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The Role of Information Acquisition and Financial Markets in International Macroeconomic Adjustment

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International macroeconomic adjustment to money supply, aggregate expenditure, and relative demand disturbances is analyzed within a framework which emphasizes the role of information. Agents are unable to directly observe disturbances and may become fully informed about disturbances only by purchasing information. We analyze how relative price and exchange rate adjustment depends on the variances of the underlying disturbances while taking into account the incentive to acquire information. We also discuss the conditions which are necessary to preclude a free-rider problem whereby uninformed agents are able to extract from observation of financial market conditions the exact information of the information buyers.

Macroeconomic adjustment to real and financial disturbances generally depends on the expectation of agents about these disturbances. Consequently, the extent to which agents are able to acquire information about different disturbances at the time their expectations are formed is an important factor influencing the sensitivity of macro variables to disturbances. For example, when agents are confused about the relative magnitudes of monetary and expenditure shocks to the economy, purely monetary shocks can influence real output decisions. The information structure of the economy, *i.e.*, the

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information sets of agents, is thus an important determinant of macroeconomic equilibrium.

The information sets of individual agents in turn depend on the ability of agents to extract information about underlying market disturbances from observation of market conditions and, if possible, by the purchase of information from information suppliers. In this paper we formulate an international macroeconomic model which highlights the role of endogenous information acquisition by agents. This model illustrates how the information structure of the economy influences the adjustment of such variables as the exchange rate and the relative domestic price to various disturbances, as well as how the nature of adjustment influences the incentive to purchase information.

Our framework builds on two strands of literature. As in much of the recent macroeconomic literature, our model is characterized by the property that agents are unable to directly observe or infer from market conditions the exact magnitude of current aggregate disturbances. Phelps (1970) and Lucas (1972, 1973, 1975) first utilized this assumption in their 'island' models of closed-economy macroeconomic adjustment. Grossman and Weiss (1982) formulated a closed-economy macro model in which agents, though situated on islands, could partially infer information about disturbances from observation of interest rates in the domestic financial market.

In the international literature, work involving island models includes papers by Bhandari (1982), Flood and Marion (1982), Kimbrough (1983, 1984), Stockman and Koh (1984), Engle and Flood (1985), Aizenman and Frenkel (1985), and Flood and Hodrick (1985a, 1985b). Only Bhandari (1982) and Flood and Hodrick (1985a), however, capture the role of financial markets in revealing information to agents. In Bhandari's paper it is assumed that while agents may observe the interest and exchange rates, they cannot observe current goods market prices. In Flood and Hodrick it is assumed that agents in the financial market possess superior information about current disturbances which is partially revealed to others through the interest and exchange rates. In contrast to these papers, we do not assume that the asymmetry in the information sets of individual agents is exogenously given. Rather, in our model agents may observe prices in both the goods and financial markets and their information sets are endogenously determined from the decision about whether or not to purchase information about the disturbances they cannot directly observe or fully infer from market conditions.

Another strand of literature on which we build relates to the economics of information markets. Grossman and Stiglitz (1980) consider the implications of allowing agents to purchase information in a financial asset-pricing model. They argue that 'informationally efficient' markets in which asset prices reveal all available information are inconsistent with an incentive to purchase information from information suppliers. Glick and Wihlborg (1985) analyze the purchase of information in an industry model of a goods market in which firms cannot directly distinguish between firm-specific and aggregate cost disturbances at the time production decisions are made. They show that a free-rider problem can arise with the consequence that the information market exists only under specific conditions. Admati and Pfleiderer (1985) demonstrate that a monopolistic information supplier may have to 'contaminate' the information it sells in order for the information market not to break down. We discuss in this paper how macroeconomic adjustment depends on the informational efficiency of financial markets and whether the existence of information suppliers depends on a similar argument.

Our analysis has a bearing on the circumstances surrounding the existence of and demand for forecast advisory services, as for exchange rates. In our framework an advisory service can be interpreted as an information supplier, if through the forecasts it sells it contributes information that otherwise would not be available to agents. We show that a demand for the services of such an information supplier/advisory service will exist if the supplier has a superior ability to assess the disturbances affecting macroeconomic equilibrium and if the free-rider problem alluded to above can be avoided.

The plan of the paper is as follows. In Section I we obtain equilibrium conditions for the domestic goods, money, and bond markets of a small open economy. In this section we assume that a given share of agents in the economy are 'informed' about all current real and financial disturbances, while the remaining share are 'uninformed.' We derive quasi-reduced form expressions for the relative price of the domestic good and for the exchange rate in terms of current disturbances and the perception errors of the uninformed about these disturbances. In Section II we analyze how the expectations of the uninformed and thus their perception errors depend on their ability to partially infer from observation of market conditions information about the underlying disturbances.

The equilibrium share of agents acquiring information by purchase and thereby becoming 'informed' is determined in Section III. In Section IV we discuss how relative price and exchange rate adjustment depend on parameters influencing the share of firms choosing to become informed. These parameters include the relative variances of disturbances, absolute variances, and the variance of a financial market error reflecting the informativeness of financial market conditions about others' expectations. In Section V we discuss factors that may explain why financial markets are not fully informative. Section VI summarizes the results of our analysis.

I. An Open-Economy Model of Goods and Asset Markets

Equilibrium in domestic goods and asset markets is based on the behavior of a large number of rational agents acting as producers in the domestic goods market and as international arbitrageurs, borrowers, and lenders in the financial market. In Section I.A we specify supply and demand equations for domestic output and develop a quasi-reduced form for the relative price (and implicitly production) of the domestic good. In Section I.B asset market conditions are specified, and a quasi-reduced form expression for the nominal exchange rate (and implicitly the domestic interest rate) is derived. The expressions derived in this section are quasi-reduced forms in the sense that they are stated partially in terms of perception errors of disturbances. These errors are not truly exogenous but depend on the disturbances themselves.

At the time agents make production or arbitrage decisions their information sets contain current market prices, including the relative price of domestic output, the exchange rate, and the domestic interest rate. All agents also know the values of any lagged disturbances to the economy. However, agents possess asymmetric information about current disturbances. Specifically, it is assumed that a subset of agents possesses full information about all current disturbances Agents with such full information are termed 'informed.' All remaining agents — referred to as 'uninformed' — lack complete information. Throughout this section (and Section II as well) we treat the share of informed agents as exogenously given. Specifically, we assume that of the large number of agents in the economy, n, a given number, m, of them, $1 \leqslant m \leqslant n$, or equivalently the share λ $(=m/n)$, are informed.

I.A. Goods Market

The supply of domestic output is determined from the rational, expected profit-maximizing behavior of agents acting as producers. All agents operate with identical quadratic cost functions. The production process is assumed to take one period, implying output produced in one period is not sold until the next. Thus, assuming price taking behavior, each agent i determines its level of output at time $t-1$, y^i_{t-1}, by maximizing $E^i_{t-1}\Pi^i_t$, the expected discounted revenue of the sale of this output in period t net of production costs in period $t-1$:

$$\langle 1\rangle \qquad E^i_{t-1}\Pi^i_t = E^i_{t-1}[\delta R_t y^i_{t-1} - k_0 y^i_{t-1} - n(y^i_{t-1})^2/(2k)], \quad k, k_0 > 0, \; i = 1 \ldots n,$$

where R_t is the relative price of domestic output, defined as the domestic price of output divided by the price level (which is a function of the domestic currency prices of domestic and foreign goods); δ is the real discount factor $0<\delta<1$; and E^i_{t-1} denotes the mathematical expectation conditional on information available to agent i at time $t-1$.[1] This information includes all market prices determined at $t-1$, disturbances in previous periods, and, if the agent is informed, current disturbances at time $t-1$.

Note that production costs of the individual agent depend on the total number of agents n. This implies that individual marginal costs, $k_0 + ny^i_{t-1}/k$, are increasing in aggregate output and reflect the presumed existence of an economy-wide scarce factor of production. Aggregate production is accordingly independent of the number of firms. Note also that our specification neglects variations in either individual or aggregate cost conditions. These considerations are addressed in Glick and Wihlborg (1985).

The first-order condition that the discounted expected price equals marginal production costs implies

$$\langle 2\rangle \qquad y^i_{t-1} = (k/n)(\delta E^i_{t-1} R_t - k_0), \qquad i = 1 \ldots n$$

or, in aggregate,

$$\langle 3\rangle \qquad Y_{t-1} = \sum_{i=1}^{n} y^i_{t-1} = k(\delta E^A_{t-1} R_t - k_0),$$

where E^A_{t-1} denotes *average* mathematical expectations at time $t-1$.

