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Review of Exchange Market Pressure Indices

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Abstract: *In this paper, we reviewed empirical exchange market pressure indices. The objective was to find out similarities and differences among them in terms of their components and weights assigned to them. The review shows that apart from Girton and Roper (1977) rest of three pressure indices are model dependent. However, they require estimation of different number of parameters for assigning weight to their components. Roper and Turnovsky (1980) require estimation of six parameters. Weymark (1995) and Pentecost et al. (2001) on the other hand requires estimation of two and one parameter for assigning weight to foreign exchange reserve and relative interest rate differential component of market pressure index.*

Keywords: *Central Bank, monetary policy reaction function, interest rate, domestic credit, foreign exchange reserves.*

1.0 Introduction

Prior to Girton and Roper (1977, hereafter GR) seminal paper, Whitman et al. (1975) argued that under managed float effective exchange rate and foreign exchange reserve changes reflect the extent of money market disequilibrium although no one has yet constructed a single composite index that measures it. GR (1977) derived such measure of market pressure and named it exchange market pressure.

Exchange market pressure reflects excess demand for domestic currency in foreign exchange market. It could either be positive or negative. Higher demand for domestic currency in foreign exchange market is consistent with its appreciation against foreign currency. Negative demand on the other hand is associated with domestic currency losing its value against foreign currency. There are two approaches to estimate exchange market pressure namely model dependent and model independent. Model dependent approach utilizes stochastic macroeconomic economic model for deriving either the components of exchange market pressure or weights assigned to them. Model independent approach on the other hand, does not require estimation of stochastic macroeconomic model for deriving weights assigned to the components. In this paper, we review both model independent and model dependent market pressure indices to determine how they compare with each other in deriving components of market pressure or weights assigned to them.

Rest of the paper proceeds as: in section 2 we derive Girton and Roper's (1977) exchange market pressure index using monetary approach to balance of payments. In section 3 Roper and Turnovsky's (1980) exchange market pressure is discussed

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and it is shown how they differ from each other in deriving exchange market pressure components and their weights. In section 3, a stochastic macro model is used to derive Weymark's (1995) market pressure index and it is compared with preceding pressure indices. In section 4, we use wealth augmented monetary model of market pressure for deriving Pentecost et al.'s (2001) market pressure is derived and compared with preceding indices. Section 5 concludes.

2.0 Girton and Roper's (1977) Monetary Model of Exchange Market Pressure

Girton and Roper (1977) used monetary approach to exchange rate determination and monetary approach to balance of payments for deriving their market pressure index. Their focus was to find out independence of Canadian monetary authorities under fixed exchange rate regime. It is based on internal and external monetary conditions and is given as:

$$\Delta m_t^d = p_t + \beta\, y_t - \alpha\, i_t \tag{2.1}$$

$$m_t^s = d_t + f_t \tag{2.2}$$

$$m_t^{d*} = p_t^* + \beta^* y_t^* - \alpha^* i_t^* \tag{2.3}$$

$$m_t^{s*} = f_t^* + d_t^* \tag{2.4}$$

Equation 2.1 is money demand function. It shows that money demand is positively and negatively associated with income and interest rate. Equation 2.3 shows money supply in economy consists of domestic credit (d_t) and foreign component (f_t). Lower case letters and asterisk denotes log form and foreign counterpart of domestic components.

Money market equilibrium implies equality of demand for and supply of money.[4] Taking the difference and equation money demand and money supply results:

$$\Delta m_t^s = \Delta d_t + \Delta f_t = \Delta p_t + \beta\, \Delta y_t - \alpha\, \Delta i_t = \Delta m_t^d \tag{2.5}$$

$$\Delta m_t^{s*} = \Delta d_t^* + \Delta f_t^* = \Delta p_t^* + \beta^* \Delta y_t^* - \alpha^* \Delta i_t^* = \Delta m_t^{d*} \tag{2.6}$$

Subtraction of foreign monetary condition (eqn: 2.6) from their domestic counterparts (eqn: 2.5) results:

$$\Delta m_t^s - \Delta m_t^{s*} = \Delta d_t + \Delta f_t - \Delta m_t^* = \Delta p_t - \Delta p_t^* + \beta \Delta y_t - \beta^* \Delta y_t^* - \alpha \Delta i_t + \alpha^* \Delta i_t^* \tag{2.7}$$

