ESA/STAT/AC. 223/S4.8

Third International Seminar on Early Warning and Business Cycle Indicators

17 – 19 November 2010
Moscow, Russian Federation

Research Study of Business Cycle and Early Warning Indicators for the Economy of Hong Kong

Sharon Ng, Eddie Kwok and Winnie Tam
Census and Statistics Department, Hong Kong, China

Research Study of Business Cycle and Early Warning Indicators for the Economy of Hong Kong

Prepared by Sharon Ng, Eddie Kwok and Winnie Tam
Census and Statistics Department
Hong Kong, China

I. Introduction

To keep track of the development of an economy, an abundant set of important official statistics such as gross domestic product, unemployment rate, consumer price index, balance of payments, retail sales, trade in goods, business expectation indices etc. have long been produced by many statistical agencies worldwide. The quality and comparability of these statistics has been enhanced significantly, thanks to the substantial progress at international level in providing a common conceptual framework and methodology. Over time, these statistical data are proved to be vital in providing insights into emerging economic problems at various fronts. Indeed, these statistics are indispensable in supporting economic analysis and policy formulation, particularly in the wake of economic and financial crises.

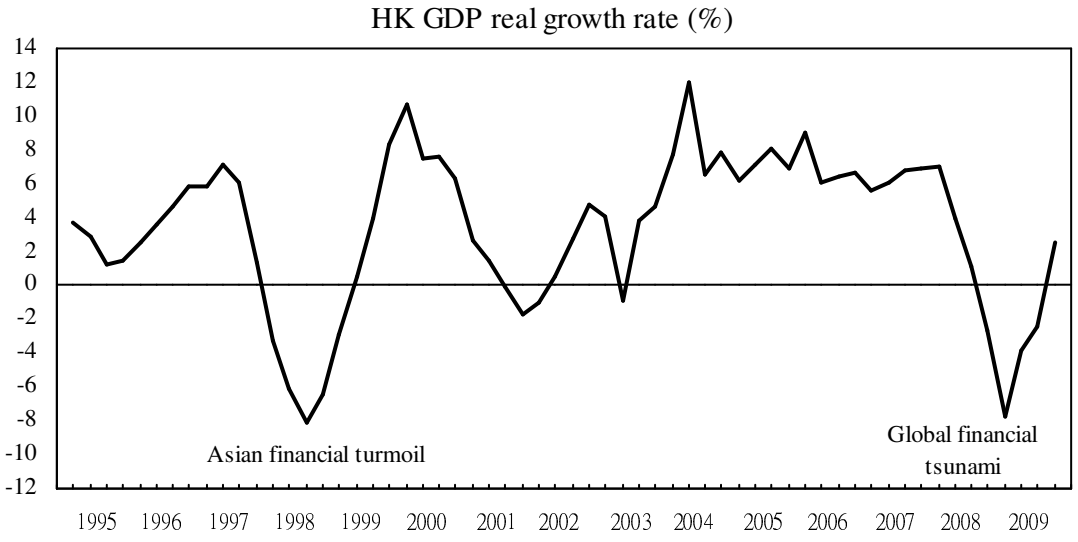
2. The outbreak of the global financial crisis in 2008 and the ensuing global economic recession has triggered the call for the development of an advanced warning statistical system. It is considered that effort should be put on producing some early warning and business cycle indicators that can effectively and correctly detect emerging economic and financial distress or crisis in advance, so that policy makers can get prepared for timely responses.

3. While early warning and business cycle indicators have merits, it should be noted that their forecasting ability is based on past relationship between the occurrence of crises and relevant data. The historical patterns may not hold in future when an economy is impacted significantly by external shocks which have no historic references. This is particularly true for economies like Hong Kong that are small and heavily influenced by external shocks.

4. Hong Kong is a small and highly externally-oriented economy. The value of our GDP was at US$211 billion in 2009, while the total value of trade in goods and services reached US$801 billion, representing 380% of GDP. Over the past 15 years, Hong Kong has undergone several business cycles under the impact of external shocks. In 1997, Hong Kong's economy was hard hit by the Asian financial turmoil. Affected by the burst of the IT bubble and the slump of the external markets following the 911 incident in 2001, Hong Kong's economy grew at a rate below trend during the period until late 2003. In end 2008, arising from the onset of the global financial tsunami, Hong Kong's GDP recorded negative

year-on-year % changes in real terms for four consecutive quarters from the fourth quarter of 2008 (Graph 1).

Graph 1: Economic growth cycles in Hong Kong in the past 15 years



5. Utilising the available high frequency indicators in Hong Kong, a research to develop an experimental composite leading indicator (CLI) that attempts to detect the turning points of business cycles of real GDP of Hong Kong has been done by the Census and Statistics Department of Hong Kong. On the other hand, a high-frequency macroeconomic model has been developed to forecast the one-quarter ahead real GDP with very short time-lag. Both methods attempt to identify possible early warning signals for the economy of Hong Kong.

6. Part II of this paper describes the analytical framework of the above research work. The selection of indicators and empirical results are then discussed in Parts III and IV respectively. A conclusion is given at the end of the paper.

