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Exchange Rate Indicators and Optimal Currency Baskets: A Macroeconomic Analysis with Application to Developing Countries

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Abstract

This paper presents a framework for deriving and estimating an optimally-weighted exchange rate index within a general equilibrium model. The weighting method is shown to be equivalent to the optimal control approach of Turnovsky (1982), suggesting that the optimally-weighted exchange rate index might also be useful for the purposes of stabilization policy. Optimally-weighted exchange rate indices are constructed for a group of Asian developing countries using a vector autoregression model. The properties of the weighted indices are examined and their usefulness for policy, both as economic indicators and as currency baskets is discussed.

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Contents

I. Introduction

A considerable literature has developed that attempts to utilize optimally the information content of a chosen set of economic variables in order to obtain improved predictions of a set of target variables (see, for example, LeRoy and Waud (1977) and Mitchell (1982)). The focus of this research has been primarily empirical and directed toward the monetary area where its policy significance lies in the development of monetary aggregates as economic indicators of monetary policy. Related theoretical work by Roper and Turnovsky (1980) has derived an optimally-weighted monetary aggregate that is tied directly to the goals of stabilization policy. In a more recent contribution (see Horne and Martin (1985)), the information approach has been combined with the concept of optimizing policy to derive and estimate an optimally-weighted indicator variable that might also be useful for the purposes of stabilization policy.

The present paper extends the authors' earlier work by applying the Kalman filter technique to estimating an optimally-weighted exchange rate index in which the weights minimize the forecast variance in a target variable. The theoretical relationship between the weighted exchange rate index and the concept of an optimal currency basket is also examined within a structural model. A weighted exchange rate index is derived for six developing countries within an unconstrained vector-autoregression (VAR) system that is used to represent the structure of the reduced-form of the model. The policy significance of the estimated indices, both as economic indicators and their potential use as optimal currency baskets is also examined.

The distinction between the concepts of an effective exchange rate index and a currency basket stabilization policy is an important one for the following analysis. Both concepts are defined as a weighted average of bilateral exchange rates but have different policy implications. The concept of a nominal effective exchange rate was first developed by Hirsch and Higgins (1970) and represents the total relationship between the actual value of the currency expressed in terms of a numeraire and the aggregate value of a relevant composite of currencies expressed in terms of the same numeraire. One important use of this index was to indicate the source of movements in international competitiveness that might emanate from exchange rate fluctuations. Development of an effective real exchange rate index (see Maciejewski (1983)) further isolated the extent to which variations in the index might reflect inflation or cost differentials between countries. As emphasized by various authors and, in particular by Rhomberg (1976), the weighting system that is adopted needs to be linked to the policy issue of interest. For example, if the main policy concern is in isolating the effects of exchange rate movements on export earnings, the appropriate weights are export shares. Alternatively, if the policy question is designed to throw light on the effects of exchange rate changes on the trade balance, the weights better reflect trade shares that maintain trade balance (see Artus and Rhomberg (1973)). The primary policy significance of effective exchange rate indices appears to lie in their value as economic indicators. In view of the critical importance of their information content, it is surprising that recent techniques for improving the information value of monetary aggregates have not been applied to exchange rate indicators. 1/

Currency baskets have a more direct operational significance as instruments of stabilization policy. Since the advent of generalized floating, many developing countries have pegged their exchange rates to a basket of currencies in order to minimize the exchange rate fluctuations, and the resulting instability to the domestic economy that may result from pegging to a single major currency or from independent floating. A considerable literature has developed that attempts to determine the optimal weights to be attached to each currency with respect to various stabilization goals (see, for example, Flanders and Helpman (1979), Branson and Katseli-Papaefstratiou (1981), Lipschitz and Sundararajan (1982), Edison and Vardal (1985), and Turnovsky (1982)). 2/ While the empirical literature has focused attention upon estimating an optimal currency basket within a partial equilibrium trade model, more recent theoretical contributions 3/ have emphasized the desirability of a general equilibrium framework. Although the role of trade flows emphasized in partial equilibrium models has particular relevance for developing countries, the assumption of exogenously-determined exchange rates appears unduly restrictive.

The framework of the paper is as follows. In section II the optimally-weighted exchange rate index is derived within a general equilibrium model using the Kalman filter technique. Section III shows how the optimal weights can be interpreted within a structural stochastic model of a small open economy that trades with two trading partners. Section IV applies the theoretical analysis to estimating a set of optimally-weighted exchange rate indices for a group of Asian developing countries that includes Thailand, Indonesia, Korea, Malaysia, Singapore and Sri Lanka. Various empirical tests are performed to examine the properties of the estimated optimally-weighted exchange rate index for each country. In the final section, the main policy implications of the analysis are discussed together with suggestions for further research

II. Theoretical Framework

The optimal weighting scheme that is assumed to be adopted as one in which the control or indicator variables are chosen such as to minimize

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1/ See, however, a recent contribution by Becketti and Hakkio (1987).

2/ For a recent survey of this literature, see Williamson (1982). See also, Takagi (1985) for a review of the conceptual and operational issues in pegging to a basket of currencies.

3/ See Turnovsky (1982) and Bhandari (1983).

the sum of the squared deviations between the values of the actual and target variables. For example, in the following analysis it is assumed that the control variables are a set of bilateral nominal exchange rates and the authorities attempt to minimize the forecast variance in real (or nominal) income.

