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Business cycles in a small open economy: The case of Hong Kong

Business cycles in a small open economy: The case of Hong Kong

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Abstract

This paper analyzes the business cycle properties of the Hong Kong economy during the 1982-2004 period, which includes the financial crisis experienced in 1997-98. We show that output, output growth rate and real interest rates volatilities in Hong Kong are higher than their respective average volatilities among developed economies. In this paper, we build a stochastic neoclassical small open economy model that seeks to replicate the main business cycle characteristics of Hong Kong, and through which we try to quantify the role played by exogenous Total Factor Productivity (transitory and permanent), real interest rates shocks and financial frictions. The main findings are that the trend volatility has to be higher than the volatility of the transitory fluctuations around the trend; that the volatility of real interest rates are mainly due to country risk spread, and that financial frictions matter to explain real interest rates countercyclicality.

Keywords: Keywords: Business Cycles, Financial Frictions, Total Factor Productivity, Country Risk Spread, Small Open Economy, Neoclassical model.

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1 Introduction

This paper analyzes the business cycle properties of the Hong Kong economy during the 1982Q1-2004Q4 period, which includes the financial crisis experienced in Hong Kong in 1997-98. We compare the cyclical component of Hong Kong with those of other small open economies[1]. In particular, we find that output volatility and that of the growth of output in Hong Kong are much higher than their average volatilities among developed economies (2.78 and 5 times higher, respectively). We also concentrate on the relationship between output and real interest rates, as a sharp increase in the interest rates in Hong Kong was observed during the financial crisis. We end by building a stochastic neoclassical small open economy model to try to replicate the main business cycle characteristics of Hong Kong, and through which we try to quantify the role played by exogenous Total Factor Productivity (TFP), both permanent and transitory, real interest rates, international and country spread, shocks and financial frictions in the business cycle characteristics of the Hong Kong economy. We include a working capital requirement and find that financial frictions seem to be important in explaining Hong Kong business cycles.

Firstly, we find that the Hong Kong economy is characterized as an emerging economy due to: *i)* high output volatility, *ii)* high volatility of the output

[1]Hong Kong is classified as a developed or emerging economy by different organizations: IFS, JPMorgan, the United Nations and the Economist Intelligence Unit count Hong Kong as an "emerging economy". On the other hand, the World Economic Outlook and the World Equity Index Group from Salomon Smith Barney categorize it as an "advanced economy". Morgan Stanley Capital International leaps Hong Kong in its developed-market index. And it is recently identified as a newly industrialized country by organizations such as Standard & Poors (2000) and the International Finance Corporation.

growth rate , *iii)* high volatility of real interest rates, *iv)* high volatility of net exports, *v)* a negative correlation between real interest rates and output. And, as in small developed economies, by *vi)* consumption roughly as volatile as output, and *vii)* a negative correlation between net exports and output similar to small developed economies.

The business cycle characteristics of the Hong Kong economy have been previously studied by Leung and Suen (2001), whose work does not include the financial crisis and post-crisis period. They analyze some aspects of the business cycle characteristics of the Hong Kong economy between 1964 and 1994 for annual data and quarterly data (1976Q1-1994Q1), using the Band-Pass filter. These authors find that the volatility of output in the 1979Q1-1996Q4 period was around 2.3%, which is higher than the standard deviation of quarterly output in the US (1.7%). They remark that, in Hong Kong *there is a marked seasonal pattern in the economic series.* Crosby (2004) also analyzes the time series properties of output, among other variables (government expenditure, exports, imports, CPI, real exchange rate), in Hong Kong, for the 1974Q3-1999Q4 period. He also applies the BP filter to detrend the series and finds that the output volatility is around 3%.

With regard to the real interest rate we observe, *first,* a sharp increase of interest rates during the Asian financial crisis. As already noted by several authors, such as Neumeyer and Perri (2005), Oviedo (2005b), Uribe and Yue (2006) among others, real interest rates during economic expansion appear to be low, while periods of economic stress are often accompanied by high real interest rates. Edwards and Susmel (2003) use univariate SWARCH models to analyze the interest rate volatility in five countries that have undergone a financial crisis: Chile, Argentina, Mexico, Brazil and Hong Kong. They conclude that in Hong Kong, unlike in other countries such as in Mexico or Brazil, the economy shifted to a high volatility interest rate state during the financial crisis, and stayed there for almost a year. In particular, interest rate volatility in Hong Kong in the 1982-2004 period was 0.68%, whereas it was only 0.21% in the US. The *second* interesting finding is that, as shown in Neumeyer and Perri (2005) for other small open emerging countries, real interest rates in Hong Kong are countercyclical (-0.32), similar to small emerging economies, and there is a clear pattern of leading the cycle[2].

The main focus of this paper is to assess the quantitative impact of exogenous shocks (interest rates shocks and TFP shocks) on the characteristics of the Hong Kong business cycles and to understand the channels through which they work. For that purpose, we develop a stochastic neoclassical small open economy model that partly follows the model built by Neumeyer and Perri (2005) and partly follows the model built by Aguiar and Gopinath (2007a). The model consists of an infinitively lived representative household, a production sector formed by an indeterminate number of competitive firms producing with the same constant returns to scale production technology, using capital and labor as inputs. As we are considering a small open economy, the foreign debt, or international bond, yields a real rate of return that is viewed as exogenous by the agents in the economy. As in Aguiar and Gopinath (2007a), we decompose the shocks of the Solow residuals into two components: a transitory productivity shock around the trend and a shock

[2] Neumeyer and Perri (2005) and Uribe and Yue (2006) stress that the real interest rates on external bonds show a negative correlation with the cycle in emerging markets.

to the trend.

As in Neumeyer and Perri (2005), we will consider the same simple theory behind the high volatility of the interest rates. We will consider that the volatility of the interest rate, at which the Hong Kong economy can borrow from international lenders, depends upon two components. On the one hand, it will be affected by the volatility of the international rate for risky assets and, on the other hand, it will depend on the country spread over the international rate.

The remainder of the paper is organized as follows. Section 2 briefly describes some characteristics of the Hong Kong business cycles and compares them to other small open developed and emerging economies. In Section 3, we develop the model. In section 4 we solve it. In section 5 we obtain the main findings. Section 6 summarizes and concludes.

2 Business cycles characteristics.

This section analyzes the business cycle properties of the Hong Kong economy, with special emphasis on the real interest rate and output. In particular, we use data obtained from Hong Kong Census and Statistics Department[3] and consider the period that includes the Asian financial crisis (1982Q1-2004Q4). We show that the economy of Hong Kong shares some characteristics with a standard emerging market economy and others with a small open developed economy. We compare the cyclical components of

[3]We also use data from the International Financial Statistics (IFS) in order to obtain the most accurate and internationally comparable results. We obtain very similar results using data from IFS and Hong Kong census.

Hong Kong with those of other small countries such as Korea, Philippines, Thailand, Netherlands, Norway and Sweden[4]. Averages for emerging and developed small open economies for a very similar period are from Aguiar and Gopinath (2004). All series have been detrended using the BP filter. The comparison is in terms of relative volatility and correlations as performed in Uribe (2007) and Aguiar and Gopinath (2004).

In the case of Hong Kong, the filter selection is not indifferent to the obtained results[5]. Time series analyses that characterize for containing high frequency components show a remarkable difference in the cyclical components obtained from the de-trending of Hodrick-Prescott (HP) and Band-Pass (BP) filters. The high-frequency components pass through the HP filter, but are removed by the BP filter. Hong Kong is an economy with high frequency components. Therefore, it seems important to eliminate the cycles that last less than 6 quarters. The series would otherwise be too seasonal. We therefore filtered all series using the BP filter at frequencies between 6 and 32 quarters with 12 leads and lags (this means that three years of data are lost both at the beginning and at the end of the sample).

Emerging economies, according to Aguiar and Gopinath (2007b) and Neumeyer and Perri (2005) are characterized by, on average, *i)* a business cycle twice as volatile as that of their developed counterparts; *ii)* also the

[4] More data description is available upon request.

[5] Rand and Tarp (2002) study some characteristics of business cycles for 50 developing countries and they argue that the cycles in these countries are shorter (between 7 and 18 quarters) than in advanced economies, making it necessary to modify the filtering procedures normally applied for industrialized countries. They also find that the *data analysis shows that a downward adjustment in the standard deviation of the Asian countries that they study, when using the BP filter instead of the HP filter, is more pronounced in Asian countries than in North African countries.*

output growth rate is twice as volatile as that of the developed economies; *iii)* output displays roughly the same autocorrelation as that of developed economies; *iv)* consumption is roughly 40 percent more volatile than income in emerging economies (in developed economies the ratio is slightly less than 1 on average); *v)* trade balance-to-output is much more countercyclical in emerging countries than in developed countries (around $-0.5/-0.8$ in emerging economies, -0.17 in developed economies); *vi)* interest rates are countercyclical and lead the cycle in emerging economies while they are acyclical and lag the cycle in developed economies.