II. Analytical Framework

Brief review of related studies

7. Numerous studies have been performed on the cyclical movement and short-term forecasting of output. The empirical research of business cycle started with Burns and Mitchell (1946), where a comprehensive list of composite leading, coincident, and lagging

indicators of business cycles was developed using various economic variables for the US economy. Since 1970s, the Organisation for Economic Cooperation and Development (OECD) has developed a system for composite leading indicator (CLI) and is now compiling the CLI for 29 member countries and 6 non-member countries. The methodology of OECD is based on various landmark work on business cycle, such as Bry and Boschan (1971), Prescott (1986), Hodrick and Prescott (1997), Christiano-Fitzgerald (1999).

8. For short-term forecasting of output, various international studies (Rathjens and Robins 1993, Miller and Chin 1996, Stark 2000, Koenig, Dolmas and Piger 2001, Angelini, Camba-Mendez, Giannone, Reichlin and Rustler 2008) have been focused on using monthly data to quarterly model forecasts, done by the traditional bridge equation, Principal Component Analysis (PCA), Vector Autoregressive (VAR) model or other time series models.

9. Regarding studies for the economy of Hong Kong, earlier work of the APEC Study Centre of the University of Hong Kong (Chan 2000) applied the Principal Component Analysis (PCA) and the bridge equation approach to form a high frequency macroeconomic forecasting model of the GDP growth. This high frequency macroeconomic forecast is supervised by Professor Richard Wong and Dr. Alan Siu, both of the University of Hong Kong, with the Nobel Laureate, Professor Lawrence Klein of the University of Pennsylvania, served as advisor on this project. Regular quarterly forecasts have been produced since 1999.

10. On the other hand, the Centre for Economic Development of the Hong Kong University of Science and Technology (Lui and Chow, 1999) has also developed a framework of macroeconomic forecasts. Their framework is based on a structural system of equations to capture the statistical regularities of major economic variables in Hong Kong, by regressing endogenous variable on its own lags, other endogenous variables and some exogenous variables, using quarterly data.

11. Gerlach and Yiu (2004) attempted a dynamic factor model for current quarter estimates of output. Genberg and Chang (2007) tried a VAR model to perform short-term forecasts of GDP using its components and other macroeconomic or monetary variables. On the other hand, Li and Kwok (2009) decomposited the output volatility of Hong Kong and analysed its cyclical movement across regions, making use of the Hodrick–Prescott (HP) filter and various Autoregressive Conditional Heteroskedasticity (ARCH) models.

Composite Leading Indicator (CLI) for real GDP of Hong Kong

12. CLI is an indicator which is constructed from economic time series (called component indicators) to predict cycles in a reference indicator chosen as a proxy for economic activity. The cyclical fluctuations of the component indicators are similar to, but precede those of the reference indicator.

13. CLI can be presented in several forms, and in our case, the amplitude adjusted CLI is used. The amplitude adjusted CLI is the average of de-trended, smoothed and normalised component series. Using this form of CLI, we can proxy the variation in economic output relative to its long term potential and identify four qualitatively different cyclical phases as below:

(1) Expansion – CLI increasing and above 100
(2) Downturn – CLI decreasing and above 100
(3) Slowdown – CLI decreasing and below 100
(4) Recovery – CLI increasing and below 100

14. In the present research study of trial compilation of CLI of Hong Kong, the method employed is similar to that of the Cyclical Analysis and Composite Indicators System (CACIS) developed by OECD. The first step involves the selection of reference indicator and component indicators. The choice depends on the economic relevance and empirical relationship between the potential component and reference indicators. Practical considerations, such as frequency and timeliness, are also given in choosing the indicators.

15. Different from the CLIs developed by OECD, quarterly series of real GDP instead of industrial production is chosen as the reference indicator in the present research study. This is because Hong Kong is highly services-oriented and the manufacturing sector only takes up less than 5% of our GDP. As for component indicators, we have adopted OECD's framework (Gyomai and Guidetti, 2008) of classifying potential indicators according to the following four categories:

(1) Early stage: the indicators measure early stages of production / consumption;
(2) Rapidly responsive: the indicators respond to the changes in economic activity rapidly, such as profits, spending, labour market turnover;
(3) Expectation-sensitive: the indicators are sensitive to expectation such as stock price and property price; and
(4) Prime movers: the indicators relate to the monetary policy and foreign economic developments such as money supply and external trade.

16. After selection of indicators, the data series are seasonally adjusted by the X-12 method to remove possible seasonal pattern. Hodrick–Prescott (HP) filter (see Annex 1 for a technical description of the method) is adopted to extract cyclical component of the series. The various component series that are used in the construction of a CLI are first normalised in order to express various indicators (which are originally measured in different units) in a common scale. This normalisation process is achieved by subtracting from 'filtered' observations the mean of the series, and dividing this by the mean absolute deviation of the series, and, finally, by adding 100 to each observation. For indicators that are counter-cyclical (e.g. unemployment rate), inversion of the series is applied.

17. To identify the potential indicators and confirm the cyclical properties with the output, cross-correlation analysis (Annex 2) and technical graphic analysis are performed to verify if the component series have a leading or simultaneously relationship with the reference series. In other words, there is evidence that the indicator is said to be leading, or at least coincident, if the lag of the component series or the component series itself exhibits a strong correlation with the reference series.

18. A technical difference between our framework and OECD's is that unlike OECD which uses turning point analysis to confirm cyclical properties, we have used cross-correlation and technical graphic analysis. The main consideration is that there are less observations and hence turning points in the quarterly data series than monthly series.

