change would take place before a change in CTN.

To implement the Granger causality test, F statistics are calculated under the null hypothesis that in Equations 2 and 3 all the coefficients of α_{0i}, $\alpha_{1i} = 0$. Following the unit root tests, stationarity can be induced by the first-differencing of the level data. Since the number of lags in the causality model is arbitrary, the regression is run twice by setting the order of lags = 4 and 5. Table 2 presents the results of the Granger causality tests for the natural logarithm of the variables. From the F statistics, the causal effect running from construction flows to the GDP in our sample is statistically rejected, in both level form and first-differences of the data. However, the hypothesis of causality from the GDP to the construction flow is not rejected in both level form and first-differences of the data. Thus, the results suggest strongly that the GDP tends to lead the amount of construction flow. One could carry out the test for different values of the lags and make sure that conclusions are robust and not model dependent. This would also provide for the longer lags necessary to account for the time lags between the two series. When the Granger-causality tests were re-run with a longer lag (7 quarters), the results remained the same as before.

Table 2 Granger causality tests for the natural logarithms of variables[a]

	F statistics	
Direction of causality	4 lags	5 lags
In level form		
CTN → GDP	1.220	0.366
GDP → CTN	5.463*	3.293*
In first differences		
CTN → GDP	0.334	0.490
GDP → CTN	4.692*	4.509*

[a]Note that * indicates significant at the 5% level. The null hypothesis of no causality is rejected if the F statistics exceed the critical values.

Thus the conclusion that construction flow is not Granger-causing GDP is robust.

It should be noted that construction output statistics are based on the value of work billed by construction firms after appropriate adjustments for work done outside the period of cash receipts. In Hong Kong, output on a contract will lag construction orders, i.e. arrival of contract, by 3 quarters to 1 year. Construction work in Hong Kong is subject to cyclical periods which last considerably longer than the normal construction activity because Hong Kong undertakes a lot of reclamation work. A minimum period of at least 10 years is likely to be required for completion of the reclamation-based development process. This is due to the time needed to prepare feasibility studies, the gazetting of plans under various ordinances, the provision of new transport infrastructure linking with the land development, the allocation of funds, land acquisition and clearance, and the completion of engineering and building works. It is also plausible that many contractors improve cashflows in the early stages of the work further by pricing early parts of the work artificially high, commonly referred to as 'front-loading'. Work on a large project is usually parcelled out into a number of individual contracts (Fleming, 1988). While it is not possible to measure the pattern of the receipt of orders over time satisfactorily, it is clear that the flow of orders will be reflected to some extent in variations in construction outputs.

Volatility of construction work and GDP

The relationship between construction flow and GDP is analogous to the saving–income relationship, which suggests a curious paradox, sometimes called the 'paradox of thrift'. The national income identity (GNP = saving + consumption) does not imply that an increase in saving will *lead* to a higher GNP. Generally, it is believed that the initial impact of a change of GDP would be on demand for construction projects and real estate, rather than on the level of construction output. A major reason for the cyclical nature of construction is that construction activity is very sensitive to credit conditions. The Keynesians argue that changes in the level of economic activity tend to cause changes in money supply, which reverses the causality suggested by the monetarists. It follows that money supply causes fluctuations in the construction flow. A decrease in income causes a fall in credit supply, which in its turn causes a drop in construction activity and employment. On the other hand, an upswing of the economy started by a lower interest rate or an increase in business confidence will raise demand for construction orders. It follows that more construction work will raise GDP through the multiplier, which in turn leads to a higher demand for construction orders. It should be noted that the demand for construction work is not autonomous. Rather it is determined by the level of GDP. Ball and Wood (1996) show that long run equilibrium levels of national income are associated with equivalent equilibrium levels of particular types of investment. If GDP rises, so will the level of construction activity needed to meet the expanded production capacity. Thus, it is expected that at higher levels of GDP an economy can absorb a higher level of construction activity. However, if the demand for construction work increases, then this, other things being equal, will raise interest rates that businesses must pay to borrow funds to finance new investment. There is some evidence that the interaction between credit supply and construction activity aggravates the inflationary pressures within the economy. Construction is an industry whose products are only weakly tradable, and in the short term construction booms tend to push up output prices rather than contribute to GDP growth. In the longer term, however, higher construction flows are likely to increase the GDP by adding to the nation's capital stock.

