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ABSTRACT

This paper examines empirically the dynamic process of regional market integration for twelve individual Asian economies by a new modeling approach, which combines DF with ECM. This new approach enables us to obtain latent regional dynamic factors, which correspond well with the 'foreign' parity variables in theory when market is imperfectly integrated and which act, in explaining domestic short-run price adjustments, as leading-indicators in an error-correction form. The power of the DF-ECM approach is illustrated in its application to measuring market integration in the developing Asian region using monthly data of the past decade.

Key words: Law of one price, market integration, dynamic factor, error-correction model

JEL: F31, F40, F15, C22, C33

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1. Introduction

The world economy of the present decade is marked by acceleration of global and regional economic integration. The accelerating trend has been fostering research in how to measure and assess the dynamic process of the integration.

As economic integration is a multi-facet and evolving phenomenon, empirical studies of the issue vary in the indices examined and the methods employed.[1] However, the 'Law of One Price' (LOP) is widely recognized as the essential principle of economic integration. Arbitrage between different markets forms the basic drive for market integration and price convergence tend to result in efficiency gain in the integrated market. How to represent and measure the process of price convergence becomes the prerequisite of any serious assessments of the impacts of integration. For example, it relates to the assessment of international spill-over and transmission channels caused by cross market/country interdependence, e.g. see (Ehrmann *et al*, 2005) and the improvement of macroeconomic forecasts through the use of market integration information, e.g. see (Giacomini and Granger, 2004).

Empirical studies of price convergence focus broadly on two major markets: goods market and financial/capital market. For the goods market, rigorous studies are carried out mostly at the micro level, e.g. see (González-Rivera and Helfand, 2001), (Barrett, 2001), (Barrett and Li, 2002) on market integration via agricultural commodity prices and (Crucini *et al*, 2005) on LOP of retail goods in EU countries. Two key difficulties apparently have hampered macro investigation in this area. One is the lack of rigorous justification for comparing aggregate price indices which are based on heterogeneous products, only part of which is internationally tradable; the other is the paucity of strong empirical verification of the purchasing power parity (PPP) hypothesis, which is intimately linked with the LOP, see (Brahmbhatt, 1998). Nonetheless, a consensus has

[1] A general survey is provided by Brahmbhatt (1998); (Adam *et al*, 2002) and (Carey, 2004) contain surveys for financial market integration.

emerged from a considerable body of empirical work on PPP that the validity of PPP should essentially rest on the long-run reversion of the real exchange rate to a stable equilibrium level, i.e. the deviation from PPP must be weakly stationary in an open and free economy, e.g. see (Taylor and Taylor, 2004) and (Sarno, 2005).

In comparison, empirical studies on capital/financial market integration have been mounting, partly because of the relatively homogeneous products here and partly because of abundantly available data in relatively high frequency, e.g. see (Carey, 2004). Various methods have been experimented in this area. For example, Adam *et al* (2002) adopt popular indicators from cross-country growth regressions of the economic growth literature, such as β-convergence and σ-convergence; Kleimeier and Sander (2000) investigate financial market integration by means of cointegration analysis, see also (Sander and Kleimeier, 2004); Flood and Rose (2005) propose to base the measure of financial market integration upon an inter-temporal asset-pricing model.

The present investigation aims at assessing empirically the dynamics of economic integration in the region of developing Asia. Our focus is to identify and measure how prices of individual economies converge to regional common trends in both the goods market and the capital market from a broad macro perspective. We develop a very pragmatic approach. Given the objective, convergence for the goods market is expected to be embodied in the verification of the PPP-based real exchange rate hypothesis. As for the capital market convergence, it is expected to be reflected through the interest rate parity (IP) condition. In the case where goods and capital markets are fully integrated, the real interest rate parity (RIP) is expected to hold. Hence, we shall focus our investigation upon the dynamic co-movement of these three sets of price parities for each Asian economy within the region.

The above purposes necessitate the use of a time-series based approach. The cross-country growth regression approach is opted out as it is found to be inadequate in representing the dynamics of convergence, e.g. see (Swaine, 1998). Instead, we propose a dynamic-factor error-correction model (DF-ECM) approach by merging the method of dynamic factor analysis (DFA) with the practically convenient ECM, which is also intimately related to the popularly used cointegration analysis in the subject field. Here, DFA provides us with a powerful tool of summarizing common movements in regional prices while filtering out country-specific idiosyncratic shocks. It thus facilitates the bridging of the gap between the concept of a 'foreign' entity, which acts as a single 'numéraire' in most of the theoretical models of international economics, and country-level data, which are generated from an imperfect world market where a particular home country faces different price disparities with different foreign economies.

The rest of the paper is organized as follows. The next section presents the DF-ECM approach. Section 3 applies the approach to analyzing the dynamics of price convergence of twelve Asian economies. Section 4 concludes.

2. Method of Investigation: The DF-ECM Approach

2.1 Basic Theories

From a highly macro perspective, the LOP can be characterized by the PPP hypothesis in the goods market:

$$(1) \qquad e_d = \frac{p_f}{p_d} \qquad \text{(PPP)}$$

where p_d denotes the aggregate price level of the domestic economy, p_f denotes the corresponding price level of the foreign economy of comparison and e_d is the exchange rate between the two.

The LOP in the capital market can be characterized by the IP hypothesis:

$$(2) \qquad \begin{aligned} (1+i_d) &= (1+i_f)(1+E[\dot{e}_d]) \\ i_d &\approx i_f + \left(\ln\left(e_d^{\varphi}\right) - \ln(e_d)\right) \end{aligned} \qquad \text{(IP)}$$

where i_d and i_f denote the interest rates of the corresponding two economies respectively, $E[\dot{e}_d]$ denotes expected change in the exchange rate and e_d^{φ} denotes forward exchange rate (this is also known as the 'covered' IP).

The RIP hypothesis should hold if goods market and financial market are integrated. This happens if the exchange rate is fully determined by the PPP. In other words, we could substitute (1) into (2) and obtain an identity between real interest rates, ri_d and ri_f:

$$(3) \qquad \begin{gathered} i_d - E[\Delta \ln(p_d)] = i_f - E[\Delta \ln(p_f)] \\ ri_d = ri_f \end{gathered} \qquad \text{(RIP)}$$

2.2 Basic theories as long-run equilibrating conditions

We adopt the common practice of regarding basic theories as long-run equilibrating conditions in the context of dynamic econometrics. From this perspective, the above theories are postulated as long-run equilibrium relations, empirically embodied in the co-trend movement between the prices concerned. The short-run fluctuations of the domestic prices are expected to regularly correct past deviations or disequilibrium from the long-run relations if the hypothetical equilibrium holds. The correction reflects price convergence and hence can serve as a key dynamic measure of market integration. The most convenient and practical representation of the correction mechanism is the ECM, see (Hendry, 1995) and (Juselius, 2006). A general bivariate ECM between the domestic and foreign variables, x_d and x_f, can be written as:

$$(4) \qquad \Delta x_{d,t} = \alpha(L)\Delta x_{d,_{t-1}} + \beta(L)\Delta x_{f,t} + \phi\underbrace{(x_d - \kappa x_f)_{t-1}}_{ec} + v_t$$

where Δ denotes difference, $\alpha(L)$ and $\beta(L)$ are finite-order lag polynomials, κ is the long-run parameter and $\phi < 0$ is expected of this feedback parameter if price convergence embodied by the '*ec*' term actually functions. When both variables are nonstationary, as are normally expected of most economic time-series variables, they are expected to be cointegrated with respect to κ. An important as well as attractive feature of (4) is that the model operates within a stationary domain where the *ec* term will be squeezed out of significance if it is nonstationary[2] and where all the regressors are structurally interpretable stationary shocks without much collinearity between one another, see e.g. (Qin and Gilbert, 2001). Moreover, the *ec* term can be regarded as a leading indicator of the short-run $\Delta x_{d,t}$. Simple cointegration analysis between nonstationary variables is inadequate without the support of such an error-correction process, see (Johansen, 2006).

With respect to (4), the three hypotheses (1)-(3) define three disequilibrium processes:

(1)' $$ec(PPP) = \ln p_d - \ln\left(p_f \big/ e_d \right)$$

(2)' $$ec(IP) = i_d - \left[i_f + E(\dot{e}) \right]$$

(3)' $$ec(RIP) = ri_d - ri_f$$

where the long-run parameter, κ, happens to be equal to unity in every case.[3]

2.3 Dynamic Factor Representation of Long-run and Short-run Shocks

In the context of regional market integration, the theoretical concept of the foreign variables, e.g. p_f and i_f, lacks directly observable statistical counterparts. Conventionally, it is common to construct a certain weighted composite goods price index for the goods market and to employ, as the norm foreign rate, the interest rate of an advanced and large economy, say US or Japan. However, there are numerous reasons to question the adequacy of these methods in providing adequate statistical representations of the hypothetical foreign variables in equilibrium.

Here, instead of designating certain observable time series as the foreign variables, we propose to represent the disequilibrium process, $\{ec\}$, in (4) by the latent common factors in

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[2] This makes it unnecessary to conduct unit-root test of the term, hence avoiding the practical difficulty of having low power test results under finite samples.

[3] This long-run parameter assumption is referred to as the 'theory of general relativity' for the PPP case and verified by Coakley *et al* (2005).

dynamic factor models (DFM) of all the price disparities between a domestic economy d vis-a-vis n foreign economies in the region:

$$\begin{aligned} Z_t &= \Gamma^* F_t^* + \varepsilon_t^* \\ F_t^* &= \Lambda^*(L) F_{t-1}^* + u_t^* \end{aligned} \tag{5}$$

since significant correlation among these foreign economies is expected when market integration occurs. In (5), $Z' = (z_1 \cdots z_n)$ is an n-vector of price disparities, i.e. $z_j = x_d - x_j$ with $j = 1, \cdots, n$, $F^{*}{}' = \begin{pmatrix} f_1^* & \cdots & f_m^* \end{pmatrix}$ is an m-vector of the latent common factors with $m<<n$, Γ^* is a parameter matrix and $\Lambda^*(L)$ is a vector of lag polynomial, both are to be estimated, ε^* and u^* are error terms with the former being an n-vector of idiosyncratic shocks of n foreign economies with respect to economy d and the latter an m-vector of common disequilibrium shocks to d. The vector, Z_t, is commonly referred to as the 'indicator set' or the set of 'manifest variables' in factor analysis. For example, it becomes $\left(\ln(p_d) - \ln(p_j e_d)\right)_t$ with respect to (1)', whereas the corresponding F^* represents $ec(PPP)$. Hence, we refer to F^* as the long-run common factors.

In view of (4), another type of common factors is desired, i.e. the common short-run external shocks, Δx_f. Similar to (5), the short-run common factors are derived from:

$$\begin{aligned} \Delta X_t &= \Gamma F_t + \varepsilon_t \\ F_t &= \Lambda(L) F_{t-1} + u_t \end{aligned} \tag{6}$$

where $\Delta X' = (\Delta x_1 \cdots \Delta x_n)$ is an n-vector of short-run shocks from the n foreign economies, e.g. $\Delta x_j = \Delta ri_j$ with $j = 1, \cdots, n$ in the case of RIP, and $F = \begin{pmatrix} f_1 & \cdots & f_l \end{pmatrix}$ is an l-vector of latent common factors of ΔX with $l<<n$. We shall refer to F as the short-run common factors.

Two recently developed statistical tests are utilized to help determine the number of factors. One test is by Bai and Ng (2005) and the other by Onatski (2005). Factor extraction is carried out by the Kalman filter algorithm, with the initial parameter estimates obtained via principal component analysis, see (Camba-Mendez *et al*, 2001) for the technical details.[4]

2.4 The DF-ECM procedure

Once both short-run and long-run common factors are extracted, we proceed to the following ECM for economy *d* using these latent factors as the explanatory variables:

$$\Delta x_{d,t} = \alpha_0 + B(L)' F_t + \Phi' F^*_{t-1} + \omega_t \tag{7}$$

where $B(L) = (\beta_1(L) \ \cdots \ \beta_l(L))$ is a *l*-vector of lag polynomial and $\Phi' = (\phi_1 \ \cdots \ \phi_m)$ is a *m*-vector of negative-feedback parameters. We refer to (7) as a DF-ECM model. Note that this model differs from (4) in two respects. The obvious one is that all the explanatory variables are now latent factors representing the relevant common dynamics of the region. The other is that the part of the short-run impact of the own-lag variable is excluded in order to focus the model on the explanation of the regional price impacts only. The very weak correlation between the regressors of an ECM should facilitate such exclusion, as mentioned above. Since the number of parameters in (7) will run up rapidly when *m* and *l* are not so small, we carry out model simplification search for each price parity of economy *d* by means of PcGets, see (Hendry and Krolzig, 2001). The key advantage of PcGets is that it carries out model reduction by the general → specific approach, see (Hendry, 1995), in a consistent and efficient manner such that the specific model resulted from a general model is guaranteed to be data-coherent and parsimoniously encompassing of the general model. In other words, the resulting specific model has survived all the commonly used diagnostic tests. Therefore, we base our empirical analysis of the dynamics of price convergence upon the specific DF-ECMs reduced by PcGets.

There are several advantages of adopting the DF-ECM approach in the present context. Primarily, the DFM enables us to extract the common movement in the price disparities among a

[4] A recent survey about dynamic factor models can be found in (Stock and Watson, 2005).

fairly large number of economies by filtering out the idiosyncratic part of price disparities of each individual economy. The resulting common factors thus correspond more consistently to the theoretical concept of foreign prices than any statistical constructs which do not filter out the idiosyncratic part.[5] Moreover, the notion of dynamic factors fits naturally with the ECM, as an ECM is essentially a special case of a stationary VAR (vector autoregressive) model expressed in terms of structural shocks, and the DFM has been linked with VAR to render a leading indicator procedure, see (Camba-Mendez *et al*, 2001). Actually, a number of recent papers have endeavoured to explore how to extend structural VARs by common factors, see e.g. (Forni *et al*, 2003), (Bernanke *et al*, 2005) and (Favero *et al*, 2005). The present DF-ECM approach offers an easy and practical solution, as the ECM provides its structural interpretation of the shocks to the latent factors, thus circumventing the well-known problem of factor interpretation.

2.5 Useful Statistical Indicators

A number of statistics and parameter estimates are particularly useful to inform us about the price convergence. Some are from the ECM procedure and the others from the DFA.

The first and foremost is the estimated parameter vector Φ in (7), as empirical verification of price convergence lies with this parameter set being significant and embodying negative feedback mechanism.[6] Note that the signs of these parameters are dependent upon the signs of the relevant parameter estimates in Γ^* of (5), e.g. ϕ_1 for f_1^* is expected to be negative if: $\sum_{i=1}^{n} \gamma_{i1}^* > 0$, $\Gamma^* = \{\gamma_{ij}^*\}_{m,n}$. Since results from sub-sample estimations are also informative of the progress of price convergence, we carry out sub-sample estimation and backward recursive

[5] Some recent papers regard the idiosyncratic part as heterogeneous dynamics in price data, e.g. due to trade costs specific to different countries, and attempt to either capture it by nonlinear dynamic models, e.g. see (Sarno *et al*, 2004) or filter out the heterogeneity by means of panel estimation methods, e.g. see (Imbs *et al*, 2005).