Output produced in period $t-1$ is sold in period t. Aggregate demand for the domestic good in period t, Y^d_t, is given by[2]

$$\langle 4\rangle \qquad Y^d_t = (b_0 - R_t + cX_t + \varepsilon_{d,t})/b, \qquad b, b_0, c > 0,$$

where X_t is real aggregate expenditure by agents on all goods, and $\varepsilon_{d,t}$ is a random relative demand disturbance with a white-noise distribution, $\tilde{\varepsilon}_{d,t} \sim N(0,\sigma^2_{\varepsilon d})$. While there are no foreign elements explicitly in this demand expression, the constant b_0 and the demand disturbance term, $\varepsilon_{d,t}$, may be interpreted as including foreign influences. It is also assumed that the foreign relative price sensitivity of demand for domestic output by foreigners is equal to that of domestic agents given by the parameter b.

Aggregate real expenditures are represented as a linear function of current aggregate output, the relative price, and a serially-correlated expenditure disturbance term:[3]

$$\langle 5\rangle \qquad X_t = Y_t + hR_t + w_t, \qquad h > 0,$$

where

$$\langle 6\rangle \qquad w_t = \rho_w w_{t-1} + \varepsilon_{w,t} \qquad 1 \geqslant \rho_w \geqslant 0,$$

and $\varepsilon_{w,t}$ is white noise, $\tilde{\varepsilon}_{w,t} \sim N(0,\sigma^2_{\varepsilon w})$, and is uncorrelated with $\varepsilon_{d,t}$.

Equilibrium in the domestic goods market requires that output produced in period $t-1$ and supplied in period t equals aggregate demand in period t: $Y_{t-1} = Y^d_t$. This condition together with ⟨3⟩, ⟨4⟩, ⟨5⟩, and ⟨6⟩ imply

$$\langle 7\rangle \qquad R_t = [b_0 - bk\delta E^{-1}_{t-1} R_t + c\delta k E^{-1}_t R_{t+1} + c\varepsilon_{w,t} + \varepsilon_{d,t} + c\rho_w w_{t-1} + (b-c)kk_0]/(1-cb)$$

Thus the relative price in period t depends on average expectations in periods $t-1$ and t of the sales price in the respective following period ($E^{-1}_{t-1} R_t$ and $E^{-1}_t R_{t+1}$), on current expenditure and demand disturbances ($\varepsilon_{w,t}$ and $\varepsilon_{d,t}$), and on the lagged expenditure disturbance (w_{t-1}).

We turn next to discussing how expectations by informed and uninformed agents depend on their individual information about market disturbances. At time $t-1$ informed agents ($i = 1 \ldots m$) know $\varepsilon_{w,t-1}$ and $\varepsilon_{d,t-1}$, while at time t they know $\varepsilon_{w,t}$ and $\varepsilon_{d,t}$. Uninformed agents ($i = m+1 \ldots n$) lack this knowledge and must infer the value of current disturbances as best they can by extracting information from observable market conditions at the time their expectations are formed. We defer until the following section the solution to this information inference problem. Instead we now derive a quasi-reduced form expression for the relative price in terms of the current and lagged values of disturbances and of the 'perception errors' of the uninformed about current disturbances.

More specifically, denote by E^U_t and E^I_t the mathematical expectations at any time t of the uninformed and informed, respectively. (Note that within each set of agents all agents are identical and need not be indexed by i.) Denote the perception errors of the uninformed at time t about expenditure and demand disturbances (by definition informed agents have no perception errors) as

$$\langle 8\rangle \qquad \Delta\varepsilon_{w,t} \equiv \varepsilon_{w,t} - E^U_t \varepsilon_{w,t}$$

$$\langle 9\rangle \qquad \Delta\varepsilon_{d,t} \equiv \varepsilon_{d,t} - E^U_t \varepsilon_{d,t}$$

We posit the following expression for the relative price in terms of disturbances and perception errors:

$$\langle 10\rangle \qquad R_t = \bar{R} + B_{r1} w_{t-1} + B_{r2}\varepsilon_{w,t} + B_{r3}\varepsilon_{d,t} + B'_{r1}\,\Delta\varepsilon_{w,t-1} + B'_{r2}\,\Delta\varepsilon_{w,t} + B'_{r3}\,\Delta\varepsilon_{d,t},$$

where $\bar{R}$ is the long-run average relative price and the B_r coefficients depend on the structural parameters of the system in a manner described below.[4] Note that the price expectations of both uninformed and informed agents, when formed rationally, must be consistent with this equilibrium. In the case of the uninformed ⟨8⟩ and ⟨10⟩ imply

$$\langle 11\rangle \qquad E^U_{t-1} R_t = \bar{R} + B_{r1} E^U_{t-1} w_{t-1} = \bar{R} + B_{r1} w_{t-1} - B_{r1}\,\Delta\varepsilon_{w,t-1},$$

since the expected perception error of all uninformed agents as well as the expected level of all future unserially correlated disturbances are zero. The fully informed firms know all current disturbances and can infer the perception errors of the uninformed agents. Thus

$$\langle 12\rangle \qquad E^I_{t-1} R_t = \bar{R} + B_{r1} w_{t-1} + B'_{r1}\,\Delta\varepsilon_{w,t-1}$$

$E^U_t R_{t+1}$ and $E^I_t R_{t+1}$ are obtained by forward dating ⟨11⟩ and ⟨12⟩ respectively. Average price expectations in any period can be expressed as a weighted average of the expectations of informed and uninformed agents:

$$\langle 13\rangle \qquad E^A_{t-1} R_t = \lambda E^I_{t-1} R_t + (1-\lambda) E^U_{t-1} R_t,$$

where $\lambda = m/n$ is the share of informed agents in the economy.

Using the method of undetermined coefficients the values of the B_r coefficients can then be found by substituting ⟨11⟩–⟨13⟩ and their forward-dated equivalents in ⟨7⟩ and comparing the resulting expression (presented in Appendix I) with ⟨10⟩. These values and their algebraic signs are given in Table 1. The corresponding coefficients for domestic output in period t (not shown) can be obtained by combining these results with ⟨2⟩ and ⟨13⟩. The coefficient signs in Table 1 assume $c/b < 1$, *i.e.*, an increase in aggregate expenditures due either to an output or relative price increase leads to a less than proportional increase in aggregate domestic demand (the marginal propensity to import is positive), and $1 - cb > 0$, *i.e.*, the substitution effect of a relative price change dominates the income effect.

Interpretation of the coefficients reported in Table 1 is intuitive. Observe first that if all agents are informed ($\lambda = 1$) then perception errors have no effect on the equilibrium price (or output). The coefficients B_{r1}, B_{r2}, and B_{r3} may thus be interpreted as the full information responses to expenditure and demand disturbances. The positive signs of the coefficients B_{r2} and B_{r3} indicate that the relative price of domestic output increases in response to a positive expenditure disturbance ($\varepsilon_{w,t}$) and a demand shift in favor of domestic goods ($\varepsilon_{d,t}$). Similarly, if expenditure disturbances are positively serially correlated ($\rho_w > 0$) output increases in response to past disturbances (w_{t-1}).