The exchange rate indicator is given by equation (1), and is defined as a set of k weighted bilateral nominal exchange rates, e_{it} between the home country and foreign countries such that the forecast variance in the target variable income, y_t, is minimized. The aim is to derive the optimal weights λ_i such that we obtain the best predictor of the target variable.

$$\Psi_t = \sum_{i=1}^{k} \lambda_i e_{it} \qquad \lambda_i \gtrless 0 \text{ and } \qquad \sum_{i=1}^{k} \lambda_i = 1 \tag{1}$$

The relationship between the bilateral exchange rates and income is captured by the reduced form of an econometric model which can be expressed by the following set of stochastic difference equations: 1/

$$Z_t = \sum_{j=1}^{L} \Pi_j Z_{t-j} + V_t \tag{2}$$

where Z_t is a ((k+1)x1) vector of variables containing the bilateral exchange rates in the first k elements and real income in the $k+1^{th}$ element. The reduced form coefficients are given by the (k+1) x (k+1) matrices Π_i, the maximum lag length is given by L, and V_t is a ((k+1)x1) vector of error terms distributed with zero means, variance-covariance matrix equal to Υ, and orthogonal to Z_{t-j}, $j>0$.

The unconditional forecast at time t of the target variable based upon all available information at time t-1 is defined as:

$$\hat{Y}_t = P[Y_t | \Omega_{t-1}] \tag{3}$$

where P[ ] is the projection operator and Ω_{t-1} contains all of the available information known at time t-1 to the policymaker such as lagged values of the bilateral exchange rates and lagged values of income. The forecast error in predicting income is:

$$V_{k+1\ t} = Y_t - \hat{Y}_t \tag{4}$$

where $V_{k+1\ t}$ is the $k+1^{th}$ element of V_t.

1/ We have excluded both deterministic and exogenous variables from the theoretical model for simplicity.

During time period t, the policymaker will receive information on the bilateral exchange rates that can be observed daily before receiving information on real income that is observed quarterly. This information can be used to obtain improved (conditional) forecast estimates of the target variable. The optimal method of updating the target forecast is based on the Kalman filter. 1/ The conditional forecast is given by:

$$Y_t^* = P[Y_t | \Omega_{t-1}, V_{1t}, V_{2t}, \ldots, V_{kt}] \quad (5)$$
$$= P[Y_t|\Omega_{t-1}] + P\{Y_t - P[Y_t|\Omega_{t-1}] | V_{1t} - P[V_{1t}|\Omega_{t-1}], \ldots, V_{kt} - P[V_{kt}|\Omega_{t-1}]\}$$

where Y_t^* represents the conditional forecast of Y_t, and the forecast errors of the bilateral exchange rates are given by $V_{1t}, V_{2t}, \ldots, V_{kt}$. Using the orthogonality property of V_t, equation (5) simplifies to

$$Y_t^* = P[Y_t|\Omega_{t-1}] + P[V_{k+1t}|V_{1t}, V_{2t}, \ldots, V_{kt}] \quad (5)'$$

The second term on the right hand side of equation (5)' is simply a regression equation between the forecast error in income and the forecast errors in the bilateral exchange rates. The Kalman regression equation can be written as:

$$V_{k+1t} = \sum_{i=1}^{k} \phi_i V_{it} + \eta_t \quad (6)$$

where η_t is an error term with zero mean and constant variance and the ϕ_is are the Kalman coefficients which are determined from the solution of the following system of equations:

$$\gamma_{11}\phi = \gamma_{12} \quad (7)$$

where ϕ is a (kxl) vector of Kalman coefficients with typical element ϕ_i, and γ_{ij} is derived from partitioning the variance-covariance matrix γ of the error terms given in (2) as follows:

$$\gamma = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}$$

where γ_{11} has dimension (kxk), γ_{12} has dimension (kxl), γ_{21} has dimension (lxk) and γ_{22} has dimension (lxl).

1/ The Kalman filter technique has been widely used in control theory and more recently in monetary theory (see, for example, LeRoy and Waud (1977), and Mitchell (1982)).

The relationship between the j^{th} optimal weight (λ_j) and the Kalman coefficients can be determined by writing equation (6) as:

$$V_{k+1t} = \sum_{i=1}^{k} \phi_i(e_{it} - P[e_{it}|\Omega_{t-1}]) + \eta_t$$

and without loss of generality solving for e_{1t} gives:

$$e_{1t} = (V_{k+1t} - \eta_t - \sum_{i=1}^{k} P[e_{it}|\Omega_{t-1}])/\phi_1 + \sum_{i=2}^{k}(\phi_i/\phi_1)e_{it} \quad (8)$$

Solving equation (1) for e_{1t} and comparing with equation (8) yields the following relationship between the Kalman coefficients and the weights:

$$\lambda_j = \frac{\phi_j}{\sum_{i=1}^{k}\phi_i} \qquad j = 1, 2, \ldots, k \quad (9)$$

It is clear from equation (9) that the weights are related to the reduced-form parameters of the econometric model via the Kalman coefficients. In general, the larger the Kalman filter coefficient on a particular control variable, the greater the weight placed on that variable because of its relatively greater contribution to improving the predictability of the target variable. For example, in the limiting case of an exchange rate index that is composed of two bilateral exchange rates where $\lambda_1 = 1$ and $\lambda_2 = 0$, the domestic exchange rate is fixed to the currency of country 1, implying that movements in the exchange rate with the second country can be ignored for the purposes of obtaining improved forecast estimates of the target variable.

III. Theoretical Application

In the above analysis, the optimally weighted exchange rate basket was interpreted as an indicator of movements in a target variable. In this section, we show how the weighted variable may also be interpreted as an optimal currency basket, i.e., as an instrument of stabilization policy within a structural model.