Table 1 reports key moments for the Hong Kong economy, for the 1982Q1-2004Q4 period, own our calculations for some small open emerging and developed economies and those moments calculated by Aguiar and Gopinath (2004) averaged over 13 emerging and 13 developed small open economies for a similar time period [6].

Insert Table 1 near here.

2.1 *Real Gross Domestic Product, Consumption, Investment and Trade*

We obtain that the volatility of Real Gross Domestic Product is 2.89%, twice as volatile as in developed small open economies and similar to emerging economies. If we take a shorter series (1982Q1-1997Q3), just prior to the

[6] The countries that these authors analyze are: 13 small emerging countries: Argentina, Brazil, Ecuador, Israel, Korea, Malaysia,Mexico, Peru, Philippines, Slovak Republic, South Africa, Thailand and Turkey; 13 small developed countries: Australia, Austria, Belgium, Canada, Denmark, Finland, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden and Switzerland.

crisis, we obtain (approximately) the same result (2.69%). The inclusion of the crisis period does not modify the Hong Kong output volatility. We also look at first differences in unfiltered log GDP as recent literature (Aguiar and Gopinath , 2007a; Boz et al. , 2008; Schmitt-Grohe and Uribe , 2008). In Hong Kong, the volatility of unfiltered first differences in log GDP is 4.76%, much higher than the average values from emerging economies. Therefore, the possibility could be considered that the permanent component of productivity shocks plays a main role in the Hong Kong economy.

The relative volatility of consumption to output in developing countries is around 40% larger than in industrial countries. Average consumption volatility over GDP in small open emerging economies is 1.45, while the value falls to 0.94 for small open developed economies. In Hong Kong, the relative volatility of consumption with respect to GDP is 0.84 for the 1982Q1-2004Q4 period. This result is also found in Leung and Suen (2001) and also similar to small open economies such as Korea or Sweden and Norway. Nevertheless, this result is not independent of the period analyzed. If we take the 1973Q1-2005Q4 time period, the consumption volatility relative to GDP increases to 1.07. Correlation between consumption and GDP is positive and high, 0.79, closer to the average for small emerging economies.

The relative volatility of investment in Hong Kong is around 3.4 times the volatility of gross domestic product, a value that matches well within the range has been found in both emerging and developed countries. This result does not depend on the period considered. We also find a strongly positive contemporaneous correlation, 0.87, between de-trended investment and GDP data in Hong Kong. The correlation between investment and output is practically the same at time zero and with a lag of one quarter (0.873 at time zero and 0.879 at a lag of one).

A striking feature of emerging market economies is the strongly countercyclical nature of the trade balance-to-GDP compared to developed economies. On average, emerging markets have a correlation of net exports to output with GDP of -0.58 and developed ones have a correlation of -0.26. In Hong Kong, the correlation between net exports over GDP and GDP is -0.33When the period immediately prior to the crisis is considered (1982Q1-1997Q4), the countercyclical value halves to -0.16. With regard to the volatility of net exports-to-GDP (2.15%), it is very similar to the average for emerging economies (around 2.09%).

2.2 *Real interest rates*

We finish this section by analyzing the cyclical component of the real interest rate (the three-month interest rate from the Hong Kong Monetary Authority (HKMA) dataset[7]) for the 1982Q1-2004Q4 period, and its relationship with the cyclical component of the GDP in Hong Kong, as it is done in Neumeyer and Perri (2005). The gross real interest rate is obtained by dividing gross nominal interest rate by the expected gross inflation rate. The expected gross inflation rate is computed as the average for the current quarter prices and the value of the GDP deflator inflation in the three preceding quarters[8].

Figure 1 shows the observed evolution of the Hong Kong gross real in-

[7] Other interest rate measures were considered such as the Hong Kong Best Lending rate from HKMA for period 1082Q1-2004Q4 or the Three-month Treasury Bill from IFS dataset for the 1993Q4-2007Q2 period. Results are similar.

[8] A four period lag to compute expected inflation has also been analyzed but the results do not vary. More details upon request.

terest rate compared to the US gross real interest rate (the real three-month Treasury bill) for the 1982Q1-2004Q4 period. It is noteworthy that the US interest rate is much more stable than the Hong Kong interest rate during the whole period. In particular, the Hong Kong interest rate increased dramatically during the Asian Financial crisis while the US interest rate remained quite stable. The Hong Kong real three-month interest rate lept 1.4 percentage points on average between 1997Q2 and 1998Q3. The US interest rate remained almost constant during the same period. Therefore, most of the rise comes from the spread in Hong Kong interest rates over world (US) interest rates.

Insert Figure 1 near here.

Figure 1: Real US and Hong Kong interest rates.

Table 2 shows the volatility and correlations of the Hong Kong interest rate, the international interest rate (US interest rate) and the country risk premium with output, consumption, investment and net exports for the period before the crisis (1982Q1-1997Q4) and a longer period that includes the Asian financial crisis (1982Q1-2004Q4). The volatility of the Hong Kong real interest rate is 0.68%, more than three times the US real interest rate volatility 0.21%. We also find a negative correlation of -0.32 (-0.39 if the financial and post-financial period is excluded)[9]. On the other hand, the correlation between US interest rate and Hong Kong output is slightly negative, -0.15,

[9] A negative correlation is also found when the real Best Lending interest rate is used for the 1980-2003 period. On the other hand, Leung and Suen (2001) report a positive correlation between the Real Best Lending rate and output, 0.32, for the 1977Q4-1994Q2 period. They calculate it as the nominal best lending rate minus CPI inflation. We calculate the three-month interest rate deflated with GDP deflator. Dotsey et al. (2003) show that results can vary depending on the deflator for interest rate used.

and the correlation between the country risk spread from Hong Kong and its output is -0.32. Correlation between Hong Kong interest rate and US interest rate is 0.56, and the correlation between Hong Kong interest rate and Hong Kong country spread is 0.95.

Insert Table 2 near here.

Table 2 also shows the volatility and correlation between real interest rates and output for other small open economies (Korea, Philippines, Netherlands, Sweden). If we compare Hong Kong interest rates to other economies, we find that the volatility of the real interest rate in Hong Kong (0.68%) is higher than in the other economies (the next higher is Sweden (0.39%)).

In the next section we develop a small open economy model with interest rate shocks, and a distinction between the transitory and permanent shocks to the TFP.

3 The economic model

3.1 *Description of the basic model*

This section describes the economic model, which is based on Neumeyer and Perri (2005) and on Aguiar and Gopinath (2007a). As we have observed that the volatility of the first log differences of GDP is quite high in Hong Kong, we have distinguished, as in (Aguiar and Gopinath , 2007a,b), the transitory and permanent shocks to the Total Factor Productivity. The model is a small open economy neoclassical model. The economy consists of identical infinitely-lived households, an indeterminate number of competitive firms producing the same single good using the same constant returns to scale technology. Households can trade a single asset in international financial markets. Firms also trade in the asset because of the assumption of working capital requirements. There are adjustment costs on both capital stock and international debt. There are external shocks to the economy that affect the real interest rate and the total factor productivity of the Hong Kong economy. Time is discrete.

3.1.1 ***Households***

Households are represented by a continuum of infinitely-lived, identical households of measure one. The representative household chooses how much to work, consume, invest and borrow, such that maximizes its lifetime utility function,

$$U = E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t, l_t\right), \tag{1}$$

where the functional form of the utility function is GHH preferences:

$$u\left(c_t, l_t\right) = \frac{1}{1-\sigma}\left[c_t - \psi \Gamma_t l_t^v\right]^{1-\sigma}, \tag{2}$$

where c_t denotes household consumption at time t, l_t denotes household labor at time t. The parameter σ is the curvature of the period utility, $\psi > 0$, and v determines the wage elasticity of labor supply, which is given by $1/(v-1)$, with $v > 1$, in order to ensure that the elasticity of labor supply is positive. The symbol $\Gamma_t = \gamma_t \Gamma_{t-1}$ represents the cumulative product of stochastic growth rates of labor-augmenting technological progress up to time t, which will be discussed below. The growth rate of the Total Factor Productivity at each period t will be given by $(\gamma_t - 1)$.