If some agents are uninformed ($\lambda < 1$) and $\rho_w > 0$, a positive expenditure perception error in period $t-1$ ($\Delta\varepsilon_{w,t-1} > 0$)—an *underestimate* of the expenditure disturbance—causes a larger price increase in period t. The reason is that because of the serially correlated nature of such disturbances the

TABLE 1. Quasi-reduced form adjustment coefficients for the relative domestic price.

$$R_t = \bar{R} + B_{r1} w_{t-1} + B_{r2}\varepsilon_{w,t} + B_{r3}\varepsilon_{d,t} + B'_{r1}\,\Delta\varepsilon_{w,t-1} + B'_{r2}\,\Delta\varepsilon_{w,t} + B'_{r3}\,\Delta\varepsilon_{d,t}$$

$\bar{R} = \text{constant}$

$$B_{r1} = \frac{c\rho_w}{1 - cb + k\delta(b - c\rho_w)} > 0$$

$$B_{r2} = \frac{c(1 + k\delta B_{r1})}{1 - cb} > 0$$

$$B_{r3} = \frac{1}{1 - cb} > 0$$

$$B'_{r1} = \frac{bk\delta(1-\lambda)B_{r1}}{1 - cb + bk\delta\lambda} > 0$$

$$B'_{r2} = \frac{-ck\delta(1-\lambda)B_{r1}}{1 - cb + bk\delta\lambda} < 0$$

$$B'_{r3} = 0$$

underestimation implies a lower average expected price for period t and therefore a dampening of the level of output produced and available for sale in period t. The overall price response is thus in excess of the full information adjustment. In contrast, an underestimate of expenditures in period t ($\Delta\varepsilon_{w,t} > 0$) implies a smaller price response in period t compared to the full information case. Intuitively, the underestimate implies a lower average expected price for period $t+1$. The resulting reduction of production in period t reduces the level of expenditures and hence demand in period t. Note that misperceptions of demand disturbances ($\Delta\varepsilon_{d,t}$) have no effect on price or output since, without any serial correlation in these disturbances, knowledge of them is of no additional value to agents when forming expectations of the future price level. Serial correlation in demand could be easily introduced but without providing much further insight.

Note also that in our specification only real expenditure or demand disturbances affect the relative price. Current and lagged monetary disturbances, which are introduced in the next section when asset markets are discussed, affect the goods market only to the extent that they enter into the perception errors of real disturbances.

Lastly, observe that the B'_{r1} and B'_{r2} coefficients for perception errors are not linear in the share of informed firms. Therefore, as in Haltiwanger and Waldman (1985), either relatively informed or relatively uninformed agents have a disproportionately large effect on market adjustment. It can be seen in our model that, as λ goes from zero to one and more agents are informed, the coefficients for perception errors decrease in absolute magnitude at a decreasing rate. Therefore, informed firms have a disproportionately large effect on adjustment.[5] The disproportionate effect of informed agents is a result of their adjustment of their own price expectations and output levels in response to the effects of the misperception errors of the uninformed. More particularly, as equation ⟨12⟩ indicates, the informed raise their expectations of the relative price when the uninformed underproduce because of an underestimation of positive expenditure disturbances.

I.B. Asset Markets

The asset sector of the economy consists of a money market equilibrium condition, an international bond market equilibrium condition determining the domestic interest rate, and a money supply rule.

The money market equilibrium condition is expressed as

$$\langle 14\rangle \qquad m_t = p_t + \beta X_t - \gamma i_t, \qquad \beta, \gamma > 0,$$

where

$$\langle 15\rangle \qquad p_t \equiv a p_t^d + (1-a)(p_t^f + s_t), \qquad 0 \leqslant a \leqslant 1,$$

and m_t is the nominal money supply; p_t is the overall price level; p_t^d is the domestic currency price of domestic output; p_t^f is the foreign currency price of foreign output; and s_t is the nominal exchange rate expressed as the domestic currency price of foreign exchange; all in log terms. X_t is the level of aggregate expenditures, as before; and i_t is the domestic interest rate. Equation ⟨15⟩ expresses the price level as a weighted average of the domestic currency price of domestic and foreign output. Assuming foreign output is available in infinitely elastic supply, p^f may be set to zero. Note that since the relative price R of domestic goods can be expressed as $1 + p^d - p$ by approximation, use of ⟨15⟩ implies

$$\langle 16\rangle \qquad p_t \equiv (R_t - 1)(1-a)/a + s_t$$

Note also that the (log of the) real exchange rate $(p^f + s - p^d)$ is negatively related to R.

Equilibrium in the international financial market is characterized by risk-neutrality of market participants. It is assumed that only informed agents participate in arbitrage and speculative activities. Uninformed firms know that their information is inferior, and, therefore, their speculation against the market cannot be profitable. Equilibrium in the international financial market is given by the following uncovered arbitrage relationship:[6]

$$\langle 17\rangle \qquad i_t = i_t^f + E_t^I s_{t+1} - s_t + \varepsilon_{i,t}$$

We have introduced a (white-noise) error term $\varepsilon_{i,t}$, $\tilde{\varepsilon}_{i,t} \sim N(0, \sigma_{\varepsilon i}^2)$ in ⟨17⟩. While this term may be interpreted as capturing the effects of transaction costs in imperfect markets, in our framework it reflects a lack of perfect knowledge by the uninformed about the exact nature of informed agents' exchange rate expectations, as given by ⟨24⟩ below. This error term plays a crucial role in our analysis since its variance determines the 'informativeness' of financial markets about informed agents' expectations of the exchange rate. We discuss potential sources of this error term's existence in Section V.

The supply of money is determined exogenously as a serially-correlated disturbance around a long-run level of $\bar{m}$

$$\langle 18\rangle \qquad m_t = \bar{m} + v_t,$$

where

$$\langle 19\rangle \qquad v_t = \rho_v v_{t-1} + \varepsilon_{v,t}, \qquad 0 \leqslant \rho_v \leqslant 1,\ \tilde{\varepsilon}_{v,t} \sim N(0, \sigma^2_{\varepsilon v}),$$

and $\varepsilon_{v,t}$ is uncorrelated with other disturbances.

Substitution of ⟨5⟩ and ⟨6⟩ and ⟨16⟩–⟨19⟩ in ⟨14⟩ and rearranging in terms of s gives

$$\langle 20\rangle \qquad s_t = \Bigg[\bar{m} + \frac{1-a}{a} - (\beta b + (1-a)/a) R_t - \beta Y_t + \gamma E^I_t s_{t+1} - \beta\rho_w w_{t-1} - \beta\varepsilon_{w,t} + \rho_v v_{t-1} + \varepsilon_{v,t} + \gamma\varepsilon_{i,t}\Bigg]\Bigg/(1+\gamma),$$

where the foreign interest rate has been assumed constant and set equal to zero. As in the goods market we derive a quasi-reduced expression for the exchange rate in terms of current and lagged disturbances and the perception errors of the uninformed. Specifically, we conjecture the expression

$$\langle 21\rangle \qquad \begin{aligned} s_t = {} & \bar{s} + B_{s1} w_{t-1} + B_{s2}\varepsilon_{w,t} + B_{s3}\varepsilon_{d,t} + B_{s4} v_{t-1} + B_{s5}\varepsilon_{v,t} \\ & + B_{s6}\varepsilon_{i,t} + B'_{s1}\,\Delta\varepsilon_{w,t-1} + B'_{s2}\,\Delta\varepsilon_{w,t} + B'_{s3}\,\Delta\varepsilon_{d,t} \\ & + B'_{s4}\,\Delta\varepsilon_{v,t-1} + B'_{s5}\,\Delta\varepsilon_{v,t} + B'_{s6}\,\Delta\varepsilon_{i,t}, \end{aligned}$$

where the uninformed perception errors about money supply and financial market disturbances are defined as

$$\langle 22\rangle \qquad \Delta\varepsilon_{v,t} \equiv \varepsilon_{v,t} - E^U_t \varepsilon_{v,t}$$

$$\langle 23\rangle \qquad \Delta\varepsilon_{i,t} \equiv \varepsilon_{i,t} - E^U_t \varepsilon_{i,t}$$

Rational expectations of the exchange rate by the informed agents which are consistent with the forward-dated equivalent of ⟨21⟩ are given by

$$\langle 24\rangle \qquad \begin{aligned} E^I_t s_{t+1} & = \bar{s} + B_{s1} w_t + B_{s4} v_t + B'_{s1}\,\Delta\varepsilon_{w,t} + B'_{s4}\,\Delta\varepsilon_{v,t} \\ & = \bar{s} + B_{s1}\rho_w w_{t-1} + B_{s1}\varepsilon_{w,t} + B_{s4}\rho_v v_{t-1} + B_{s4}\varepsilon_{v,t} \\ & \quad + B'_{s1}\,\Delta\varepsilon_{w,t} + B'_{s4}\,\Delta\varepsilon_{v,t} \end{aligned}$$

using ⟨6⟩, ⟨19⟩, and ⟨22⟩.

As shown in Appendix I, the values of the B_s coefficient in terms of the previously determined B_r coefficients can be obtained by using ⟨3⟩, ⟨10⟩, ⟨12⟩, and ⟨24⟩, and comparing with ⟨21⟩. These coefficients and their signs are reported in Table 2. Corresponding coefficients for the domestic interest rate (not shown) can be obtained by combining these results with ⟨17⟩ and ⟨24⟩.