Short-term forecast of real GDP of Hong Kong

19. While CLI is useful in providing a qualitative early reference on turning points of the economy, it does not contain explanatory power in predicting output growth. For predicting short-run output growth, we attempt to make use of the potential high frequency component indicators identified in the above study of trial CLI, coupled with selected relevant indicators, to form a monthly Vector Autoregressive (VAR) model. The main outputs of the VAR model are twofold: (a) forecasting of current quarter real GDP growth rate before the end of quarter and (b) decomposing the sources of volatility in the growth of real GDP, thus helps to identify the main drivers of volatility in economic growth.

20. In the VAR model, the real GDP growth rates in first two months of a quarter are first estimated based on the high frequency indicators and substitute back to the model, before

forecasting the growth of the remaining month. To achieve this, recursive estimation, in which parameters are estimated recursively by constantly updating the information set when the forecast moves forward in time, is preformed.

21. Technically, the VAR model, suggested by Sims (1980), is applied to analyse the dynamics of output and component series. One area of controversy for VAR is whether the variables included should be stationary or not. For non-stationary time series, regression of one time series variable on one or more time variables can often give spurious results due to the effect of common trend. Stationarity can usually be achieved by first differencing. First-difference specifications are taken in the estimation where appropriate, as checked by the Dickey-Fuller unit root test (Dickey-Fuller, 1979).

22. As for the lag structure, an inappropriate lag selection can give rise to problems of overparameterization and oversimplification. The optimal lag length is selected by some lag order selection criteria where appropriate.

23. An unrestricted VAR is given below in Equation (1):

$$\text{VAR (p) model for } y_t \text{ in level form: } y_t = \mu + \sum_{k=1}^{p} B_k y_{t-k} + \varepsilon_t \qquad (1)$$

24. Each equation in the unrestricted VAR can be estimated efficiently using ordinary least squares (OLS). Assuming the relationship identified in the past continues to hold in the forecast period, the period ahead forecasts can be obtained by simply substituting the estimated coefficients and their past values in the equation.

25. For cointegrated relationship, i.e. a long-run stationary combination between two variables, as identified in cointegration test (Johansen, 1991), according to Engle and Granger (1987), the VAR in error correction model (ECM) in Equation (2) is also considered, which can be treated as the unrestricted VAR in first difference without the error correction term.

$$\text{In the ECM: } \Delta y_t = \mu + \sum_{h=1}^{p-1} M_h \Delta y_{t-h} + \Pi y_{t-1} + \varepsilon_t \qquad (2)$$

$$\text{where } \Delta y_t = y_t - y_{t-1}, \ \Pi = \sum_{k=1}^{p} B_k - I_G \text{ and } M_h = -(\sum_{k=h+1}^{p} B_k) \text{ for } h = 1,2,...,(p-1)$$

26. For Equation (2), the first difference of variables should be stationary. Even if y_t

is non-stationary, somehow the product Πy_{t-1} (i.e. the error correction term) is stationary, with the assumption that $\{\varepsilon_t\}$ is a vector white noise. The rows of the matrix Π are interpreted as vectors whose elements are the coefficients of long-run equilibrium relationships between elements of y_t. The difference between Πy_{t-1} and some constant measures the extent to which elements of vector y_{t-1} are out of long-run equilibrium and the current change, Δy_t, is driven to correct this disequilibrium. The rank of Π tells us the maximum number of linearly independent cointegrating vectors, or equivalently, the number of independent long-run equilibrium relationships.

27. For characterizing the dynamic behavior of VAR, variance decomposition is performed by the Cholesky Triangularisation which amounts to using a recursive structural model (Keat, 1996), in which ordering of the variables is set by speed of reaction to the other variable. The variance decomposition breaks down the variance of forecast errors that can be attributed to shocks originating from each endogenous variable (e.g. retail sales, local companies incorporated, etc.).

III. Selection of Indicators

28. Table 1 summaries the set of potential component indicators selected for CLI compilation, analysed by four types of categories, namely the early stage, rapidly responsive, expectation-sensitive, and prime movers. As discussed above, they are chosen mainly by considering the economic relevance and empirical relationship with the reference indicator, i.e. real GDP. The ensuring paragraphs describe the specific considerations and the relevance of the indicators to the economy of Hong Kong.

29. For early stage indicators, we have applied the selection criteria of OECD to include data that provide indication into future production and consumption activities. The data selected for the present research include number of building consents and newly completed private buildings, number of local company incorporated and amount of loans and advances for use in Hong Kong. Besides, demographic factor (i.e. household formation in terms of number of domestic households in Hong Kong) is also included to test its empirical relationship with real GDP.

30. For rapidly responsive indicators, we have included private consumption related data such as retail sales, number of motor vehicles / private cars newly registered and consumer price index. On the business side, data on business receipts of various economic sectors,

especially the financial sector, are included. Purchasing Managers' Index (PMI)[1] is included as a business sentiment indicator; while labour market data (including unemployment rate and employed persons) are also included to provide insight into how the labour market reacts with the real output. Electricity consumption is included as well to measure the level of economic activities.

