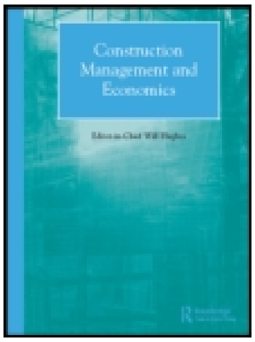

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NOTE
A longitudinal analysis on the relationship between construction output and GDP in Hong Kong

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The relationship between construction output and economic growth has been well discussed by construction economists. Most of the previous studies found a positive correlation between gross domestic product (GDP) per capita and various measures of construction output. However, cross-sectional analysis was commonly adopted but longitudinal analysis has been called upon. Furthermore, recent research argued that non-linear relationship between GDP and construction output exists because of different stages of economic development in different countries. They explained the phenomenon by means of the change of the growth rates of construction output at different stages of economic development, but the argument has not yet been rigorously tested. With the availability of long time-series of data of Hong Kong construction industry, this paper attempts to test longitudinally the relationship between the real growth rate of construction output and the real growth rate of GDP. It was found that the growth rate of GDP led that of construction output, and as the growth rate of GDP increased, the growth rate of construction output was marginally diminishing. It agrees with the proposition that construction industry is relatively inefficient in productivity improvement and the accumulation of capital investment results in a marginally diminishing growth of construction output.

Keywords: Hong Kong construction industry, construction growth, GDP growth, economic development

Introduction

The relationship between construction output and economy has received great attention. It is well recognized that construction industry contributes a major portion to gross domestic product (GDP). However, many studies concentrated on the simple relationship between gross value (or value added) of construction output and GDP (or GDP per capita). An argument on the different proportion of construction output towards GDP in developing versus developed countries has been established and received intensive studies (Turin, 1973; World Bank, 1984; Wells, 1986; Ofori, 1990; Bon, 1992; Crosthwaite, 2000; Chan, 2001; Jin and Lu, 2002; Lopes *et al.*, 2002). It was argued that, in early stages of economic development, the share of construction output in GDP increased but ultimately declined in industrially advanced countries. By means of input-output analysis, Bon (1988, 1992) also showed that the interdependence of construction sector with other economic sectors changed with respect to economic growth. Cross-sectional analysis is often used for studying their relationship. It compares data across different countries at a particular period of time. For example, Crosthwaite (2000) made use of cross-sectional analysis on 150 countries and found an inverted U-shaped relationship between construction spending share in GDP with GDP per capita. Jin and Lu (2002) also found a non-linear relationship between the share of construction output in GDP with the GDP per capita across 34 countries and regions. Most of them explained the phenomenon by means of the change of the growth rates of construction output at different stages of economic development. For example,

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Lopes *et al.* (2002) posited that 'an increasing growth in GDP per capita may not correspond to a relative increase in construction volume'. However, it is not convincing to draw this conclusion by means of cross-sectional analysis because of the heterogeneity of built environment among different countries. Besides the stages of economic development, many factors such as size of country, topology of land and even culture are highly different among countries. Without controlling these differences, the conjecture on the relationship between construction growth and economic growth becomes implausible. A more direct approach is making use of longitudinal (also known as time series or intertemporal) analysis, which studies data of one single country or city along a certain period of time. It controls the characteristics of built environment constant, unless there is structural change of the industry. Unfortunately, very few empirical studies were conducted on this longitudinal relationship between the growth rates of construction output and the economy. In fact, many previous studies, including Crosthwaite (2000) and Jin and Lu (2002), called for longitudinal analysis of the relationship as cross-country study involved a lot of ambiguities including the differences in the accuracy of data, construction industry settings, government intervention and culture, to name just a few. Admittedly, the difficulty of longitudinal study lies on the availability of long time-series data.

Fortunately, a long series of relevant and reliable data is available from the Government of Hong Kong. Tse and Ganesan (1997) did make use of it to study the relationship between construction flow and *GDP* in Hong Kong, but they simply tested the Granger causality between them and assumed the same extent of inflation of the two series. Therefore, this paper is trying to analyse longitudinally the relationship between the growth rate of construction output and that of *GDP* of Hong Kong. This paper will also make use of *real* rates of growth instead of nominal rates so as to eliminate the different extent of inflation on the construction output and that on the general economy of Hong Kong.