The structural model that is specified is based on a simplified version of Turnovsky's model and the optimal currency weights are derived and interpreted using the technique discussed in Section II. In this way, the equivalence between the Kalman filter technique used in this study, and the optimal control technique used by Turnovsky can be demonstrated. The structural model is a small open economy that trades goods and bonds with two other countries, countries (1) and (2). Each country produces a single commodity with the domestic good assumed to be an imperfect substitute for the two goods produced overseas. Perfect capital mobility is assumed so that interest parity holds together with static expectations. 1/

The equations of the model are given below.

$$y_t = \alpha p_t \qquad \alpha > 0 \qquad (10)$$

$$y_t = \beta_1(q_{1t} - e_{1t} - p_t) + \beta_2(q_{2t} - e_{2t} - p_t) + \beta_3(r_{1t} - e_t + c_t) + u_{1t} \qquad \beta_1, \beta_2 > 0, \ \beta_3 < 0 \qquad (11)$$

$$c_t = \delta_0 p_t + \delta_1(q_{1t} + e_{1t}) + \delta_2(q_{2t} + e_{2t}) \qquad \delta_0 + \delta_1 + \delta_2 = 1 \qquad (12)$$

$$e_{1t} = u_{2t} \qquad (13)$$

$$e_{2t} = u_{3t} \qquad (14)$$

$$0 = (1-\lambda)e_{1t} + \lambda e_{2t} \qquad (15)$$

where y_t = real domestic output (in logs)

p_t = price of domestically-produced good (in logs)

r_{1t} = nominal interest rate in country 1

q_{it} = price of good produced in country i (in terms of currency of i) (in logs), i = 1,2

e_{it} = current exchange rate between domestic currency and currency of country i, in logs, defined as the number of units of foreign currency per unit of domestic currency (in logs)

c_t = domestic cost-of-living (measured in domestic currency), in logs

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1/ In the model used by Turnovsky (1982, pp. 340-341) a portfolio balance equation is specified. However, since the parameters in this equation do not affect the optimal weights, the portfolio balance equation is excluded from the model in this paper to simplify the results. In the Turnovsky model, rational expectations are assumed; however, if all disturbances are independently distributed over time, $e^E_{1,t+i,t} = e^E_{2,t+i,t} = p^E_{t+i,t} = c^E_{t+i,t}$ i.e. all rationally formed expectations are static and the expression for the real interest rate term is simplified to that given in equation (11).

u_{1t} = stochastic disturbance in demand for domestic output

u_{2t} = stochastic disturbance in bilateral exchange rate between country 1 and domestic country

u_{3t} = stochastic disturbance in bilateral exchange rate between country 2 and domestic country

Equation (10) is an aggregate supply function in which real domestic output is assumed to be a positive function of domestic prices. In equation (11), demand for domestic output is assumed to be a negative function of domestic prices relative to foreign prices of its two trading partners adjusted for exchange rates, and a negative function of the domestic real interest rate. Equation (12) expresses the domestic cost-of-living as a weighted average of domestic and foreign prices expressed in domestic currency. Bilateral nominal exchange rates are assumed to be driven stochastically as given in equations (13) and (14). 1/ Finally, the identity expressing the currency basket is given in equation (15).

Consider the reduced-form of the trivariate system consisting of y_t, e_{1t}, and e_{2t}.

$$y_t = v_{1t} \tag{16}$$

$$e_{1t} = v_{2t} \tag{17}$$

$$e_{2t} = v_{3t} \tag{18}$$

where

$$v_{1t} = k\{x_t + u_{1t} + (\beta_1 + \beta_3\delta_1 - \beta_3)u_{2t} + (\beta_2 + \beta_3\delta_2)u_{3t}\}$$

$$v_{2t} = u_{2t}$$

$$v_{3t} = u_{3t}$$

$$k = \frac{\alpha}{\beta_1 + \beta_2 - \beta_3\delta_0 + \alpha}$$

$$x_t = (\beta_1 + \beta_3\delta_1)q_{1t} + (\beta_2 + \beta_3\delta_2)q_{2t} + \beta_3 r_t$$

1/ Turnovsky (1982, p. 341) uses a relative stochastic exchange rate equation that is obtained by subtracting equation (13) from (14). Since domestic and foreign prices are assumed to be exogenous, movements in nominal and real exchange rates are identical in Turnovsky's model.

The Kalman filter equation is given by:

$$v_{1t} = \phi_1 v_{2t} + \phi_2 v_{3t} + \eta_t \tag{19}$$

where η_t is a stochastic white noise error term, and the Kalman coefficients are determined from the following expressions:

$$\phi_1 = \frac{\sigma_{33}\sigma_{12} - \sigma_{23}\sigma_{13}}{\sigma_{22}\sigma_{33} - \sigma_{23}^2} \tag{20}$$

$$\phi_2 = \frac{\sigma_{22}\sigma_{13} - \sigma_{23}\sigma_{12}}{\sigma_{22}\sigma_{33} - \sigma_{23}^2} \tag{21}$$

where $\sigma_{ij} = E[v_{it}v_{jt}] \; \forall i_{ij}$

From the expressions of the reduced-form error terms, we have:

$$\sigma_{12} = k(\beta_1 + \beta_3\delta_1 - \beta_3)\bar{\sigma}_{22}$$

$$\sigma_{13} = k(\beta_2 + \beta_3\delta_2)\bar{\sigma}_{33}$$

$$\sigma_{23} = 0$$

$$\sigma_{22} = \bar{\sigma}_{22}$$

$$\sigma_{33} = \bar{\sigma}_{33}$$

where $\bar{\sigma}_{ii} = E[u_{it}^2]$ and we have followed Turnovsky and assumed for simplicity that the cross-covariances between the structural disturbances are zero.