We first discuss the coefficients B_{s1}–B_{s6}, which represent the full information response (*i.e.*, $\lambda = 1$) of the exchange rate to current and lagged disturbances. The domestic currency appreciates (s falls) in response to a current expenditure ($\varepsilon_{w,t}$) and increases to a relative demand shift for domestic goods ($\varepsilon_{d,t}$). It also increases in response to lagged expenditure disturbances (w_{t-1}) if these disturbances are positively correlated over time (since $\rho_w > 0$ implies $Br_1 > 0$). Intuitively, such disturbances, by inducing a higher relative price and production of the domestic good, in turn raise money demand. A currency appreciation offsets the excess money demand pressure by lowering the overall

TABLE 2. Quasi-reduced form adjustment coefficients for the exchange rate.

$$s_t = \bar{s} + B_{s1} w_{t-1} + B_{s2}\varepsilon_{w,t} + B_{s3}\varepsilon_{d,t} + B_{s4} v_{t-1} + B_{s5}\varepsilon_{v,t} + B_{s6}\varepsilon_{z,t}$$
$$+ B'_{s1}\,\Delta\varepsilon_{w,t-1} + B'_{s2}\,\Delta\varepsilon_{w,t} + B'_{s3}\,\Delta\varepsilon_{d,t} + B'_{s4}\,\Delta\varepsilon_{v,t-1} + B'_{s5}\,\Delta\varepsilon_{v,t}$$
$$+ B'_{s6}\,\Delta\varepsilon_{z,t}.$$

$\bar{s} =$ constant

$$B_{s1} = \frac{-B_{r1}[((1-a)/a) + \beta(1+k\delta b)/c]}{1+\gamma(1-\rho_w)} < 0$$

$$B_{s2} = \frac{-B_{r2}[((1-a)/a) + \beta/c] - \gamma B_{s1}}{1+\gamma} < 0$$

$$B_{s3} = \frac{-B_{r3}[((1-a)/a) + \beta b]}{1+\gamma} < 0$$

$$B_{s4} = \frac{\rho_v}{1+\gamma(1-\rho_v)} > 0$$

$$B_{s5} = \frac{1}{1+\gamma(1-\rho_v)} > 0$$

$$B_{s6} = \frac{\gamma}{1+\gamma} > 0$$

$$B'_{s1} = \frac{-B_{r1}[((1-a)/a) + \beta b]b\delta k(1-\lambda)}{(1+\gamma)(1-cb+bk\delta\lambda)} < 0$$

$$B'_{s2} = \frac{B_{r1}[((1-a)/a) + \beta/c]ck\delta(1-\lambda)}{(1+\gamma)(1-cb+bk\delta\lambda)} + \frac{\gamma B'_{s1}}{1+\gamma} \gtrless 0$$

$$B'_{s3} = 0$$

$$B'_{s4} = 0$$

$$B'_{s5} = 0$$

$$B'_{s6} = 0$$

price level. For symmetric reasons current and lagged positive money supply disturbances ($v_{t-1}, \varepsilon_{v,t}$) create excess money supply pressure and cause the domestic currency to depreciate.

The remaining coefficients (B'_{s1}–B'_{s6}) represent the additional effect on the exchange rate of misperceived disturbances. Note first that the exchange rate is unaffected by misperceptions of a relative demand shift ($\Delta\varepsilon_{d,t}$), or of lagged and current money supply disturbances ($\Delta\varepsilon_{v,t-1}, \Delta\varepsilon_{v,t}$). The reason is that these misperceptions in themselves do not affect expectations of the future relative price nor of the exchange rate and hence have no influence on money demand. However, an underestimation of expenditures in period $t-1$ ($\Delta\varepsilon_{w,t-1} > 0$) dampens the currency appreciation, while a similar misperception in period $t(\Delta\varepsilon_{w,t} > 0)$ has an ambiguous effect.

This completes the derivation of the quasi-reduced expressions for the goods and asset markets. The full reduced forms for the relative price and the exchange rate are derived in the following section by determining how the perception errors of the uninformed depend on their ability to infer information about current disturbances from observable market conditions.

II. Information Inference and Market Equilibrium

In this section we first derive explicit solutions for the misperceptions of uninformed agents based on their available information. This information, as we discuss below, includes signals provided by observable market conditions about directly unobservable (to them) current disturbances. We then determine full reduced-form equilibrium expressions for the relative domestic price and the exchange rate.

In any given period t, the information set of all agents, including that of the uninformed, contains the following directly observable market prices: R_t, the relative price of domestic output; s_t, the (log of the) exchange rate; and i_t, the domestic interest rate. In addition, their information sets are assumed to include all lagged disturbances, as well as the structural parameters of all behavioral equations, the moments of all distribution functions, and the share of informed agents, λ. Note also that knowledge of s and R implies through ⟨16⟩ knowledge of the price level, p. Current aggregate output, expenditure quantities, and the money supply are not observable.

With the above information set, the market clearing conditions in the money, financial, and goods market at any time t provide to the uninformed the following three composite signals about underlying current disturbances:

(i) a money market signal:[7]

⟨25⟩ $$Z_t^M = \varepsilon_{v,t} - \beta(1 + \delta k\lambda(B_{r1} + B'_{r1}))\varepsilon_{w,t}$$

(ii) a financial market signal:[8]

⟨26⟩ $$Z_t^B = (B_{s1} + B'_{s1})\varepsilon_{w,t} + B_{s4}\varepsilon_{v,t} + \varepsilon_{i,t}$$

(iii) a goods market signal:[9]

⟨27⟩ $$Z_t^G = [c(1 + \delta k\lambda(B_{r1} + B'_{r1}))\varepsilon_{w,t} + \varepsilon_{d,t}]/(1 - ch)$$

To proceed we next analyze the perception errors influencing the equilibrium relative price (and implicitly output) and the exchange rate (and implicitly the interest rate). From ⟨10⟩ and Table 1 recall that the quasi-reduced expression for the relative price depends on current and lagged perception errors of the expenditure disturbance, $\Delta\varepsilon_{w,t}$ and $\Delta\varepsilon_{w,t-1}$, but not on the demand disturbance, $\Delta\varepsilon_{d,t}$ (since $B'_{r3} = 0$). To derive explicit solutions for these errors it is necessary to evaluate the underlying conditional expectations, $E_t^U w_t$ and $E_{t-1}^U w_{t-1}$.

As described in Appendix II, evaluation of this expectation based on the information set which includes all variables and parameters given above, and in particular the signals Z^M, Z^B and Z^G results in the following expression:

⟨28⟩ $$E_t^U\varepsilon_{w,t} = [1 - \theta_v\theta_i\theta_d]\varepsilon_{w,t} - [(1 - \theta_v)\theta_i\theta_d/\beta']\varepsilon_{v,t} + [(1 - \theta_i)\theta_d/\beta'']\varepsilon_{i,t} + [(1 - \theta_d)/(c\beta'/\beta)]\varepsilon_{d,t}$$

where

$$\langle 29\rangle \qquad \theta_r \equiv \frac{\sigma^2_{\varepsilon r}}{\sigma^2_{\varepsilon r}+(\beta')^2\sigma^2_{\varepsilon w}} > 0, \qquad 0 \leqslant \theta_r \leqslant 1$$

$$\langle 30\rangle \qquad \theta_i \equiv \frac{\sigma^2_{\varepsilon i}}{\sigma^2_{\varepsilon i}+\theta_r(\beta'')^2\sigma^2_{\varepsilon w}} \qquad 0 \leqslant \theta_i \leqslant 1$$

$$\langle 31\rangle \qquad \theta_d = \frac{\sigma^2_{\varepsilon d}}{\sigma^2_{\varepsilon d}+\theta_r\theta_i(c\beta'/\beta)^2\sigma^2_{\varepsilon u}} \qquad 0 \leqslant \theta_d \leqslant 1$$

$$\langle 32\rangle \qquad \beta' \equiv \beta(1+\delta k\lambda(B_{r1}+B'_{r1})) > 0$$

$$\langle 33\rangle \qquad \beta'' \equiv (B_{s1}+B'_{s1}+\beta' B_{s4})$$

The term θ_r is the variance of the money supply disturbance ($\varepsilon_{r,t}$) relative to a weighted sum of the variances of the money supply and expenditure disturbances ($\varepsilon_{w,t}$). We shall refer to θ_r as the 'relative money variance.' The term θ_i is the variance of the financial market error term ($\varepsilon_{i,t}$) relative to a weighted sum of the variances of the financial market error and the expenditure disturbance. We refer to θ_i as the 'relative financial error variance.' The θ_d term, the 'relative demand variance', is the variance of the relative demand disturbance ($\varepsilon_{d,t}$) relative to a weighted sum of the relative demand disturbance and the expenditure disturbance.[10]