Girton and Roper (1977) did not assume that absolute Purchasing Power Parity holds. Absolute Purchasing Power Parity holds only if deviations from its absolute version are stationary. Non-stationary real exchange rate is consistent with non-holding of absolute version of PPP. Relative version of PPP can be given as:

$$\Delta p_t = \Delta p_t^* + \Delta s_t + \Delta q_t \tag{2.8}$$

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[4] $\Delta d_t = \dfrac{\Delta D_t}{B_{t-1}}$ and $\Delta f_t = \dfrac{\Delta F_t}{B_{t-1}}$ where B_t refers to domestic monetary base.

where Δs_t denotes logged change in nominal exchange rate.[5] Stationary real exchange rate (q_t) imply that changes in nominal exchange and foreign price are equally reflected in domestic prices (Δp_t). Re-write equation 2.8 as:

$$\Delta s_t + \Delta q_t = \Delta p_t - \Delta p_t^* \quad (2.9)$$

Substitution of equation (2.9) in (2.7) and re-arranging the resulting equation yields:

$$\Delta s_t = \Delta q_t - \Delta d_t - \Delta f_t + \Delta m_t^* + \beta \Delta y_t - \beta^* \Delta y_t^* - \alpha \Delta i_t + \alpha^* \Delta i_t^* \quad (2.10)$$

Δq_t will disappear if PPP holds. However, Girton and Roper (1977) assumed deviations from PPP (Δq_t) to be a linear function of domestic credit and foreign money growth (Haache and Townend, 1981):

$$\Delta q_t = \theta \Delta d_t - \theta^* \Delta m_t^* \ \theta, \theta^* \geq 0 \quad (2.11)$$

Substituting of 2.11 for deviation from purchasing power parity in (2.10) and re-arranging the resulting equation yields:

$$\Delta s_t = -(1-\theta)\Delta d_t + (1-\theta^*)\Delta m_t^* - \Delta f_t + \beta \Delta y_t - \beta^* \Delta y_t^* - \alpha \Delta i_t + \alpha^* \Delta i_t^* \quad (2.12)$$

It is evident from the above equation that domestic component of money supply (Δd_t) and foreign money supply (Δm_t^*) are no longer minus and plus unity. Δf_t is still minus unity because θ is unrelated to part of growth in money supply those results from foreign exchange reserve changes (Haache and Townend, 1981). Hence 2.13 can be written as:

$$\Delta s_t + \Delta f_t = -(1-\theta)\Delta d_t + (1-\theta^*)\Delta m_t^* + \beta \Delta y_t - \beta^* \Delta y_t^* - \alpha \Delta i_t + \alpha^* \Delta i_t^* \quad (2.14)$$

Sum of exchange rate and foreign exchange reserve changes appearing on left-hand side of equation 2.15 measure exchange market pressure ($\Delta s_t + \Delta f_t$) without estimating any structural macro model. Assuming perfect capital mobility holds and is given as:

$$\Delta s_{t+1} = \Delta i_t - \Delta i_t^* = -\delta \Delta d_t + \delta^* \Delta m_t^* \quad (2.15)$$

Equation 2.15 is a parity condition and shows that differential between domestic and foreign interest rate is fully reflected in expected exchange rate units.[6] Substitution of 2.15 in (2.14) and rearrangement of resulting equation gives:

$$\Delta s_t + \Delta f_t = -(1-\delta-\theta)\Delta d_t + (1-\delta^* - \theta^*)\Delta m_t^* + \beta \Delta y_t - \beta^* \Delta y_t^* \quad (2.16)$$

Assuming that: $\phi_1 = (1-\delta-\theta)$ and $\phi_2 = (1-\delta^* - \theta^*)$. Substituting these values for coefficients of Δd_t and Δm_t^* yields Girton and Roper's (1977) equation of exchange market pressure:

$$\Delta s_t + \Delta f_t = -\phi_1 \Delta d_t + \phi_2 \Delta m_t^* + \beta_1 \Delta y_t - \beta_2 \Delta y_t^* + v_t \quad (2.17)$$