Table 1: Potential component indicators choice in the analysis

Information category:	Indicator:
Early stage	Private buildings with consents to commence work Newly completed private buildings Loans and advances for use in Hong Kong Local companies incorporated Household formation
Rapidly responsive	Motor vehicles / private cars newly registered Retail sales Business receipts (Restaurant / Banking / Financing / Financial markets and asset management) Purchasing Managers' Index CPI Unemployment rate / Number of employed persons Electricity consumption
Expectation-sensitive	Hang Seng Index Price of private domestic premises Rent of private domestic premises Consideration of agreements for sales and purchase residential building units
Prime movers	Visitor arrival Monetary variables (monetary base / M1 / M2) Foreign currency reserve assets - Exchange Fund Hong Kong Interbank Offered Rates (3-month) External trade (total export / import / total trade / total river cargo throughput) Effective exchange rate

31. For expectation-sensitive indicators, data of stock and domestic property prices are

[1] The Hong Kong Purchasing Managers' Index is a monthly index published by Markit Economics, featuring research data from a survey of purchasing managers in companies operating in Hong Kong. Around 300 companies, stratified by Standard Industrial Classification (SIC) group, based on industry contribution to GDP, have been selected in the survey to represent the true structure of the Hong Kong economy.

included, as the two asset markets are highly expectation-sensitive in Hong Kong. Furthermore, the transactions of the residential property market, measured in terms of the consideration of agreements for sales and purchase residential building units, are also included.

32. For prime movers, monetary variables, from narrow money (foreign currency reserve assets / monetary base) to M1 / M2, Hong Kong Interbank Offered Rates and effective exchange rates are included. Another important prime mover is external demand, which is captured through data of external trade in goods and visitors' arrivals.

33. Data series of all potential component indicators are measured in logarithms where appropriate. The time series range from January 1990 to June 2010, except for a few indicators (such as some business receipt indices, Purchasing Manager Index and monetary base) which are not available in early 1990s. For data frequency, except a few business receipt indices which only have quarterly data, monthly data have been used for all other variables.

IV. Empirical Results

Cross correlation analysis

34. An analysis of cross correlation results helps us identify the empirical relationship between real GDP and the potential component indicators. The results (Table 2) are generally in line with the economic principles regarding the pro-cyclical (i.e. positive correlation as shown in the Table 2) or counter-cyclical (i.e. negative correlation) natures of the indicators.

35. Table 2 shows the cross correlation coefficients at different lags of the component series with real GDP. The volatility of the cycle of the component series is measured by the standard deviation (SD), which is also shown in the table. If the lags of a component series exhibits a strong correlation with GDP (i.e. the correlation coefficients at $\gamma(-1)$ /$\gamma(-2)$ /$\gamma(-3)$ are significant), it implies that the past information of the component series is closely related to the present GDP cycle. Then, we can confirm that component series as leading indicator. On the other hand, it is a lagging indicator if the lags of the GDP (i.e. the correlation coefficients at $\gamma(1)$/ $\gamma(2)$/ $\gamma(3)$ are significant) exhibits a stronger correlation with the component series. Coincident indicators are those having significant simultaneous correlation with GDP at $\gamma(0)$.

Table 2: Cross correlation of cyclical properties under Hodrick-Prescott trend

Variables	SD (%)	Cross Correlation of Output with						
		$\gamma(-3)$	$\gamma(-2)$	$\gamma(-1)$	$\gamma(0)$	$\gamma(1)$	$\gamma(2)$	$\gamma(3)$
GDP	2.5	0.31	0.61	0.84	1.00	0.84	0.61	0.31
					Early Stage			
Private buildings with consents to commence work	34.9	0.19	0.29	0.30	0.17	0.02	-0.09	-0.19
Newly completed private buildings	28.2	-0.23	-0.37	-0.30	-0.31	-0.25	-0.17	-0.08
Loans and advances for use in Hong Kong	4.3	-0.44	-0.22	0.04	0.30	0.48	0.58	0.58
Local companies incorporated	21.8	0.33	0.42	0.38	0.36	0.19	-0.02	-0.17
Household formation	0.5	-0.01	0.04	0.07	0.07	0.06	0.04	0.02
					Rapidly responsive			
Motor vehicles newly registered	18.5	-0.24	0.04	0.32	0.54	0.54	0.42	0.23
Private cars newly registered	20.4	-0.23	0.03	0.28	0.48	0.46	0.34	0.16
Total retail sales	4.3	0.25	0.52	0.72	0.84	0.71	0.49	0.23
Total restaurant receipts	3.9	0.10	0.30	0.46	0.60	0.51	0.38	0.23
Banking – business receipts	9.1	0.34	0.43	0.60	0.52	0.36	0.25	0.15
Financing (except banking) – business receipts	20.8	0.27	0.54	0.74	0.77	0.59	0.36	0.13
Financial markets & asset management – business receipts	23.4	0.22	0.52	0.71	0.73	0.54	0.31	0.09
Purchasing Managers' Index	9.1	0.50	0.59	0.58	0.40	-0.04	-0.39	-0.58
CPI	1.5	-0.38	-0.31	-0.16	0.04	0.26	0.41	0.51
Unemployment rate	18.5	0.03	-0.27	-0.57	-0.80	-0.85	-0.73	-0.50
Number of employed persons	1.3	0.05	0.28	0.49	0.64	0.69	0.60	0.43
Electricity consumption	3.6	0.06	0.04	-0.03	-0.03	-0.04	-0.05	0.02
					Expectation-sensitive			
Hang Seng Index	16.2	0.44	0.68	0.83	0.78	0.53	0.24	-0.05
Housing price index	10.5	-0.05	0.20	0.44	0.58	0.56	0.43	0.24
Rental Index	6.5	-0.18	0.12	0.45	0.72	0.83	0.77	0.59
Consideration of agreements for sales and purchase	24.6	0.10	0.34	0.47	0.45	0.26	0.06	-0.06
					Prime movers			
Visitor arrival	12.5	0.30	0.37	0.34	0.43	0.19	0.02	-0.09
M1	7.4	0.30	0.36	0.33	0.19	-0.01	-0.22	-0.32
M2	3.1	0.11	0.26	0.36	0.40	0.38	0.35	0.30
Monetary base	13.4	-0.03	-0.16	-0.35	-0.52	-0.67	-0.72	-0.64
Foreign currency reserve assets – Exchange Fund	5.1	-0.26	-0.23	-0.25	-0.27	-0.32	-0.34	-0.33
Hong Kong Interbank Offered Rates – 3-month	64.3	0.05	0.13	0.23	0.36	0.48	0.57	0.56
Total export	5.6	0.28	0.48	0.64	0.79	0.70	0.50	0.23
Import	6.4	0.24	0.46	0.65	0.80	0.72	0.51	0.24
Total trade	6.0	0.26	0.47	0.65	0.80	0.72	0.51	0.23
Total river cargo throughput	6.1	-0.34	-0.28	-0.10	0.06	0.14	0.13	0.00
Effective exchange rate	2.3	0.20	0.24	0.25	0.18	0.07	-0.09	-0.23