[6] One commonly-used measure of the PPP adjustment speed is 'half-life', see e.g. (Cecchetti *et al*, 2002). However, that measure does not reflect how price adjustment reacts to long-run disequilibrium dynamics as explicitly as the parameters, Φ. It can also be misleading when the price adjustment dynamics is more complex than a simple first-order autoregressive process, see (Chortareas and Kapetanios, 2004).

estimation to study the time-evolving profiles of the estimated Φ.[7] The next set of statistics summarises the model fits based on the reduced ECMs. Two statistics are reported in the paper: the adjusted R^2 and Schwarz information criterion.

Three useful statistics are derived from the DFA process.[8] The first is the communality of each indicator variable, z_j, in (5), which is in effect the correlation coefficient of an indicator variable with respect to its explained part by all the factors.[9] An ordered sequence of all the communalities shows the rank of the proportion of variance in each price disparity, z_j, being explained by the common long-run factors. The mean of all the communalities is also calculated to enable us to compare the states of different price disparities, e.g. PPP versus IP, which are explained by the common factors.

The second statistic is the temporal correlation coefficient, i.e. at time t, between all the indicator variables and their fitted values in a DFM, e.g. $\tau_t^2 = corr^2\left\lfloor Z_t, (\hat{\Gamma}^* \hat{F}^*)_t \right\rfloor$ if based on (5). This statistic exploits the fact that all indicator variables are of the same nature by definition. We refer to this statistic as the covariation coefficient. Its time series is useful for informing us how the panel of bilateral price disparities of an economy vis-a-vis individual foreign economies co-move with the set of the long-run common factors over time.

The third statistic is the pooled redundancy coefficient between the long-run PPP and the long-run IP common factors.[10] This statistic is used as a measure of the cross interaction in the common price disparity dynamics between the goods market and the capital market, or more precisely, as an indicator of which market explains more of the other market in terms of its price

[7] Backward recursive method means to conduct a sequence of estimation from full sample to sub samples by dropping the earliest observations one by one.

[8] See (Tucker and MacCallum, 1997) for detailed discussions about these statistics.

[9] Instead of the commonly used multiple correlation R^2, adjusted R^2 is used here to accommodate the fact that the numbers of factors can vary across different economies.

[10] The pooled coefficient is the sum of the redundancy indices over all the relevant factors, and the redundancy index is defined as the product of squared canonical correlation and the proportion of the variance of the explained factor set contained in its canonical variates, see (Hair *et al*, 1998). These statistics are computed by means of the biplot and singular value decomposition macros for Excel developed by Lipkovich and Smith (2001).

disparity common factor dynamics. To further enhance the information power, this coefficient is calculated for both simultaneous data sets and lagged data sets at a six-month interval to illustrate how the two sets of common factors interact with each other sequentially.

Finally, principal components analysis is applied to the long-run factors of all the economies to help us see how much in common the set of the long-run factors of each individual economy has with those of other economies. Specifically, the proportion of the variance (POV) of all the factors being explained by the first three principal components is chosen as an indicator of the regional commonality, since covariance among the factors within one set, i.e. for one particular economy, is normally expected to be rather low.[11] To filter out the within-set correlation effect, POV is also calculated for five subsets of the long-run factors, each grouped by the within-set factor order. For example, subset one contains the first factors of all the twelve factor sets and subset two contains all the second factors. In order to see the time profile of POV, the full sample is divided into three sub-samples: one prior to the Asian financial crisis, another one for the post-crisis period and the third for the post-2000 period.

3. Application: the Case of Developing Asia

During the past decade, the Asian economy has developed vigorously. Unsurprisingly, literature on the regional economy has been accruing, e.g. see (Aminian, 2005), (Click and Plummer, 2005), (Kawai, 2005), (Plummer and Click, 2005), (Plummer, 2006) and (Rana, 2006).[12]

In the present study, twelve Asian economies are examined: Bangladesh, China, Hong Kong, India, Indonesia, Korea, Malaysia, Pakistan, the Philippines, Singapore, Taiwan, and Thailand. Table 1 gives the aggregate trade shares of these economies. Noticeably, the trade shares have

[11] The choice of the first three principal components is based on the finding that the proportions of variance explained by any subsequent components are smaller than 10%.

[12] To keep the paper short, we skip the literature survey. A useful website is the 'Regional Cooperation and Integration in Asia' at http://www.aric.adb.org/regionalcooperation/index.asp .

remained almost unchanged, making it more intriguing as whether and how much regional integration has been progressing.

In addition to the twelve economies, Nepal, Sri Lanka, Vietnam and Japan are included in the regional variable set. The USA is then added as the representative of the main ex-regional impact, making the number of foreign economies sixteen for each domestic economy, i.e. $n=16$.

3.1 Data Issues

Monthly data series are used for the period of 1994-2005, though a few data series are shorter.[13] For PPP, the general price index of CPI is used. All prices are converted into US dollar comparable prices. Although it is desirable to have an aggregate price index which is closely associated with tradable commodities, e.g. export or import price indices, such data series are not only hard to compile but also problematic for the Asian economies under consideration because the basket of tradable commodities can differ considerably from one economy to another. In comparison, the CPI baskets are more similar across different economies. Moreover, CPI is also a commonly accepted index in the derivation of inflation and hence the real interest rate.

As for interest rates, short-term (three-month or 90-day) inter-bank lending rates are chosen. Covered interest rate parity is calculated whenever forward exchange rate data are available. The expected exchange rate changes are assumed zero otherwise, amounting to the use of uncovered interest rate parity. However, the mixed use of both versions of IP here should not affect our results. Detailed information on the data series is given in the Appendix.[14]

In order to carry out DFA, all the indicator variable series are transformed into zero-mean and unit-variance series. Three-month difference is used in the case of the two interest rate parities and twelve-monthly difference is used in the case of PPP.

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[13] One advantage of the Kalman filter algorithm is that it can handle not only unbalanced panel data but also mixed-frequency data sets.

[14] The choice of data here simply confirms to the convention of the relevant empirical literature, though it is not free of problems. For example, it is well-known that the interest rate data from economies where there lacks well-developed sovereign bond markets may not give an accurate picture of the capital market.

3.2 Empirical Implementation

A summary of the basic modeling procedure is as follows. For each of the three price parity conditions, one set of long-run factors and one set of the corresponding short-run factors are extracted for each of the twelve Asian economies using models (5) and (6) respectively. The indicator sets are based on equations (1)', (2)' and (3)'. The number of factors in each case is taken as the larger number of the two test statistics reported in Table 2. As for the lag lengths relating to (5) and (6), we find that one lag is adequate for all the short-run factors, i.e. L=1 in (6), as well as the long-run factors under the IP condition, but that two lags are required for certain cases of the long-run factors under the PPP and RIP conditions (see the note in Table 3 for the details of these cases). The DF-ECM of (7) is then run for each case with long enough lags (generally 9). The model is reduced into a data-coherent, specific model by PcGets. Three sets of reduction are carried out: one using full-sample data, another using the post Asian crisis data sample, i.e. from 1998M7 onwards, and the last using the post 2000M1 data sample only. The results reported in Table 3 and Figures 2-13 are based on the reduced specific models.

3.3 Regional results

Several features are noticeable from the adjusted R^2 and Schwarz criterion statistics given in Table 3. First, the power of the model fits increases over time for almost all the economies, illustrating clearly that the dynamics of both goods and capital prices of each economy has become increasingly responsive to regional price parity factors, especially for the post Asian crisis period. Second, the increase in the model fits over time is most noticeable in the case of nominal interest rate parity whereas the model fits of the goods market parity are relatively more constant. This suggests that goods market integration has proceeded earlier than capital market integration. The latter has become more visible only since the Asian crisis. Noticeably, the East Asian economies which suffered badly during the crisis are those which show earlier IP integration, such as Indonesia, Korea, Malaysia and Thailand (see their full-sample fits in Table

3). Third, the model fits of the goods market parity remain generally the highest among the three parity scenarios whereas the model fits of the real interest rate parity remain the lowest. This shows that the degree of goods market integration is generally more advanced than that of the capital market integration, and that integration of goods and capital markets among the Asian economies is still very low with the exception of a few relatively advanced economies such as Korea and Singapore. These facts are confirmed also by the average communality statistics in Table 4. On average, the amount of individual variations in PPP captured by regional common factors is the highest while the amount of individual variations in RIP captured by regional common factors is the lowest.

Noticeably, the communality statistics are substantially larger than the covariation coefficients plotted in Figure 1. The relatively large communality statistics manifest the heavy presence of slow mean reversion in bilateral price parity series, a stylised fact commonly observed in the literature, e.g. see (Obstfeld and Rogoff, 2000). But this feature is absent in the time profile of the covariation coefficients shown in Figure 1. The time profile reveals that progress of individual Asian economy in regional integration remains highly diverse and generally quite low. On the whole, it was only from 2000 onwards that the interest rate disparities have converged more towards the regional factors among the southeast economies of Indonesia, Malaysia, Singapore, and Thailand. Disparities in PPP remain diversified and relatively stable over time. This finding also implies that idiosyncratic shocks form a substantial part of the data deviation at each observation point, thus endorsing the immense usefulness of DFA for its convenient removal of heterogeneous information from aggregate data.[15]

The pooled redundancy coefficients in Table 5 reveal that regionally common price disparities are significantly interrelated between goods market and capital market and that the

[15] Similar findings are also reported in (Qin, 2006), which examines the PPP process of five OECD countries using monthly data.

interrelationship has strengthened noticeably during the post Asian crisis period. The latter clearly illustrates that the regional goods market parity factors move in tandem with the capital market parity factors, especially in the more recent years. However, as to whether the PPP factors explain more of the IP factors or vise versa, the situation varies from economy to economy, from sub sample to full sample and from simultaneous data sets to data sets with different lag gaps.

It is easily seen from Table 6 that there are reasonably high degrees of commonality among the long-run factors of the twelve economies. The POV values under the PPP condition are in general larger than those of the other two conditions, indicating again higher goods market integration than capital market integration. In terms of the POV time profile, progress in regional integration is discernible under both IP and the PPP conditions.

Finally, there are a few noticeable common features in the recursive estimates of the long-run factor feedback coefficients in Figures 2-13.[16] Chiefly, the impact of the Asian financial crisis is discernible from most of the coefficient estimates of those economies which were badly affected by the crisis. Also, the coefficient estimates of the IP condition become more significant during the post Asian crisis period, confirming the previous observation that capital market integration is a fairly recent event. Furthermore, many of the coefficient estimates exhibit non-constant features, with the RIP condition showing the most fragile features and the PPP condition having relatively more constant features. In fact, for the post-crisis sub-sample period, the parameter non-constancy is widely observed from the mid-sample split Chow test results during PcGets model reduction, see (Hendry and Krolzig, 2001).[17] Small-sample uncertainty is probably a major factor of the poor constancy. Nevertheless, it is remarkable that significant feedback

[16] Only the factors whose coefficient estimates are significant during model reduction under either full-sample or sub-sample periods are plotted. In each of these figures, $\sum_{i=1}^{n} \gamma_{ij}^{*}, \quad j = 1, \cdots, m$ is reported with its standard error (in brackets). Notice that the majority of them are statistically insignificant from zero.

[17] To keep the paper short, these test results are not reported, nor are the PcGets test results of the model reduction.

coefficients of the PPP parity are found in every case in spite of the fact that many of the economies studied here still operate under noticeably imperfect market conditions and that monthly data for only about ten years was used. Our finding reverses the common finding that PPP holds only for long-span data of low frequency, e.g. see (Taylor and Taylor, 2004).

3.4 Individual economies

Let us now briefly describe some pronounced features of the individual economies from the empirical results.

Bangladesh: There is noticeable progress towards capital market integration both from the model fits shown in Table 3 and the recursive coefficient estimates in Figure 2. Price adjustment towards regional PPP remains relatively stable. The redundancy coefficients in Table 5 suggest that over the longer period (i.e. full sample) the PPP factors explain the IP factors but the direction reverses during the recent period, i.e. the sub-sample results.

China: The economy demonstrates greater goods market integration than capital market integration, as shown from the model fit statistics in Table 2 and the recursive coefficient estimation of Figure 3. The recursive graphs reveal that adjustment of interest rate dynamics towards regional IP is mostly a post-2000 phenomenon, due to the recent banking sector reforms. On the other hand, there is significant evidence of PPP despite the tight policy control over exchange rate. In comparison, the significance of the feedback coefficients under the RIP condition is relatively weak, showing considerably slow integration in the goods and capital markets. The redundancy coefficients in Table 5 show that the IP factors explain the PPP factors more significantly than vise versa.

Hong Kong: Price adjustments towards regional parities behave fairly regularly except for the case of RIP, as seen from Figure 4. The PPP factors demonstrate stronger explanatory power over the IP factors until the time lags exceed one year, as shown from the redundancy coefficients in Table 5.

India: Prices adjust to regional goods market parity at a somewhat more constant manner than to capital market parity, whereas integration of the two markets is the most fragile, as shown from the recursive graphs in Figure 5. The covariation coefficients of the PPP condition ((Figure 1) have, however, shown a significant rise since 2003, which appears to correspond to the country's 5% rise in the total trade share shown in Table 1. The redundancy coefficients show a marked increase in the sub-sample over the full sample with the IP factors gaining more explanatory power over longer lags as shown from the sub-sample results.

Indonesia, Malaysia and Thailand: Similar features are discernible from these economies. A significant shift in the recursive coefficient estimates of Figures 6, 8 and 13 demonstrates the severity that they suffered from the Asian crisis. But in spite of that, the models for IP and PPP fit quite well, indicating that capital market integration has not significantly lagged behind the goods market integration (Table 3). Moreover, the covariation coefficients of these economies share similar time profile as shown in Figure 1. The interaction between the IP and the PPP factors, as measured by the redundancy coefficients in Table 5, is not unilateral in direction for Indonesia and Thailand whereas the direction is from IP to PPP in the case of Malaysia.

Korea: As shown in Figure 7, there is a clear shift in the coefficient estimates under both IP and RIP conditions during the Asian crisis. This is partly due to the fact that capital market integration was relatively advanced prior to the crisis (e.g. see the full-sample fit in Table 3). Goods price adjustment towards regional parities is relatively regular. But there is no clear singular direction of interaction between the IP and the PPP factors, as measured by the redundancy coefficients in Table 5.

Pakistan: Relatively constant feedback coefficient estimates for both the IP and PPP conditions are observed in Figure 9. The IP model fit catches up with the PPP model starting from the late 1990s. And as shown in Table 5, there is no singular direction of interaction between the IP and the PPP factors.