The GHH preferences were first proposed by (Greenwood et al. , 1988) and have the special property that labor supply depends only on the current wage and is independent of consumption or income (there are no wealth effects on the labor supply decision). In a small open economy, this type of preferences better captures the relative volatility of consumption with respect to output (see Correia et al. , 1995). A well known fact in the small open economy RBC literature is that with Cobb-Douglas preferences over consumption and leisure, the model predicts too much consumption smoothing. GHH preferences are introduced in the model to increase consumption volatility. Also, as noted in Fernández-Villaverde et al. (2010), these preferences are able of generating a contraction in consumption, labor and output after a positive shock to the interest rate level.

In order for these GHH preferences to be consistent with a balanced growth path, the disutility of work in the market has to increase with the cumulative growth rate of labor-augmenting technological progress Γ_{t-1}. It has to be assumed that $\beta\gamma_{ss}^{1-\sigma} < 1$ to ensure that utility is finite. As we will see, this condition coincides with the transversality condition and the No-Ponzi game conditions that should also be satisfied.

Assuming, as in Neumeyer and Perri (2005), that at the time households make their investment decisions, they know the rate of return of international real bonds (see also Uribe and Yue , 2006; Fernández-Villaverde et al., 2010), but they do not know the rates of return of domestic physical capital, the household budget constraint at time t can be written as follows:

$$c_t + i_t + b_t + \varkappa(b_t) = w_t l_t + r_t k_{t-1} + R_{t-1} b_{t-1}, \tag{3}$$

where the subscript t denotes that for the corresponding variable, the history of shocks up to those which have been revealed at the beginning of time t, is known. Therefore, for example, b_{t-1} means that the amount of foreign bonds that households have at the beginning of period t depends on the history of shocks revealed up to the beginning of period $t-1$. Shocks revealed at the beginning of period t do not affect the real interest rates on the international bonds held by households at time t, R_{t-1}. Households spend their labor income, $w_t l_t$, and capital income, $r_t k_{t-1}$, and the returns from foreign asset holdings, $R_{t-1} b_{t-1}$, on consumption, c_t, investment, i_t, foreign bonds, b_t, and the cost of holding foreign bonds, $\varkappa(b_t)$, which are included in order to avoid a unit root for the foreign bonds (see, among others, Neumeyer and Perri , 2005). We assume that the bond holding cost function is $\varkappa(b_t) = \left[\frac{\chi}{2} y_t \left(\frac{b_t}{y_t} - \overline{b}\right)^2\right]$, i.e., the cost of holding bonds are applied to the amount of bonds that households buy at period t[10].

The law of motion for the physical capital is:

$$k_t = i_t + (1-\delta) k_{t-1} - \phi(k_{t-1}, k_t), \tag{4}$$

where $0 < \delta < 1$ is the rate of capital depreciation and $\phi(k_{t-1}, k_t)$ denotes the adjustment costs. We assume the same adjustment cost function of capital

[10] In this way, the adjustment costs of international bonds can be decentralized as in Uribe and Yue (2006), through *financial intermediation by domestic banks. Then, the shadow interest rate faced by domestic agents will take into account the operational costs domestic banks face* (see page 19 in Uribe and Yue , 2006).

as in Neumeyer and Perri (2005),

$$\phi(k_{t-1}, k_t) = \frac{\varphi}{2} k_{t-1} \left(\frac{k_t - k_{t-1}\gamma_{ss}}{k_{t-1}} \right)^2, \tag{5}$$

where $\varphi > 0$. This adjustment cost is included in order to reduce investment-to-output volatility.

Finally, we also assume that household borrowing is bounded below so as to rule out Ponzi schemes, therefore:

$$\lim_{j \to \infty} E_t \frac{b_{t+j}}{\prod_{s=0}^{j} R_{t+s-1}} \geq 0, \tag{6}$$

$$\lim_{j \to \infty} E_t \frac{k_{t+j}}{\prod_{s=0}^{j} R_{t+s-1}} \geq 0. \tag{7}$$

Hence, the household's problem is to choose the sequence of consumption, labor, investment in physical capital and foreign asset holdings such that maximize the expected utility (1) subject to the budget constraint (3), the capital accumulation constraint (4) and the No-Ponzi game conditions (6) and (7), taking as exogenously given a sequence of prices of labor, capital and of foreign assets, $\{w_t, r_t, R_{t-1}\}_{t=0}^{\infty}$ and for given values of initial foreign assets, b_{-1}, and physical capital, k_{-1}.

$$-\frac{U_{l_t}}{U_{c_t}} = w_t \tag{8}$$

$$U_{c_t}\left[1+\varphi\left(\frac{k_t}{k_{t-1}}-\gamma_{ss}\right)\right] = \dots \tag{9}$$

$$\dots = \beta E_t U_{c_{t+1}}\left[1-\delta+r_{t+1}+\frac{\varphi}{2}\left(\left(\frac{k_{t+1}}{k_t}\right)^2-\gamma_{ss}^2\right)\right],$$

$$U_{c_t}\left[1+\chi\left(\frac{b_t}{y_t}-\bar{b}\right)\right] = \beta R_t E_t U_{c_{t+1}}. \tag{10}$$

and the budget constraint at each period:

$$c_t + k_t - (1-\delta)k_{t-1} + \frac{\varphi}{2}k_{t-1}\left(\frac{k_t}{k_{t-1}}-\gamma_{ss}\right)^2 + \dots$$

$$b_t + \frac{\chi}{2}y_t\left(\frac{b_t}{y_t}-\bar{b}\right)^2 = w_t l_t + r_t k_{t-1} + R_{t-1}b_{t-1}. \tag{11}$$

These equations show that *i)* the marginal rate of substitution of leisure for consumption has to be equal to their relative price, *ii)* the Euler equation for capital, *iii)* the Euler equation for foreign bonds and *iv)* that the household budget constraint must be satisfied. Moreover, the transversality conditions for physical capital and foreign assets must hold:

$$\lim_{t\to\infty}\beta^t U_{c_t} k_t = 0, \tag{12}$$

$$\lim_{t\to\infty}\beta^t U_{c_t} b_t = 0. \tag{13}$$

With specific GHH preferences we obtain the following (14), (15) and

(16) equations:

$$\psi v \Gamma_{t-1} l_t^{(v-1)} = w_t, \tag{14}$$

$$(c_t - \psi\Gamma_{t-1} l_t^v)^{-\sigma}\left[1+\varphi\left(\frac{k_t}{k_{t-1}}-\gamma_{ss}\right)\right] = \beta E_t (c_{t+1} - \psi\Gamma_t l_{t+1}^v)^{-\sigma}\ldots$$

$$\left[1-\delta+r_{t+1}+\frac{\varphi}{2}\left(\left(\frac{k_{t+1}}{k_t}\right)^2-\gamma_{ss}^2\right)\right], \tag{15}$$

$$(c_t - \psi\Gamma_{t-1} l_t^v)^{-\sigma}\left[1+\chi\left(\frac{b_t}{y_t}-\bar{b}\right)\right] = \beta R_t E_t (c_{t+1} - \psi\Gamma_t l_{t+1}^v)^{-\sigma}. \tag{16}$$

3.1.2 *The production sector*

In this economy, the production sector is formed by an indeterminate number of identical competitive firms. Firms produce a tradable good, whose spot price is normalized to unity without loss of generality, according to the following Cobb-Douglas production function

$$y_t = z_t k_{t-1}^{\alpha}\left[\Gamma_t l_t\right]^{1-\alpha}, \tag{17}$$

where y_t is final output that is realized at the end of period t, k_{t-1} is the stock of physical capital and l_t is labor, both hired at the beginning of period t, z_t is the stochastic variable that will characterize the transitory component of the total factor productivity (whose value is known at the beginning of period t), and Γ_t denotes the cumulative stochastic growth rate of labor-augmenting technological change. The transitory component of the Total Factor Productivity, z_t, will be characterized, as usual, as an AR (1) process:

$$\log(z_t) = \rho_z \log(z_{t-1}) + \varepsilon_{z,t}, \tag{18}$$

where $|\rho_z| < 1$ and $\varepsilon_{z,t}$ is a zero mean, i.i.d. process, drawn from a Normal distribution, with $Var(\varepsilon_{z,t}) = \sigma_z^2$.

The law of motion for Γ_t is as follows:

$$\Gamma_t = \gamma_t \Gamma_{t-1}, \tag{19}$$

where $(\gamma_t - 1)$ denotes the shock to the growth rate of the Total Factor Productivity, i.e., the permanent shock to the Total Factor Productivity. We assume, as in Aguiar and Gopinath (2007a), that the law of motion for γ_t is given by the following expression:

$$\log(\gamma_t) = \rho_\gamma \log(\gamma_{t-1}) + (1 - \rho_\gamma) \log(\gamma_{ss}) + \varepsilon_{\gamma,t}, \tag{20}$$

where $(\gamma_{ss} - 1)$ denotes the deterministic growth rate of the Total Factor Productivity in the Balanced Growth Path (BGP), $|\rho_\gamma| < 1$ and $\varepsilon_{\gamma,t}$ is a zero mean, i.i.d. process, drawn from a Normal distribution, with $Var(\varepsilon_{\gamma,t}) = \sigma_\gamma^2$. A positive realization of $\varepsilon_{\gamma,t}$ implies that productivity growth is temporarily above its long run mean. It is also incorporated in the trend productivity Γ_t and, hence, results in a permanent productivity increase. Therefore a change in the permanent income as opposed to a change in the transitory income, will make consumption to increase more than current income, explaining why consumption can be more volatile than income in emerging economies.