36. Selection of component series of the trial CLI are based on the evidence of a strong leading and simultaneous property, with cross correlation coefficients at least 0.5 or above. The volatility of the cycle of the series is also a relevant consideration, since a relatively less volatile series should produce a more reliable CLI. Other factors, including whether the

component series are high frequency data, and the possible feedback from the component to real GDP, are also taken into account.

37. For early stage indicators, the correlation between construction-related data and GDP is found to be weak, at around 0.3. Their cyclical components are also quite volatile, with a standard deviation of close to or over 30%. On the other hand, while the number of local companies incorporated seems to be a weakly leading indicator, its volatility is quite large.

38. For rapidly responsive indicators, retail sales data exhibit the strongest leading property, followed by business receipts of banking sector and the PMI. These indicators have relatively low level of volatility, yet it should be noted that banking sector business receipts are of quarterly frequency while the other two are monthly data. On the other hand, variables in labour market provide useful lagging information as expected, i.e. real GDP should be leading the development in the labour market.

39. For expectation-sensitive indicators, stock price is found to be strongly leading, yet the level of standard deviation is quite high. Conversely, housing price and rental index seems to a lagging indicator, with its correlation with real GDP at $\gamma(1)$ higher than that at $\gamma(-1)$. Yet, rental index is less volatile than the housing price.

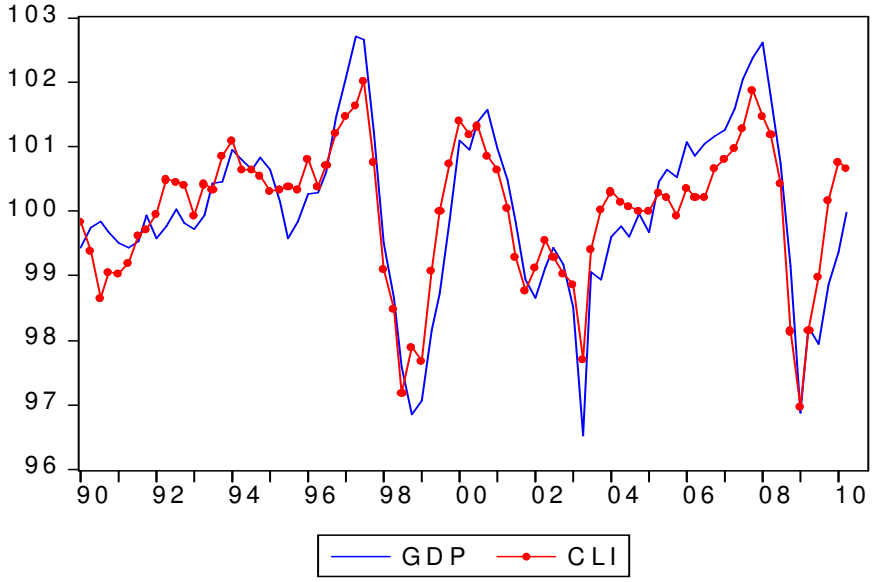
40. For prime movers, external trade data establish strong relationship with GDP, given Hong Kong's reliance on external trade. The leading property of external trade data is also reasonably strong, with correlation coefficients at $\gamma(-1)$ over 0.6. On the other hand, visitor arrivals is found to be a weakly leading indicator with relatively low correlation (slightly above 0.3 at $\gamma(-1)$). For monetary variables, M1 and M2 are found to have week leading correlation of below 0.4.

Trial CLI of real GDP of Hong Kong

41. Based on the cross-correlation analysis and technical graphical analysis, coupled with considerations on the economic interpretation, data frequency and volatility of the cycles of the potential indicator data series, four indicators are selected to form the components of CLI of Hong Kong. The selected indicators are: retail sales, Purchasing Mangers' Index, Hang Seng Index and total trade. It can be noted that the indicators so chosen come from only three categories, viz. rapidly responsive, expectation-sensitive and prime movers. Early stage indicators are either too volatile or their correlations with real GDP are too weak for inclusion as component indicators.