$\Delta s_t + \Delta f_t$ in equation 2.17 denotes Girton and Roper's (1977) Exchange Market Pressure index. It is applicable to all exchange rate regimes. Under free float foreign exchange reserve changes are held constant ($\Delta f_t = 0$)) and entire pressure is absorbed by exchange rate changes (Δs_t >0). Under fixed exchange rate regime,

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[5] Nominal exchange rate refers to number of units of domestic currency per unit of foreign currency. Hence a rise in the exchange rate denotes the depreciation of domestic currency

[6] Violation of perfect capital mobility provides opportunity to foreign exchange arbitrageurs to make profit.

foreign exchange reserve changes absorb entire pressure $(\Delta f_t > 0)$ and exchange rate is held fixed (Δs_t >0). Under managed float, both exchange rate and foreign exchange reserves changes restore foreign exchange market equilibrium.
Equation 2.17 further show that an increase in domestic credit (Δd_t) and foreign income (Δy_t^*) either decrease the value of domestic currency or reduces the country's foreign exchange reserves or both and hence increases pressure. A rise in domestic income or foreign money, on the other hand, either increase value of domestic currency against foreign currency in foreign exchange market or increase foreign exchange reserves of the country or both under managed float. Furthermore, GR assigns equal weight to both components of market pressure. Hence it does not require estimation of any macro model for deriving components of market pressure or weights assigned to them. It can easily be constructed by simply summing up exchange rate and foreign exchange reserve changes.

3.0 Roper and Turnovsky's (1980) Model of Exchange Market Pressure

Contrary to GR (1977), Roper and Turnovsky (1980) derived optimum trade-off that faced by monetary authorities between foreign exchange reserve and exchange rate changes when stabilizing output in stochastic IS-LM frame work that includes foreign sector. It is given as:

$$y_t = b_1 y_t - b_2 i_t - b_3 s_t + u_{1t} \quad (3.1)$$

$$m_t = a_1 y_t - a_2 i_t + u_{2t} \quad (3.2)$$

$$i_t = i_t^* + E_t \Delta s_{t+1} \quad (3.3)$$

$$E_t \Delta s_{t+1} = \theta(\bar{S} - S_t) \qquad 0 \leqq \theta \leqq 1 \quad (3.4)$$

New variables included in the model are equilibrium exchange rate level ($\bar{S}$) and next period expected exchange rate level (s_{t+1}). $u_{1t} = u_{2t} = v_t$ are stochastic disturbances. Δ Refers to first difference operator. All parameters in eqn. (3.1) are assumed positive with b_1 satisfying additional restriction $0 < b_1 < 1$. Equation 3.2 explains domestic money market equilibrium conditions. It shows that domestic nominal money balances (m_t) are positively and negatively correlated with domestic income and interest rate respectively. Equation 3.3 is perfect capital mobility and states equates domestic interest rate to foreign interest rate (i_t^*) plus expected exchange rate changes ($E_t \Delta s_{t+1}$).Evolution of expected exchange rate is given in eqn. (3.4). It indicates that if current spot exchange rate is above the long-term equilibrium rate then one period ahead exchange rate is expected to depreciate and vice versa.
Given deviations from equilibrium exchange rate ($s_t = \bar{S} - S_t$); we can write eqn. (3.4) as $E_t \Delta S_{t+1} = \theta s_t$. This expression of expected exchange rate changes enables us to write eqn. (3.3) as

$$i_t = i_t^* + \theta s_t \quad (3.5)$$

Substitution of eqn. (3.5) in and rearrangement of resulting equation yields:

$$y_t = \frac{-b_2 i_t^* - b_2\theta s_t - b_3 s_t + u_{1t}}{(1-b_1)} \tag{3.6}$$

Similarly substitution of interest rate expression $i_t = i_t^* + \theta s_t$ in equation (3.2) and rearrangement of resulting equation results:

$$m_t = a_1 y_t - a_2 i_t^* - a_2\theta s_t + u_{2t} \tag{3.7}$$

Solving (3.6) and (3.7) for m_t:

$$m_t = \frac{-a_1 b_2 i_t^* - a_1 b_2 \theta s_t - a_1 b_3 s_t + a_1 u_{1t})}{(1-b_1)} - a_2 i_t^* - a_2\theta s_t + u_{2t} \tag{3.8}$$