Construction is an investment-goods industry, and is therefore characterized by a labour market that is highly flexible (Ball and Wood, 1995; Ganesan *et al.*, 1996). Thus, productivity in construction has not increased at the same rate as elsewhere. Ball and Morrison (1995) argue that all types of fixed investment are considerably more volatile than national income. It is expected that short term growth rates of construction flows can easily fluctuate a lot due to changes in capacity utilization, even if the rate of capacity growth is quite steady. Groak (1994) argues that construction activities are determined significantly by projects, not by firms. Because of the flexibility of the construction industry, the construction activity can be slowed down through the extension of construction durations. In a separate study, Chan and Kumaraswamy (1995) show that construction duration is directly related to its costs. An investment goods industry is, generally, subject to fluctuations in demand resulting from changes in expectations. The greater the volatility of constructions the larger the uncertainty faced by market players. There is a widely held view that very large fluctuations brought about by factors outside the control of government are damaging to the overall efficiency of the industry, and that policies should be established to make the construction industry more stable. Thus, the effect of construction on the economy through the production process and through the effects of credit constraint can be as important as the effect of the economy on the construction sector (Hillebrandt, 1985). It is, thus, argued that construction is a sector of dynamic development with a growth rate exceeding that of the aggregate economy (Sugden in Turin, 1975; Sebestyen, 1980).

The measures of volatilities can be based on the *ex post* variances of the rates of growth around a trend to avoid statistical biases. Based on F tests, it may be preferable to compare volatility of construction activity with that of GDP, and identify whether there is a significant change of volatility across time periods. Because of the political shock arising from the 4 June 1989 incident, we expect there to have been significant change in the two periods 1983–1989 and 1990–1995 (Tse, 1996). First, for each GDP and CTN, we compare the volatilities between the two periods 1983Q1–1989Q4 versus 1990Q1–1995Q1. Then, we compare the volatilities of GDP and CTN in the three periods 1983Q1–1989Q4, 1990Q1–1995Q1 and 1983Q1–1995Q1. A series can be used to calculate a set of N continuously compounded growth rates as follows: $z_i = \log(x_i/x_{i-1})$ where x_i and x_{i-1} denote GDP or CTN at current market prices at times i and $i-1$, respectively. The next step is to estimate the average growth rate: $z_{\mathrm{m}} = \sum z_i/N$, which represents the slope of the trend line x_{i}. The average growth rate is then used in calculating the per-period variance: $\sigma_x^2 = \sum(z_i - z_{\mathrm{m}})^2/(N-1)$. Note that the value of the per-period variance depends upon the length of time over which each growth rate is measured. The measure of volatility around a constant trend line is adequate for short periods. Despite the small sample size, the F statistics are adjusted by the degree of freedom. The results are reported in Table 3, and Figure 1 depicts the movement of GDP and CTN over time.

The results show that the volatility of construction activity in the period of 1983Q1–1989Q4 is significantly larger than it is in 1990Q1–1995Q1. Moreover, Table 4 shows that the average trend growth rates of GDP and CTN are significantly different in the period 1983Q1–1989Q4. Also, while the volatility

Table 3 Results of *F* tests for construction and GDP fluctuations[a]

Period	σ^2_{GDP}	σ^2_{CTN}	$\sigma^2_{CTN}/\sigma^2_{GDP}$	$\sigma^2_{CTN/GDP}$
1983Q1–1989Q4	0.06274#	0.08481#*	1.352	0.00378
1990Q1–1995Q1	0.06499	0.05075*	0.781	0.00436
1983Q1–1995Q1	0.06335	0.07126	1.125	0.00286

[a]Figures marked with # and * are statistically different at 10% and 5% levels of significance, respectively.