42. Graph 2 plots the trial CLI against the reference series (i.e. real GDP). It shows that the CLI is a valid representative of the output cycle, with the main peaks and troughs around the turning points all closely targeted.

Graph 2: Cycle of CLI and GDP, 1990 Q1 – 2010Q2



43. Statistically, the cyclical properties of CLI and GDP can be confirmed by the cross correlation analysis. It is observed that the simultaneously cross correlation between the CLI and real GDP is as high as 0.89. For one quarter ahead, CLI also exhibits a strong correlation of 0.86 with real GDP, which should be sufficient to provide some early signal regarding the turning point of the local economy.

Table 3: Cross correlation of cyclical properties, CLI & GDP

SD	Cross Correlation of Output with						
	γ(-3)	γ(-2)	γ(-1)	γ(0)	γ(1)	γ(2)	γ(3)
1.06	0.44	0.69	0.86	0.89	0.65	0.33	0.01

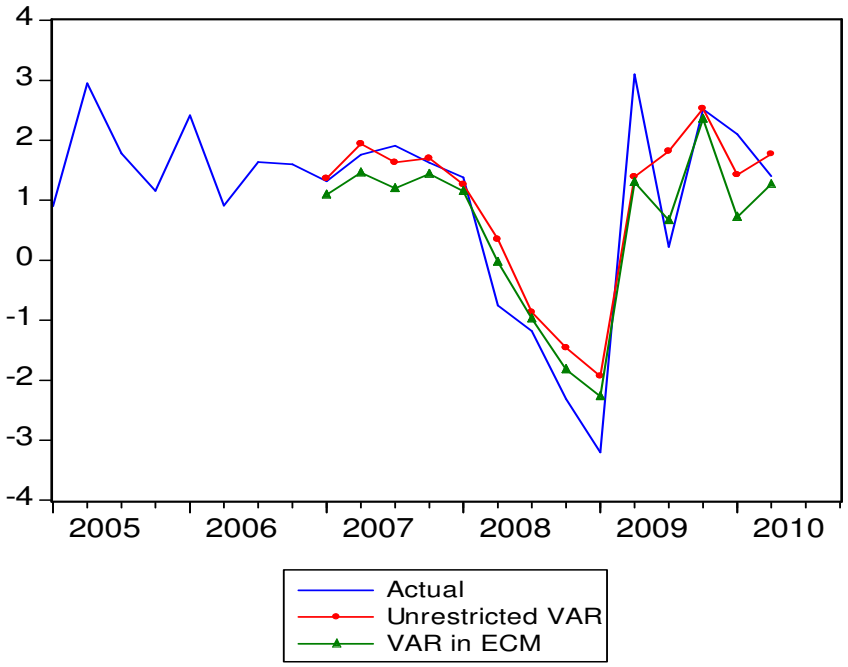
44. Given that the component indicators are all of monthly frequency, a monthly CLI can theoretically be compiled. However, empirically the performance of the monthly CLI can only be verified with reference to a "made-up" series of monthly GDP, say by interpolating the quarterly series using quadratic-match sum method.

VAR models for short-term forecasting

45. Regarding the forecasting of GDP growth using the unrestricted VAR and VAR in

error correction form (ECM), the data series of retail sales, stock price, total trade are included in the models. These series have been used in constructing CLI. PMI is not included due to its relatively short data series. In addition, we have included four more variables, viz. number of employment, rental index, the number of local companies incorporated and the number of visitor arrival. The results of model forecasts of quarter-to-quarter real GDP growth for the period from the first quarter of 2007 to the second quarter of 2010 are shown in Graph 3.

Graph 3: Current-quarter forecasting GDP growth (%), 2007 Q1 – 2010 Q2



46. The results show that the forecasted growth rates are consistent with the actual growth rates, suggesting the VAR using high frequency indicators could yield good explanatory power. Model under ECM specification seems to be more sensitive to the negative shock than the unrestricted specification and provides a closer prediction for economic downturn. Overall, the results are satisfactory, in particular the economy has become more volatile due to ups and downs brought by the external stock of 2008 global economic crisis.

47. Still, targeting the turning point is not an easy task. For 2008 second quarter when real GDP turned from positive to negative growth, and for 2009 second quarter when real GDP recovered rapidly from negative to positive growth, both the unrestricted and ECM VAR models do not target well. This is probably due to some external factors that affected the economy at that particular time points but have not been captured by the model.

48. Another output of the VAR models is the variance decomposition[2] of real GDP growth, which helps to explain the sources of volatility in economic growth. The results are given at Table 4. In simple terms, the estimates in the table can be interpreted as the percentage contribution of the endogenous variables (e.g. local companies incorporated, retail sales, etc.) in a quarter to the volatility of real GDP growth of the ensuing 8 quarters.