The Philippines: The model fits show a significant lag in interest rate integration as compared to goods market integration. Interestingly, the time profile of its covariation coefficients does not quite fit that of neighbouring economies such as Malaysia and Indonesia. After the Asian Crisis, the direction of interaction between the IP and the PPP factors settles to IP→PPP. This is shown in Table 5.

Singapore: Price adjustments towards regional parities are discernible for all the three parity conditions, as seen in Figure 12. The regularity of the adjustment is somewhat affected by the Asian crisis, even though the economy withheld the storm. The covariation coefficients share common pattern with those of Southeast Asian economies, as shown in Figure 1, as well as the common disparities shown in Table 4. From Table 5, no singular direction of interaction between the IP and the PPP factors are evident.

Taiwan: Recursive coefficient estimates in Figure 12 reveal poor constancy even though Taiwan's currency did not depreciate as much as the other Asian economies during the Asian crisis. As in the case of the Philippines, the direction of interaction between the IP and the PPP factors settles to IP→PPP during the post Asian Crisis period. The interest rate disparities hardly show any common features with the regional factors, as shown in Figure 1.

4. Concluding remarks

This paper examines empirically the dynamic process of regional economic integration of twelve Asian economies by a new modeling approach, which combines DFA with ECM. Under the DF-ECM approach, latent regional common factors are obtained via DFA. These factors bear better correspondence with the theoretical variables representing the foreign parity than those measures derived by traditional methods, especially under the situation where there is a wide range of dynamic data information about the market which is imperfectly integrated. Moreover, the extracted long-run factors match well with the error-correction term in an ECM, which in turn lends its structural interpretation conveniently to both the long-run and the short-run common factors extracted from the DFM. The ECM framework also allows us to fully exploit the general-to-specific model reduction strategy.

The power of the DF-ECM approach is illustrated in the application of the method to the issue of market integration in the Asian region. In brief, we find that feedback adjustment to price disparities is significantly observable in every case when the disparities are represented in terms of regional factors, that regional integration proceeds stronger and longer in goods market price parities than in capital market parities for most of the Asian economies, that integration of goods and capital markets is the weakest, that capital market integration shows marked progress since the late 1990s, and that there is significant interaction between the price parities of the two markets.

Appendix: Data sources

Economy	Code	Variable	Source
Bangladesh	BG	CPI	Datastream
		Exchange rate: Bangladesh Taka to US$ WMR rate	Datastream
		Interest rate: Bank rate	Datastream
China	CH	CPI	Datastream
		Exchange rate: Market rate	Datastream
		Interest rate: 3-months Interbank Offered rate	Datastream
Hong Kong	HK	CPI	Datastream
		Exchange rate: Hong Kong $ to US$ rate	Datastream
		Interest rate: 3-months Interbank rate	Datastream
		Forward rate: HK$ to US$ 3-Month BBI rate	Datastream
India	ID	CPI	Datastream
		Exchange rate: Indian Rupees to US$	Datastream
		Interest rate: 91-day CD Middle rate	Datastream
		Forward rate: ID rupee to US$ 3-month WMR rate	Datastream
Indonesia	IN	CPI	Datastream
		Exchange rate: Indonesian Rupiah to US$	Datastream
		Interest rate: Indonesia Certificates (SBI) rate: 90 days auction result	CEIC
		Forward rate: Indonesian Rupiah to US$ 3-months	Datastream
Korea	KO	CPI	Datastream
		Exchange rate: South Korean Won to US$	Datastream
		Interest rate: Commercial Paper 91-days middle rate	Datastream
Malaysia	ML	CPI	Datastream
		Exchange rate: Malaysian Ringgit to US$	Datastream
		Interest rate: 3-months Interbank middle rate	Datastream
		Forward rate: Malaysian Ringgit to US$ 3-month WMR rate	Datastream
Pakistan	PK	CPI	Datastream
		Exchange rate: Pakistan Rupees to US SBP rate	Datastream
		Interest rate: 90-day Repo rate	Datastream
Philippines	PH	CPI	Datastream
		Exchange rate: Philippine Peso to US$	Datastream
		Interest rate: 90-day Manila Reference rate	BSP
		Forward rate: Philippine Peso to US$ 3-month WMR rate	Datastream
Singapore	SG	CPI	Datastream
		Exchange rate: Singapore $ to US$	Datastream
		Interest rate: 3-months Interbank middle rate	Datastream
		Forward rate: Singapore $ to US$ 3-month WMR rate	Datastream
Taiwan	TW	CPI	Datastream
		Exchange rate: Taiwan New $ to US$	Datastream
		Interest rate: 90-day Money Market middle rate	Datastream
		Forward rate: Taiwan New $ to US$ 3-months	Datastream
Thailand	TH	CPI	Datastream
		Exchange rate: Thai Baht to US$ Bid rate	Datastream
		Interest rate: 3-months Interbank offered rate (BB)	Datastream
		Forward rate: Thai Baht to US$ 3-month WMR rate	Datastream
Nepal	N/A	CPI	Datastream
		Exchange rate: National Currency Unit to US$	Datastream
		Interest rate: Prime Lending rate	Datastream
Vietnam	N/A	CPI	Datastream
		Exchange rate: Vietnamese Dong to US$ WMR rate	Datastream
		Interest rate: Prime Lending rate	Datastream

Japan	N/A	CPI	Datastream
		Exchange rate: Japanese Yen to US$ GTIS	Datastream
		Interest rate: 3-months CD middle rate	Datastream
		Forward rate: Japanese Yen to US$ 3-month BBI rate	Datastream
USA	N/A	CPI	Datastream
		Interest rate: 3-months Interbank Offered rate (LDN:BBI)	Datastream

Note: BBI stands for Barclays Bank International; WMR stands for WM/Reuters; SBP stands for State Bank of Pakistan; GTIS stands for Global Treasury Information Services; BSP stands for Bangko Sentral ng Pilipinas; BB stands for Bangkok Bank; LDN stands for London; BBA stands for British Bankers Association

References

Adam, K., Jappelli, T., Menichini, A., Padula, M. and Pagano, M. (2002) Analysis, compare and apply alternative indicators and monitoring methodologies to measure the evolution of capital market integration in the European Union, *Report to the EU Commission*, *Centre for Studies in Economics and Finance*, University of Salerno.

Aminian, N. (2005) Economic integration and prospects for regional monetary cooperation in East Asia, *Structural Change and Economic Dynamics*, **16**, 91-110.

Bai, J. and Ng, S. (2005) Determining the number of primitive shocks in factor models. manuscript downloadable at: http://www-personal.umich.edu/~ngse/research.html .

Barrett, C.B. (2001) Measuring integration and efficiency in international agricultural markets, *Review of Agricultural Economics*, **23**, 19-32.

Barrett, C.B. and J.-R. Li (2002) Distinguishing between equilibrium and integration in spatial price analysis, *American Journal of Agricultural Economics*, **84**, 292-307.

Bernanke, B.S., Boivin, J. and Eliasz, P. (2005) Measuring the effects of monetary policy: A factor-augmented vector autoregressive (FAVAR) approach, *The Quarterly Journal of Economics*, **120**, 387-422.

Brahmbhatt, M. (1998) Measuring global economic integration: A review of the literature and recent evidence, The World Bank.

Camba-Mendez, G., Kapetanios, G., Smith, R.J. and Weale, M.R. (2001) An automatic leading indicator of economic activity: Forecasting GDP growth for European countries. *Econometrics Journal*, **4**: S56-S90.

Carey, M. (2004) Global financial integration: a collection of new research, *FRB International Finance Discussion Paper*, no. 821.

Cecchetti, S.G., Mark, N.C. and Sonora, R.J. (2002) Price index convergence among United States cities, *International Economic Review*, **43**, 1081-99.

Chortareas, G. and Kapetanios, G. (2004) How puzzling is the PPP puzzle? An alternative half-life measure of convergence to PPP, *Queen Mary Economics Discussion Papers*, 522.

Click, R.W. and Plummer, M.G. (2005) Stock market integration in ASEAN after the Asian financial crisis, *Journal of Asian Economics*, **16**, 5-28.

Coakley, J., Flood, R.P., Fuertes, A.M. and Taylor, M.P. (2005) Purchasing power parity and the theory of general relativity: the first tests, *Journal of International Money and Finance*, **24**, 293-316.

Crucini, M.J., Telmer, C.I. and Zachariadis, M. (2005) Understanding European real exchange rates, *American Economic Review*, **95**, 724-38.

Ehrmann, M., Frantzscher, M. and Rigobon, R., (2005) Stocks, bonds money markets and exchange rates: measuring international financial transmission, *NBER Working Paper Series*, no. 11166.

Favero, C.A., Marcellino, M. and Neglia, R. (2005) Principal components at work: the empirical analysis of monetary policy with large data sets, *Journal of Applied Econometrics*, **20**, 603-20.

Flood, R.P. and Rose, A. (2005) A new approach to asset integration: methodology and mystery, *Pacific Economic Review*, **10**, 5-28.

Forni, M., Giannone, D., Lippi, M. and Reichlin, L. (2003) Opening the black box: Structural factor models versus structural VARs, *CEPR Discussion Papers*, 4133.

Giacomini, R. and Granger, C.W.J. (2004) Aggregation of space-time processes, *Journal of Econometrics*, **118**, 7-26.

González-Rivera, Gloria and Steven M. Helfand (2001) The extent, pattern, and degree of market integration: A multivariate approach for the Brazilian rice market, *American Journal of Agricultural Economics*, **83**, 576-92.

Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C. (1998) *Multivariate Data Analysis*, New Jersey: Prentice Hall PTR.

Hendry, D.F. (1995) *Dynamic Econometrics*, Oxford: Oxford University Press.

Hendry, D.F. and Krolzig, H.-M. (2001) *Automatic Econometric Model Selection Using PcGets*. London: Timberlake Consultants Ltd. .

Imbs, J., Mumtaz, H., Ravn, M.O. and Rey, H. (2005) PPP strikes back: Aggregation and the real exchange rate, *Quarterly Journal of Economics*, **120**, 1-43.

Johansen, S. (2006) Cointegration: An overview, in TC. Mills and K. Patterson eds. *Palgrave Handbook of Econometrics, vol.I Econometric Theory*, New York: Palgrave MacMillan, pp. 540-77.

Juselius, K. (2006) *The Cointegrated VAR Model: Econometric Methodology and Macroeconomic Applications*, Oxford: Oxford University Press.

Kawai, M. (2005) East Asian economic regionalism: progress and challenges, *Journal of Asian Economics*, **16**, 29-55.

Kleimeier, S. and Sander, H. (2000) Regionalisation versus globalization in European financial market integration: Evidence from co-integration analyses, *Journal of Banking and Finance*, **24**, 1005-43.

Lipkovich, I. and Smith, E.P. (2001) Biplot and singular value decomposition macros for Excel. *Department of Statistics, Virginia Tech Blacksburg*, free software downloadable at: http://www.stat.vt.edu/facstaff/epsmith.html .

Obstfeld, M. and Rogoff, K. (2000) The six major puzzles in international macroeconomics: Is there a common cause? *NBER Working Paper*, no. W7777; also in B. Bernanke and K. Rogoff (eds.) *NBER Macroeconomics Annual*, Cambridge MA.

Onatski, A. (2005) Determining the number of factors from empirical distribution of eigenvalues. *Economics Discussion Paper Series, Columbia University, 0405-19*.

Plummer, M.G. (2006) The ASEAN economic community and the European experience, *ADB Working Paper Series on Regional Economic Integration*, no. 1.

Plummer, M.G. and Click, R.W. (2005) Bond market development and integration in ASEAN, *International Journal of Finance and Economics*, **10**, 133-42.

Qin, D. (2006) Uncover latent PPP by dynamic factor error correction model (DF-ECM) approach: Evidence from five OECP countries, paper in draft.

Qin, D. and Gilbert, C.L. (2001) The error term in the history of time series econometrics, *Econometric Theory*, **17**, 424-50.

Rana, P.B. (2006) Economic integration in East Asia: Trends, prospects, and a possible roadmap, *ADB Working Paper Series on Regional Economic Integration*, no. 2.

Sander, H. and Kleimeier, S. (2004) Convergence in Eurozone retail banking? What interest rate pass-through tells us about monetary policy transmission, competition and integration, *Journal of International Money and Finance*, **23**, 461-92.

Sarno, L. (2005) Towards a solution to the puzzles in exchange rate economics: where do we stand? *Canadian Journal of Economics*, **38**, 673-708.

Sarno, L., Taylor, M.P. and Chowdhury, I. (2004) Nonlinear dynamics in deviation s from the law of one price: a broad-based empirical study, *Journal of International Money and Finance*, **23**, 1-25.

Stock J.H. and Watson, M.W. (2005) Implications of dynamic factor models for VAR analysis, *NBER Working Paper Series*, no. 02138.

Swaine, D.G. (1998) What do cross-sectional growth regressions tell us about convergence? *Federal Reserve Bank of Boston Working Paper*, no. 98-4.

Taylor, A.M. and Taylor, M.P. (2004) The purchasing power parity debate, *Journal of Economic Perspectives*, **18**, 135-58.

Tucker, L.R. and MacCallum, R.C. (1997) *Exploratory Factor Analysis*, incomplete manuscript downloadable from: http://www.unc.edu/~rcm/book/factornew.htm .

Table 1. Trade shares (annual average in percentage)

		1995-96	1999-2000	2001-2002	2003 – 2005
BG	In the region plus USA	0.586	0.517	0.538	0.506
	In total domestic demand	0.216	0.247	0.251	0.267
CH	In the region plus USA	0.662	0.650	0.627	0.628
	In total domestic demand	0.316	0.330	0.371	0.486
HK	In the region plus USA	0.807	0.832	0.840	0.838
	In total domestic demand	1.165	1.263	1.137	1.151
ID	In the region plus USA	0.382	0.371	0.389	0.402
	In total domestic demand	0.203	0.231	0.246	0.298
IN	In the region plus USA	0.681	0.711	0.704	0.732
	In total domestic demand	0.421	0.486	0.466	0.426
KO	In the region plus USA	0.628	0.650	0.643	0.663
	In total domestic demand	0.451	0.555	0.529	0.571
ML	In the region plus USA	0.758	0.773	0.776	0.781
	In total domestic demand	1.007	0.899	0.915	0.903
PK	In the region plus USA	0.439	0.410	0.397	0.411
	In total domestic demand	0.315	0.265	0.268	0.285
PH	In the region plus USA	0.721	0.770	0.790	0.808
	In total domestic demand	0.615	0.690	0.676	0.661
SG	In the region plus USA	0.726	0.729	0.723	0.708
	In total domestic demand	1.313	1.326	1.333	1.428
TW	In the region plus USA	0.723	0.730	0.729	0.726
	In total domestic demand	0.983	0.984	0.959	0.969
TH	In the region plus USA	0.668	0.683	0.689	0.671
	In total domestic demand	1.046	0.934	0.960	0.980

Note: Trade is defined as exports plus imports; total domestic demand is GDP plus imports.