Re-arranging above equation yields:

$$m_t = -\left[\frac{a_1(b_3 + b_2\theta)}{(1-b_1)} + a_2\theta\right] s_t - \frac{(a_1 b_2 + a_2) i_t^*}{(1-b_1)} + a_1 u_{1t} + u_{2t} \tag{3.9}$$

Negative exchange rate in 3.9 confirms that monetary authorities can change exchange rate by changing foreign exchange reserves against domestic currency (decreasing m_t).Eqn (3.9) can be re-written as

$$\left[\frac{a_1(b_3 + b_2\theta)}{1-b_1} + a_2\theta\right] s_t = m_t - \frac{(a_1 b_2 + a_2) i_t^*}{(1-b_1)} + a_1 u_{1t} + u_{2t} \tag{3.10}$$

$$s_t = -\frac{(1-b_1)}{a_1(b_3 + b_2\theta) + a_2\theta} m_t - \frac{(a_1 b_2 + a_2) i_t^*}{(1-b_1)} + a_1 u_{1t} + u_{2t} \tag{3.11}$$

Hence Roper and Turnovsky's model yields model-dependent Exchange Market Pressure given as: $EMP_t = \Delta s_t + \eta \Delta m_t$

where $\partial \Delta s_t / \partial \Delta m_t = \eta$ and $-\dfrac{(1-b_1)}{a_1(b_3 + b_2\theta) + a_2\theta}$

Contrary to GR (1977) that assigns equal weight to exchange rate and foreign exchange reserves changes, Roper and Turnovsky's model requires estimating six parameters from IS-*LM* model for assigning weight to foreign exchange reserve component of exchange market pressure index.

These include income elasticity of money demand a_1, interest elasticity of money demand a_2, output sensitivity to its own level b_1, interest elasticity of domestic output b_2, output sensitivity to exchange rate changes b_3 and exchange rate deviation from its long-run equilibrium level θ. This ensures that exchange market pressure index is not weighted by more volatile component.

4.0 Weymark's (1995) Model

Weymark (1995) developed a small open economy model that consists of nominal money demand, price equation, uncovered interest rate parity, money supply process and monetary authority response function to exchange rate fluctuations for constructing exchange market pressure. It is given as:

$$m_t^d = p_t + b_1 y_t - b_2 i_t + v_t \tag{4.1}$$

$$p_t = a_0 + a_1 p_t^* + a_2 s_t \quad (4.2)$$

$$i_t = i_t^* + E_t S_{t+1} - s_t \quad (4.3)$$

$$m_t^s = m_{t-1}^s + \Delta d_t + \Delta f_t \quad (4.4)$$

$$\Delta f_t = -\bar{\rho}_t \Delta s_t \quad (4.5)$$

New variables introduced in this model are inherited money stock (m_{t-1}^s) and policy authority's time invariant response coefficient ($\bar{\rho}_t$). The asterisk denotes foreign counterparts of domestic variables. Small letters denote that all variable used are in logarithms. The notation $E_t s_{t+1}$ represents rational agents' expected value of exchange rate one period ahead based on the information currently available.

Equation 4.1 is money demand (m_t^d). It shows that money demand is positively and negatively associated with income (y_t) and interest rate (i_t) respectively. Similarly, equation 4.2 shows that any change in nominal exchange rate (s_t) and foreign price (p_t^*) is fully reflected in domestic prices. However, absolute version of purchasing power parity is assumed not to hold as it allows for systematic deviation given by a_0. Equation (4.3) is uncovered interest rate parity which indicates that domestic interest rate is determined by foreign interest after adjustments for the expected change in exchange rate. Equation (4.4) shows that inherited money stock (m_{t-1}^s), domestic component of monetary base, namely domestic credit ($\Delta d_t = \frac{\Delta D_t}{B_{t-1}}$) and foreign exchange reserves ($\Delta f_t = \frac{\Delta F_t}{B_{t-1}}$) determine current money supply. B_t is domestic monetary base. Money multiplier is assumed constant and intervention is assumed unsterilized.[7] Equation 4.5 is monetary authorities' response to exchange rate movements. Negative sign indicate that the Central Bank smooth exchange rate changes by selling and purchasing foreign exchange reserves. It purchases foreign exchange reserves (Δf_t>0) when there is appreciating pressure on domestic currency in foreign exchange market (i.e. $\Delta s_t < 0$) and vice versa. It ranges between $0 \le \bar{\rho}_t \le \infty$. $\rho_t = \infty$ is consistent with fixed exchange rate regime. $\rho_t = 0$ in free float regime and $0 < \rho_t < \infty$ for intermediate exchange rate system. In practice monetary authority's response function ρ_t is time-varying. The Central Bank may not intervene each time domestic currency is under pressure. There is possibility that monetary authorities may abstain from intervening in foreign exchange market and allow exchange rate to absorb entire pressure. In such a case, the monetary authority's response function equals zero ($\rho_t = 0$). ρ_t>0 is consistent with the Central Bank leaning against the wind and purchases foreign exchange reserves when there is already depreciating pressure on domestic currency. ρ_t<0 occurs