It is interesting to point out here the role of the variances of money supply and financial market disturbances and their implications for the ability of the uninformed to infer the magnitude of the current expenditure disturbance. In the case that there are no money supply disturbances, *i.e.*, $\varepsilon_{r,t}=\sigma^2_{\varepsilon r}=0$, ⟨29⟩ and ⟨30⟩ imply $\theta_r=0$, $\theta_i=1$, and $\theta_d=1$, and consequently ⟨28⟩ implies $E^U_t\varepsilon_{d,t}=\varepsilon_{d,t}$. Thus when there are no money supply disturbances, the uninformed can perfectly infer the current expenditure disturbance. Intuitively, the observable money market signal, Z^M, when it contains no noise from money supply shocks, fully reveals the expenditure disturbance (see ⟨25⟩). Once the expenditure disturbance is revealed the financial market signal, Z^B, can be decomposed to yield full knowledge of the financial market error, and the goods market signal Z^G reveals the relative demand disturbance. Note from ⟨28⟩ that, in general, the uninformed underestimate any positive expenditure disturbance (since $0<\theta_r\theta_i\theta_d$), and partially attribute any particular money disturbance to a fall in expenditures.

Consider the other extreme case in which there are no errors in international financial markets, *i.e.*, $\varepsilon_{i,t}=\sigma^2_{\varepsilon i}=0$. In this case, ⟨30⟩ implies $\theta_i=0$, and ⟨28⟩, in turn, $E^U_t\varepsilon_{w,t}=\varepsilon_{w,t}$, since the three signals jointly permit revelation of the money market disturbance, the relative demand disturbance, and the expenditure disturbance.

The results above emphasize the importance of noisiness in financial market signals if such signals are not to reveal costlessly to the uninformed full information about disturbances which they cannot observe directly. For without such noisiness the uninformed have no incentive to purchase information about these disturbances. In the following section we return to this issue when we analyze the determinants of the decision to purchase information and how the circumstances we have just discussed influence the existence of an equilibrium.

To touch on an issue which we shall also consider at greater length in Section III, it is interesting to examine how the informativeness of the two signals about expenditure disturbances might influence the incentive to purchase information. In the absence of money supply variations ($\varepsilon_{v,t} = \sigma^2_{\varepsilon v} = 0$), the money market signal freely reveals full knowledge of $\varepsilon_{u,t}$ and no incentive to purchase information about this disturbance should arise. An examination of expression ⟨25⟩ indicates that this result does not depend on the existing share of informed agents in the economy.

However, in the absence of financial market errors ($\varepsilon_{i,t} = \sigma^2_{\varepsilon i} = 0$) a free-rider problem arises in the market for information purchase and no agent will purchase information. To understand why this is so consider the case when no one is initially informed. Then Z^B in ⟨27⟩ conveys no information. Since the current expenditure disturbance cannot be perfectly inferred from the money market and goods market signals, an incentive to purchase such information exists. But as soon as one agent chooses to purchase this information then Z^B, which directly reflects this information, will permit all remaining agents to costlessly know what $\varepsilon_{u,t}$ is. All agents thus have an incentive to free ride on the decision by others to purchase information. Thus, a financial market imperfection or an inability by the uninformed to determine how the informed form expectations is necessary to prevent Z^B from perfectly revealing knowledge about $\varepsilon_{w,t}$ if an information market is to exist.

Noting that the signals Z^M, Z^B and Z^G imply consistency constraints on expectations of expenditure, money, interest rate, and financial market disturbances, it is straightforward at this point to use ⟨25⟩, ⟨26⟩, ⟨27⟩, and ⟨28⟩ to obtain

⟨34⟩ $$E_t^U\varepsilon_{v,t} = -\beta'\theta_i\theta_v\theta_d\varepsilon_{w,t} + [1-(1-\theta_v)\theta_i\theta_d]\varepsilon_{v,t} + [(\beta'/\beta'')(1-\theta_i)\theta_d]\varepsilon_{i,t} + [(1-\theta_d)\beta/c]\varepsilon_{d,t}$$

⟨35⟩ $$E_t^U\varepsilon_{i,t} = \beta''\theta_i\theta_v\theta_d\varepsilon_{w,t} + [(\beta''/\beta')(1-\theta_v)\theta_i\theta_d]\varepsilon_{v,t} + [1-(1-\theta_i)\theta_d]\varepsilon_{i,t} - [(\beta\beta''/(\beta'c))(1-\theta_d)]\varepsilon_{d,t}$$

⟨36⟩ $$E_t^U\varepsilon_{d,t} = -[(c\beta'/\beta)(cb-\theta_i\theta_v\theta_d)]\varepsilon_{w,t} + [(c/\beta)(1-\theta_v)\theta_i\theta_d]\varepsilon_{v,t} - [(c\beta'/(\beta\beta''))(1-\theta_i)\theta_d]\varepsilon_{i,t} - [cb-\theta_d]\varepsilon_{d,t}$$

It is also straightforward to show that in the absence of either money supply or interest rate disturbances $E_t^U\varepsilon_{v,t} = \varepsilon_{v,t}$, $E_t^U\varepsilon_{i,t} = \varepsilon_{i,t}$, and $E_t^U\varepsilon_{d,t} = \varepsilon_{d,t}$, assuming some agents are informed.

We now proceed to derive the full equilibrium expressions for the relative price and exchange rate by using ⟨8⟩, ⟨22⟩, ⟨23⟩, ⟨28⟩, and ⟨34⟩ to substitute in ⟨10⟩ and ⟨21⟩:

⟨37⟩ $$R_t = \bar{R} + B_{r1}w_{t-1} + B_{r2}\varepsilon_{w,t} + B_{r3}\varepsilon_{d,t} + B^*_{r1}\varepsilon_{w,t-1} + B^*_{r2}\varepsilon_{w,t} + B^*_{r}\varepsilon_{d,t-1} + B^*_{r3}\varepsilon_{d,t} + B^*_{r4}\varepsilon_{v,t-1} + B^*_{r5}\varepsilon_{v,t} + B^*_{r8}\varepsilon_{i,t-1} + B^*_{r6}\varepsilon_{i,t}.$$

$$\langle 38\rangle \qquad s_t = \bar{s} + B_{s1}w_{t-1} + B_{s2}\varepsilon_{w,t} + B_{s3}\varepsilon_{d,t} + B_{s4}v_{t-1} + B_{s5}\varepsilon_{v,t}$$
$$+ B_{s6}\varepsilon_{i,t} + B^*_{s1}\varepsilon_{w,t-1} + B^*_{s2}\varepsilon_{w,t} + B^*_{s7}\varepsilon_{d,t-1} + B^*_{s3}\varepsilon_{d,t}$$
$$+ B^*_{s4}\varepsilon_{v,t-1} + B^*_{s5}\varepsilon_{v,t} + B^*_{s8}\varepsilon_{i,t-1} + B^*_{s6}\varepsilon_{i,t}$$

where coefficients without an asterisk (*) are the full information coefficients found in Tables 1 and 2, while coefficients with an asterisk represent the 'excess adjustment' that results from imperfect information. These coefficients are presented in Table 3.[11]

Table 3 enables us to analyze the additional (positive or negative) response to disturbances induced when there is asymmetric information among agents about current disturbances. To repeat what was concluded earlier, with full information among all agents ($\lambda = 1$), and the same serial correlation assumptions as above, the relative price rises in response to a current or lagged expenditure disturbance and to a demand disturbance (since $B_{r1}, B_{r2}, B_{r3} > 0$). With full information, the relative price is unaffected by money or financial market disturbances.[12] If agents possess asymmetric information ($0 < \lambda < 1$), however, the overall response to expenditure disturbances differs from the full information response. Moreover, we see that money and financial market disturbances, because they affect the expectations of the uninformed, also enter into the determination of the equilibrium relative price.