Table 2. Tests for number of factors (Onatski / Bai-Ng):

	IP		RIP		PPP	
	Long run	Short run	Long run	Short run	Long run	Short run
BG	5 / 5	5 / 1	5 / 4	5 / 5	5 / 5	5 / 5
CH	5 / 6	5 / 1	5 / 5	5 / 5	5 / 3	5 / 5
HK	5 / 5	5 / 1	5 / 4	5 / 3	5 / 4	5 / 5
ID	5 / 4	5 / 1	5 / 5	5 / 6	5 / 4	5 / 6
IN	5 / 4	5 / 1	5 / 5	5 / 3	5 / 5	5 / 6
KO	5 / 3	5 / 1	5 / 4	5 / 3	5 / 3	5 / 5
ML	5 / 6	5 / 1	5 / 4	5 / 3	5 / 2	5 / 5
PK	5 / 6	5 / 1	5 / 5	5 / 4	5 / 6	5 / 4
PH	5 / 5	5 / 1	5 / 6	5 / 4	5 / 5	5 / 4
SG	5 / 5	5 / 1	5 / 6	5 / 6	5 / 5	5 / 4
TW	5 / 6	5 / 1	5 / 4	5 / 4	5 / 6	5 / 5
TH	5 / 5	5 / 1	5 / 5	5 / 3	5 / 5	5 / 4

Note: The larger number is adopted when the two test statistics differ.

Table 3. DF-ECM (7) Model-fit statistics based on PcGets specific model results:

		Full sample		1998M7 – 2005M12		2000M1 – 2005M12	
		Adjusted R^2	Schwarz criterion	Adjusted R^2	Schwarz criterion	Adjusted R^2	Schwarz criterion
BG	IP	0.4031	-2.4734	0.6326	-2.7214	0.6533	-2.7547
	RIP	0.1675	-2.4791	0.7565	-2.9685	0.9331	-3.6412
	PPP	0.9231	-8.1813	0.9004	-8.2406	0.9517	-7.9514
CH	IP	0.5678	-1.0497	0.7484	-1.1304	0.6462	-1.3426
	RIP	0.5614	-0.8674	0.7465	-1.1962	0.4048	-1.3884
	PPP	0.8876	-8.1852	0.9281	-9.2626	0.9702	-10.3998
HK	IP	0.7861	0.2237	0.8801	-0.6670	0.8290	-1.6074
	RIP	0.3287	1.0567	0.8001	0.0225	0.8762	-1.4457
	PPP	0.9651	-9.2634	0.8547	-9.2350	0.9209	-9.3692
ID	IP	0.6423	0.5386	0.8061	-1.3343	0.8401	-1.8026
	RIP	0.5737	-4.0207	0.7797	-5.7022	0.8537	-6.0547
	PPP	0.9817	-9.5973	0.9928	-10.340	0.9976	-10.418
IN	IP	0.7872	2.0869	0.9458	0.8690	0.9010	-0.2096
	RIP	0.7734	1.9525	0.8776	1.1922	0.8548	0.0611
	PPP	0.9655	-5.0449	0.9831	-5.7517	0.9911	-6.8517
KO	IP	0.7675	1.297	0.9532	-1.6967	0.8068	-2.8591
	RIP	0.7809	1.0762	0.9238	-1.1030	0.9465	-5.2167
	PPP	0.9554	-6.4022	0.9627	-6.6096	0.9670	-7.5336
ML	IP	0.8796	-1.8613	0.9090	-2.0912	0.8839	-5.6495
	RIP	0.7186	-1.0403	0.8151	-1.3099	0.5348	-5.1018
	PPP	0.9716	-7.1288	0.9726	-8.3021	0.9777	-12.146
PK	IP	0.6694	1.3335	0.8639	0.1816	0.9516	-0.5188
	RIP	0.5677	1.2901	0.6199	0.9388	.8346	-0.2176
	PPP	0.9271	-7.4566	0.9740	-7.9013	0.9886	-8.5680
PH	IP	0.4637	0.9230	0.5301	0.8003	0.4179	1.0184
	RIP	0.2827	0.9683	0.5556	0.8558	0.6912	0.8897
	PPP	0.9633	-6.9308	0.9761	-7.3094	0.9767	-7.8990
SG	IP	0.7419	-1.3883	0.9228	-2.5437	0.8228	-2.7073
	RIP	0.4948	-0.3270	0.8781	-1.9810	0.9626	-3.3936
	PPP	0.9708	-8.2689	0.9498	-8.7620	0.9356	-9.0952
TW	IP	0.4280	-0.7691	0.8884	-3.3369	0.9504	-4.1583
	RIP	0.6063	-0.9813	0.7964	-2.7002	0.7990	-3.1634
	PPP	0.9363	-7.5993	0.9387	-7.5753	0.9640	-8.0646
TH	IP	0.7201	0.9114	0.9809	-1.6956	0.8856	-2.6774
	RIP	0.6775	1.3589	0.9646	-1.2207	0.8339	-2.5495
	PPP	0.9717	-6.8425	0.9925	-8.7103	0.9904	-9.1495

Note: Two lags are identified and used for equation (5) in the RIP case for China, Hong Kong, Indonesia, the Philippines, Taiwan, and the PPP case for India and Korea. One lag is found adequate for the rest cases.

Table 4. Communality coefficients based on the long-run common factors: The average and the largest six in sequence

		Average	1st	2nd	3rd	4th	5th	6th
BG	IP	0.778	0.969 (CH)	0.886 (JP)	0.876 (MY/TH)	0.873 (TW)	0.864 (SG)	0.853 (KO)
	RIP	0.614	0.922 (TH)	0.874 (KO)	0.740 (PK)	0.727 (MY)	0.693 (TW)	0.683 (IN)
	PPP	0.834	0.931 (ID)	0.929 (US)	0.917 (MY)	0.909 (PH/PK)	0.901 (IN)	0.885 (KO)
CH	IP	0.809	0.997 (JP)	0.938 (BG)	0.931 (SG)	0.922 (US)	0.920 (TH)	0.895 (IN)
	RIP	0.641	0.829 (JP)	0.825 (IN)	0.820 (BG)	0.753 (PH)	0.722 (US)	0.721 (PK)
	PPP	0.871	0.982 (HK)	0.981 (US)	0.972 (ID)	0.935 (BG)	0.925 (PH)	0.921 (SG)
HK	IP	0.655	0.940 (BG)	0.886 (IN)	0.872 (TH)	0.823 (CH)	0.804 (JP)	0.726 (VI)
	RIP	0.530	0.808 (TH)	0.757 (KO)	0.719 (IN)	0.676 (JP)	0.608 (MY)	0.526 (CH)
	PPP	0.905	0.974 (US)	0.966 (ID)	0.961 (MY)	0.951 (IN)	0.948 (KO)	0.930 (PH)
ID	IP	0.698	0.909 (IN)	0.884 (TH)	0.853 (JP)	0.794 (SG)	0.787 (BG)	0.760 (KO)
	RIP	0.565	0.787 (TH)	0.730 (KO)	0.721 (JP)	0.637 (IN)	0.630 (ML)	0.616 (HK)
	PPP	0.837	0.957 (HK)	0.951 (TW)	0.945 (PH)	0.937 (ML)	0.926 (JP)	0.924 (US)
IN	IP	0.891	0.923 (JP)	0.918 (SG)	0.914 (US)	0.910 (BG)	0.904 (CH/TW/ID)	0.901 (ML)
	RIP	0.742	0.811 (TH)	0.807 (ML)	0.800 (JP)	0.797 (KO)	0.785 (PH)	0.782 (SG)
	PPP	0.843	0.906 (US)	0.894 (KO)	0.891 (ID)	0.881 (CH/PH)	0.854 (TH)	0.846 (PK)
KO	IP	0.748	0.914 (JP)	0.903 (IN)	0.898 (BG)	0.870 (US)	0.861 (SG)	0.833 (TW)
	RIP	0.655	0.865 (JP)	0.828 (BG)	0.811 (ML)	0.810 (US)	0.708 (HK)	0.703 (TW)
	PPP	0.858	0.952 (US)	0.943 (IN)	0.913 (PH)	0.907 (ID)	0.902 (CH)	0.892 (PK)
ML	IP	0.741	0.943 (JP)	0.917 (BG)	0.907 (TH)	0.871 (US)	0.867 (CH)	0.861 (SG)
	RIP	0.601	0.834 (TH)	0.832 (JP)	0.764 (KO/BG)	0.656 (US)	0.633 (CH)	0.614 (HK)
	PPP	0.870	0.966 (IN)	0.964 (US)	0.953 (ID)	0.942 (PH/BG)	0.885 (PK)	0.873 (CH)
PK	IP	0.627	0.879 (IN)	0.769 (JP)	0.738 (BG)	0.723 (TH)	0.697 (SG)	0.692 (NP)
	RIP	0.520	0.710 (IN)	0.707 (BG)	0.682 (TH)	0.657 (JP)	0.613 (KO)	0.557 (SG)
	PPP	0.848	0.956 (ID)	0.954 (US)	0.952 (HK)	0.930 (CH)	0.904 (NP)	0.895 (MY)
PH	IP	0.683	0.896 (IN)	0.891 (TH)	0.809 (CH)	0.804 (KO)	0.71 (VI)	0.683 (US)
	RIP	0.568	0.871 (TH)	0.802 (KO)	0.705 (IN)	0.625 (CH)	0.621 (SG)	0.614 (PK)
	PPP	0.883	0.967 (ID)	0.964 (US)	0.945 (NP)	0.929 (HK)	0.927 (BG)	0.896 (JP)
SG	IP	0.732	0.928 (TH)	0.925 (CH)	0.837 (US)	0.823 (JP)	0.820 (KO)	0.799 (ML)
	RIP	0.589	0.851 (TH)	0.786 (KO)	0.783 (IN)	0.708 (CH)	0.665 (ID)	0.642 (ML)
	PPP	0.817	0.947 (US)	0.935 (ID)	0.924 (HK)	0.883 (ML)	0.870 (JP)	0.864 (PH)
TW	IP	0.714	0.933 (JP)	0.902 (IN)	0.897 (TH)	0.870 (BG)	0.842 (CH)	0.837 (SG)
	RIP	0.458	0.782 (TH)	0.742 (JP)	0.679 (KO)	0.594 (US)	0.548 (HK)	0.541 (PH)
	PPP	0.847	0.972 (US)	0.959 (ID)	0.950 (HK)	0.917 (BG)	0.916 (NP)	0.886 (CH)
TH	IP	0.838	0.950 (JP)	0.945 (BG)	0.933 (SG)	0.919 (US)	0.903 (IN)	0.895 (TW)
	RIP	0.753	0.914 (BG)	0.891 (JP)	0.870 (US)	0.852 (PH)	0.825 (IN)	0.824 (ML)
	PPP	0.853	0.956 (ID)	0.938 (US)	0.930 (PH)	0.920 (BG)	0.919 (HK)	0.890 (PK)

Note: Adjusted R^2 is used instead of the simple R^2 so as to make scenarios with different factor numbers comparable.

Table 5. Pooled Redundancy coefficients between the IP and PPP long-run factor sets

		lags	0	6	12	18	24
BG	PPP→IP	full sample	0.4961	0.4670	0.4737	0.4810	0.4212
		sub sample	0.5615	0.5643	0.5575	0.5434	0.5679
	IP→PPP	full sample	0.4330	0.3903	0.3943	0.4003	0.4133
		sub sample	0.5268	0.6333	0.6277	0.6362	0.6829
CH	PPP→IP	full sample	0.4150	0.4406	0.4077	0.4255	0.4829
		sub sample	0.6268	0.6668	0.6386	0.6448	0.7230
	IP→PPP	full sample	0.6094	0.5803	0.6455	0.6256	0.5814
		sub sample	0.6840	0.7867	0.7391	0.7856	0.7648
HK	PPP→IP	full sample	0.5080	0.5178	0.4972	0.4128	0.3784
		sub sample	0.7209	0.6847	0.7221	0.7142	0.7684
	IP→PPP	full sample	0.3741	0.4080	0.4848	0.4388	0.4349
		sub sample	0.6207	0.6149	0.7241	0.7760	0.7894
ID	PPP→IP	full sample	0.2792	0.3476	0.3218	0.3177	0.2492
		sub sample	0.5459	0.5435	0.5342	0.4875	0.3121
	IP→PPP	full sample	0.2675	0.2678	0.3237	0.3021	0.2467
		sub sample	0.5676	0.5333	0.5568	0.5758	0.6088
IN	PPP→IP	full sample	0.2795	0.3653	0.4088	0.3501	0.3152
		sub sample	0.5733	0.6595	0.7018	0.7046	0.7701
	IP→PPP	full sample	0.3771	0.3833	0.4736	0.4390	0.4479
		sub sample	0.6706	0.6654	0.6471	0.7072	0.7518
KO	PPP→IP	full sample	0.3007	0.4207	0.3842	0.3546	0.3072
		sub sample	0.4909	0.5585	0.6614	0.6536	0.7252
	IP→PPP	full sample	0.2916	0.3035	0.3524	0.4057	0.3772
		sub sample	0.5943	0.5888	0.6129	0.6933	0.7160
ML	PPP→IP	full sample	0.3632	0.3835	0.4556	0.3483	0.3144
		sub sample	0.5242	0.5966	0.6287	0.6421	0.6808
	IP→PPP	full sample	0.3974	0.4415	0.4102	0.4043	0.4524
		sub sample	0.6399	0.6575	0.7048	0.7442	0.7411
PK	PPP→IP	full sample	0.4305	0.4968	0.4858	0.4189	0.4683
		sub sample	0.5951	0.6557	0.7143	0.6951	0.7618
	IP→PPP	full sample	0.4835	0.4628	0.4756	0.4532	0.4716
		sub sample	0.7266	0.7370	0.6322	0.6823	0.7152
PH	PPP→IP	full sample	0.3930	0.4599	0.4426	0.4121	0.4292
		sub sample	0.5579	0.5667	0.5769	0.5810	0.5608
	IP→PPP	full sample	0.4879	0.4586	0.4857	0.4561	0.3128
		sub sample	0.5349	0.6866	0.7586	0.8057	0.7313
SG	PPP→IP	full sample	0.4497	0.4217	0.3979	0.4210	0.4230
		sub sample	0.6529	0.6444	0.5483	0.5586	0.6659
	IP→PPP	full sample	0.3796	0.4379	0.4502	0.4583	0.4326
		sub sample	0.5381	0.6408	0.6034	0.6607	0.6145
TW	PPP→IP	full sample	0.3788	0.4554	0.4778	0.4721	0.4635
		sub sample	0.6152	0.7144	0.6938	0.7006	0.7650
	IP→PPP	full sample	0.5485	0.5603	0.5935	0.6120	0.5620
		sub sample	0.7008	0.7515	0.6456	0.6230	0.5694
TH	PPP→IP	full sample	0.2983	0.3291	0.3160	0.2539	0.2542
		sub sample	0.4862	0.5466	0.4992	0.5187	0.5222
	IP→PPP	full sample	0.3314	0.3103	0.3150	0.3154	0.3096
		sub sample	0.6183	0.5422	0.5831	0.6806	0.6892

Note: Sub sample covers 1998M7-2005M12. In the lagged scenarios, lags apply to the 'causing' set of factors.