Expressing the formulae for the Kalman coefficients in terms of the structural parameters yields:

$$\phi_1 = \frac{\sigma_{12}}{\sigma_{22}} = k(\beta_1 + \beta_3\delta_1 - \beta_3) \tag{22}$$

$$\phi_2 = \frac{\sigma_{13}}{\sigma_{33}} = k(\beta_2 + \beta_3\delta_2) \tag{23}$$

Using equation (9), the expression for the optimal weight is given by

$$\lambda = \frac{\phi_2}{\phi_1 + \phi_2}$$

$$= \frac{k(\beta_2 + \beta_3\delta_2)}{k(\beta_2 + \beta_3\delta_2) + k(\beta_1 + \beta_3\delta_1 - \beta_3)}$$

$$= \frac{\beta_2 + \beta_3\delta_2}{\beta_1 + \beta_2 - \beta_3\delta_0} \qquad (24)$$

where we have used the property $\delta_0 + \delta_1 + \delta_2 = 1$.

Equation (24) shows that the optimal weights are directly related to the Kalman coefficients that measure the responsiveness of the reduced-form "noise" in the target variable (domestic output) to "noise" in the two control variables (bilateral exchange rates). The optimal weights depend upon three types of structural parameters; the elasticity of demand for domestic output with respect to the two relative prices (β_1 and β_2), and the real interest rate (β_3) respectively, and the consumption share elasticities (δ_0, δ_1, and δ_2). 1/ In the special case in which domestic demand for the home good is inelastic with respect to relative prices ($\beta_1 = \beta_2 = 0$), the optimal weight on the bilateral exchange rate between the home country and country 2 equals the ratio of consumption (or import) shares.

An interesting property of the optimal weight is that since the signs of the real interest rate and relative price effects on demand for domestic output are opposite in the equation for the weight λ, negative Kalman coefficients, and hence negative weights can occur. For example, a positive bilateral exchange rate shock may depreciate the domestic currency, increasing domestic demand and output through the relative price effect but this may be more than offset by a fall in domestic output resulting from a rise in real interest rates. If the authorities maintain a fixed currency basket (in terms of domestic currency), and, in response to a disturbance, the currency of one trading partner (country (1)) appreciates against country (2), the domestic authorities will appreciate the domestic currency against country (2) by (λ), and depreciate the domestic currency against country (1) by ($1-\lambda$). A negative weight means that the domestic currency can depreciate against the currencies of both countries 1 and 2.

1/ This is the same expression as that derived in Turnovsky (1982, equation (18)). To derive Turnovsky's more general formula for the weights (Turnovsky, 1982, equation (12)) where disturbances in domestic demand arising from overseas (x_t) are correlated with relative movements in the exchange rate, allow σ_{x2} and σ_{x3} to not equal zero. Defining the relative exchange rate error term as $u_{4t} = u_{3t} - u_{1t}$ and imposing the conditions $\sigma_{x4}/\sigma_{44} = \sigma_{x3}/\sigma_{33} = -\sigma_{x2}/\sigma_{22}$ yields the desired result.

The optimal weights in a currency basket are designed to minimize variability in some policy target and will, in general, depend upon the policy goals of the authorities, the assumed underlying structure of the economy, and the type of shocks affecting the domestic economy. A recent analysis by Edison and Vardal (1985) serves as a useful departure point for summarizing some of the key findings obtained in earlier studies. Edison and Vardal derive a set of optimal currency weights within a model of the trade sector in which exchange rates are set exogenously, and the assumed objective of the authorities is to minimize fluctuations in the production of exports. Their analysis can be viewed as an extension of earlier work by Artus and Rhomberg (1973), Flanders and Helpman (1981), Branson and Katseli (1981, 1982), and Lipschitz and Sundararajan (1980, 1984). As a partial equilibrium model, it may also be interpreted as a special case of the general equilibrium approach adopted by Turnovsky (1982).

The currency basket weights derived by Edison and Vardal are found to be a function of export share weights, and the covariances of domestic prices and foreign prices, and exchange rates. The larger the export share (or the elasticity of trade) between the home country and a given foreign country, and the weaker the relationship between the domestic relative price and the exchange rate, the larger is the weight attached to the currency of that country. The underlying economic rationale is that by assigning a large weight to the currency of that country in the basket, the authorities can stabilize fluctuations in the bilateral exchange rate, and thereby reduce fluctuations in export production. If purchasing power holds between the home country and all its trading partners except one particular country, it is optimal to peg the exchange rate to the currency of that country in order to prevent disturbances in that country from creating export instability. In the limiting case in which all covariances between relative domestic prices and exchange rates are zero, trade weights correspond with optimal basket weights. 1/

In a general equilibrium framework in which exchange rates are endogenously determined by both trade and financial flows, the determination of the optimal weights is more complex. The optimal weights in the Turnovsky model depend upon both real and financial shocks, the underlying structural parameters of the model, and the assumed stabilizing objective of the authorities. Futher extension and sensitivity analysis of Turnovsky's model by Bhandari (1985) shows that trade shares within a general equilibrium model play a relatively minor role in the determination of the optimal weights. Trade weights coincide with the optimal weights in the special case in which the rest of the world consists of trading partners of identical size and parameter values, and the home economy's trade is equally shared with these countries and all price and income elasticities for bilateral trade between each pair of countries are identical.

1/ Case 1 in Edison and Vardal in which relative domestic prices are uncorrelated with exchange rates corresponds with the special case of the Turnovsky model discussed above in which domestic demand for the home good is inelastic with respect to relative prices.