More specifically, from Table 3 $B^*_{r2} < 0$ and $B^*_{r1} > 0$ imply that, relative to the full information case, the price first undershoots and then overshoots in response to a current expenditure shock if expenditure shocks are positively serially correlated. Intuitively, in the period the disturbance first occurs, the uninformed underestimate its magnitude (since $\Delta\varepsilon_{w,t} > 0$, as seen by substituting ⟨28⟩ in ⟨8⟩ and observing that the coefficient of the terms involving $\varepsilon_{w,t}$ is positive). Consequently, they infer serially-correlated expenditure and sales price levels in the following period which are lower than in the full information case. The resulting reduction of current production implies lower expenditures and demand in the current period and lower sales in the following. Since without full information, the uninformed confuse expenditure and asset market disturbances, for similar reasons the relative price first falls and then rises in response to a money supply disturbance (since $B^*_{r5} < 0, B^*_{r4} > 0$).

It is also interesting to investigate the adjustment of the exchange rate. Here we are particularly interested in understanding the circumstances under which the exchange rate may overshoot in response to monetary disturbances. As discussed in Section I, with full information ($\lambda = 1$) the domestic currency depreciates in response to a current or lagged money supply increase (since $B_{s4} > 0, B_{s5} > 0$). With asymmetric information ($0 < \lambda < 1$), the additional effect of a current money supply increase (B^*_{s5}) is ambiguous. The money supply disturbance itself is underestimated ($\Delta\varepsilon_{v,t} > 0$, as seen by substituting ⟨34⟩ in ⟨22⟩), and is partially interpreted as a fall in expenditures, implying in turn an underestimate of the actual level of expenditures as well ($\Delta\varepsilon_{w,t} > 0$, as seen by substituting ⟨28⟩ in ⟨8⟩). Recall though that money supply misperceptions of the uninformed have no affect on the exchange rate ($B'_{s5} = 0$), since they do not affect expectations of the relative price or of the exchange rate itself. (Note that to the extent the money supply disturbance also contributes to misperceptions about $\varepsilon_{i,t}$ and $\varepsilon_{d,t}$, these additional misperceptions will also have no effect on the

Table 3a. Full reduced-form adjustment coefficients for the relative domestic price.

$$R_t = \bar{R} + B_{r1} w_{t-1} + B_{r2} \varepsilon_{w,t} + B_{r3} \varepsilon_{d,t} + B^*_{r1} \varepsilon_{w,t-1} + B^*_{r2} \varepsilon_{w,t} + B^*_{r7} \varepsilon_{d,t-1}$$
$$+ B^*_{r3} \varepsilon_{d,t} + B^*_{r4} \varepsilon_{v,t-1} + B^*_{r5} \varepsilon_{v,t} + B^*_{r8} \varepsilon_{i,t-1} + B^*_{r6} \varepsilon_{i,t}$$

where $\bar{R}$, B_{r1}, B_{r2}, and B_{r3} are as given in Table 1.

$$B^*_{r1} = B'_{r1}\theta_v\theta_i\theta_d = \frac{bk\delta(1-\lambda)B_{r1}\theta_v\theta_i\theta_d}{1-cb+bk\delta\lambda} > 0$$

$$B^*_{r2} = B'_{r2}\theta_v\theta_i\theta_d = \frac{-c\delta(1-\lambda)B_{r1}\theta_v\theta_i\theta_d}{1-cb+bk\delta\lambda} < 0$$

$$B^*_{r7} = -(B'_{r1}\beta/(\beta'c))(1-\theta_d) < 0$$

$$B^*_{r3} = -(B'_{r2}\beta/(\beta'c))(1-\theta_d) > 0$$

$$B^*_{r4} = (B'_{r1}/\beta')(1-\theta_v)\theta_i\theta_d > 0$$

$$B^*_{r5} = (B'_{r2}/\beta')(1-\theta_v)\theta_i\theta_d < 0$$

$$B^*_{r8} = -(B'_{r1}/\beta'')(1-\theta_i)\theta_d < 0 \qquad \text{if } \beta'' > 0$$

$$B^*_{r6} = -(B'_{r2}/\beta'')(1-\theta_i)\theta_d > 0 \qquad \text{if } \beta'' > 0$$

Table 3b. Full reduced-form adjustment coefficients for the exchange rate.

$$s_t = \bar{s} + B_{s1} w_{t-1} + B_{s2} \varepsilon_{w,t} + B_{s3} \varepsilon_{d,t} + B_{s4} \varepsilon_{w,t-1} + B_{s5} \varepsilon_{v,t} + B_{s6} \varepsilon_{i,t}$$
$$+ B^*_{s1} \varepsilon_{w,t-1} + B^*_{s2} \varepsilon_{w,t} + B^*_{s7} \varepsilon_{d,t-1} + B^*_{s3} \varepsilon_{d,t} + B^*_{s4} \varepsilon_{v,t-1} + B^*_{s5} \varepsilon_{v,t}$$
$$+ B^*_{s8} \varepsilon_{i,t-1} + B^*_{s6} \varepsilon_{i,t}$$

where $\bar{s}$, B_{s1}, B_{s2}, B_{s3}, B_{s4}, B_{s5}, and B_{s6} are as given in Table 2.

$$B^*_{s1} = B'_{s1}\theta_v\theta_i\theta_d < 0$$

$$B^*_{s2} = B'_{s2}\theta_v\theta_i\theta_d \gtrless 0$$

$$B^*_{s7} = -(B'_{s1}\beta/(\beta'c))(1-\theta_d) > 0$$

$$B^*_{s3} = -(B'_{s2}\beta/(\beta'c))(1-\theta_d) \gtrless 0$$

$$B^*_{s4} = (B'_{s1}/\beta')(1-\theta_v)\theta_i\theta_d < 0$$

$$B^*_{s5} = (B'_{s2}\beta/(\beta'))(1-\theta_v)\theta_i\theta_d \gtrless 0$$

$$B^*_{s8} = -(B'_{s1}/\beta'')(1-\theta_i)\theta_d > 0$$

$$B^*_{s6} = -(B'_{s2}/\beta'')(1-\theta_i)\theta_d \gtrless 0$$

exchange rate since $B'_{s6} = B'_{s7} = 0$.) The effect of the expenditure underestimate (B'_{s2}), however, is ambiguous. On the one hand, it implies lower future demand and induces lower current production, current aggregate expenditures, and a dampening in the relative price rise of domestic output. This causes the domestic currency to depreciate (s to rise) by *more* to the money supply increase than in the full information case. On the other hand, the underestimate also implies a smaller expected depreciation and hence a lower interest rate in the bond market. The resulting increase in the demand for money causes the domestic currency to depreciate by *less* than in the full information case. Thus the exchange rate overshoots its full information equilibrium response to a money supply disturbance only if this latter effect is relatively small.

The effect in the following period of a money supply disturbance is unambiguous ($B^*_{t4}<0$). Again both the expenditure and money supply increases are underestimated. But the money supply underestimate has no effect on the exchange rate in the following period ($B'_{t4}=0$). The expenditure misperception, however, unambiguously causes a dampening of the exchange rate depreciation in the following period. Intuitively, the corresponding expenditure underestimate in period $t-1$ implies a lower expected relative price for period t, lower production in $t-1$, and consequently lower expenditure and demand in period $t-1$. The lower level of supply in period t generates a higher relative price of domestic output and accordingly a dampening in the depreciation that would otherwise occur. Thus while Dornbush-like (1976) overshooting of the exchange rate (as well as of the relative price of *foreign* goods) may occur in the same period as a money supply disturbance, the exchange rate undershoots in the following period.[13] Consequently, confusion about the current money supply changes leads to greater variability in the exchange rate.

Exchange rate overshooting to a current money supply increase accords with the results of Flood and Hodrick (1985b) and Engel and Flood (1985). These authors assume that goods prices and output are set in response to perceived disturbances at the beginning of each period and are sticky until the end of the period. It is this stickiness in prices that causes the exchange rate to overshoot. In our model, the supply of output is fixed from the previous period due to a technological production lag, while the price in each period adjusts in response not just to expected disturbances, but in response to unexpected disturbances as well. Thus prices are not sticky. Overshooting results from the existence of asymmetric information and the confusion on the part of some agents about the magnitude of disturbances.