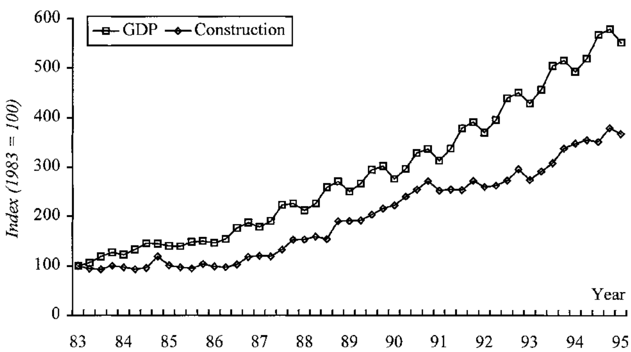

Figure 1 Growth in Hong Kong GDP and construction for the period 1983–1995

Table 4 Average trend growth rates of construction and GDP

Period	GDP	CTN	GDP/CTN
1983Q1–1989Q4	0.0410	0.0286	1.43[a]
1990Q1–1995Q1	0.0287	0.0253	1.13
1983Q1–1995Q1	0.0356	0.0272	1.31

[a]Statistically significant at the 5% level.

of the construction activity is significantly larger than that of GDP in the period 1983Q1–1989Q4, their volatilities are not significantly different in the whole period 1983Q1–1995Q1. Furthermore, average trend growth rates of GDP and CTN in the period 1990Q1–1995Q1 as well as the whole period 1983Q1–1995Q1 are not significantly different (Table 4). This evidence suggests that construction activity seems to be more stable during 1990s than it was before. In addition, we compare the volatility of construction flow's GDP share in the three periods. The volatility is computed using the Kalman filter technique, which allows the trend and cyclical components to vary stochastically with time (Harvey, 1989). The results (Table 4) show that the economy has had greater construction flow/GDP share fluctuations in the period 1990Q1–1995Q1. Since there were no marked changes of volatility of GDP in these periods, this suggests that GDP volatility is not transmitted as greater disturbances to the construction sector. Rather, the combined effects of economic fluctuations and uncertainty are the likely cause of the construction volatility. It is also interesting to note that the average value of the CTN/GDP share decreases from 9.4% in 1983Q1–1995Q1 to 9.2% in 1990Q1–1995Q1. It seems that there is a strong inter-temporal diversion of the series. The reason for the gradual decreasing CTN/GDP share may be due to the effect of a substitution away from buildings and towards equipment over time (Ball and Wood, 1996). Consequently, the shift towards new methods of construction requires less construction work per unit of GDP.

Conclusion

Using unit root tests and Granger causality tests, we have tested the lead–lag relationship between gross domestic product and construction flow. Although some propose that a decrease in construction activity causes a fall in income and employment (e.g. Hillebrandt, 1985), we argue that a change of GDP initially will affect demand for construction projects, then housing and credit availability, and then the level of construction output. Construction cycles tend to be associated with periods of easy credit. The results, while fitting with Hong Kong's data in the period of 1983Q1–1995Q1, are consistent with our arguments. We have found that GDP leads construction flows, and not vice versa, at least in the short term.

It has been argued that short term growth rates of construction activities tend to exhibit much greater fluctuations than the aggregate economy. However, based on *F* tests, we show that: (i) the volatility of the construction flows in the period of 1983Q1–1989Q4 is significantly larger than it is in 1990Q1–1995Q1, (ii) the volatility of the construction flows is significantly larger than that of GDP in the period of 1983Q1–1989Q4, and (iii) the difference between the volatilities of GDP and of construction flows is not significantly different from zero in the whole period 1983Q1–1995Q1. However, there is evidence of an inter-temporal diversion of the GDP and the construction flow. We show that the average value of the CTN/GDP share was higher in 1983Q1–1995Q1 than the period of 1990Q1–1995Q1.