The arrangement of the paper is as follows: the ensuing section will introduce the rationale behind the relationship between the growth rate of the construction output and that of the economy. The hypothesis will also be set out. Then data, methodology and the stationarity of the time series will be discussed in the next section. The results of the empirical test will be elaborated in the fifth section before a conclusion is presented.

Theoretical justification

Theoretically, *GDP* of a country is the sum of its consumer expenditure, investment spending and government purchases. The role of the construction industry in national economy can be viewed in the context of the role that physical investment plays in economic development. There are three functions of capital investment in attaining economic growth: accumulation, efficient allocation and rapid technological catch-up (World Bank, 1993). The importance of technological progress on economic growth was raised as early as in Abramovitz (1956), Solow (1956) and Denison (1968). They attributed economic growth to the increase of capital and labour input, and technological progress as measured by total factor productivity (TFP). But a simply accumulation of physical investment is subject to diminishing returns (Krugman, 1995).

There have been quite a lot of studies on TFP of construction industry in Hong Kong (Chau and Walker, 1988; Chau, 1990, 1993, 1998), so it is not repeated here. Chau (1998) posited that construction industry in Hong Kong was relatively slow in technological progress, especially when compared with high-tech industries such as computer hardware manufacturing. He further argued that as building designs varied greatly from project to project, the scale of industrialization in construction was much more limited than other manufacturing industries. In Singapore, Tan (2000) also found that the main contribution to construction output growth was capital accumulation instead of efficiency improvement, thus diminishing returns were inevitable. Another room for efficiency improvement lies on the quality of human resources, which was found to be slow in the US construction industry, too (Stokes, 1981). Furthermore, the specificity and institutional framework of construction industry affect the efficiency allocation of the industry. For example, Fox *et al.* (2002) discussed comprehensively the causes of the lags of productivity improvement in construction industries compared with manufacturing. They concluded that low repetitiveness of building design was attributable to the low productivity of construction industry. Williamson (1986) also argued that asset specificity of construction contracts raised the transaction costs in construction projects. The opportunism behaviour of contractors is especially difficult to monitor during period of high growth rate and full load. Therefore, it is plausible to put forward our argument that Hong Kong being classified as an advanced industrialized city (World Bank, 1999), the growth of construction output should be marginally diminishing with the growth of GDP.

Data and methodology

Generally, construction output is either measured by value-added of construction works or gross value of construction works (*GVC*). In this paper, we chose *GVC* performed by main contractors.[1] The rationale of choosing *GVC* follows the line of thought of Chau (1993). He argued that measuring output as value-added was based on the assumption that intermediate inputs had no effect on the output. However, he further contended that such an assumption was unrealistic in the construction industry since the contribution of intermediate inputs, such as new materials and tools, in the industry to productive efficiency could not be ignored. Similarly, Tse and Ganesan (1997) also made use of *GVC* as a proxy of construction output.

Data of nominal *GVC* are available from the *Hong Kong Monthly Digest of Statistics* published by the Census and Statistics Department (various issues). Tender price index (*TPI*)[2], which measures the trend of contractor's price levels in accepted tenders for new works, is used as a deflator to obtain real *GVC* from nominal *GVC*. The Government of Hong Kong SAR (various issues) provides data of quarterly expenditure-based *GDP* and *GDP* implicit deflator (GDPD) at the 1990 price levels ($GDPD_{1990} = 100$). The data period ranges from the first quarter of 1984 to the second quarter of 2002. This research deflates *GVC* by tender price index and *GDP* by *GDP* implicit deflator (as shown in Equation (1)) to obtain their real values (*RGVC* and *RGDP*, respectively) so as to eliminate their different extent of inflation.

$$RGVC_t = \frac{GVC_t}{TPI_t}$$
$$RGDP_t = \frac{GDP_t}{GDPD_t} \tag{1}$$

In this study, Granger causality test is firstly applied to establish the causal linkage between *RGVC* and *RGDP*. Then regression analysis will be applied to investigate the non-linear relationship between *RGVC* and *RGDP*. Before that, Augmented Dickey-Fuller (ADF) unit root test (Dickey and Fuller, 1979) is required to test the stationarity of the series so as to avoid spurious results. Specifically, the ADF test is based on the null hypothesis that $\alpha = 0$ in the following formulation of any time series Y_t:

$$\Delta Y_t = \mu + \delta T + \alpha Y_{t-1} + \sum_{i=1}^{n} \beta_i \Delta Y_{t-i} + u_t \tag{2}$$

where $\Delta Y_t = Y_t - Y_{t-1}$, μ is a drift term and T is the time trend, n is the number of lags necessary to obtain white noise and u_t is the error term. The optimal lag length is selected by minimizing the Akaike information criterion (AIC) and Schwarz criterion (SC) over different choices for the length of the lag. The results of the ADF test are shown in Table 1. The statistics are compared with the critical values given in Mackinnon (1991). It showed