IV. An Empirical Application

1. Determination of the Optimal Weights

In this section, a set of Kalman coefficients and optimal currency weights are derived utilizing the method presented in Section II. To generalize the empirical results, an unconstrained vector autoregression (VAR) system is used to represent the structure of the reduced-form of the model (see Sims (1980)). One advantage of the VAR methodology is that it is unnecessary to specify a particular structural model although sets of exclusionary restrictions can be imposed on the coefficients to classify variables as either exogenous or endogenous. The Kalman filter technique highlights the relative importance of "noise" in bilateral exchange rates that might be utilized to augment the predictability of the target variable. Provided the VAR system includes the equations for all the relevant variables, the informational content of these disturbances can be captured without specifying a structural model.

The variables chosen for inclusion in the VAR system consist of one target (real output), 1/ six control variables (a set of bilateral nominal exchange rates), and three additional variables, domestic money stocks, domestic prices, and foreign prices. 2/ Each equation also contains a constant, a set of seasonal dummy variables and a linear time trend. In contrast to a partial equilibrium trade model, the VAR framework allows exchange rates to be endogenous, and influenced by both real and monetary factors. The VAR system is specified with each variable having a lag length of one quarter. Since the lag length is the same in each equation, this has the advantage that ordinary least squares yields asymptotically efficient parameter estimates (see Sargent (1979)). 3/ All of the data are expressed in logarithms and are filtered by using first differences to render the time series stationary.

1/ For the purpose of illustrating the weighting technique, we have chosen as the target variable real output and as the control or indicator variables nominal exchange rates. If the weighted exchange rate index is viewed solely as an indicator, a more appropriate choice of target variable is nominal income. However, our interest is also in the potential usefulness of the weighted index as an instrument of stabilization policy in which case the instrument available to the authorities is fixing the nominal exchange rate to a basket of currencies. Implicitly, it can be assumed that for short-run policy purposes, domestic and foreign prices adjust fairly slowly.

2/ Because of the absence of quarterly data on real GDP for some countries, an index of industrial or manufacturing production was used (see Appendix 2). Choice of a limited set of bilateral exchange rates is somewhat arbitrary, and based upon the relative importance of bilateral trade with the home country.

3/ The restriction that the lag length is one quarter is to allow for sufficient degrees of freedom.

The estimation strategy that is adopted to derive the optimal weights consists of the following three steps:

(a) Estimation of the VAR system (equation (2)) and derivation of the error terms, V_{it}.

(b) Estimation of the Kalman filter coefficients, ϕ_i, (equation(6)) using the V_{it} error terms.

(c) Derivation of the optimal weights, λ_i, from the Kalman coefficients (equation (9)).

The sample of countries chosen are six developing countries: Malaysia, Singapore, Korea, Indonesia, Sri Lanka, and Thailand estimated over the period 1973(1)-1985(4). Choice of these countries was motivated by several factors. First, with the exception of Indonesia, all countries adopted a currency basket for at least some of the sample period. As shown in Appendix I, Malaysia and Singapore were the most consistent countries in their choice of exchange rate arrangements, adopting a currency basket continuously since 1977. In contrast, Sri Lanka and Indonesia adopted a managed float for much of the period while Korea and Thailand shifted from pegging their exchange rates to the U.S. dollar (1973-1977), to adopting a currency basket from 1981-85 (Korea), and from 1980-81 and 1985-86 (Thailand). 1/ Second, in all countries, domestic stabilization goals are closely related to developments in the trade sector, and hence the adoption of a currency basket that stabilizes output fluctuations is likely to be of considerable interest to the authorities. Third, with the exception of Singapore, these countries are also characterized by relatively undeveloped capital markets, and hence the portfolio behavior of private speculators can be ignored.

The optimal weights for the exchange rate indices of each country are presented in Table 1 below. As noted earlier, these weights may be positive or negative, and thus the relative importance of a particular currency in the index is measured by the absolute magnitude of its weight. In particular, the results support the general prediction noted earlier; namely that optimal weights are unlikely to correspond to bilateral trade weights. 2/

2. Properties of the optimally-weighted exchange rate indices

The usefulness of the weighted index as an indicator of output movements upon whether a sizeable reduction in forecast output variance

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1/ The implications of shifts in policy regime for the stability of the weights are discussed in subsection 3.

2/ In Table 1, bilateral trade weights are adjusted to sum to unity. Trade weights with the six partner countries represent between 60 percent to 70 percent of a trade-weighted exchange rate that includes all trading partners.

Table 1. Currency Weights 1/ 2/

Trading Partners	Sri Lanka Optimal Weight	Sri Lanka Trade Weight	Thailand Optimal Weight	Thailand Trade Weight	Indonesia Optimal Weight	Indonesia Trade Weight	Korea Optimal Weight	Korea Trade Weight	Malaysia Optimal Weight	Malaysia Trade Weight	Singapore Optimal Weight	Singapore Trade Weight
United States	1.69	0.18	1.79	0.31	-0.42	0.19	14.46	0.41	-0.51	0.28	-0.01	0.36
United Kingdom	-2.35	0.25	-0.35	0.07	-0.15	0.03	-0.38	0.04	0.33	0.09	-0.11	0.09
Germany, Fed. Rep.	0.0	0.11	-3.28	0.11	0.38	0.08	-0.02	0.08	-0.93	0.11	-0.15	0.11
Japan	-0.54	0.27	-1.12	0.39	1.21	0.45	-9.37	0.38	0.39	0.34	0.19	0.30
Hong Kong			0.19	0.07			0.0	0.05				
Singapore	0.61	0.09	3.75	0.05	-1.89	0.19			2.93	0.11		
Australia					1.89	0.06	-3.69	0.04	-1.21	0.07	0.18	0.05
Malaysia											0.89	0.09
India	1.61	0.11										

1/ Optimal weights are estimated over the sample periods: Thailand (1973(3)-85(4)); Indonesia (1983(1)-85(4)); Korea (1973(1)-85(2)); Malaysia (1973(1)-85(4)); Singapore (1973(1)-85(3)); Sri Lanka (1973(1)-84(4)).