Firms borrow from international lenders to pay a fraction θ of their labor cost in advance of sales. Working capital is a within-period loan contracted at the beginning of each period and, as market for the services of capital is frictionless, firms can make the payments to the owners of capital, foreign lenders, at the end of the period when production is realized. Perfect competition eliminates profits in equilibrium so when the firm sells its output, y_t, at the end of the period, the firm pays the end-of-period labor payments $(1-\theta)w_t l_t$, that is, the remaining fraction $(1-\theta)$ of its labor cost at the end of period t; pays the rental services to the owners of capital $r_t k_{t-1}$ and the repay the working capital loan (principal/plus interest $R_{t-1}\theta w_t l_t$)[11].

Thus, the firm's problem is to choose labor and capital and to maximize profits while taking output and input prices as well as interest rates on foreign debt as given and subject to working capital constraint:

$$\max \pi_t = y_t - w_t l_t - r_t k_{t-1} - (R_{t-1} - 1)\theta w_t l_t.$$

The necessary and sufficient first-order conditions for an (interior) optimum are then given by

$$z_t \alpha k_{t-1}^{\alpha-1} \left[\Gamma_t l_t\right]^{1-\alpha} = r_t, \tag{21}$$

$$z_t(1-\alpha) k_{t-1}^{\alpha} \Gamma_t^{1-\alpha} l_t^{-\alpha} = w_t \left[1 + \left(R_{t-1} - 1\right)\theta\right], \tag{22}$$

where (21) and (22) show that marginal productivity of capital and labor equal their marginal cost, interest rate and the labor cost, respectively.

[11] We will also solve for the case in which $\theta = 0$ to compare the difference in results with and without the inclusion of working capital requirements.

3.1.3 *International financial markets*

Agents in this economy can buy and sell international foreign assets in international financial markets. The evolution of the level of net holding of foreign assets is given by:

$$b_t - \theta w_t l_t = TB_t + R_{t-1}\left[b_{t-1} - \theta w_t l_t\right], \tag{23}$$

where TB_t is trade balance at period t, which in our model, is calculated as:

$$TB_t = y_t - c_t - i_t - \varkappa(b_t). \tag{24}$$

The goods produced in-country that are not used in consumption, investment or bonds holding costs are the country's net exports. The country's net foreign asset position in period t is the household's asset position, b_{t-1}, net of the firm's working capital debt, $\theta w_t l_t$.

Following Neumeyer and Perri (2005) we decompose the real interest rate of Hong Kong into two components: an international interest rate and a country spread. The country risk, D_t, is computed as the ratio between Hong Kong real interest rates, R_t, and international interest rates, R_t^*:

$$R_t = R_t^* D_t. \tag{25}$$

Taking logarithms on the above expression, we have:

$$\log R_t = \log R_t^* + \log D_t. \tag{26}$$

The Hong Kong economy is a small open economy so that it cannot affect the world real interest rate R_t^*. Our interest is in the effect of fluctuations in real interest rates on the economy, not in the source of those fluctuations.

The difference between the real interest rates observed in Hong Kong and the international interest rate is the country spread. As we saw in Section 2, we have used the real 3-month interbank offered rate that is provided by the HKMA dataset for the Hong Kong real interest rates. The international interest rate is the real US 3-month Treasury Bill rate. The real international interest rate has been calculated following the same procedure as for the Hong Kong interest rate. The country spread will capture the Hong Kong's idiosyncratic default risk. Consequently, this assumption creates two sources of volatility in R_t; one that is due to changes in the international preference of investors regarding risky assets, R_t^*, and a second one that is the country spread, D_t.

Regarding the stochastic process for each component of the interest rates, even though the correlation between the world interest rate and the country risk process is around 0.28, we assume, as in Neumeyer and Perri (2005), that both the international interest rate process and the country risk process are uncorrelated. In particular, we assume that the percentage deviation from trend of international interest rates follows an AR(1) process,

$$\widehat{R}_{t+1}^* = \rho_{R^*} \widehat{R}_t^* + \varepsilon_{R^*,t+1}, \tag{27}$$

where $\widehat{R}_{t+1}^*$ denotes the percentage deviation of the world interest rate from its trend, $|\rho_{R^*}| < 1$ and $\varepsilon_{R^*,t+1}$ is a zero mean, i.i.d. process, drawn from a Normal distribution, with $Var(\varepsilon_{R^*,t}) = \sigma_{R^*}^2$.

With regard to the country spread, we assume that it is driven only by exogenous factors (completely independent on the domestic factors)[12]. In particular, we assume that the percentage deviation of trend from the country risk, $\widehat{D}_t$, follows an autoregressive process of the form

$$\widehat{D}_{t+1} = \rho_D \widehat{D}_t + \varepsilon_{D,t+1}, \tag{28}$$

where $\widehat{D}_{t+1}$denotes the percentage deviation of the Hong Kong risk spread from its trend, $|\rho_D| < 1$ and $\varepsilon_{D,t+1}$ is a zero mean, i.i.d. process, drawn from a Normal distribution, with $Var(\varepsilon_{D,t}) = \sigma_D^2$.

3.1.4 *The competitive equilibrium*

Given initial conditions for the endogenous state variables (k_{-1}, b_{-1}) and exogenous state variables $(z_{-1}, \Gamma_{-1}, \gamma_{-1}, R_{-1}^*, D_{-1})$, an equilibrium is a sequence of quantities $\{c_t, l_t, k_t, b_t, y_t, z_t, \gamma_t\}_{t=0}^{\infty}$ and prices $\{w_t, r_t\}_{t=0}^{\infty}$, such that all economic agents maximize the objective functions subject to their constraints, taken as given the equilibrium prices, and all markets clear:

1) Given the equilibrium prices $\{w_t, r_t\}_{t=0}^{\infty}$ and the exogenous sequence for $\{R_t\}_{t=0}^{\infty}$, households' choice $\{c_t, l_t, k_{t+1}, b_{t+1}\}_{t=0}^{\infty}$ maximize their welfare

[12]Several authors argue that the Asian financial crisis was due to external factors: *i)* Some argue that it was caused by a change in expectations from foreign investors Obstfeld (1996); Radelet and Sachs (1998); Chang and Velasco (1998); Edwards (1998); Calvo and Mendoza (2000); *ii)* others refer to a contagion among countries common shocks that affect all countries simultaneously (Masson , 1998) or tight trade linkages (Eichengreen et al. , 1996; Caramazza et al. , 2000). Furthermore, Gruss and Mertens (2010) mention that there is not empirical evidence in favor of domestic fundamentals in explaining fluctuations in spreads, specifically not during the 1997 East Asian crisis. With respect to other small open economies, Uribe and Yue (2006) estimate a VAR with panel data from a group of emerging economies and conclude that at least two thirds of the movements in country spreads are explained by exogenous innovations

given their budget constraints.

2) Given the equilibrium prices $\{w_t, r_t\}_{t=0}^{\infty}$ and the exogenous sequence for $\{R_t\}_{t=0}^{\infty}$, firms' choice $\{k_t, l_t\}_{t=0}^{\infty}$ maximize their profits.

3) The law of motion for the exogenous state variables is given by the above processes (18), (19), (20), (27) and (28).

4) All markets clear.