Table 1 Augmented Dickey-Fuller (ADF) unit root tests

Time series variables		Level		Growth rates	
		Trend	No trend	Trend	No trend
$RGVC_t$	At 3-lag	−1.58	−0.38	−4.36*	−4.40*
$RGDP_t$	At 4-lag	−4.99*	−1.07	−4.62*	−4.54**

* and ** indicate significant at the 1% and the 5% levels, respectively. The critical values of the ADF statistics are −4.09 and −3.47 with trend; and −2.60 and −1.95 without trend, at the 1% and the 5% levels of significance, respectively.

that both *RGVC* and *RGDP* were non-stationary in level terms without trend, but the two series were stationary in their first differenced (i.e. growth rate) terms with and without trend. Therefore, this study uses the first differenced terms of the time series, which can be interpreted as the growth rates of the variables.

To test whether the growth rate of *RGDP* leads the growth rate of *RGVC*, or if there exists any feedback effects between the two, the Granger causality test is used. Granger (1969) put forward the causality test by testing the null hypothesis that $\beta_{0i} = 0$ and $\beta_{1i} = 0$ in the following bi-variate regressions:

$$\begin{aligned}\ln\frac{RGVC_t}{RGVC_{t-1}} &= \sum_{i=1}^{n}\alpha_{0i}\ln\frac{RGVC_{t-i}}{RGVC_{t-i-1}} + \sum_{i=1}^{n}\beta_{0i}\ln\frac{RGDP_{t-i}}{RGDP_{t-i-1}} + u_t \\ \ln\frac{RGDP_t}{RGDP_{t-1}} &= \sum_{i=1}^{n}\alpha_{1i}\ln\frac{RGDP_{t-i}}{RGDP_{t-i-1}} + \sum_{i=1}^{n}\beta_{1i}\ln\frac{RGVC_{t-i}}{RGVC_{t-i-1}} + v_t\end{aligned} \tag{3}$$

After establishing the causality linkage between the two, a regression model of Eq. 4 will be conducted to test the non-linear relationship (marginal diminishing effect) between them. Since autocorrelations are commonly found in longitudinal study, autocorrelation coefficient, ρ is incorporated in the model. The order of lag, i of the correlations between the error term ε_t and its lag is determined by the correlogram Q-statistics.

$$\begin{cases}\ln\dfrac{RGVC_t}{RGVC_{t-1}} = c + \alpha_1\ln\dfrac{RGDP_t}{RGDP_{t-1}} + \alpha_2\left(\ln\dfrac{RGDP_t}{RGDP_{t-1}}\right)^2 + \varepsilon_t \\ \varepsilon_t = \rho\varepsilon_{t-i} + \omega_t\end{cases} \tag{4}$$

where c is a constant term, α_1, α_2 and ρ are the coefficients to be estimated and ε_t and ω_t are error terms.

If α_2 is statistically significant and negative in sign, it implies a marginal diminishing impact of the economy on the construction output in Hong Kong during the testing period.

Results

The results, as shown in Table 2, showed that the growth of *RGDP* Granger caused the growth of *RGVC* as its null hypothesis could be rejected at either two or four lags. It implies that the real growth of the economy leads the real growth of the construction output and not vice versa, at least in the short term. This causality linkage supports our regression model in regarding *RGDP* as independent variable. The result also agrees with that of Tse and Ganesan (1997).

Table 2 Granger causality tests results

Null hypotheses	F statistics	
	At 2 lags	At 4 lags
$\ln(RGDP_t/RGDP_{t-1})$ does not Granger Cause $\ln(RGVC_t/RGVC_{t-1})$	14.45*	4.80*
$\ln(RGVC_t/RGVC_{t-1})$ does not Granger Cause $\ln(RGDP_t/RGDP_{t-1})$	4.76	2.28

*Significance at the 1% level.