Table 6. Proportion of Variance Explained by the First Three Principal Components of the Long-Run Factors of the Twelve Economies

	All factors of 12 economies	All 1st factors	All 2nd factors	All 3rd factors	All 4th factors	All 5th factors
IP						
Full sample	0.6490	0.8497	0.9585	0.9327	0.7740	0.7529
Sub samples						
1994M2-1997M6	0.7472	0.7989	0.8728	0.9130	0.8194	0.8726
1998M6-2005M12	0.8095	0.8557	0.9706	0.9624	0.8982	0.8329
2000M1-2005M12	0.8533	0.8363	0.9196	0.9515	0.8966	0.9116
RIP						
Full sample	0.6669	0.7691	0.9535	0.9312	0.8501	0.7676
Sub samples						
1994M2-1997M6	0.7180	0.6884	0.8694	0.9224	0.9122	0.8909
1998M6-2005M12	0.7803	0.8085	0.9684	0.9851	0.8564	0.7467
2000M1-2005M12	0.7437	0.7567	0.9103	0.9684	0.8026	0.8087
PPP						
Full sample	0.6876	0.7691	0.9535	0.9312	0.8501	0.7676
Sub samples						
1994M2-1997M6	0.8626	0.9178	0.9144	0.9144	0.9492	0.9410
1998M6-2005M12	0.8461	0.9091	0.9664	0.9088	0.9181	0.8640
2000M1-2005M12	0.9086	0.9386	0.9745	0.9494	0.9603	0.9216

Note: The case 'all 6th factors' is not calculated as there are only a few cases where six factors are used, see Table 2.

Figure 1. Time series of covariation coefficients based on the long-run common factors (annual moving average of monthly series)

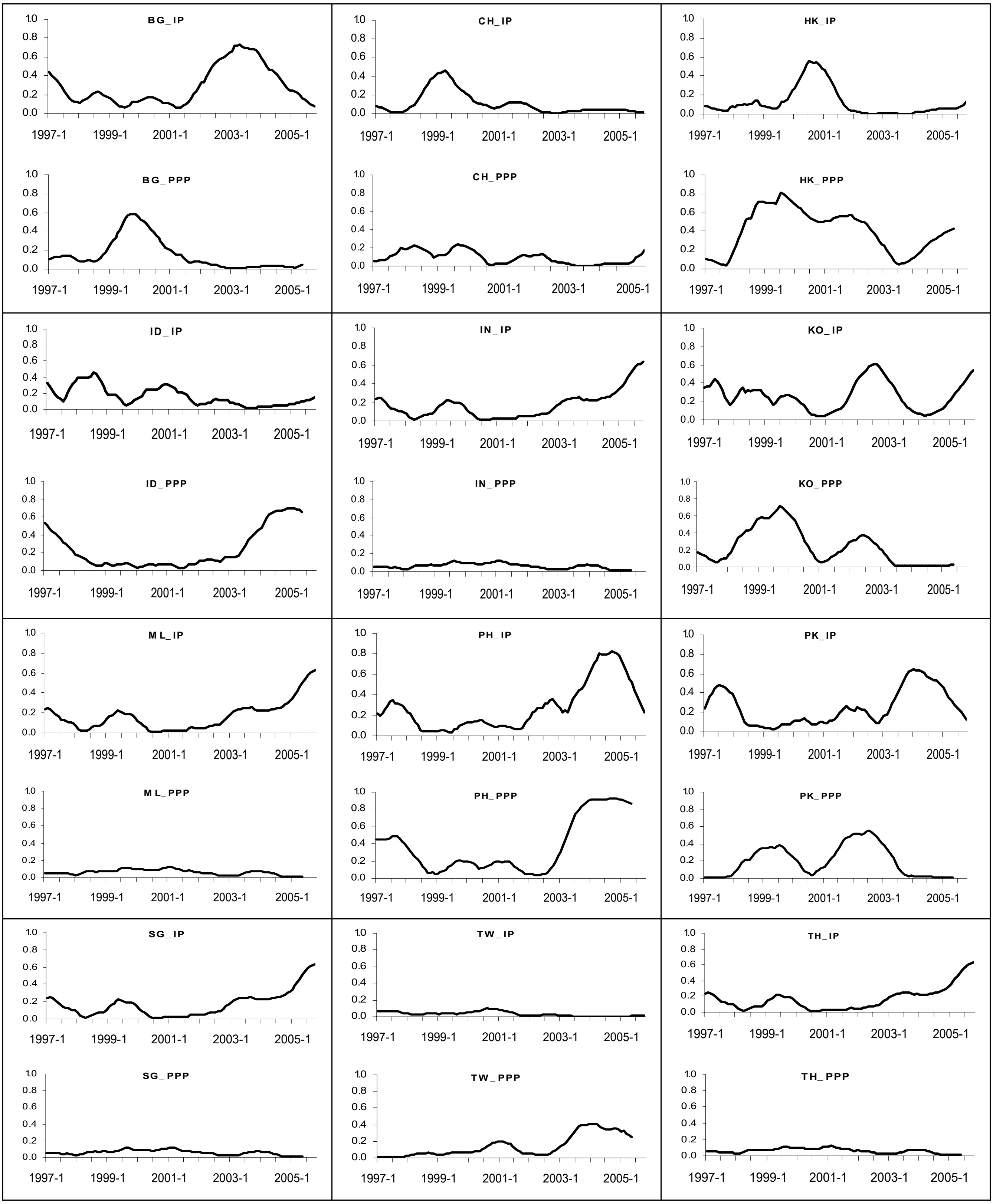
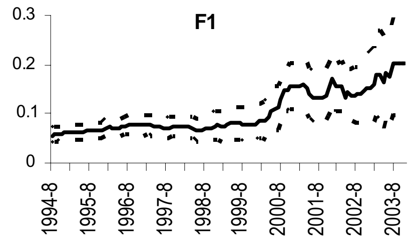
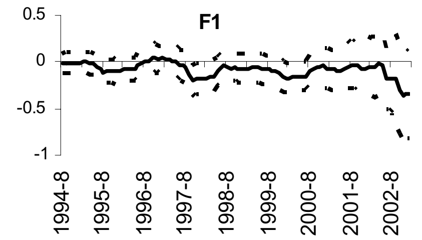
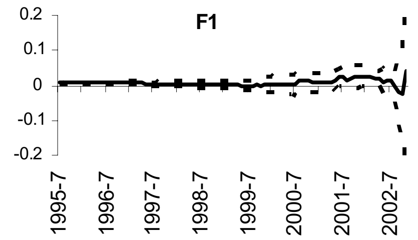
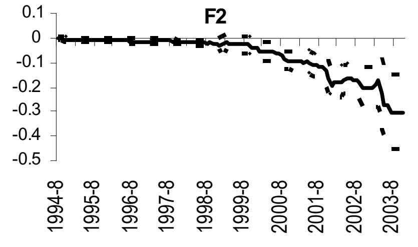
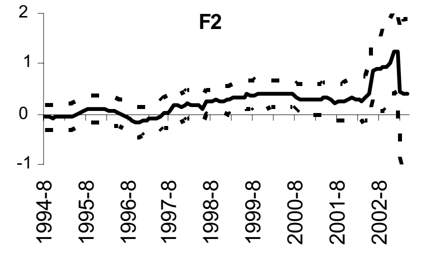
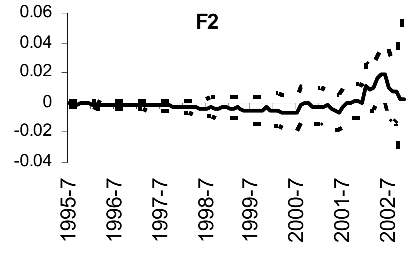
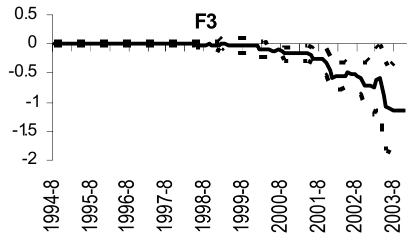
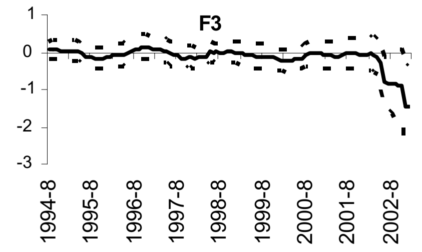
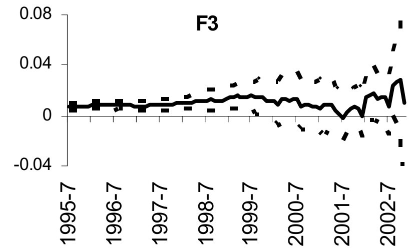
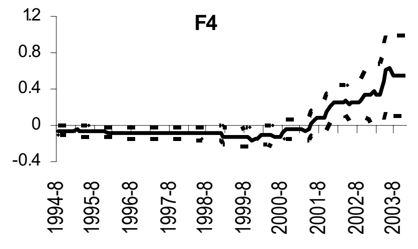
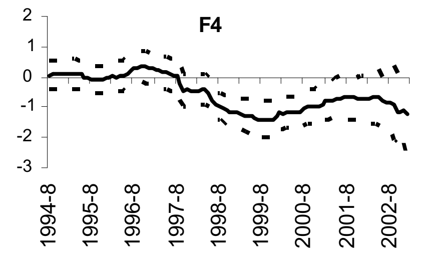
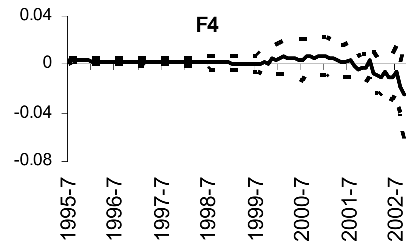
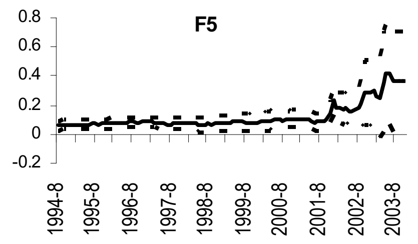
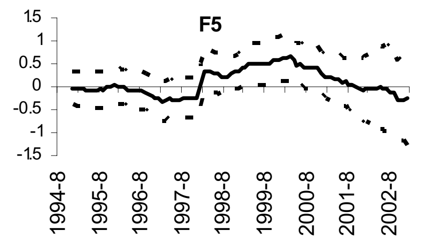
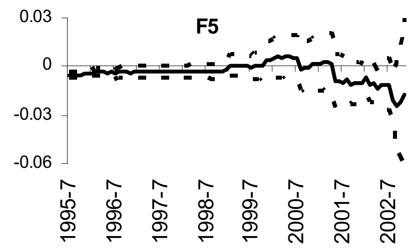
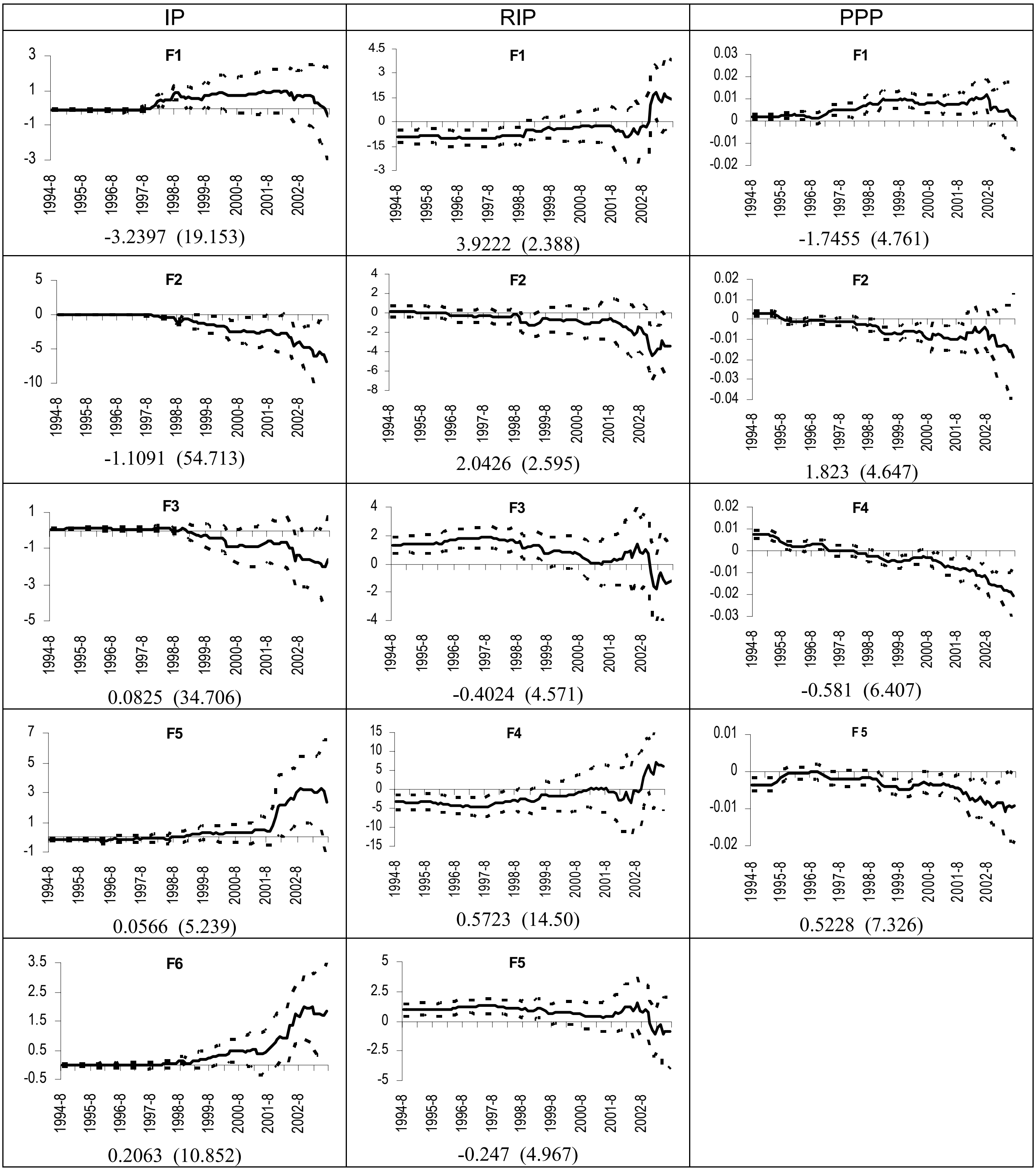