Adjustment to other disturbances can be explained in a similar manner. Without going into specifics, we note that although misperceptions of relative demand disturbances do not affect the relative price directly ($B^*_{t3}=0$), they may indirectly cause excess adjustment by creating confusion and misperceptions about other disturbances.

III. Information Purchase and Market Equilibrium

We turn now to the determination of the information market equilibrium, *i.e.*, the equilibrium share of informed agents λ. It is assumed that the supply of information about current disturbances is provided by an outside advisory service or information gatherer at a cost to the purchaser. For simplicity, we also assume that the information sold each period is made available before the production and arbitrage decisions for that period are determined.

There are different ways of specifying the nature of the information supplied by the advisory service. The simplest specification is that the service possesses full knowledge of all current disturbances—$\varepsilon_{x,t}$, $\varepsilon_{r,t}$, $\varepsilon_{d,t}$, and $\varepsilon_{i,t}$—and sells this information as a package. This presumes that the service has equal ability in evaluating goods market and asset market disturbances.

A perhaps more realistic specification posits that the service has a comparative advantage in evaluating only one particular type of disturbance. Assume, for example, that the service has a comparative advantage in evaluating the expenditure disturbance $\varepsilon_{u,t}$. Is information about this one disturbance sufficient to allow an agent to become informed about all other current disturbances as well? Yes, for the discussion in Section II implies that any additional information about a particular disturbance enables the agent receiving this information to infer the remaining disturbances from the rest of his information set. The combination of a new signal with those already contained in the information set (Z^M, Z^B, Z^G) permits the revelation of the disturbances individually if the new signal represents a different composite of the disturbances. We assume for simplicity that what information suppliers sell contains information only about the expenditure disturbance.

One remaining issue concerns whether the service sells knowledge of the expenditure disturbance directly or indirectly in the form of a signal containing this knowledge. For example, a service with a comparative advantage in evaluating expenditure disturbances $\varepsilon_{u,t}$ may choose not to sell knowledge of $\varepsilon_{u,t}$ directly but rather to sell a signal such as an exchange rate forecast that reflects this knowledge. There are reasons to argue that, in fact, an advisory service will prefer to sell a signal like an exchange rate forecast in order to overcome a free-rider problem. We discuss this issue in Section V.

We treat the supply side of the information purchase decision as simply as possible and assume that each agent can acquire information at a fixed cost x from an external supply source that enables the agent to become fully informed about all disturbances.[14]

The equilibrium share of informed agents, denoted by λ^*, is determined when no uninformed agent can increase its expected production profits by purchasing information.[15] Define $E_t^i\bar{\Pi}_{t+1}^i$ as the output-optimized level of expected discounted revenue of firm i, conditional on information available to agent i at the time production decisions in period t are made. Formally, the expression for $E_t^i\bar{\Pi}_{t+1}^i$ may be obtained by inserting the expression for the optimal output level y_t^i given by ⟨2⟩ into the (forward-dated) expected discounted revenue expression $E_t^i\Pi_{t+1}^i$ given by ⟨1⟩. Rearranging gives the following quadratic formula:

$$E_t^i\bar{\Pi}_{t+1}^i = \frac{k}{2n}(\delta E_t^i R_{t+1} - k_0)^2. \tag{39}$$

At the time production decisions are made $E_t^i\bar{\Pi}_{t+1}^i = E_t^I\bar{\Pi}_{t+1}^i$ for the informed agents, $i=1\ldots m$; and $E_t^i\bar{\Pi}_{t+1}^i = E_t^U\bar{\Pi}_{t+1}^i$ for the uninformed agents, $i=m+1\ldots n$. Prior to the purchase of information about current disturbances, all agents possess the same information set. Denote the corresponding expectation operator by E_t.

The incentive to purchase information can be written as the difference between the expected profits of being informed and remaining uninformed:

$$T \equiv E_t[E_t^I\bar{\Pi}_{t+1}^i - E_t^U\bar{\Pi}_{t+1}^i - x], \tag{40}$$

where x is the fixed cost of purchasing information.[16] Using ⟨11⟩ and ⟨12⟩ forward-dated for the expected price in $t+1$ in ⟨39⟩, expression ⟨40⟩ reduces to

$$T = \frac{k\delta^2}{2n}(B_{r1} + B'_{r1})^2 \sigma^2_{\Delta\varepsilon u} - x, \tag{41}$$

where

$$\sigma^2_{\Delta\varepsilon u} \equiv \sigma^2_{\varepsilon u} \theta_r \theta_i \theta_d (c\beta' \beta)^2 \tag{42}$$

is the variance of expenditure perception errors. Appendix III describes how ⟨41⟩ is derived and Appendix II shows how ⟨42⟩ is obtained. Observe that this variance depends on all relative variances as well as the absolute levels of all variances. The latter effect is captured by a change in $\sigma^2_{\varepsilon u}$ while holding θ_r, θ_i, and θ_d constant.

Expression ⟨41⟩ for the incentive to purchase information is identical across agents and across periods. This incentive depends on the variance of expenditure perception errors, the share of informed agents (since B'_r and $\sigma^2_{\Delta\varepsilon u}$ depend on λ), the cost of information, and the structural parameters of the system.[17] Current or past disturbances do not enter into this expression, since at the time the information purchase decision is made they do not differentially affect the expected profits to being informed or uninformed.

Equilibrium occurs for $0<\lambda^*<1$, when $T=0$; for $\lambda^*=0$ when $T<0$; and for $\lambda^*=1$, when $T>0$. Disregarding the effects of λ on $\sigma^2_{\Delta\varepsilon u}$ which can be considered secondary,[18] and assuming an interior solution for λ, we find by setting $T=0$, and substituting in from Table 1 for B'_r:[19]

$$\lambda^* = (1/b)[B_{r1}(1-cb+bk\delta)(\sigma^2_{\Delta\varepsilon u} k\delta^2/2nx)^{1/2}] - (1-cb)/(b\delta k) \tag{43}$$

The equilibrium share of informed agents is clearly decreasing in the cost of information (x) and increasing in the price adjustment response to expenditure disturbances (B_{r1}) and in the variance of the expenditure perception error ($\sigma^2_{\Delta\varepsilon u}$). This equilibrium share is constant over time as long as the structural parameters of the system, the distribution functions, and the cost of information are unchanged.

From expressions ⟨42⟩ and ⟨43⟩ we can discern how the share of informed agents depends on the individual disturbance variances underlying $\sigma^2_{\Delta\varepsilon u}$. Note that as a result of the fixed cost of purchasing information, $\sigma^2_{\Delta\varepsilon u}$ must attain a minimum level (given the levels of all other parameters) before any agent has an incentive to purchase information. Thus if any of the relative or absolute variance levels in ⟨43⟩ is equal to zero, then $\sigma^2_{\Delta\varepsilon u}=0$ and $\lambda^*=0$.

IV. Macroeconomic Adjustment with Endogenous Information Purchase

In Sections I and II we analyzed relative price and exchange rate adjustment to disturbances while assuming the economy share of informed agents was exogenous. We saw in Section II that the perception errors of the uninformed depended in part on the variances of these disturbances. From Table 3 it can be seen that increases in the relative money or demand variance (θ_r, θ_d) as well as increases in the relative financial market error (θ_i) *magnify* the excess response of the relative price and exchange rate to expenditure disturbances. Increases in the relative expenditure (decreases in relative money) or relative demand variance as well as in the relative financial market error magnify the excess response to money supply disturbances. In Section III we observed that increases in these same variances also induce the purchase of information. Inspection of the expressions for the coefficients of adjustment in Table 3 indicates that this generally *dampens* the degree of change. Thus when information purchase is endogenous the relative variance of disturbances may have opposing effects on the magnitude of the excess adjustment response.

The excess adjustment coefficients which we are interested in analyzing further are particularly those associated with expenditure and money supply disturbances—B^*_{r1}, B^*_{r2}, B^*_{r4}, B^*_{r5}. Since these coefficients generally depend on disturbance variances in the same manner, we shall focus on the coefficient B^*_{r1}, which represents the excess adjustment response to lagged expenditure disturbances, as a representative example.