[7]Unsterilized intervention implies that Central Bank does not offset the effects of the purchase and sale of foreign exchange reserves on monetary base.

when the monetary authority leans with wind – that is, the Central Bank purchases foreign exchange reserves ($\Delta f_t > 0$) when domestic currency is already under pressure to depreciate ($\Delta s_t > 0$) and vice versa. Substitution of equation 4.2 in 4.1 yields

$$m_t^{\,d} = a_0 + a_1 p_t^{\,*} + a_2 s_t + b_1 y_t - b_2 i_t + v_t \qquad (4.6)$$

Substitution of equation 4.3 in 4.6 and rearranging the resulting equation gives:

$$m_t^{\,d} = a_0 + a_1 p_t^{\,*} + (a_2 + b_2) s_t + b_1 y_t - b_2 (i_t^{\,*} + E_t s_{t+1} - s_t) + v_t \qquad (4.7)$$

Continuous money market equilibrium results:

$$\Delta d_t - \bar{\rho}_t \Delta s_t = a_1 \Delta p_t^{\,*} + (a_2 + b_2)\Delta s_t + b_1 \Delta y_t - b_2 \Delta i_t^{\,*} - b_2 \Delta E_t s_{t+1} + \Delta v_t \qquad (4.8)$$

Above equation indicate that exchange rate change required to restore money market equilibrium subsequent to exogenous disturbance also depend on monetary authority's response function $\bar{\rho}_t$. Sources of exogenous disturbance are changes in foreign price, domestic income, foreign interest rate, domestic credit, expectation about future exchange rate change, and random money demand shock (Δv_t).

Re-arranging equation 4.8 gives:

$$\Delta s_t = \frac{1}{-(\bar{\rho}_t + a_2 + b_2)} \left[a_1 \Delta p^* + b_1 \Delta y_t - b_2 \Delta i_t^{\,*} - \Delta d_t + v_t - b_2 \Delta E_t s_{t+1} \right] \qquad (4.9)$$

$$\Delta s_t = \frac{1}{\beta_t} \left[X_t - b_2 \Delta E(s_{t+1}) \right]$$

Where $\beta = -[\bar{\rho}_t + a_2 + b_2]$ and $X_t = \left[a_1 \Delta p_t^{\,*} + b_1 \Delta y_t - b_2 \Delta i_t^{\,*} + v_t - \Delta d_t \right]$

Equation (4.9) shows that excessive demand for money $EDM_t = \left[a_1 \Delta p^* + b_1 \Delta y_t - b_2 \Delta i_t^{\,*} + v_t - \Delta d_t \right]$ or agents' expectations about future exchange rate changes $b_2 \Delta E_t S_{t+1} > 0$ or both may cause exchange rate to change. Actual exchange rate also depends on the Central Bank response function ($\bar{\rho}_t$) and on exchange rate (a_2) and interest rate (b_2) sensitivity of money demand. EDM_t also suggests that an increase in domestic credit will not increase pressure on domestic currency if it is accompanied with increase in demand for domestic monetary aggregates.