Figure 2. Backward recursive $\hat{\phi}_{d,j}$ in PcGets reduced specific models of (7): Bangladesh

IP	RIP	PPP
		
-2.7086 (1.9196)	4.0982 (2.2550)	-2.2784 (5.9439)
		
-0.2894 (3.9863)	0.1432 (6.3873)	1.1891 (9.7453)
		
0.4001 (3.8653)	0.3568 (115.868)	-2.1874 (5.4505)
		
-0.8626 (2.7776)	0.1145 (10.5948)	-0.3787 (14.8616)
		
-1.2976 (4.6732)	1.4202 (26.5985)	0.5310 (14.6588)

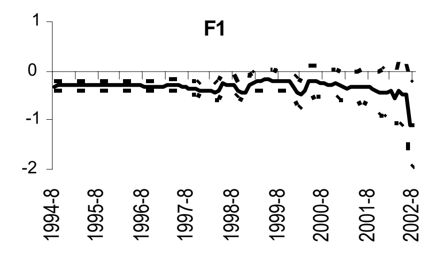
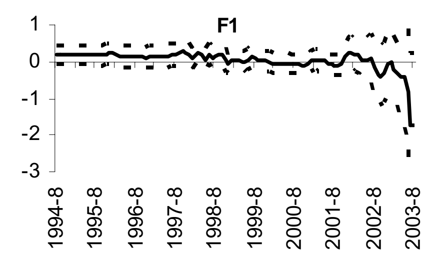
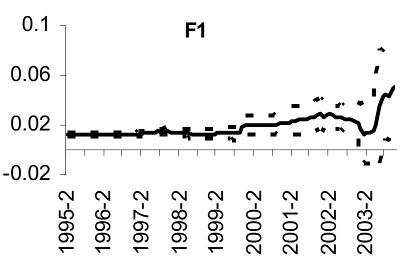
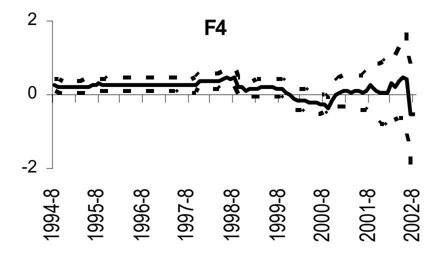
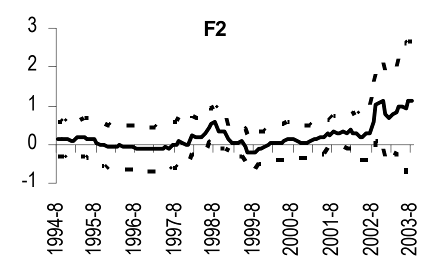
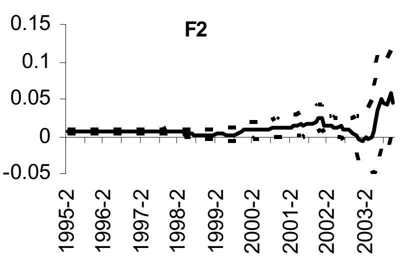
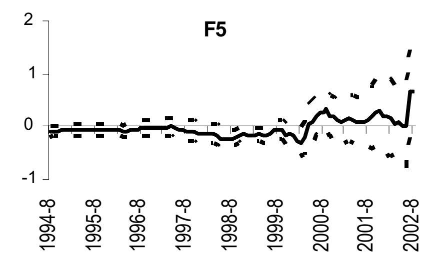
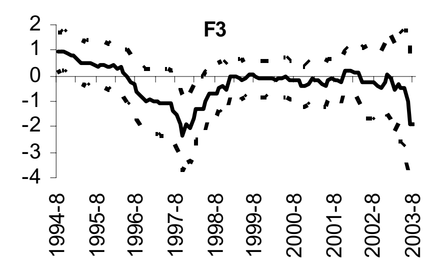
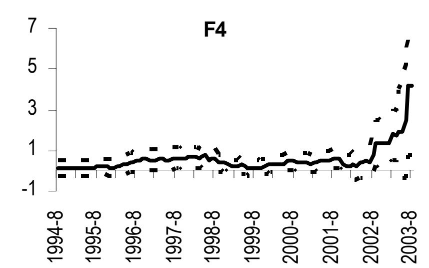
Note: F* denotes the factor number. The coefficients of those insignificant factors in both full-sample and sub-sample estimations are excluded. The starting sub-sample covers 2003M7-2005M12. The two dotted curves form 95% confidence interval. $\sum_{i=1}^{n} \gamma_{i1}^{*}$, with its standard error in bracket, is given at the bottom of each graph.

Figure 3. Backward recursive $\hat{\phi}_j$ in PcGets reduced specific models of (7): China



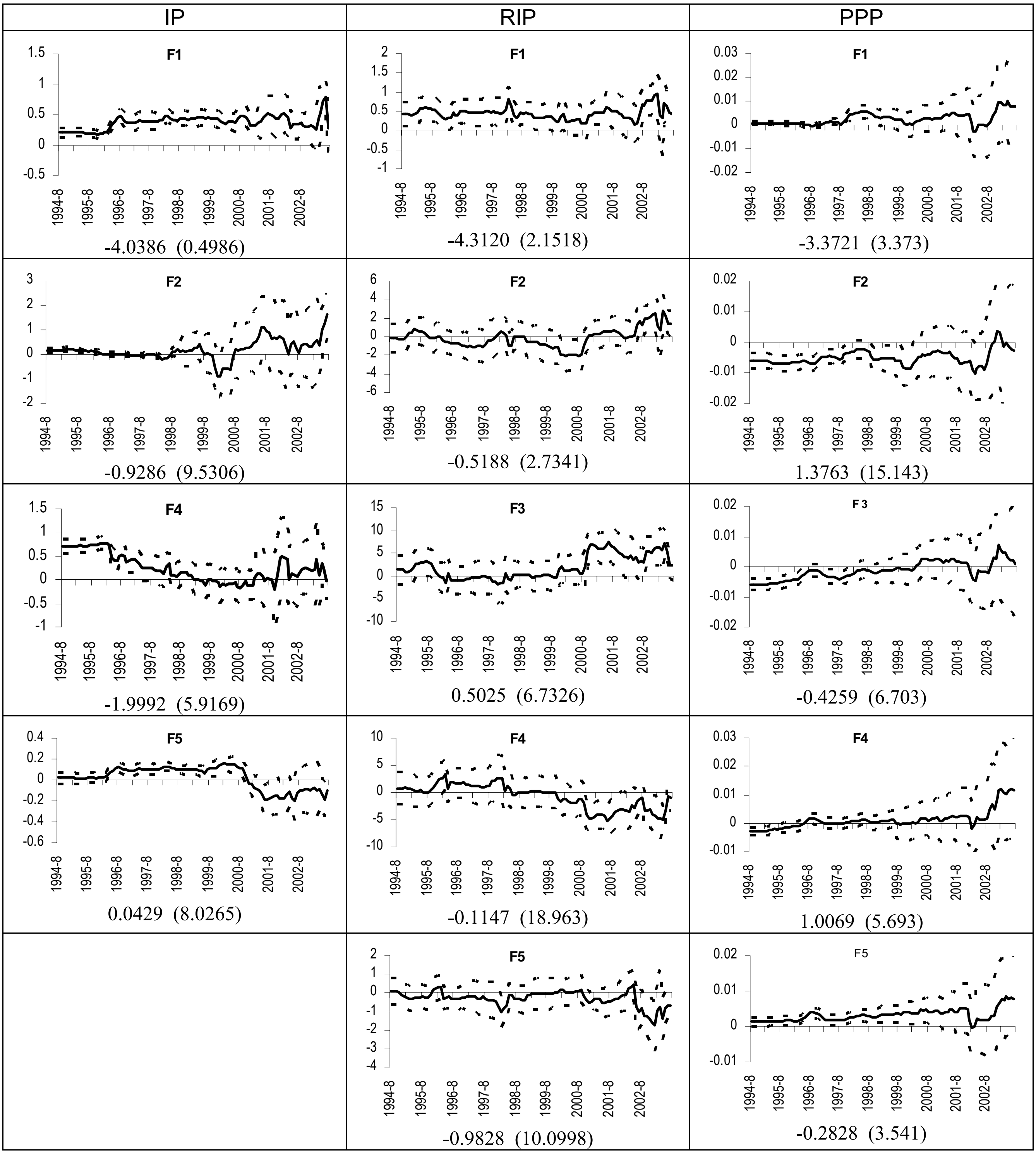
Note: See the note of Figure 2.

Figure 4. Backward recursive $\hat{\phi}_j$ in PcGets reduced specific models of (7): Hong Kong

IP	RIP	PPP
 4.0068 (6.9351)	 -4.0007 (0.9799)	 -3.8761 (3.1897)
 -1.6479 (16.998)	 0.5760 (2.289)	 0.4140 (9.8331)
 0.3727 (8.5303)	 -0.3153 (1.716)	
	 -0.5083 (1.139)	

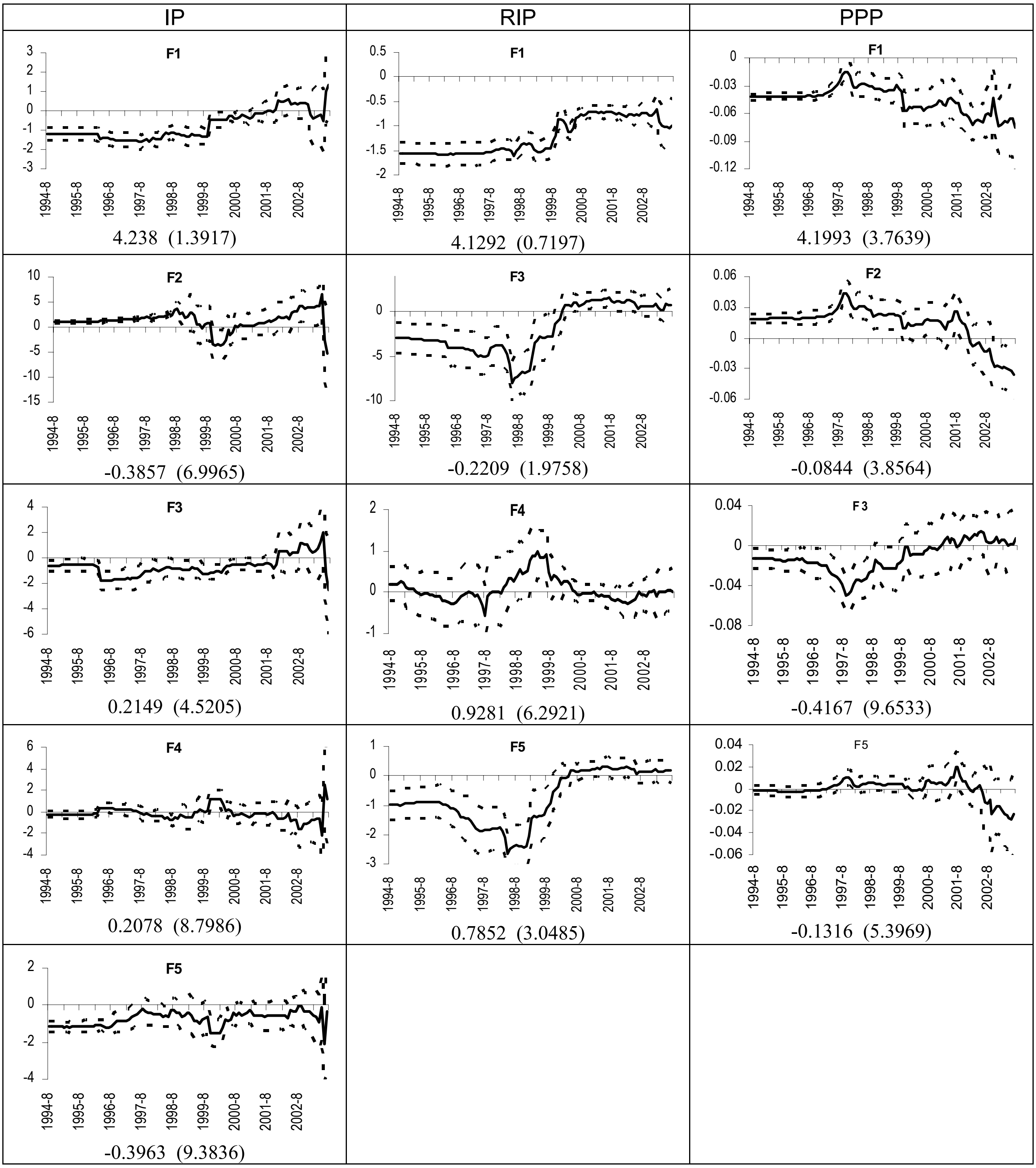
Note: See the note of Figure 2.