The solution to the above competitive equilibrium is a non-linear system. A strategy to solve DSGE models consists of linearizing the first-order conditions and constraints around the deterministic balanced growth path. In order to guarantee that all variables are stationary in the balanced growth path equilibrium, some variables have to first be scaled by the cumulative growth rate of labor-augmenting technological progress Γ_{t-1}. Once the variables have been normalized, the above FOC's can be written as follows:

$$\psi v l_t^{(v-1)} = \widehat{w}_t, \tag{29}$$

$$(\widehat{c}_t - \psi l_t^v)^{-\sigma}\left[1 + \varphi\left(\frac{\gamma_t \widehat{k}_t}{\widehat{k}_{t-1}} - \gamma_{ss}\right)\right] = \beta\gamma_t^{-\sigma} E_t(\widehat{c}_{t+1} - \psi l_{t+1}^v)^{-\sigma} \ldots$$

$$\left[1 - \delta + r_{t+1} + \frac{\varphi}{2}\left(\left(\frac{\gamma_{t+1}\widehat{k}_{t+1}}{\widehat{k}_t}\right)^2 - \gamma_{ss}^2\right)\right], \tag{30}$$

$$(\widehat{c}_t - \psi l_t^v)^{-\sigma}\left[1 + \chi\left(\frac{\widehat{b}_t}{\widehat{y}_t} - \overline{b}\right)\right] = \beta R_t \gamma_t^{-\sigma} E_t(\widehat{c}_{t+1} - \psi l_{t+1}^v)^{-\sigma}, \tag{31}$$

$$\widehat{c}_t + \gamma_t \widehat{k}_t - (1-\delta)\widehat{k}_{t-1} + \frac{\varphi}{2}\widehat{k}_{t-1}\left(\frac{\gamma_t \widehat{k}_t}{\widehat{k}_{t-1}} - \gamma_{ss}\right)^2 + \ldots$$

$$\gamma_t \widehat{b}_t + \frac{\chi}{2}\widehat{y}_t\left(\frac{\widehat{b}_t}{\widehat{y}_t} - \overline{b}\right)^2 = \widehat{w}_t l_t + r_t \widehat{k}_{t-1} + R_{t-1}\widehat{b}_{t-1}. \tag{32}$$

From firms:

$$\widehat{y}_t = z_t \widehat{k}_{t-1}^{\alpha} \left[\gamma_t l_t\right]^{1-\alpha}, \tag{33}$$

$$z_t \alpha \widehat{k}_{t-1}^{\alpha-1} (\gamma_t l_t)^{1-\alpha} = r_t, \tag{34}$$

$$z_t (1-\alpha) \widehat{k}_t^{\alpha} \gamma_t^{1-\alpha} l_t^{-\alpha} = \widehat{w}_t \left[1 + (R_{t-1} - 1)\,\theta\right], \tag{35}$$

$\widehat{k}_{t-1} \equiv k_{t-1}/\Gamma_{t-1}$, $\widehat{b}_{t-1} \equiv b_{t-1}/\Gamma_{t-1}$, $\widehat{w}_t \equiv w_t/\Gamma_{t-1}$, and $\widehat{y}_t \equiv y_t/\Gamma_{t-1}$.

We use the Schul decomposition to compute linear decision rules [13]. The balanced growth path equilibrium characterizes the long-run features of the economy in which the variables output, y_t, consumption, c_t, stock of physical capital, k_t, stock of foreign bonds, b_t, and the wage rate, w_t, grow at an exogenous rate, γ_{ss}, and the variables foreign interest rate, R_t, physical capital return, r_t, and labor, l_t, remain constant. Once the policy functions are obtained, the aggregate variables are recovered, with the same length as is the data, and they are filtered (using the BP filter).

4 Model solution

This section sets out the parameters used in the model and analyzes the quantitative implications of the model. Firstly, we obtain the conditions to be satisfied along the balanced growth path equilibrium. Secondly, we describe the calibration procedure for some of the parameter values. Thirdly,

[13]We base on Sims´(2001) model that was further developed by Klein (2000). The MATLAB code for computing the equilibria is based on the one developed by Oviedo (2005a) and Schmitt-Grohe and Uribe (2004). The MATLAB code for computing solutions in this paper is available from the authors upon request.

we describe the processes for the technology and interest rates. Finally, we report the moments generated by the model and compare them with the data.

4.1 *Balanced Growth Path*

As mentioned above, output, y_t, consumption, c_t, the stock of physical capital, k_t, the stock of foreign bonds, b_t, and the wage rate, w_t, grow at an exogenous rate on the balanced growth path equilibrium, γ_{ss}, and the foreign interest rate, R_t, physical capital return, r_t, and labor, l_t, remain constant.

On the balanced growth path equilibrium, the following conditions hold:

$$\psi v l_{ss}^{(v-1)} = \widehat{w}_{ss}, \tag{36}$$

$$1 = \beta \gamma_{ss}^{-\sigma}(1-\delta+r), \tag{37}$$

$$1 = \beta R_{ss} \gamma_{ss}^{-\sigma}, \tag{38}$$

$$\widehat{c}_{ss} + [\gamma_{ss} - (1-\delta)]\widehat{k}_{ss} + \gamma_{ss}\widehat{b}_{ss} = \widehat{w}_{ss} l_{ss} + r\widehat{k}_{ss} + R_{ss}\widehat{b}_{ss}, \tag{39}$$

$$\widehat{y}_{ss} = \widehat{k}_{ss}^{\alpha} \left[\gamma_{ss} l_{ss}\right]^{1-\alpha}, \tag{40}$$

$$\alpha \widehat{k}_{ss}^{\alpha-1}(\gamma_{ss} l_{ss})^{1-\alpha} = r_{ss}, \quad \text{and} \tag{41}$$

$$(1-\alpha)\widehat{k}_{ss}^{\alpha}\gamma_{ss}^{1-\alpha} l_{ss}^{-\alpha} = \widehat{w}_{ss}\left[1 + (R_{ss}-1)\,\theta\right], \tag{42}$$

from which we obtain the balanced growth path values for $\widehat{w}_{ss}, l_{ss}, \widehat{k}_{ss}, r_{ss}, \widehat{c}_{ss}, \widehat{y}_{ss}$ taking into account that $z_{ss} = 1$[14].

[14] As it is standard in small open economies, the balanced growth path for $\widehat{b}_{ss}$ is not uniquely determined. This is because the condition (38) only gives the relationship between the parameters β and γ_{ss}, and the deterministic value for the Hong Kong interest rate R_{ss}, which is determined outside the model.

4.1.1 *Parameter values*

Some numbers need to be given to the parameters of the model in order to obtain numerical solutions. Some of the model parameters will be calibrated and some others will be set ad-hoc and not calibrated. The calibration exercise assigns values to the model's parameters so that the deterministic balanced growth path equilibrium matches key averages from quarterly Hong Kong data. We will use data for Hong Kong for the 1982Q1-2004Q4 period. We assume that a time period in our model corresponds to one quarter. Parameter values are presented in Table 3.

Insert Table 3 around here.

First of all, the following condition on the parameters has to be satisfied $\beta\gamma_{ss}^{1-\sigma} < 1$ in order to guarantee that the utility function is well defined. This is the same condition that is obtained from the Transversality Condition (12).

The parameters that have been calibrated to mimic the balanced growth path equilibrium of the Hong Kong economy are: the exogenous growth rate γ_{ss}, the labor weight ψ and the depreciation rate δ. And the parameter calibrated to match some volatilities is the adjustment cost to capital φ. In particular, the parameter γ_{ss} has be chosen such that it matches the average growth rate of the real output in Hong Kong between 1982Q1 and 2004Q4. The observed average growth rate of the real GDP in Hong Kong in the 1982Q1-2004Q4 period is 1.3%. Therefore, $\gamma_{ss} = 1.013$.

We assume a value for the discount factor $\beta = 0.987$, not too far from the more standard value in Real Business Cycles (Aguiar and Gopinath , 2007a), $\beta = 0.98$, and consistent with a not too high depreciation rate for the stock of capital. We set the utility curvature $\sigma = 2$ following Aguiar and Gopinath (2007a).

The calibration of the parameter δ, that represents the constant depreciation rate of physical capital, is chosen such that the ratio of investment over GDP in the balanced growth path equilibrium matches the data. In particular, we have that,

$$\frac{\widehat{i}_{ss}}{\widehat{y}_{ss}} = (\gamma_{ss} - 1 + \delta)\frac{\widehat{k}_{ss}}{\widehat{y}_{ss}} = 0.27.$$

Likewise, we have that, $\widehat{k}_{ss}/\widehat{y}_{ss} = \alpha/r_{ss}$ and that, from conditions (37) and (38), we know that, $r_{ss} = R_{ss} - 1 + \delta$. On the other hand, we have that from the condition (38),$1 = \beta R_{ss}\gamma_{ss}^{-\sigma}$. Therefore, $R_{ss} = \gamma_{ss}^{\sigma}/\beta$. In consequence,

$$(\gamma_{ss} - 1 + \delta)\frac{\alpha}{\frac{\gamma_{ss}^{\sigma}}{\beta} - 1 + \delta} = 0.27$$

On the other hand, we have to take into account that:

$$Labor\ share = \frac{1-\alpha}{\left[1 + \theta\left(\frac{\gamma_{ss}^{\sigma}}{\beta} - 1\right)\right]}$$

If there is no working capital requirement, $\theta = 0$, and assuming that the labor income share in total income is 0.6, then the capital exponent is $\alpha = 0.4$ and the quarterly constant depreciation rate is $\delta = 0.042$. Nevertheless, if there is a working capital requirement where all labor is paid in advance, $\theta = 1$, then the capital exponent is $\alpha = 0.376$ (it is lower because part of the income is used to pay the interest for the foreign borrowing) and the quarterly constant depreciation rate $\delta = 0.054$.