Re-arranging equation 2.48 yields:

$$(\bar{\rho}_t + a_2 + b_2)\Delta s_t = -[a_1 \Delta p_t^{\,*} + b_1 \Delta y_t - b_2 \Delta i_t^{\,*} - \Delta d_t + v_t - b_2 \Delta E_t s_{t+1}]$$

$$\bar{\rho}_t \Delta s_t + (a_2 + b_2)\Delta s_t = -[a_1 \Delta p_t^{\,*} + b_1 \Delta y_t - b_2 \Delta i_t^{\,*} - \Delta d_t + v_t - b_2 \Delta E_t s_{t+1}]$$

Substitution of $-\bar{\rho}_t \Delta s_t = \Delta f_t$ from equation 4.5 and re-arranging the resulting equation yields:

$$(a_2 + b_2)\Delta s_t = [a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* - \Delta d_t + v_t - b_2 \Delta E_t s_{t+1} + \Delta f_t] \qquad (4.10)$$

Multiplication of both sides of equation (2.10) by $\frac{1}{a_2 + b_2}$ yields:

$$\Delta s_t = \frac{-[a_1 \Delta p_t^* + b_1 \Delta y_t - b_2 \Delta i_t^* + v_t - \Delta d_t - b_2 \Delta E s_{t+1} + \Delta f_t]}{a_2 + b_2} \quad (4.11)$$

Exchange rate elasticity with respect to foreign exchange reserves in eqn. (4.11) is given as:

$$\eta = -\frac{\partial \Delta s_t}{\partial \Delta f_t} = \frac{-1}{a_2 + b_2} \quad (4.12)$$

Thus Weymark (1995) model dependent Exchange Market Pressure can be given as:

$$EMP_t = \Delta s_t + \eta \Delta f_t \quad (4.13)$$

The construction of Weymark (1995) exchange market pressure index requires η which further requires estimates of interest rate elasticity of real money demand (b_2) and exchange elasticity of domestic price (a_2). Contrary to Roper and Turnovsky (1980) model that requires estimating six parameters, Weymark's (1995) Exchange Market Pressure index estimates of two parameters namely interest sensitivity of money demand and exchange rate elasticity of domestic prices for its construction.

5.0 An Alternative Exchange Market Pressure Model

Pentecost et al. (2001) also followed model dependent approach and used short-term wealth augmented monetary model of foreign exchange market for deriving their Exchange Market Pressure index. The model assumes imperfect asset substitutability, violation of purchasing power parity and non-bank financial wealth as sole determinant of demand for all assets. The model in log linear form is given as: $\Delta m_t - \Delta p_t = \alpha \Delta y_t + \varphi \Delta w_t + \beta \Delta i_{mt} - \gamma \Delta i_t - \delta \Delta i_t^*$ (5.1)

Where α, φ and $\beta > 0$ and γ and $\delta < 0$.

w_t is non-bank private sector wealth and i_{mt} is own short-term interest rate on nominal money balances. Positive association between real money demand and its own interest rate reflect the fact that money held in form of bank deposits earns low but positive interest rate.

Money supply in economy is determined by domestic credit and foreign exchange reserve changes. Assuming unity multiplier, we can write money supply as:

$$\Delta m_t = \Delta d_t + \Delta f_t \quad (5.2)$$

Money market equilibrium condition requires equality of demand for and supply of money and can be written as:

$$\Delta m_t = \Delta d_t + \Delta f_t = \Delta p_t + \alpha \Delta y_t + \beta \Delta i_{mt} + \varphi \Delta w_t - \gamma \Delta i_t - \delta \Delta i_t^* \quad (5.3)$$

Foreign country demand for real money balances is identical to domestic demand for real money balances and is given as:

$$\Delta m_t^* - \Delta p_t^* = \alpha \Delta y_t^* + \beta \Delta i_{m,t}^* + \varphi \Delta w_t^* - \gamma \Delta i_t - \delta \Delta i_t^* \quad (5.4)$$

Domestic bonds are assumed closer substitutes of domestic real money balances than their foreign counterparts. This ensures that domestic interest rate elasticity of real money balances is greater than foreign interest rate $\gamma > \delta$.