Figure 5. Backward recursive $\hat{\phi}_j$ in PcGets reduced specific models of (7): India



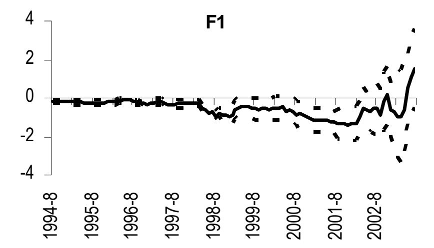
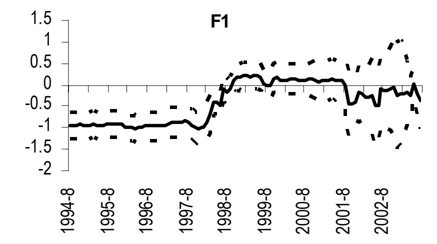
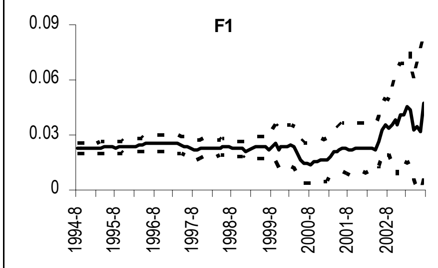
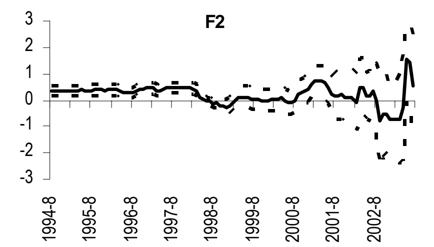
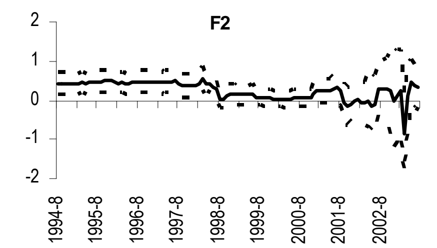
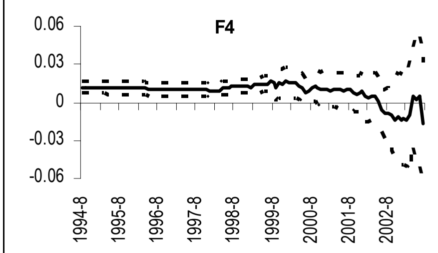
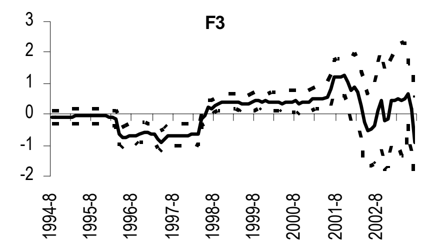
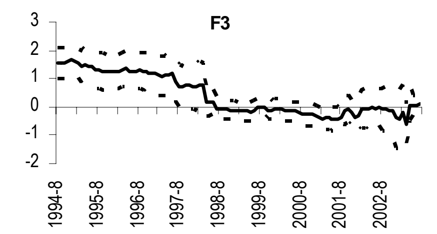
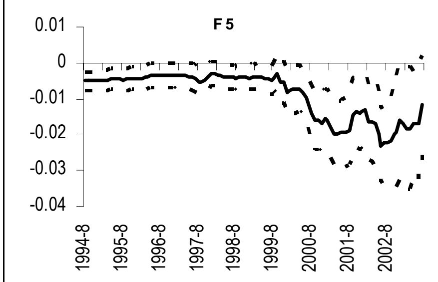
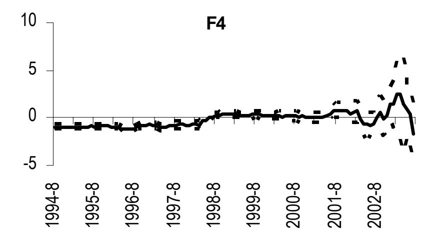
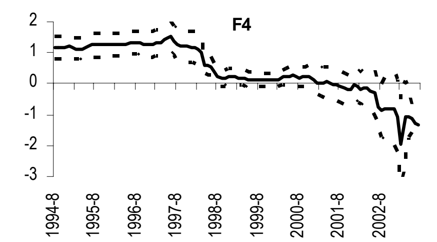
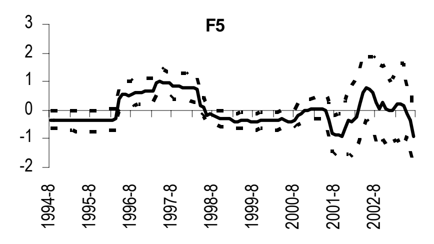
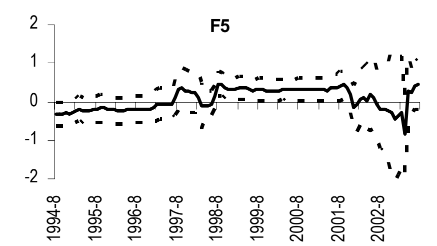
Note: See the note of Figure 2.

Figure 6. Backward recursive $\hat{\phi}_j$ in PcGets reduced specific models of (7): Indonesia



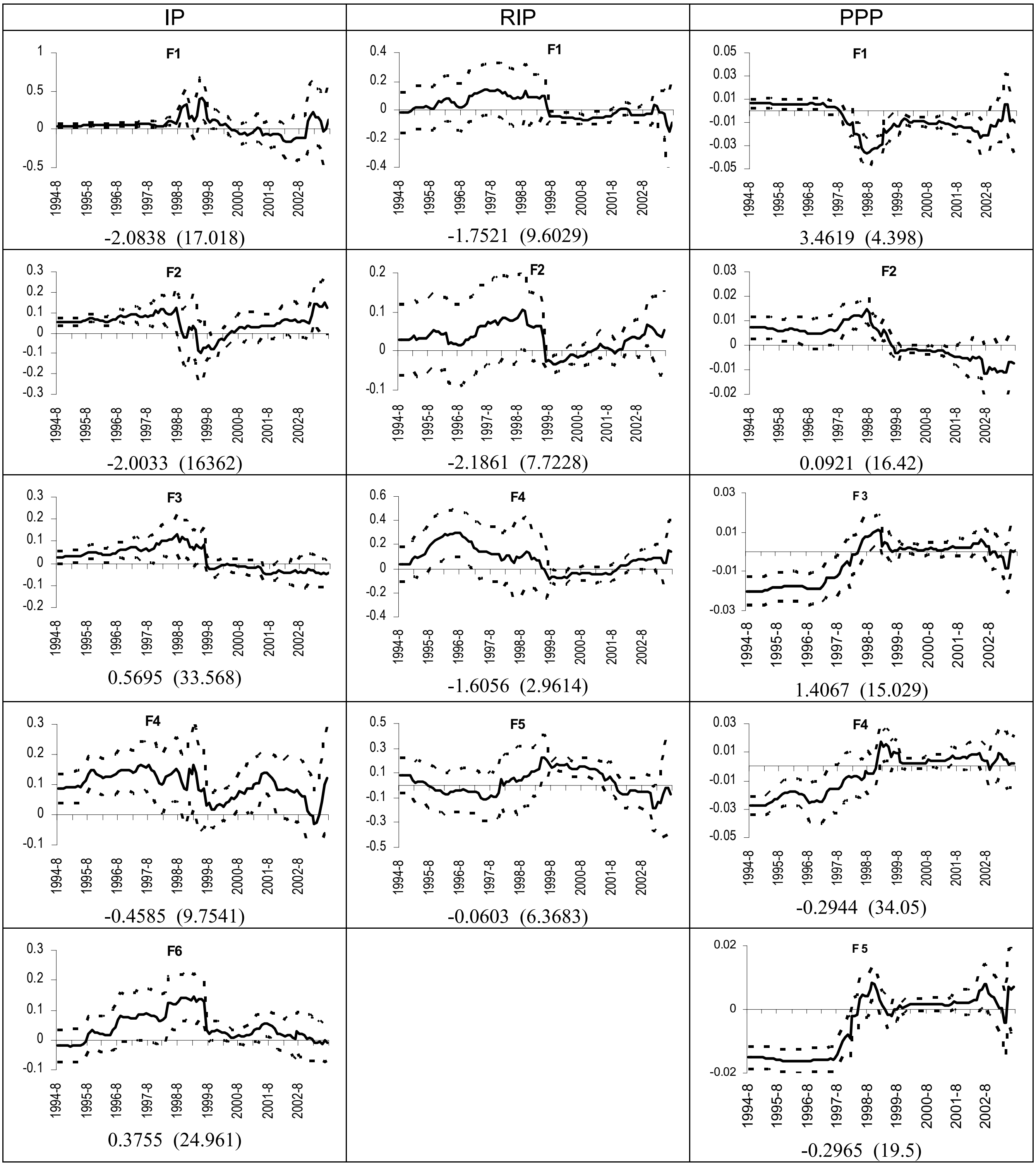
Note: See the note of Figure 2.

Figure 7. Backward recursive $\hat{\phi}_j$ in PcGets reduced specific models of (7): Korea

IP	RIP	PPP
 4.0276 (4.7016)	 3.6115 (2.5333)	 -3.1491 (1.8946)
 -1.3969 (14.28)	 -2.5033 (9.9045)	 -0.9272 (4.1075)
 0.4651 (44.32)	 1.4804 (18.009)	 0.6059 (6.1437)
 1.2952 (15.686)	 0.2955 (10.406)	
 0.3035 (3.8611)	 -0.0021 (3.4399)	

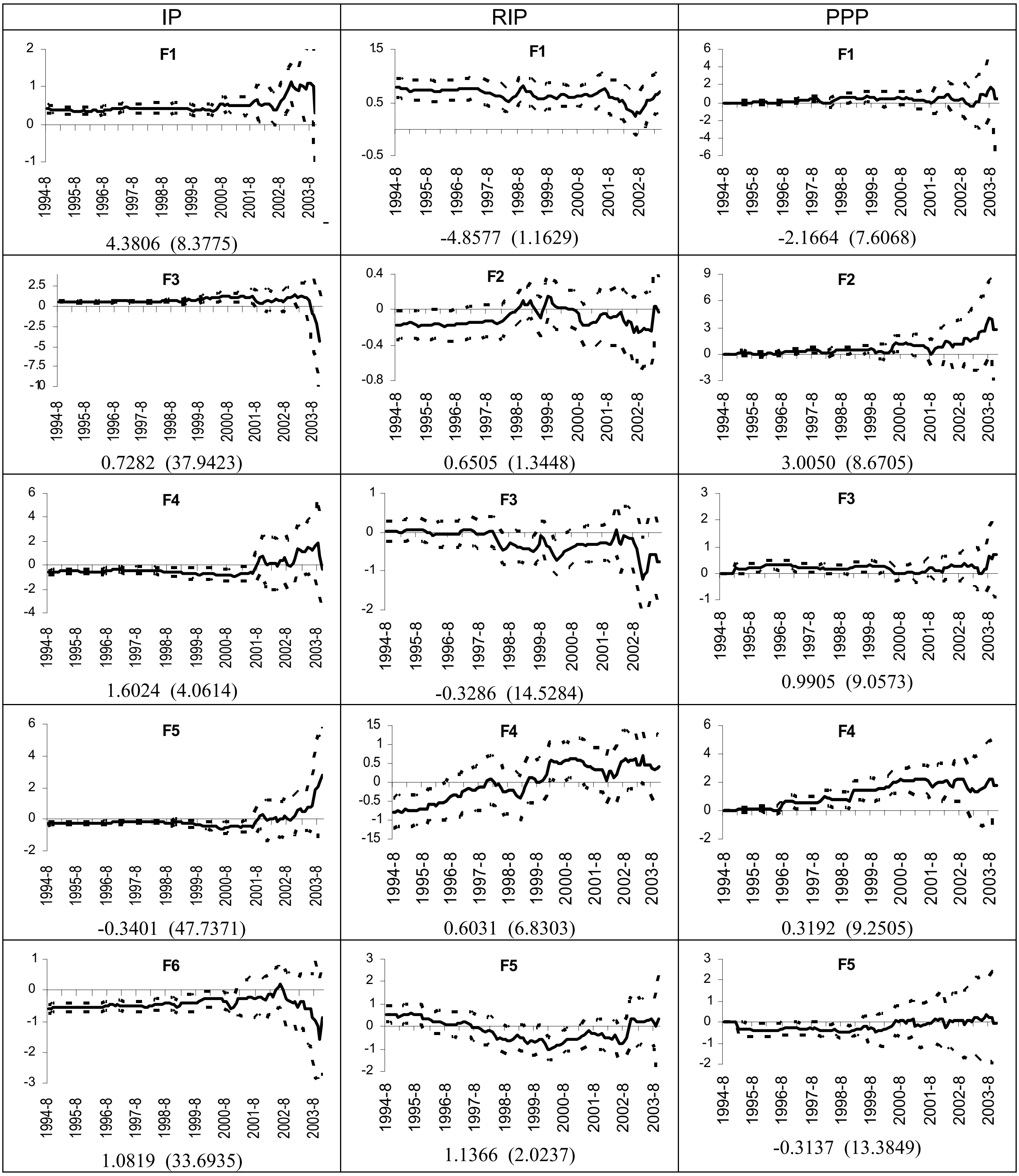
Note: See the note of Figure 2.

Figure 8. Backward recursive $\hat{\phi}_j$ in PcGets reduced specific models of (7): Malaysia



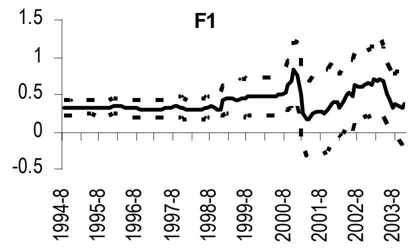
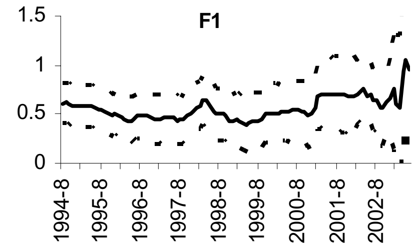
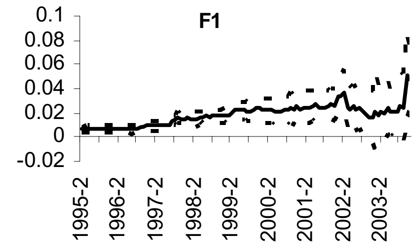
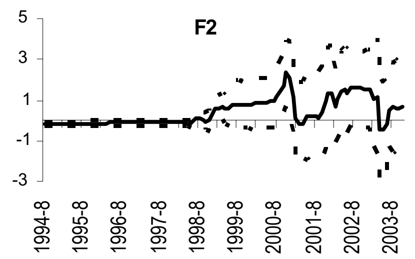
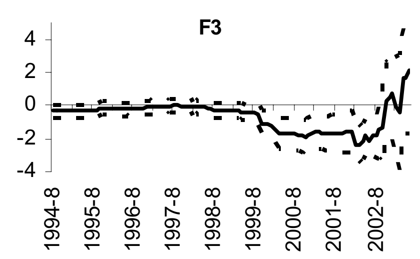
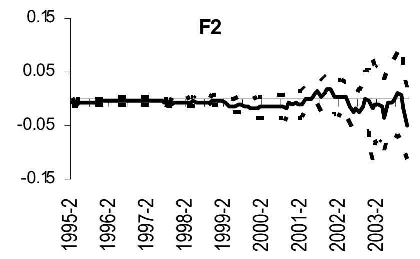
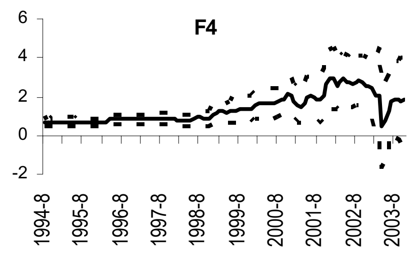
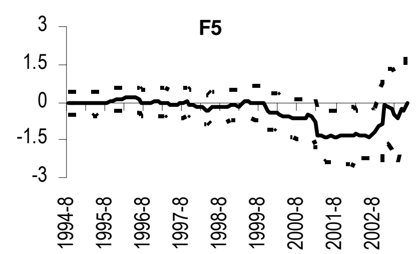
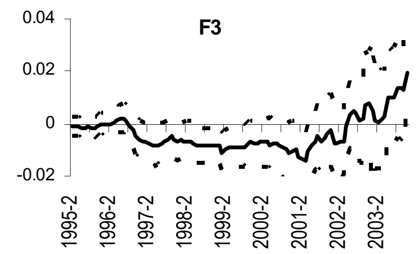
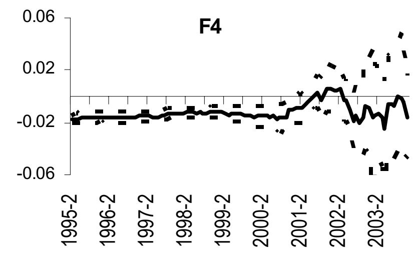
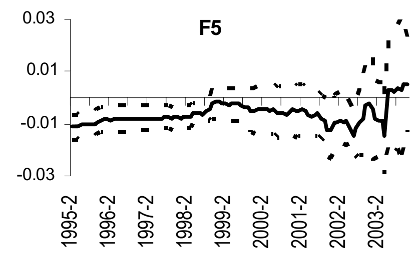
Note: See the note of Figure 2.