2/ Trade weights are derived from bilateral trade shares normalized to sum to unity. Source: IMF, Direction of Trade Statistics.

can be achieved through the use of the currency basket as a policy instrument. Two "within-sample" tests are used to assess the superiority of the optimally-weighted index, relative to a set of unweighted bilateral exchange rates, and to a trade-weighted exchange rate index derived from bilateral trade weights. The first test estimates the reduction in forecast variance in the target variable that arises from the inclusion of the bilateral exchange rate noise variables in the information set. This test compares the non-optimal output forecast variance that is obtained from the VAR system with the optimal output forecast variance from the Kalman filter regression. The second test compares the optimal output forecast variance from the Kalman filter regression with the forecast variance of output from a smaller VAR system that includes the same set of variables as the larger VAR system except that the six bilateral exchange rates are replaced by the trade-weighted exchange rate index. This test can be interpreted as a measure of the loss of efficiency that results from not using the noise variables in the information set and from aggregation across bilateral exchange rates using trade weights.

The results of these tests are given in Table 2. For all countries, the first test shows a sizeable reduction in output forecast variance of between 9 and 37 percent from the inclusion of the exchange rate noise variables. The second test shows that the use of a trade-weighted exchange rate index results in an efficiency loss of between 20 and 47 percent.

Table 2. Percentage Reduction in Output Forecast Variance of Countries

Country	Test 1	Test 2
Sri Lanka	16.0	27.0
Thailand	23.0	34.0
Indonesia	29.0	36.0
Korea	9.0	20.0
Malaysia	30.0	47.0
Singapore	37.0	43.0

3. Stability of weights

In the event of significant shifts in the nature of disturbances affecting both output and exchange rates, the weights are likely to alter. As noted earlier, all countries, and especially Korea, Thailand and Sri Lanka altered their exchange rate regimes during the sample period. Shifts in policy regimes may also affect the stability of the weights if these shifts alter the behavioral structural coefficients since it has been shown in both sections II and III that the optimal weights are a function of the structural coefficients. From a policy perspective, the difficulty is to isolate the effect on the weights of the change in policy regime from economic disturbances within the period. Ideally, it would be useful to have some idea of how the weights alter in response to the relative importance of different types of shocks. 1/

From an operational perspective, the likelihood of changes in the currency weights means that the Kalman filter technique offers a distinct advantage over "fixed weight" indices since the index can be updated easily to incorporate new information and thereby allow the weights to change over time.

4. Behavior of optimally-weighted exchange rate indices

Chart 1 shows the time paths of the optimally-weighted exchange rate indices compared with indices derived from bilateral trade weights. For three countries, notably Korea, Indonesia, and Sri Lanka, the two indices move fairly closely together after 1977. In particular, the optimally-weighted index lies below the trade-weighted exchange rate index, suggesting a weaker currency. For the remaining three countries, sharp movements in the trade-weighted exchange rate index, especially an appreciation in the index in 1974(4) and a subsequent depreciation in 1978(2) and 1979(2) are amplified in the optimally-weighted index.

V. Conclusions and Policy Implications

The purpose of this study has been to derive and estimate an optimally-weighted exchange rate index within a general equilibrium model. The optimal weights are designed to minimize the forecast variance of a target variable and are constructed using a Kalman filter technique that captures the informational contribution of current shocks to bilateral exchange rates. The optimal weights were also shown to be equivalent to the weights derived from optimal control theory. This was demonstrated in Section II in which we applied the Kalman filter approach to deriving a set of weights using a simplified version of Turnovsky's (1982) model. A further advantage of the optimal weights is that they can be fairly easily derived and updated.

The optimal weights were estimated for a group of Asian developing countries using the Kalman filter technique outlined in Section II within a vector autoregression system in which real output was assumed to be the target variable. The empirical results show that in general the optimal weights do not correspond with bilateral trade weights. The two tests that were conducted demonstrated the informational superiority of the optimally-weighted exchange rate index relative to a trade-weighted exchange rate index.

1/ This is the subject of future investigation.

The optimally-weighted exchange rate indices have a dual significance for policy. First, these indices may serve as economic indicators and may be used to improve forecasts of an unobserved target variable for the current period. Weighted exchange rates constructed in the above manner may be particularly useful to policymakers when the target variable is real or nominal income that is observed at less frequent intervals than an intermediate target such as exchange rates. Further, the use of the Kalman filter technique enables the continuous updating of new information, allowing the computation of flexible weights.