Table 4: Variance decomposition of real GDP growth using unrestricted VAR model

Quarter	S.E. (%)	Local companies incorporated	Retail sales	Employment	Hang Seng Index	Rental Index	Visitors' arrival	Total trade	GDP
1	1.2	6.9	26.8	2.4	3.0	1.4	11.0	14.7	33.9
2	1.5	4.6	27.4	1.6	18.5	1.7	11.0	11.6	23.7
3	1.6	9.8	25.7	1.5	17.8	1.8	9.7	12.3	21.4
4	1.6	9.9	25.0	1.6	17.1	4.8	9.2	11.8	20.6
5	1.7	9.7	24.5	1.7	16.5	5.5	8.9	13.1	20.0
6	1.7	9.6	24.3	2.1	16.1	5.7	8.8	13.8	19.6
7	1.7	9.4	24.2	2.6	15.8	5.6	8.7	14.4	19.4
8	1.7	9.3	24.2	2.8	15.7	5.6	8.6	14.6	19.4

49. As shown in Table 4, retail sales, stock price and total trade are the three main components in explaining the growth volatility of GDP. Altogether, they explained more than 50% of the growth volatility of real GDP from the short run of 2 ensuing quarters up to the longer run of 8 ensuing quarters. Visitors' arrival and local companies incorporated also have a role to play, accounting for about 20% of growth volatility of real GDP. Rental and employment accounted for just less than 10% in the longer run. Real GDP growth itself also has an effect on its own growth volatility in the ensuing quarters.

V. Conclusion

50. In this research work, we have identified four statistical indicators that exhibit good leading properties for real GDP in Hong Kong. The four indicators are retail sales, Purchasing Mangers' Index (PMI), Hang Seng Index and total trade. Accordingly, a trial

[2] Technically, the variance decomposition, as performed under an unrestricted VAR by the Cholesky Triangularisation (amounting to using a recursive structural model), shows the proportions of the forecast error variance of a shock on the endogenous variables (e.g. local companies incorporated, retail sales, etc.). We focus on the forecast error variance of GDP growth due to other endogenous variables in the present analysis. The Cholesky ordering is set such that the source of the one period ahead variation of GDP growth is dependent on other endogenous variables.

Composite Leading Indicator (CLI) has been constructed using these indicators as components. On the other hand, we have fit the VAR models for forecasting current quarter real GDP.

51. Both the CLI and the VAR models are found to perform satisfactorily using historical data. Yet, they are not without limitations. The time series of PMI is short while Hang Seng Index, though showing obvious leading property, is highly volatile. In particular, the forecasting ability depends on the specification of the models and the selection of relevant indicators. Furthermore, there is no guarantee that the models will still be valid when the next economic crisis occurs. The experimental CLI and VAR models compiled in this research work can only be regarded as the first step, on which further research and analysis will be required.

52. The construction of CLI and various forecasting models demands good quality statistical indicators with high frequency and short time lag. Such indicators in their own right should also provide early warning signals. It is the responsibility of statistical offices of various economies to ensure that the statistical indicators so compiled can meet the expectations of users. In Hong Kong, the Census and Statistics Department is endeavoured to provide adequate, relevant, reliable and timely statistics to facilitate policy formulation and assessment within the government and decision making in the community. A case in point is the development of a set of weekly business sentiment indicators shortly after the outbreak of global financial crisis. The indicators are compiled based on a panel survey with small and medium-sized enterprises (SMEs) that tracks the current and expected situations of these companies in terms business receipts, employment and credit access. Furthermore, to better gauge the possible impact of the European debt problem on export performance, views on new export orders of import and export firms have been even collected at weekly intervals since June 2010. The business sentiment indicators compiled from these surveys serve as timely and useful high frequency references for the Government in assessing the latest economic situation and facilitate the monitoring of effectiveness of policies.

53. Upon the onset of the 2008 global financial crisis, policy makers worldwide have relied on an abundant set of statistical data in gauging the latest economic situation and formulating appropriate counter-cyclical policies. It is generally acknowledged that the existing set of data have served the purpose well. Yet, the crisis has indeed revealed a need for more in-depth understanding of the financial sector, particularly on the volatility and risks in this sector and how they impact on the real economy. Consideration may be given to the development of a set of early warning indicators for this important sector. Given the highly globalised financial market, the deliberation process can be initiated at international level and should involve not only statistical organisations, but also monetary authorities and central

banks.

References

Angelini, E., Camba-Mendez, G., Giannone, D., Reichlin, L. and Rustler, G., 2008. Short-term forecasts of euro area GDP growth. European Central Bank Working Paper 949, 1-31

Bry, G. , Boschan, C. , 1971. Cyclical Analysis of time series: selected procedures and compute programs. NBER.

Burns, A. F., Mitchell, W. A.,1946. Measuring Business Cycles. NBER.

Christiano, L. J. , Fitzgerald, T. J. , 1999. The band pass filter, NBER Working Paper 7257, 1-73

Chan, C.S., 2000. High frequency macroeconomic forecasting model for Hong Kong. APEC Study Centre, Hong Kong Institute of Economic and Business Strategy, University of Hong Kong.

Dickey, D.A., Fuller, W.A., 1979. Distribution of the estimators for autoregressive time-series with a unit root. Journal of the American Statistical Association 74 (366), 427-431.

Engle, R.F., Granger, C.W.J. 1987. Cointegration and error correction: representation, estimation, and testing. Econometrica 55, 251-276.

Koenig, E., Dolmas, S., Piger, J.M., 2001. The use and abuse of "real-time" data in economic forecasting. Federal Reserve Bank of St. Louis Working Paper 15, 1-49

Gerlach, S., Yiu, M., 2004. A dynamic factor model for current-quarter estimates of economic activity in Hong Kong. Hong Kong Institute for Monetary Research Working Paper 16, 1-24.