Figure 9. Backward recursive $\hat{\phi}_j$ in PcGets reduced specific models of (7): Pakistan



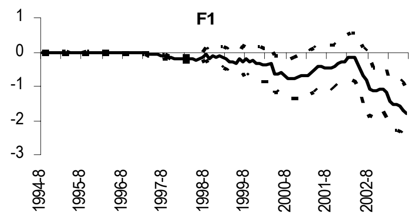
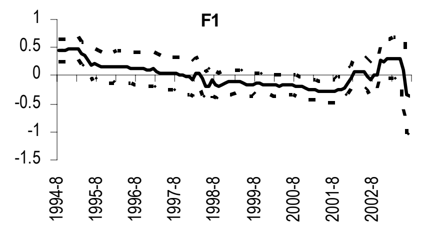
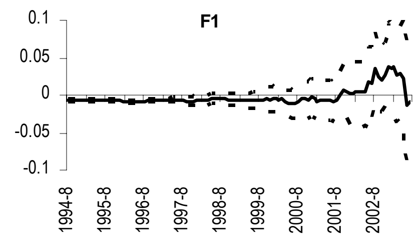
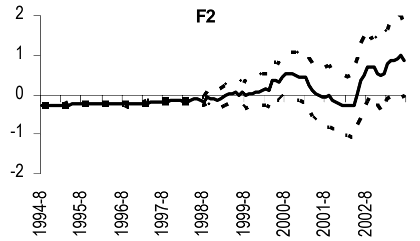
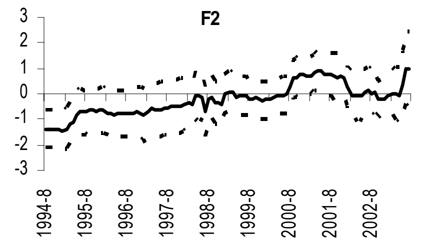
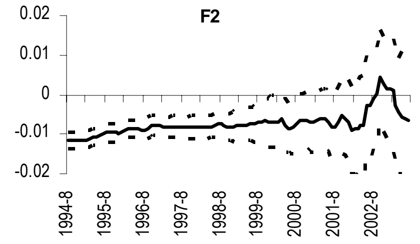
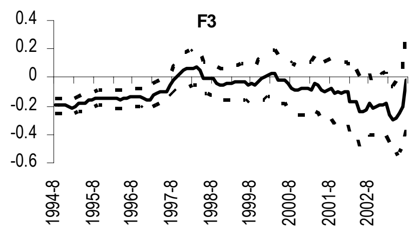
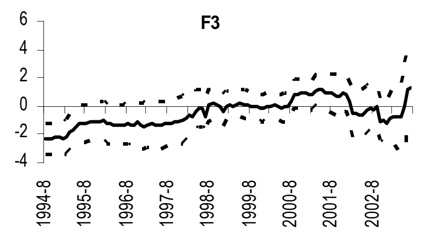
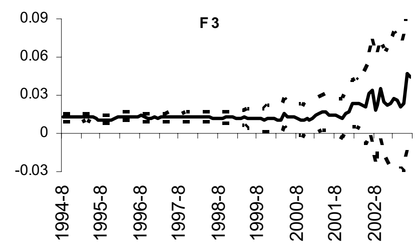
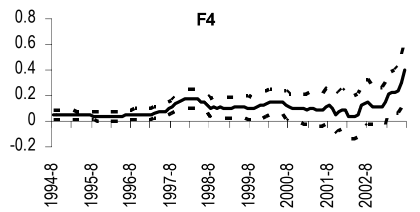
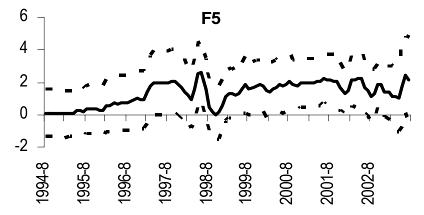
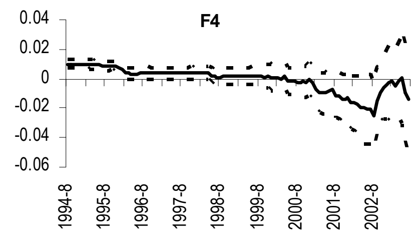
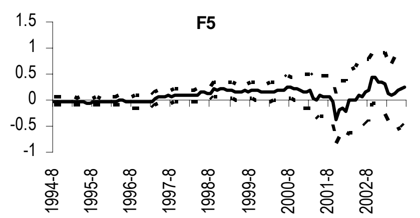
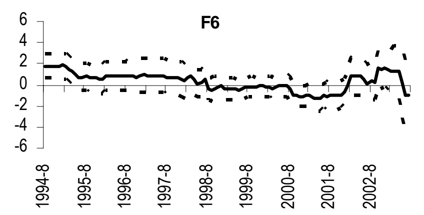
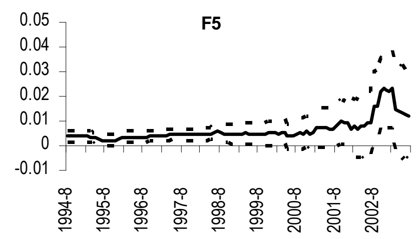
Note: See the note of Figure 2.

Figure 10. Backward recursive $\hat{\phi}_j$ in PcGets reduced specific models of (7): Philippines

IP	RIP	PPP
 -4.3689 (1.1742)	 -4.1692 (1.1743)	 -3.6965 (2.8827)
 -0.1996 (9.1034)	 0.1019 (16.248)	 -0.7156 (14.1743)
 -0.2678 (9.0693)	 -0.7811 (1.6369)	 0.9376 (6.0282)
		 -0.1768 (8.8596)
		 0.7714 (9.2442)

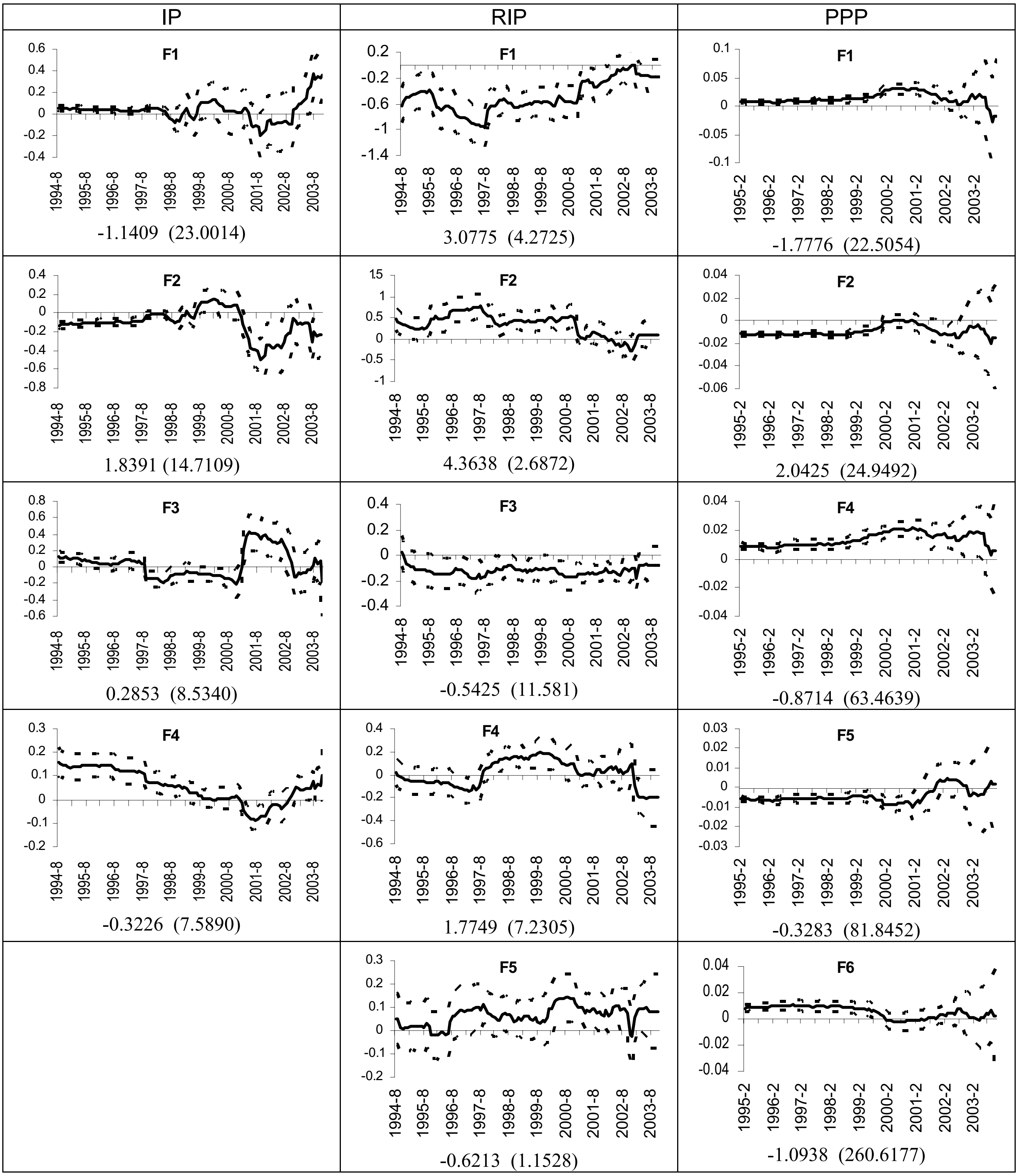
Note: See the note of Figure 2.

Figure 11. Backward recursive $\hat{\phi}_j$ in PcGets reduced specific models of (7): Singapore

IP	RIP	PPP
 2.8112 (10.264)	 -3.8040 (0.6703)	 0.1105 (9.4932)
 1.3830 (11.831)	 -0.2421 (1.0679)	 3.4069 (6.4264)
 1.1882 (11.294)	 0.0054 (2.5159)	 0.0805 (1.0679)
 -1.2903 (15.547)	 -0.1336 (3.0165)	 1.0884 (23.272)
 -0.2407 (2.121)	 0.3713 (6.3289)	 -1.7395 (9.6190)

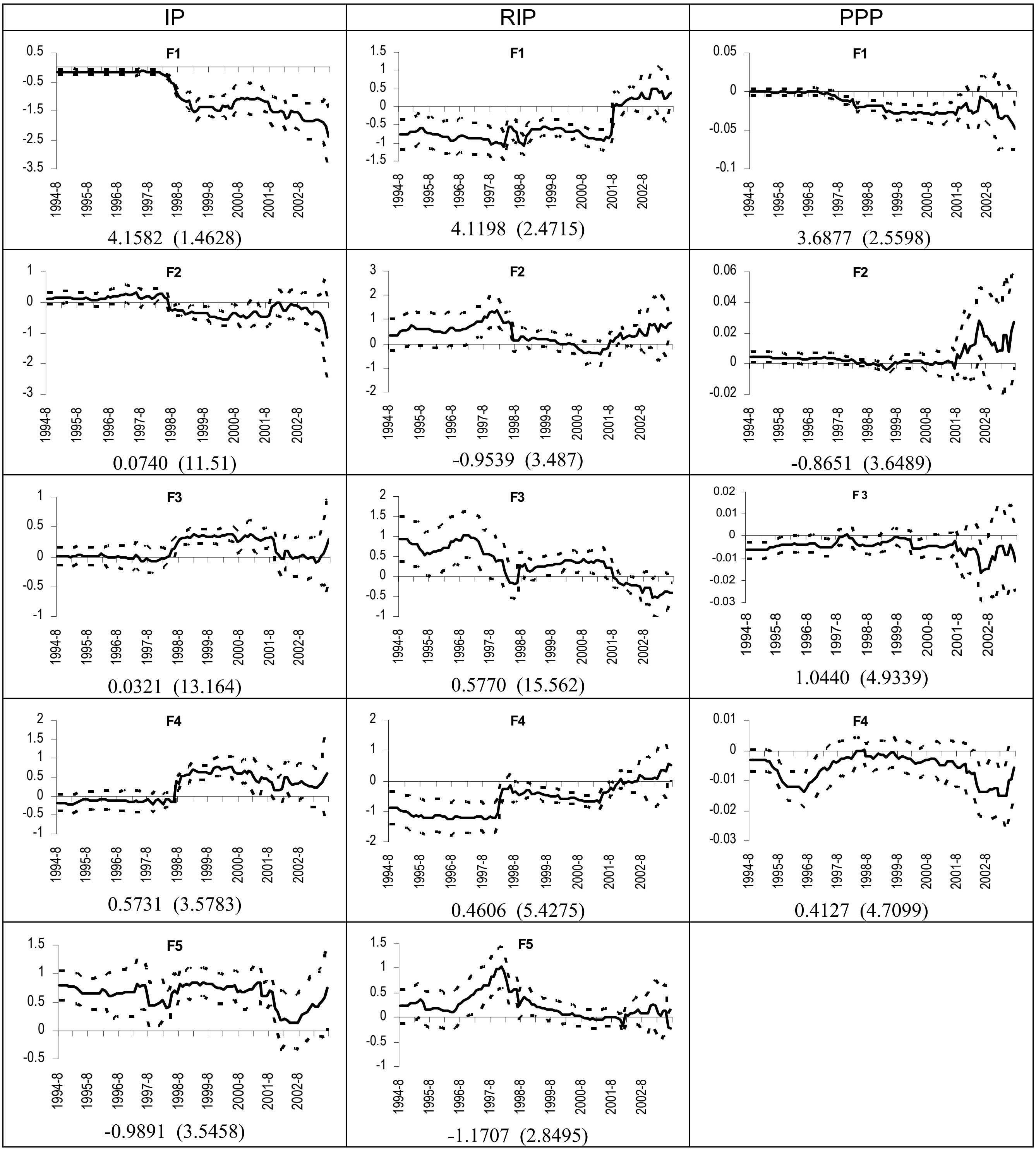
Note: See the note of Figure 2.

Figure 12. Backward recursive $\hat{\phi}_j$ in PcGets reduced specific models of (7): Taiwan



Note: See the note of Figure 2.

Figure 13. Backward recursive $\hat{\phi}_j$ in PcGets reduced specific models of (7): Thailand



Note: See the note of Figure 2.

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