Figure 1 depicts the time series of *RGDP* and *RGVC* in level terms, while Figure 2 shows the scatters of the growth rate of *RGVC* against the growth rate of *RGDP* during the testing period from the first quarter in 1984 to the second quarter in 2002 in Hong Kong. The scatter diagram justifies the proposition of non-linear relationship between the growth of the construction output and the economy. It best fits a second order regression curve – see Figures 1–3.

The results in Table 3 showed that the growth rate of *RGDP* had strong curvilinear relationship with the growth rate of *RGVC*. Autocorrelation of the error terms at 2-lag (*AR(2)*) existed. All the coefficients were statistically significant at the 5% level and the explanatory power was reasonably good (20.3%) in time series study. The coefficient of $[\ln(RGDP_t/RGDP_{t-1})]^2$ was significantly negative which agreed with our hypothesis

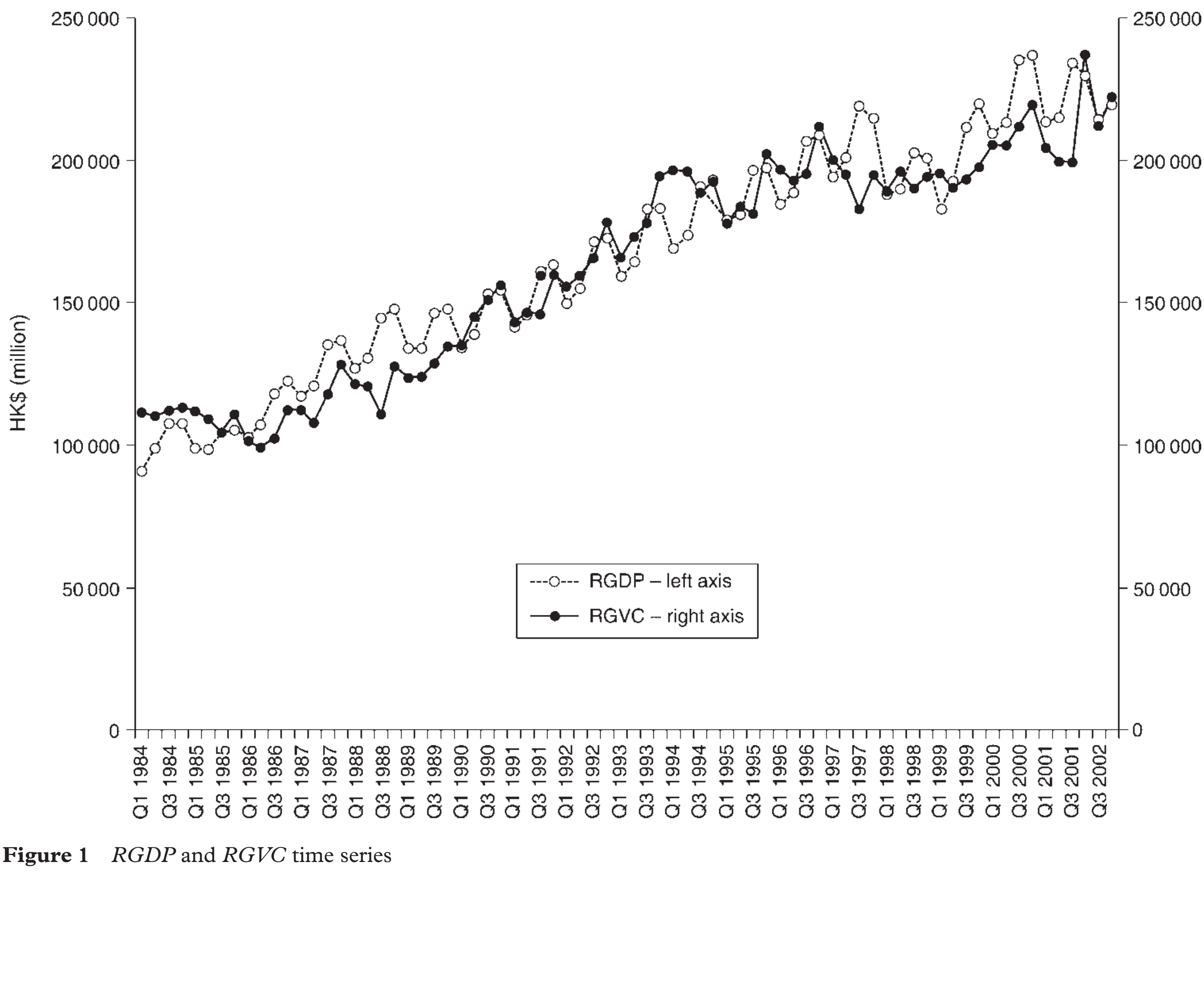

Figure 1 *RGDP* and *RGVC* time series

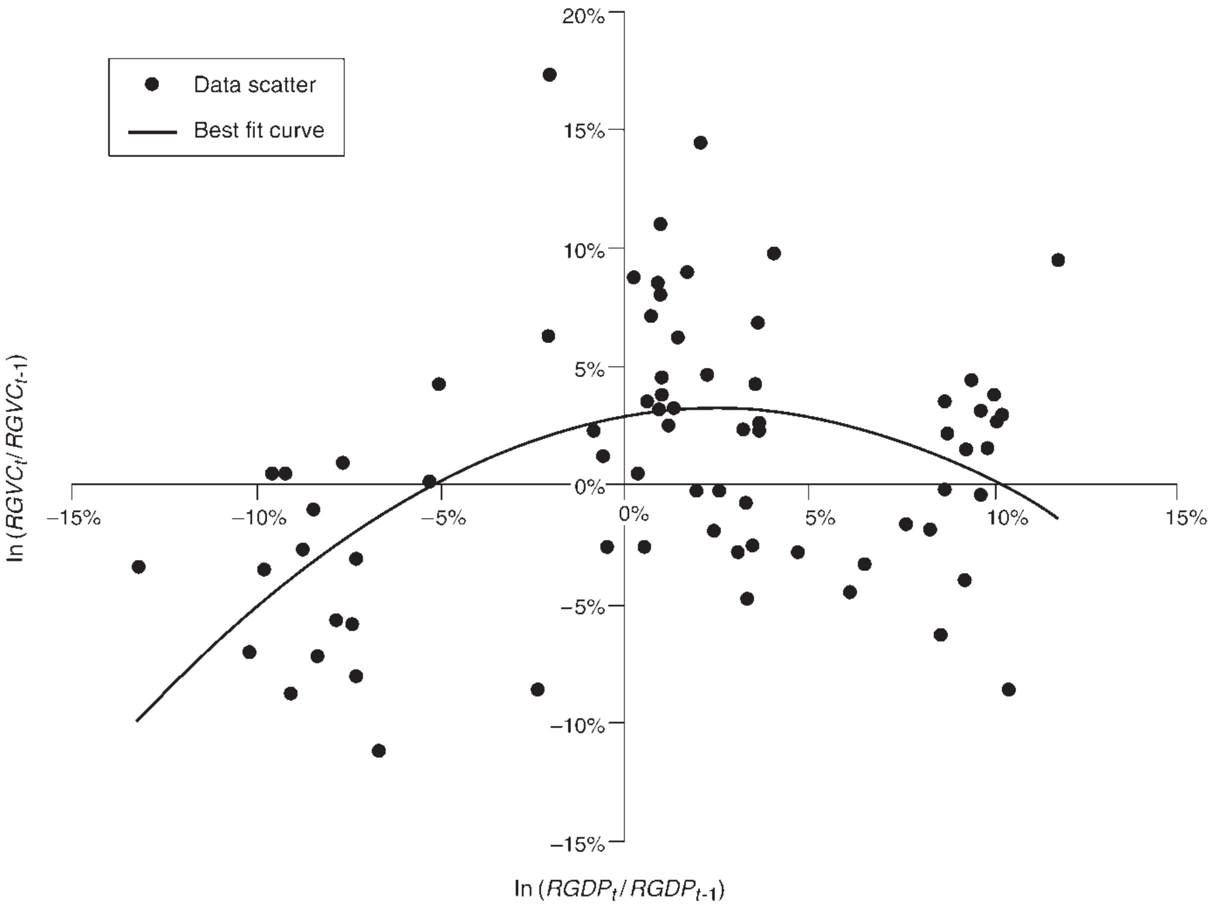

Figure 2 Scatters of *RGVC* growth rate and *RGDP* growth rate

Table 3 Regression results

Independent variables	Coefficients	t-statistics	ρ-value
$ln(RGDP_t/RGDP_{t-1})$	0.2638	2.1605	0.0343
$[ln(RGDPt/RGDP_{t-1})]^2$	−5.3897	−4.4430	0.0000
Constant term	0.0291	4.1075	0.0001
AR(2)	−0.2514	−2.0585	0.0434
Dependent variable	$ln(RGVC_t/RGVC_{t-1})$		
F-statistic	6.9790		
Prob(F-statistic)	0.0004		
Adjusted R^2	20.4%		
DW statistic	2.28		
No. of observations	73 (1984Q1 – 2002Q2)		

that the real growth of construction output is a marginal diminishing function with the growth of real *GDP* in advanced industrialized city. Empirically, the maximum real rate of growth of construction output was about 2.80% throughout the testing period.