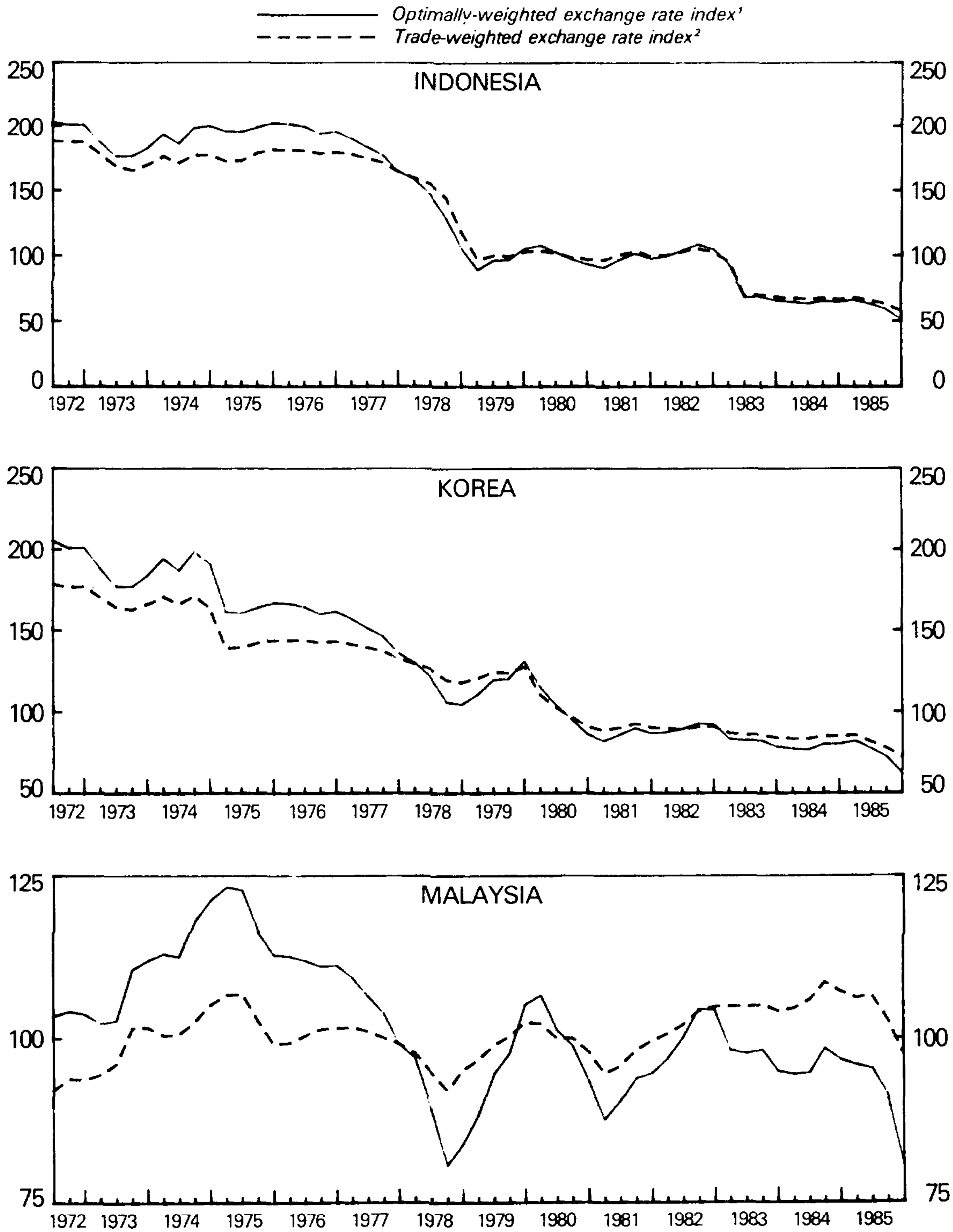
There is a further potential application of the optimally-weighted exchange rate variable that is of more direct operational significance. Within a structural model, the weights constructed using the Kalman filter technique are equivalent to weights derived from optimal control theory. Hence, the same technique can be used to construct the weights for an optimal currency basket within a general equilibrium model. It needs to be recognized, however, that the weights derived in Section III are estimated from an unconstrained VAR framework that may correspond to a number of structural models. An interpretation of the weighted exchange rate index as an optimal currency basket instrument that has usefulness for stabilization policy would require that either the weights be estimated within a structural model (or constrained VAR system), or a demonstration of the precise conditions under which the derived currency basket is superior to an alternative set of weighted control variables in stabilizing output.

The construction of an optimal currency basket within a general equilibrium framework using a Kalman filter technique may offer a number of advantages in designing stabilization policy. First, the use of a general equilibrium approach enables the exchange rates to be endogenous, thereby allowing the direction and magnitude of exchange rate movements to respond to systematic influences and unanticipated shocks. Second, a shift in policy regime may alter the structural parameters and cause the optimal weights to change. This means that it is unlikely that the weights for a currency basket estimated over a given sample period can be assumed to be "fixed" for new sample periods. This need for flexibility in the weights is automatically achieved in computing optimal weights since structural shifts will result in larger prediction errors in variables, and this is translated into changes in the weights. A disadvantage of using the optimal weights to policymakers is they may prefer fixed trade weights; however, these weights are not tied to policy goals and are unlikely to correspond to optimal weights.

CHART 1

OPTIMALLY-WEIGHTED EXCHANGE RATE INDEX AND BILATERAL TRADE-WEIGHTED EXCHANGE RATE INDEX, 1972:Q2 to 1985:Q4

(1980 = 100)