Nominal exchange rate that links domestic and foreign money market is given as:

$$S_t = Q_t\left(\frac{P_t}{P_t^*}\right) \tag{5.6}$$

According to eqn. (5.6) nominal exchange rate is simply real exchange rate multiplied by domestic to foreign price ratio. Real exchange rate is exogenous and is determined by real factors. Hence 5.6 can be written as:

$$\Delta s_t = \Delta p_t - \Delta p_t^* + \Delta q_t \tag{5.7}$$

Violation of purchasing power parity (PPP) is allowed in eqn. (5.7)

Differential growth in relative output changes results changes in real money demand which in turn is determined by real exchange rate and relative interest rate differential changes. This relationship can be written as:

$$(\Delta y_t - \Delta y_t^*) = \psi\Delta q_t - \lambda(\Delta i_t - \Delta i_t^*) \tag{5.8}$$

Solving equation (5.3) for Δp_t yields:

$$\Delta p_t = \Delta d_t + \Delta f_t - \alpha\Delta y_t - \beta\Delta i_{mt} - \varphi\Delta w_t + \gamma\Delta i_t + \delta\Delta i_t^* \tag{5.9}$$

Similarly, the solution of (5.4) for Δp_t^* yields

$$\Delta p_t^* = \Delta m_t^* - \alpha\Delta y_t^* - \beta\Delta i_{m,t}^* - \varphi\Delta w_t^* + \delta\Delta i_t + \gamma\Delta i_t^* \tag{5.10}$$

Subtracting 5.10 from 5.9 and re-arranging resulting equation yields:

$$\Delta p_t - \Delta p_t^* = \Delta d_t + \Delta f_t - \alpha\Delta y_t - \beta\Delta i_{m,t} - \varphi\Delta w_t + \gamma\Delta i_t + \delta\Delta i_t^* - \Delta m_t^* + \alpha\Delta y_t^* + \beta\Delta i_{m,t}^* + \varphi\Delta w_t^* - \gamma\Delta i_t^* - \delta\Delta i_t$$

Substituting equation (5.7) for nominal exchange rate in the above equation and re-arranging the resulting equation yields:

$$\Delta s_t - \Delta f_t = (\Delta d_t - \Delta m_t^*) - \alpha(\Delta y_t - \Delta y_t^*) - \beta(\Delta i_{m,t} - \Delta i_{m,t}) - \vartheta(\Delta w_t - \Delta w_t^*) + (\delta - \gamma)(\Delta i_t^* - \Delta i_t) + \Delta q_t$$

Substituting equation 5.8 in the above equation and its re-arrange results:

$$\left[\Delta s_t + \beta(\Delta i_{m,t} - \Delta i_{m,t}^*) - \Delta f_t\right] = (\Delta d_t - \Delta m_t^*) + (1 - \alpha\psi)\Delta q_t + (\alpha\lambda + \gamma - \delta)(\Delta i_t^* - \Delta i_t) - \vartheta(\Delta w_t - \Delta w_t^*) \tag{5.11}$$

Left hand side of eqn. (5.11) is market pressure in wealth-augmented monetary model. It is a simple sum of nominal exchange rate changes, changes in relative interest rate differential and foreign exchange reserve changes. It indicates that the Central Bank can restore foreign exchange market equilibrium using interest rate. Positive sign indicates that the Central Bank can alleviate pressure either by increasing interest, allowing exchange rate depreciation or selling foreign exchange reserve or any combination of all these variables. Equation 5.11 further show that relevant determinants of Exchange Market Pressure in a wealth-augmented monetary model are relative changes in monetary aggregates, real exchange rate changes, relative changes in long-term interest rate differential and relative changes in non-bank private sector wealth.

6.0 Conclusion

This paper reviewed both model dependent and model independent exchange market pressure indices. Market pressure index is called model dependent because either the components or weights assigned to them or both are derived from stochastic macroeconomic model. The objective was to check how market pressure indices differ from each other in terms of their components or weights assigned to them or both.

The review reveals that though GR (1977) pressure index though derived from domestic and foreign monetary condition yet it can be constructed simply by summing up exchange rate and foreign exchange reserve changes. It does not require estimation of any macro model for assigning weights to its components and is therefore, called model independent exchange market pressure index. Contrary to GR (1977) rest of three indices namely Roper and Turnovsky (1980), Weymark (1995) and Pentecost et al. (2001) are model dependent because they require estimation of parameters from macroeconomic model for assigning weight to their weight. Roper and Turnovsky (1980) require estimation of six parameters for assigning weight to foreign exchange reserve components of exchange market Pressure. Similarly, Weymark (1995) requires two parameters to be estimated from macro model for assigning weight to foreign exchange reserve component. Pentecost et al. (2001) need one parameter to be estimated from macro model for assigning weight to relative interest rate differential component. Further, Pentecost et al. (2001) includes interest rate as an additional component of market pressure.

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