The parameter ψ has been chosen such that the average hours worked, per working-age population, for the period analyzed (1982-2004) is 28.3% ($l_{ss} = 0.283$). From the condition (36), we have that,

$$\psi = \frac{\widehat{w}_{ss}^{(1-\nu)} l_{ss}}{\nu},$$

where, we set the parameter ν to 1.6 following Neumeyer and Perri (2005)[15].

On the other hand, from the equation (41), we have that,

$$\frac{\widehat{k}}{l_{ss}} = \left(\frac{\alpha}{r}\right)^{1/(1-\alpha)} \gamma_{ss},$$

and from equation (42), we have that,

$$\widehat{w}_{ss} = \frac{(1-\alpha)\left(\frac{\widehat{k}}{l_{ss}}\right)^{\alpha} \gamma_{ss}^{1-\alpha}}{\left[1+\theta\left(\frac{\gamma_{ss}^{\sigma}}{\beta}-1\right)\right]} = \frac{(1-\alpha)\left(\frac{\alpha}{r}\right)^{\alpha/(1-\alpha)} \gamma_{ss}}{\left[1+\theta\left(\frac{\gamma_{ss}^{\sigma}}{\beta}-1\right)\right]}.$$

Consequently, we obtain that,

$$\frac{\psi\nu}{l_{ss}^{(1-\nu)}} = \frac{(1-\alpha)\left(\frac{\alpha}{\frac{\gamma_{ss}^{\sigma}}{\beta}-1+\delta}\right)^{\alpha/(1-\alpha)} \gamma_{ss}}{\left[1+\theta\left(\frac{\gamma_{ss}^{\sigma}}{\beta}-1\right)\right]}.$$

Substituting $l_{ss} = 0.283$, and taking into account the rest of parameters previously obtained, we obtain a value for ψ equal to 2.3282 if $\theta = 0$ and a value for ψ equal to 1.863 if $\theta = 1$.

[15] It is set in between 1.5 and 1.7 by different authors: Neumeyer and Perri (2005) set as 1.6, Mendoza (1991) as 1.5 and Correia et al. (1995) as 1.7.

The parameter of the adjustment cost to capital φ is chosen to replicate the relative volatility of investment to GDP ($= 3.4$).

The value for $\bar{b}$ from the bond holding cost function has been chosen such that the consumption-GDP ratio is close to the observed one[16]. The parameter of the adjustment cost to holding bonds χ is the same as in Schmitt-Grohe and Uribe (2003), and guarantees that the foreign bonds do not explode ($\chi = 10^{-3}$).

4.1.2 *Dynamics of Interest rates and Productivity*

With regard to the law of motion of the shock processes for the interest rates (domestic and international), they have been taken as exogenous processes determined outside the model. And, with regard to the two components of the total factor productivity (the transitory and the permanent components) their persistence has been taken outside the model, and their respective volatility have been calibrated.

As mentioned above, we decompose the Hong Kong real interest rate into two components: the world real interest rate R_t^*, and the Hong Kong risk spread D. Following Neumeyer and Perri (2005), we have estimated equations (27) and (28) by OLS, obtaining their respective persistence parameters: $\rho_{R*} = 0.903405$ and $\rho_D = 0.897795$. The volatility of the world real interest rate is 0.21% and the volatility of the Hong Kong interest rate is 0.68%.

With respect to productivity, we have calibrated the parameters σ_{ϵ_z}, and σ_{ϵ_γ}. Regarding the standard deviation of the innovation to these two compo-

[16] Our business cycles properties are robust to changes to $\bar{b}$.

nents of the TFP, we have calibrated σ_{ϵ_z} in order to replicate the standard deviation of the output and σ_{ϵ_γ} in order to replicate the volatility of the growth rate of output. We find that, in order to mimic these two moments, σ_{ϵ_γ} has to be much higher than σ_{ϵ_z}, 1.56 times higher if $\theta = 0$ and 1.86 times higher if $\theta = 1$. As for the parameter ρ_z, a standard value in the literature, 0.95, has been chosen. Finally, we have used the smallest positive value for the parameter ρ_γ, in order to be as close as possible to the observed autocorrelation for the growth of unfiltered output. However, we have not been able to capture a zero autocorrelation for the growth of unfiltered output as is noted.

The processes and the value of the parameters are shown in Table 4.

Insert Table 4 around here.

5 Results: Model Performance

In this section, we try to match the unconditional moments from the data to the moments obtained with the model under two scenarios. The first one does not consider the presence of working capital ($\theta = 0$). The other one takes into account the working capital requirements. We assume that 100% of the labor cost is paid in advance ($\theta = 1$). In both scenarios we calibrate the parameters σ_{ϵ_z}, σ_{ϵ_γ} and φ in order to replicate the output volatility, the volatility of the output growth and the relative volatility of investment to output observed in the data. Table 5 compares some unconditional moments from the data and those implied by the model with and without the presence of working capital.

Insert Table 5 around here.

As can be seen, the results in terms of the correlation of the interest rates with output, it is too low if the assumption of working capital is not considered, and quite close to the observed one when the working capital requirements are included. This is because by reducing the presence of working capital, the negative impact that the interest rates have on labor demand is reduced[17]. In terms of the rest of the moments, both models show similar results. The model overestimates the relative volatility of consumption (12% if $\theta = 0$ and 20% if $\theta = 1$)[18], net exports are much less countercyclical than in the data (-0.01 if $\theta = 0$ and 0.04 if $\theta = 1$, compared to -0.33 in the data), and the correlation of investment and output is too low (0.35 if $\theta = 0$ and 0.44 if $\theta = 1$, compared to 0.87 in the data). All in all, because the model with the assumption of working capital fits the correlation of interest rates with output better (-0.12 if $\theta = 0$ and -0.31 if $\theta = 1$, compared to -0.32 in the data), we take this model as the benchmark model and we compute three different experiments in order to assess the role of the productivity shocks and the interest rate shocks: *i)* First, we consider a model economy without permanent productivity shocks, *ii)* then, we consider a model economy without international interest rate shocks and *iii)* finally, we consider a model economy with no country risk premium shock.

[17]Unlike Neumeyer and Perri (2005), we do not perform the analysis under the hypothesis that the country spread depends on domestic shocks. We only consider the case in which it is assumed that the country spread is driven by exogenous factors, since this case captures quite well the correlation between the Hong Kong interest rate and its GDP.

[18]The assumption of Cobb-Douglas preferences does not change significantly this result.

5.1 *Relevance of permanent versus transitory components of the Total Factor Productivity*

In Table 6 we show the business cycle characteristics if the permanent shock to the TFP is not considered. As already mentioned, the permanent shock of the TFP has to be higher than the transitory component in order to mimic the observed volatilities of the GDP and of the growth of the GDP. If we calibrate the value for σ_{ϵ_z} in order to mimic the volatility of the GDP, and we do not consider the permanent component of the shock to the TFP, then the volatility of the growth of the GDP is only 50% of its observed value (2.24% instead of 4.76%). Therefore, as in emerging economies, in order to explain the high output growth volatility in the Hong Kong economy, we need to include a stochastic trend. Furthermore, if the stochastic trend is not included, the results are quite bad for the volatility of consumption growth and for the volatility of investment growth rate . And, as expected, we obtain a lower volatility of consumption relative to GDP. The results for the rest of the statistics are very similar.

Insert Table 6 near here.

5.2 *Relevance of the interest rate shocks*

In this subsection, we analyze the business cycle characteristics when only the shock to the international interest rate, R^*, is considered, and when only the shock to country risk premium is considered. Table 7 shows the results under these two scenarios. As expected, the correlation between the interest rate and the output is more negative when only the shock to country risk premium is considered. We obtain a correlation between the interest rate and output of -0.29 when no international interst rate shocks are included, and a correlation of -0.23 when no country spread shocks are included, compared to a negative correlation of -0.32 in the data. If no risk premium is considered, the volatility of the interest rate is practically equal to its observed volatility (0.63 compared to 0.68 in the data). If no international interest rate shock is considered, the volatility of the interest rate is only 0.37% of its observed volatility.

Without international interest rate shocks, the correlation between the trade balance to output and output is higher than in the benchmark case, but the correlation between the trade balance to output ratio and the interest rate is closer to data if no country spread shock is included. The results for the rest of the statistics is very similar.