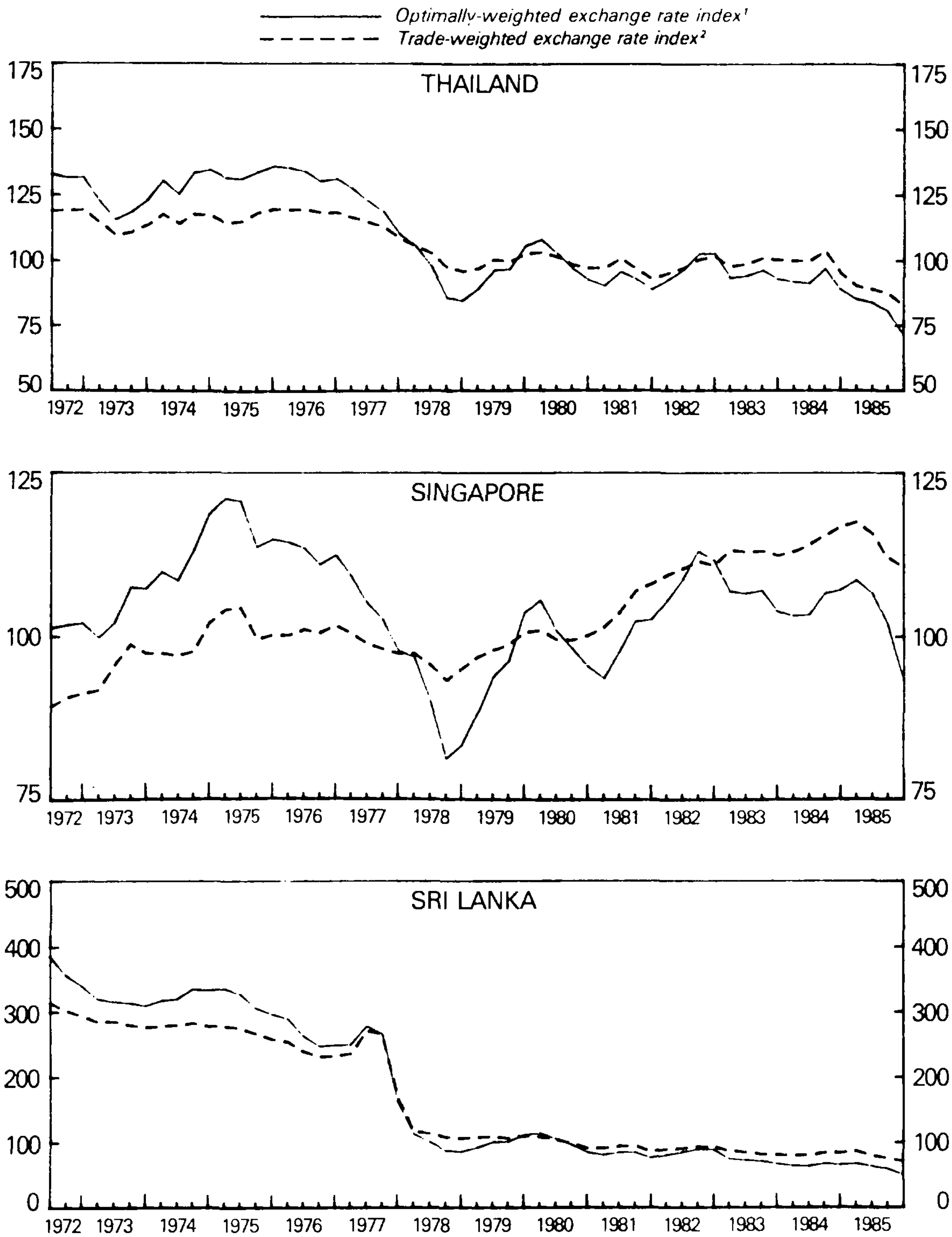
1 Estimated series

2 Trade weights derived from bilateral trade shares normalized to sum to unity.

CHART 1 (concluded)

OPTIMALLY-WEIGHTED EXCHANGE RATE INDEX AND BILATERAL TRADE-WEIGHTED EXCHANGE RATE INDEX, 1972:Q2 to 1985:Q4

(1980 = 100)



[1] Estimated series

[2] Trade weights derived from bilateral trade shares normalized to sum to unity

Exchange Rate Arrangements of Indonesia, Korea, Malaysia, Singapore, Sri Lanka and Thailand; 1971-1986

Year	Exchange Rate Arrangement			
	Pegged to U.S. dollar	Currency Basket	Managed Float or Float	Other
1971/72	All countries			
1973	Korea, Indonesia, Sri Lanka			Thailand 1/
1974	Korea, Indonesia Sri Lanka, Thailand		Malaysia, Singapore	
1975	Korea, Indonesia Thailand		Malaysia, Singapore Sri Lanka	
1976	Korea, Indonesia Thailand		Malaysia, Singapore Sri Lanka	
1977	Korea, Indonesia Thailand	Malaysia, Singapore, Sri Lanka		
1978	Korea	Malaysia, Singapore, Thailand	Sri Lanka, Indonesia	
1979	Korea	Malaysia, Singapore, Thailand	Sri Lanka, Indonesia	
1980		Malaysia, Singapore, Thailand	Korea, Indonesia, Sri Lanka	
1981		Malaysia, Korea, Singapore, Thailand	Sri Lanka, Indonesia	
1982	Indonesia, Thailand	Malaysia, Singapore	Korea, Sri Lanka	
1983	Thailand	Malaysia, Singapore, Korea	Indonesia, Sri Lanka	
1984		Malaysia, Singapore, Korea	Indonesia, Sri Lanka	Thailand 2/
1985		Malaysia, Singapore, Korea, Thailand	Indonesia, Sri Lanka	
1986		Malaysia, Singapore, Thailand	Korea, Indonesia, Sri Lanka	

Sources: International Monetary Fund, Annual Reports of the Executive Board, 1971-1986.

1/ Pegged to French franc.

2/ Limited flexibility vis-a-vis U.S. dollar.

Data Base

Bilateral nominal exchange rates: IMF, International Financial Statistics, line ae.

Domestic money stock: IMF, International Financial Statistics, line 34.

Domestic and foreign prices: IMF, International Financial Statistics, line 64.

Real output:

Indonesia: index of crude petroleum production (1980=100), IMF, International Financial Statistics, line 66aa

Korea: quarterly GDP (1980 prices), staff estimates

Malaysia: index of industrial production (1980=100), IMF, International Financial Statistics, line 66

Singapore: index of manufacturing production (1980=100), IMF, International Financial Statistics, line 63 ey

Sri Lanka: annual GDP (1980 prices) spread over four quarters, staff estimates

Thailand: annual GDP (1980 prices) spread over four quarters, staff estimates

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