The result of this paper is particularly important for policymakers in that, in the short term, it is the macroeconomic policy of government which affects output, and influences the construction activity. Our finding is also contrary to the view that construction is more volatile than the aggregate economy. Although Hong Kong is a very special case, we suggest there is a need for the development of new economic analysis to assist in the understanding of the construction process.

References

Akintoye, A. and Skitmore, M. (1994) Models of UK private sector quarterly construction demand. *Construction Management and Economics*, **12**(1), 3–13.

Ashley, R., Granger, C.W.J. and Schmalensee, R. (1980) Advertising and aggregate consumption: an analysis of causality. *Econometrica*, **48**, 1149–67.

Ball, M. and Morrison, T. (1995) Housing investment fluctuations: an international comparison. Paper presented to 'The Cutting Edge', 1–2 September 1995, Department of Land Economy, University of Aberdeen.

Ball, M. and Wood, A. (1995) How many jobs does construction expenditure generate? *Construction Management and Economics*, **13**(4), 307–18.

Ball, M. and Wood, A. (1996) Does building investment affect economic growth? *Journal of Property Research*, **13**(2), 99–114.

Chan, D.W.M. and Kumaraswamy, M.M. (1995) A study of the factors affecting construction durations in Hong Kong. *Construction Management and Economics*, **13**(4), 319–33.

Engle, R.F. and Granger, C.W.J. (1987) Co-integration and error correction representation, estimation and testing. *Econometrica*, **55**(2), 251–76.

Engle, R.F. and Granger, C.W.J. (1991) *Long-Run Economic Relationships.* Oxford University Press, London.

Fleming, S. (1988) Construction. In *The Structure of British Industry*, Johnson, P. (ed.). Unwin Hyman, London.

Ganesan, S., Hall, G. and Chiang, Y.H. (1996) *Construction In Hong Kong – Issues in Labour Supply and Technology Transfer.* Avebury, UK.

Granger, C.W.J. (1969) Investigating casual relations by econometric methods and cross-spectral methods. *Econometrica*, **34**, 541–51.

Granger, C.W.J. and Newbold, P. (1974) Spurious regressions in econometrics. *Journal of Econometrics*, **2**, 111–20.

Groak, S. (1994) Is construction an industry? *Construction Management and Economics*, **12**(4), 287–93.

Harvey, A.C. (1989) *Forecasting, Structural Time Series Models and the Kalman Filter.* Cambridge University Press.

Hillebrandt, P.M. (1985) *Economic Theory and The Construction Industry*, 2nd Edn. Macmillan, London.

Huang, B.N. (1995) Do Asian stock market prices follow random walks? Evidence from the variance ratio test. *Applied Financial Economics*, **5**, 251–56.

Ng, S. (1995) Testing for homogeneity in demand systems when the regressors are nonstationary. *Journal of Applied Econometrics*, **10**, 147–63.

Ong, S.E. (1994) Structural and vector autoregressive approaches to modelling real estate and property stock prices in Singapore. *Journal of Property Finance*, **5**(4), 4–18.

Sebestyen, G. (1980) Appropriate Technology in the Construction and Building Materials Industry. In *Appropriate Industrial Technology for Construction and Building Materials.* United Nations Industrial Development Organisation Monographs on Appropriate Industrial Technology No. 12. United Nations, New York.

Thornton, J. (1993) Money, output and stock prices in the UK: evidence on some (non)relationships. *Applied Financial Economics*, **3**, 335–38.

Tse, R.Y.C. (1996) Housing return and the determinants of capitalization rate – with reference to Hong Kong. *Journal of Property Research*, **13**, 115–29.

Turin, D.A. (ed.) (1975) *Aspects of the Economics of Construction.* Godwin, London.