Therefore, as in emerging economies, the country spread is the component that best explains the volatility and countercyclical behavior of the real interest rate in Hong Kong.

Insert Table 7 near here.

6 Concluding Remarks

This paper analyzes the business cycle properties of the Hong Kong economy during the 1982Q1-2004Q4 period, which includes the financial crisis suffered in Hong Kong in 1997-98. We show that the volatility of the output, of the growth rate of output and of real interest rates in Hong Kong are higher than their respective average volatilities among developed economies. These characteristics are obtained even when the financial crisis and post-financial crisis period is excluded from the analysis.

We build a stochastic neoclassical small open economy model that seeks to replicate the main business cycle characteristics of Hong Kong, and through which we try to quantify the role played by exogenous TFP (transitory and permanent) shocks and two components of the real interest rates (international and country risk spread shocks) in the business cycles characteristics of the Hong Kong economy.

We work on a description of the economy based on Neumeyer and Perri (2005) model and on Aguiar and Gopinath (2007a) model. We find, firstly, that, in order to replicate the high volatility of the growth of the Hong Kong GDP, the volatility of the trend has to be higher than the volatility of the transitory fluctuations around the trend. Furthermore, the model with permanents shocks to TFP better captures some other second moments (volatility of consumption growth and volatility of investment growth), without making worse in the rest of the statistics. Secondly, that the country risk premium is the component that explains the high volatility of the Hong Kong interest rates and, hence, is the responsible for the fact that interest rates in Hong Kong are countercyclical. Thirdly, that both working capital requirements are also relevant to explain the countercyclicality of the intenrest rates.

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Table 1: Business Cycles in Hong Kong and in several emerging and developed economies

	σ_Y	$\sigma_{\Delta Y}$	σ_C/σ_Y	σ_I/σ_Y	$\sigma_{NX/Y}$	$\rho_{C,Y}$	$\rho_{I,Y}$	$\rho_{NX/Y,Y}$
Hong Kong	2.89	4.76	0.84	3.40	2.15	0.79	0.87	-0.33
Average Emerging	2.02	1.87	1.32	3.96	2.09	0.74	0.87	-0.58
Korea	2.57	1.71	1.23	2.45	2.48	0.89	0.84	-0.70
Philippines	2.58	1.66	0.51	4.47	2.21	0.62	0.86	-0.60
Thailand	5.56	2.25	1.25	3.65	6.25	0.98	0.99	-0.95
Average Developed	1.04	0.95	0.94	3.42	0.71	0.69	0.75	-0.26
Netherlands	1.01	0.88	1	2.38	0.52	0.73	0.77	-0.29
Norway	1.18	1.46	1.57	4.24	1.45	0.77	0.14	-0.08
Sweden	1.22	1.45	1.05	4.46	0.71	0.13	0.79	0.01

Note: Data for average emerging and average developed economies comes from Aguiar and Gopinath (2004). All series are logged and filtered using BP filter, except Net exports. Series for Hong Kong, Korea, Philippines, Thailand, Netherlands, Norway and Sweden are filtered at frequencies between 6 and 32 with 12 leads and lags, except first differences in output. Statistics are based on quarterly data for the 1982Q1-2004Q4 period. Standard deviations (volatilities) are in percentages.

Table 2: Interest rates. Volatility and correlations

	Hong Kong 1	Hong Kong 2	Korea	Philippines	Netherlands	Sweden
σ_R	0.68	0.57	0.26	0.17	0.19	0.39
σ_R/σ_Y	0.24	0.21				
σ_D	0.58	0.56				
$\rho_{Y,R}$	-0.32	-0.39	-0.98	-0.57	0.33	-0.11
$\rho_{Y,USR}$	-0.15	-0.05				
$\rho_{Y,D}$	-0.32	-0.39				
$\rho_{C,R}$	-0.22	-0.10	-0.98	-0.64	0.55	-0.25
$\rho_{I,R}$	-0.11	-0.01	-0.93	-0.50	0.50	0.003
$\rho_{NX/Y,R}$	-0.13	-0.50	0.96	0.39	-0.48	-0.35

Note: All series are logged and BP filtered, except net exports and interest rates. *Hong Kong 1* denotes that all statistics have been calculated using Hong Kong data for the period 1982Q1-2004Q4, and *Hong Kong 2* that they have been calculated for the period 1982Q1-1997Q4, which is the period before the Asian financial crisis. Standard deviations (volatilities) are in percentages. The volatility of the U.S. interest rate in the period 1982Q1-2004Q4 is 0.21 and in the period before the Asian financial crisis is 0.19. USR denotes the U.S. interest rate, and D denotes the country spread.

Table 3: Parameter values

Parameter Name	Sign	Value
Preference parameters		
Discount factor	β	0.987
Utility curvature	σ	2
Labor curvature	υ	1.6
Labor weight	ψ	2.3282 (θ= 0)
Labor weight	ψ	1.863 (θ= 1)
Technology parameters		
Technological progress growth	γ	1.3
a) *No Working Capital*	θ	0.0
Depreciation rate	δ	4.2
Capital exponent (production)	α	0.4
Adjust. cost (capital)	φ	9.12
Adjust. cost (bonds)	χ	10^{-3}
b) *Working Capital*	θ	1.0
Depreciation rate	δ	5.4
Capital exponent (production)	α	0.376
Adjust. cost (capital)	φ	1.61
Adjust. cost (bonds)	χ	10^{-3}

Note: The capital adjustment cost varies in the computed Experiments.

Table 4: Interest rates and productivity

Process	Parameter	Value
$\widehat{R}^*_t = \rho_{R^*}\widehat{R}^*_{t-1} + \epsilon_{R^*,t}$	ρ_{R^*}	0.903405
	$\sigma_{\epsilon_{R^*}}$	0.21%
$\widehat{D}_t = \rho_D \widehat{D}_{t-1} + \epsilon_{D,t}$	ρ_D	0.897795
	σ_{ϵ_D}	0.55%
$\widehat{z}_t = \rho_z \widehat{z}_{t-1} + \epsilon_{z,t}$	ρ_z	0.95
	σ_{ϵ_z}	σ_y
$\widehat{\gamma}_t = \rho_\gamma \widehat{\gamma}_{t-1} + \epsilon_{\gamma,t}$	ρ_γ	10^{-9}
	σ_{ϵ_γ}	$\sigma_{\Delta y}$

Table 5: Results. Data and Model with and without Working capital

		$\theta = 0$	$\theta = 1$	Data
a) Standard deviations				
Output	σ_y	2.89	2.89	2.89
Output growth	$\sigma_{\Delta y}$	4.76	4.76	4.76
Consumption	σ_c/σ_y	0.94	1.00	0.84
Investment	σ_I/σ_y	3.40	3.40	3.40
Interest rate	σ_R	0.68	0.68	0.68
Consumption growth	$\sigma_{\Delta c}$	4.28	4.25	3.98
Investment growth	$\sigma_{\Delta I}$	9.36	9.40	11.87
b) Cross-correlations with Output				
Consumption	$\rho_{c,y}$	0.87	0.86	0.79
Investment	$\rho_{i,y}$	0.35	0.44	0.87
Trade Balance	$\rho_{tb/y,y}$	-0.01	0.04	-0.33
Interest Rate	$\rho_{R,y}$	-0.13	-0.31	-0.32
c) Cross-correlations with Interest rates				
Consumption	$\rho_{c,R}$	-0.43	-0.61	-0.22
Investment	$\rho_{i,R}$	-0.81	-0.82	-0.11
Trade Balance	$\rho_{tb/y,R}$	0.36	0.58	-0.13
d) Cross-correlations with Output growth				
Consumption growth	$\rho_{\Delta c,\Delta y}$	0.96	0.96	0.41
Investment growth	$\rho_{\Delta i,\Delta y}$	0.45	0.42	0.14
Trade Balance	$\rho_{tb/y,\Delta y}$	-0.02	-0.09	-0.08
e) Cross-correlations with Trade Balance				
Consumption growth	$\rho_{\Delta c,tb/y}$	-0.01	-0.12	-0.04
Investment growth	$\rho_{\Delta i,tb/y}$	-0.01	-0.20	-0.05

Note: All moments are calculated from the model using parameters reported in Tables 5 and 6. The values for the parameters σ_{ϵ_z}, σ_{ϵ_γ} and φ are equal to 1.11645%, 1.74045% and 7.2799, respectively, if $\theta = 0$, and are equal to 0.922%, 1.7176725% and 5.68687532, respectively, if $\theta = 1$. To compute the correlation of tb/y with output growth, or with consumption growth or with investment growth, since tb/y is BP filtered, and eliminated the first and last K values, the same is done with the unfiltered otuput growth, consumption growth and investment growth.