Genberg, H., Chang, J., 2007, A VAR framework for forecasting Hong Kong's output and inflation. Hong Kong Institute for Monetary Research Working Paper 2, 1-25.

Gyomai, G.., Guidetti, E.. 2008. OECD system of composite leading indicators. OECD, 1-18

Hodrick, R.J., Prescott, E.C., 1997. Postwar U.S. business cycles: an empirical investigation. Journal of Money, Credit & Banking 29, 1-18.

Johansen, S., 1991. Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. Econometrica 59, 1551-1580.

Keating, J.W., 1996. Structural Information in Recursive VAR Orderings. Journal of Economic Dynamics and Control 20, 1557-1580.

Li, K.-W., Kwok, M.-L., 2009. Output volatility of five crisis-affected East Asia economies. Japan and the World Economy 21, 172-182.

Lui and Chow, 1999. Forecasting Hong Kong economy for 1999. Centre for Economic Development, Hong Kong University of Science and Technology

Miller, P. J., Chin, D., 1996. Using monthly data to improve quarterly model forecasts. Federal Reserve Bank of Minneapolis Quarterly Review, Spring, 16-33.

Rathjens, P., Robins, R., 1993. Forecasting quarterly data using monthly information. Journal of Forecasting 12, 321-330.

Prescott, E.C., 1986. Theory ahead of business cycle measurement. Federal Reserve Bank of Minneapolis Quarterly Review, Fall 9-22.

Sims, C. ,1980. Macroeconomics and Reality. Econometrica 48, 1-48.

Stark, T., 2000. Does current-quarter information improve quarterly forecasts for the U.S. economy?. Federal Reserve Bank of Philadelphia Working Paper 2, 1-60.

Annex 1

Hodrick and Prescott (HP) Filter

We use the HP filter (Hodrick and Prescott 1997, Prescott 1986) to generate the smoothed trend series from the original time series, and the business cycle component is the difference between the trend series and the original series. The original time series and the trend component are indicated, respectively, by $\{y_t, t = 1,2,.....,T\}$ and $\{\tau_t, t = 1,2,.....,T\}$. Thus, $\{c_t = y_t - \tau_t\}$ is the cyclical component of the series y_t. The HP filter gives a two-sided linear filter that computes the smoothed series τ of y by minimizing the variance of y around τ, subject to a penalty that constrains the second difference of τ. The HP filter chooses τ to minimize:

$$\underset{\tau_t}{Min} \sum_{t=1}^{T} (y_t - \tau_t)^2, \tag{3}$$

subject to

$$\sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \leq \mu. \tag{4}$$

The growth of the trend is limited by the value of μ in Equation (4). The smaller is the value of μ, the smoother the trend path is.[3] On the contrary, if the value of μ is very large (i.e. when $\mu \to \infty$), there will not be any constraint, and we would have smoothed too little. If so, the 'smoothed' trend is just the original series (i.e. $y_t = \tau_t$) and we will not have the business cycle component.

The optimization problem is solved by using the Lagrangian method, which takes the form of an objective function of Equation (3) less the product of the Lagrangian multiplier (λ) and the constraint (Equation 4), shown as:

$$L = \sum_{t=1}^{T} (y_t - \tau_t)^2 - \lambda \left[\sum_{t=2}^{T-1} (\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})^2 - \mu \right]. \tag{5}$$

There is a positive correlation between λ and μ. In Prescott (1986), μ is chosen when the Lagrange multiplier λ is 1600 for quarterly data (14400 for monthly data), which shall produce a correct degree of smoothness in the fitted trend. The use of the HP filter effectively eliminates the variations at all frequencies of 32 quarters (i.e. 8 years) or greater and induce a stationary cyclical component in the series.

[3] A zero value of μ suggests that the constraint is very straight, and the trend will effectively become linear. If the series is integrated of order 1 (i.e. level non-stationary but difference stationary), a zero value of μ would imply that the business cycle component is not stationary.

Annex 2

Cross Correlation

We examine the cross correlation between output (GDP) and macroeconomic variables so as to relate the discussion to business cycle. Cross correlation is defined as:

$$\gamma_{xy}(l) = \frac{c_{xy}(l)}{\sqrt{c_{xx}(0)}.\sqrt{c_{yy}(0)}}, \tag{6}$$

where $l = 0,\pm1,\pm2,...$, while

$$c_{xy}(l) = \left\{ \begin{array}{l} \sum_{t=1}^{T-1}((x_t - \bar{x})(y_{t+1} - \bar{y}))/T, l = 0,1,2,... \\ \sum_{t=1}^{T+1}((y_t - \bar{y})(x_{t-1} - \bar{x}))/T, l = 0,-1,-2,... \end{array} \right\}, \tag{7}$$

$$c_{xx}(0) = \sum_{t=0}^{T}(x_t - \bar{x})^2/T, \tag{8}$$

and

$$c_{yy}(0) = \sum_{t=0}^{T}(y_t - \bar{y})^2/T. \tag{9}$$

T indicates the time period. Since the cyclical components are stationary, the mean and the variance of the cyclical series do not change over time. The cyclical component is obtained from the original series after being inserted into the HP filter. Equation (6) is used to run the cross correlation and obtain the estimated coefficients. To examine how the macroeconomic variables are correlated with GDP, we fix the GDP as x, and the other macroeconomic variables would then be y in Equation (6).

- END -