As most construction projects are dependent on loan financing, financial cost is generally considered one of the factors affecting construction output (Punwani, 1997). DiPasquale and Wheaton (1992) model also suggested that construction output depended on property price level, which in turn depended on interest rate and basic economic factors. However, their effects are highly interdependent and may be overlapping. Tse and Ganesan (1997) contended that a change of *GDP* initially would affect demand for construction projects, then housing and credit availability, and then the level of construction output. In other words, the effects of price levels and financial cost on construction output may have been reflected in the change of *GDP*. In order to show whether there are any net effects of real interest rate and property price on construction output, the model is revised into Eq. (5) and tested again. Real interest rate *(RI)* is calculated by subtracting quarterly inflation rate (consumer price index) from nominal interest rate (the best lending rate offered by bank as a proxy). Property price is also proxied by the general price index *(PI)* of residential property reported by the Rating and Valuating Department of the Hong Kong SAR Government. Since both of them are non-stationary at level terms, first differenced series are exploited. Moreover, since *RI* is already in percentage term, it is not necessary to take natural logarithm on this series.

$$\begin{cases} \ln \dfrac{RGVC_t}{RGVC_{t-1}} = c + \alpha_1 \ln \dfrac{RGDP_t}{RGDP_{t-1}} + \alpha_2 \left(\ln \dfrac{RGDP_t}{RGDP_{t-1}} \right)^2 \\ \qquad + \beta \left(\dfrac{RI_t}{RI_{t-1}} \right) + \gamma \ln \dfrac{PI_t}{PI_{t-1}} + \varepsilon_t \\ \varepsilon_t = \rho \varepsilon_{t-i} + \omega_t \end{cases} \tag{5}$$

However, the two variables of *RI* and *PI* were found to be statistically insignificant in explaining the change of *RGVC*, while the effects of *RGDP* remained more or less the same in the new specification (Results not shown).

Conclusions

Although there were many cross-country comparisons confirming that the contribution of construction towards the economy varied across different stages of development, cross-sectional analysis was deficient in achieving *ceteris paribus*. This paper carried out empirical tests on the Granger causality as well as regression analysis of the relationship between the real growth rate of construction output and the real growth rate of *GDP* in Hong Kong longitudinally from 1984 to 2002. The results showed that the real growth rate of *GDP* led that of construction output. It established the causal linkage from the economy to the construction sector. The regression model also showed that construction growth and economic growth were not linearly related. The growth of construction output was marginally diminishing with the growth of *GDP*, both series are in real terms. The results echo Chau's (1998) and Tan's (2000) contentions that construction growth was largely attributable to capital accumulation instead of efficiency improvement. It has important implication on the benefits of physical investment on the national economy, especially in industrialized countries. The limitation of this longitudinal analysis is the assumption of no structural change of the industry over time; it deserves further study by using panel data approach which incorporates both cross-sectional as well as longitudinal analysis in one data set.

Notes

1. The gross value of construction works (GVC) performed by main contractors is the construction output of projects in which contractors take the role of main contractors, not including the construction output of projects in which they take the role of subcontractors. Subcontractors' works are excluded to avoid double counting. Construction works include:
   - new construction works;
     (a) demolition;
     (b) site formation; piling and other sub-structure works preceding the actual erection of structures;
     (c) erection of new buildings and structures; and
     (d) installation of service facilities.
   - renovation works; and
     (a) major alteration and conversion works on existing structures.
   - maintenance of buildings
     (a) restoration of existing buildings and structures to normal conditions.

   (Building, Construction and Real Estate Statistics Section, Census and Statistics Department of HKSAR, 2002).
2. The TPI series ($TPI_{1989Q4} = 1000$) is extracted from the website of Hong Kong Levett and Bailey Chartered Quantity Surveyors Limited at http://www.lnb.com.hk/cost-data/hongkong/cost-tenderprice-data-1968-now.html

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