Table 6: Results. No Permanent Shock

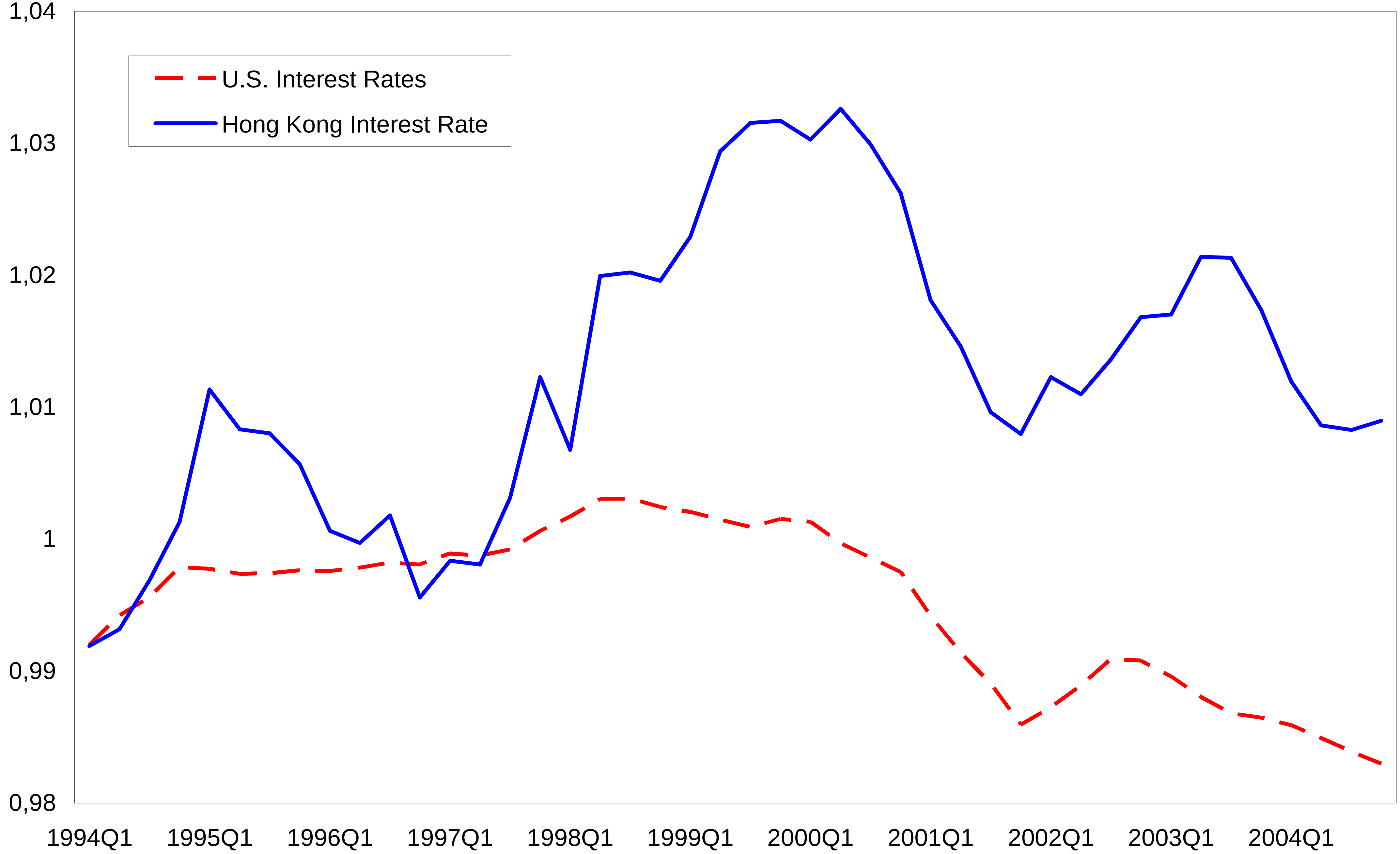
		No Permanent shock	Benchmark Model	Data
a) Standard deviations				
Output	σ_y	2.89	2.89	2.89
Output growth	$\sigma_{\Delta y}$	2.23	4.76	4.76
Consumption	σ_c/σ_y	0.95	1.00	0.84
Investment	σ_I/σ_y	3.40	3.40	3.40
Interest rate	σ_R	0.68	0.68	0.68
Consumption growth	$\sigma_{\Delta c}$	2.08	4.25	3.98
Investment growth	$\sigma_{\Delta I}$	8.83	9.40	11.87
b) Cross-correlations with Output				
Consumption	$\rho_{c,y}$	0.85	0.86	0.79
Investment	$\rho_{i,y}$	0.46	0.44	0.87
Trade Balance	$\rho_{tb/y,y}$	0.07	0.04	-0.33
Interest Rate	$\rho_{R,y}$	-0.29	-0.31	-0.32
c) Cross-correlations with Interest rates				
Consumption	$\rho_{c,R}$	-0.64	-0.61	-0.22
Investment	$\rho_{i,R}$	-0.81	-0.82	-0.11
Trade Balance	$\rho_{tb/y,R}$	0.56	0.58	-0.13
d) Cross-correlations with Output growth				
Consumption growth	$\rho_{\Delta c,\Delta y}$	0.84	0.96	0.41
Investment growth	$\rho_{\Delta I,\Delta y}$	0.28	0.42	0.14
Trade Balance	$\rho_{tb/y,\Delta y}$	-0.22	-0.09	0.08
e) Cross-correlations with Trade Balance				
Consumption growth	$\rho_{\Delta c,tb/y}$	-0.29	-0.12	-0.04
Investment growth	$\rho_{\Delta I,tb/y}$	-0.23	-0.20	-0.05

Note: All moments are calculated from the model using parameters reported in Tables 5 and 6. The values for the parameters σ_{ϵ_z}, σ_{ϵ_γ} and φ are equal to 0.922%, 1.7176725% and 5.68687532, respectively, if there is permanent shock, and are equal to 1.2714725%, 0.0% and 5.77846673, respectively, if there is not permanent shock. To compute the correlation of tb/y with output growth, or with consumption growth or with investment growth, since tb/y is BP filtered, and eliminated the first and last K values, the same is done with the unfiltered otuput growth, consumption growth and investment growth.

Table 7: Results: No Country Spread Shock, no International Interest rate Shock

		No Country Spread Shock	No International Interest rate Shock	Data
a) Standard deviations				
Output	σ_y	2.89	2.89	2.89
Output growth	$\sigma_{\Delta y}$	4.76	4.76	4.76
Consumption	σ_c/σ_y	0.87	1.01	0.84
Investment	σ_I/σ_y	3.40	3.40	3.40
Interest rate	σ_R	0.25	0.63	0.68
b) Cross-correlations with Output				
Consumption	$\rho_{c,y}$	0.96	0.86	0.79
Investment	$\rho_{i,y}$	0.58	0.44	0.87
Trade Balance	$\rho_{tb/y,y}$	0.09	0.12	-0.33
Interest Rate	$\rho_{R,y}$	-0.23	-0.29	-0.32
c) Cross-correlations with Interest rates				
Consumption	$\rho_{c,R}$	-0.35	-0.61	-0.22
Investment	$\rho_{i,R}$	-0.62	-0.83	-0.11
Trade Balance	$\rho_{tb/y,R}$	0.16	0.27	-0.13
d) Cross-correlations with Output growth				
Consumption growth	$\rho_{\Delta c,\Delta y}$	0.99	0.96	0.41
Investment growth	$\rho_{\Delta i,\Delta y}$	0.61	0.42	0.14
Trade Balance	$\rho_{tb/y,\Delta y}$	-0.06	-0.05	0.07
e) Cross-correlations with Trade Balance				
Consumption growth	$\rho_{\Delta c,tb/y}$	-0.07	-0.09	0.03
Investment growth	$\rho_{\Delta i,tb/y}$	-0.18	-0.18	-0.05

Note: All moments are calculated from the model using parameters reported in Tables 5 and 6. The values for the parameters σ_{ϵ_z}, σ_{ϵ_γ} and φ are equal to 0.93%, 1.74% and 2.04, respectively, if there is no country spread shock, and are equal to 0.927%, 1.7207015% and 5.782, respectively, if there is not international interest rate shock. To compute the correlation of tb/y with output growth, or with consumption growth or with investment growth, since tb/y is BP filtered, and eliminated the first and last K values, the same is done with the unfiltered otuput growth, consumption growth and investment growth.


U.S. Interest Rates
Hong Kong Interest Rate
1,04
1,03
1,02
1,01
1
0,99
0,98
1994Q1
1995Q1
1996Q1
1997Q1
1998Q1
1999Q1
2000Q1
2001Q1
2002Q1
2003Q1
2004Q1