Observe first that ⟨41⟩ implies for $T=0$

$$\langle 44\rangle \qquad B'_{r1} = (2nx/(k\delta^2))^{1/2}/\sigma_{\Delta\varepsilon w} - B_{r1}$$

Substituting in the definition of B^*_{r1} in Table 3 gives

$$\begin{aligned}\langle 45\rangle \qquad B^*_{r1} &= B'_{r1}\theta_r\theta_i\theta_d \\ &= [(2nx/(k\delta^2))^{1/2} - \sigma_{\Delta\varepsilon w}B_{r1}]\theta_r\theta_i\theta_d/\sigma_{\Delta\varepsilon w} \\ &= \frac{(2nx/(k\delta^2))^{1/2}}{\sigma_{\varepsilon w}(c\beta'/\beta)}(\theta_r\theta_i\theta_d)^{1/2} - \theta_i\theta_r\theta_d B_{r1},\end{aligned}$$

where the definition of $\sigma^2_{\Delta\varepsilon w}$ by ⟨42⟩ has been used. The value of B^*_{r1} given by ⟨44⟩ is defined only for parameter values such that $0<\lambda<1$, *i.e.*, such that $\sigma^2_{\varepsilon w}$, θ_i, θ_r, and θ_d are sufficiently large for information purchase to occur but not large enough for all firms to become informed.

Consider an increase in the expenditure variance ($\sigma^2_{\varepsilon w}$), while holding relative variances constant. Such a shift implies an equiproportionate increase in the variance levels of all individual disturbances. It is easily seen that $dB^*_{r1}/d\sigma_{\varepsilon w} < 0$. In other words, as the variances of *all* disturbances increase in proportion such that relative variances remain constant, the 'excess' adjustment coefficient B^*_{r1} decreases. This result can be understood by observing that only relative variances affect the excess adjustment coefficient directly, while the variance levels affect information purchase as well. In the limit, with all variances increasing proportionately, all firms choose to become informed and all excess adjustment coefficients become zero.

We turn lastly to the effects on excess adjustment of the relative variances of disturbances, focusing on θ_i, the relative financial market error variance. We determine first the value of θ_i when the variance of the financial market error is not sufficiently large for information purchase to occur ($\lambda=0$) because of the fixed cost of information. Note that θ_i given by ⟨30⟩ is not defined when $\lambda=0$. In the absence of any information purchase, the financial market signal (Z^B) possesses no information content about expenditure disturbances, and depends only on ε_i. Since it can be shown that the denominator of θ_i is equal to the variance of Z^B, which in this instance equals $\sigma^2_{\varepsilon i}$, θ_i then takes on the value of 1.

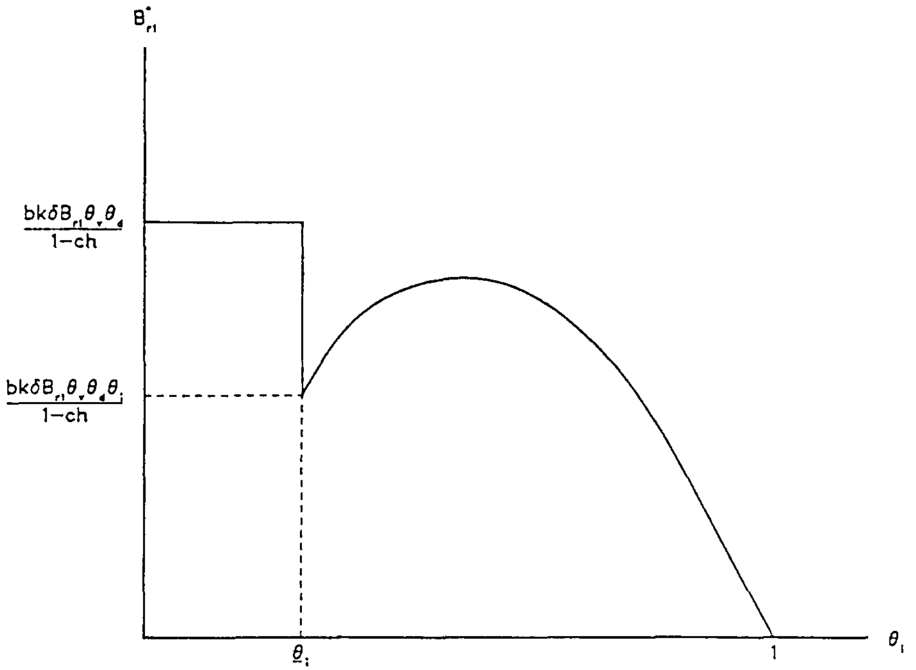

FIGURE 1. Excess adjustment as a function of θ_i.

Accordingly, with $\lambda = 0$ and $\theta_i = 1$, the expression for the degree of excess adjustment in Table 3 reduces to $B^*_{r1} = bk\delta B_{r1}\theta_v\theta_d/(1-cb)$.

For increasing levels of θ_i (holding θ_v and θ_d constant), when θ_i attains the threshold level $\underline{\theta}_i$ at which at least one agent becomes informed, the financial market then conveys information to the uninformed, and the degree of excess adjustment (B^*_{r1}) falls discretely. Thus, at the threshold level of the financial market error variance, excess adjustment is *smaller* than in the absence of any such variance. This is illustrated in Figure 1. As θ_i increases further, the financial market becomes less informative, B^*_{r1} increases to a (possibly global) maximum, whereafter the greater inducement to purchase information causes B^*_{r1} to decline.[20] As increases in θ_i cause λ to approach one, all agents become informed and B^*_{r1} approaches zero.

V. The Source of Financial Market Errors

Throughout this paper we have emphasized that observable market conditions must not be perfectly informative if an incentive to purchase information is to exist. This point accords with Grossman and Stiglitz's argument (1980) that informationally efficient prices are incompatible with the existence of information acquisition. In our model in the absence of an error (ε_i) in the equilibrium condition for international financial markets ((17)), the information market is subject to a free-rider problem. As shown in Section II, without this error an incentive for purchasing information exists, but as soon as a single agent does so, all remaining agents become costlessly informed. Thus no agent would be willing to pay for information.[21]

Many observers of international financial markets would argue that equilibrium in international financial markets holds without any deviation. We now briefly motivate why observable financial market conditions may not exactly reveal the information of the relatively well-informed agents, even when markets adjust instantaneously and there are no transaction costs.[22]

Rational expectations models usually rely on the assumption that all agents know the exact rules by which others form expectations. Financial market errors may arise from the lack of perfect knowledge about such rules. In our particular model the general goal of the uninformed when observing financial conditions is to infer the expectations of the informed about the future exchange rate ($E_t^i s_{t+1}$), and it has been assumed that the uninformed base their inferences on knowledge of the rule ⟨24⟩ by which the informed agents form their expectations. The uninformed may in fact lack perfect knowledge about this rule and hence about the coefficients of adjustment in the financial market signal. Thus the financial market error may capture this kind of imperfect knowledge in a crude way.

It is also possible that the uninformed are unable to distinguish between the effects in the market of informed agents and of monetary authorities who may intervene to an unknown extent. Consequently, the uninformed agents may be confused about the extent to which the financial market reflects the expectations of relatively well-informed private agents or the activities of monetary authorities.

Another possibility is that the information supplier in fact introduces confusion into the financial market in order to overcome free-rider problems and to create a demand for its services (compare Admati and Pfleiderer, 1985). It may do so by itself participating in international financial markets in an unpredictable manner. Alternatively, as we have suggested, it may sell an exchange rate forecast without directly specifying to the potential purchaser the particular knowledge upon which it is based. While those who do purchase the forecast will then be provided with information about the specific knowledge of the service, those who remain uninformed would be unable to discern the extent to which the expectations of the informed (revealed through market signals) are based on their knowledge of either the expenditure, money, or relative demand disturbance.

VI. Summary

We have developed a macroeconomic model of relative price and exchange rate adjustment in which there is demand for costly information about market disturbances which cannot be inferred perfectly by agents from market signals. When all agents are fully informed about current disturbances, our results conform to standard macroeconomic theory: the relative price of domestic goods increases in response to a current or lagged expenditure shock, or to a demand shock. The relative price is not affected by money disturbances or financial market errors, since under full information, agents can distinguish between real and financial shocks. The domestic currency appreciates in response to expenditure and domestic demand disturbances and depreciates in response to current or lagged money supply increases. When some agents are not fully informed, we find that relative price and exchange rate adjustment in excess of the full information case generally occurs in response to current expenditure, money supply, and relative demand shocks. We interpret the excess adjustment to current money supply disturbances as a form of Dornbusch-type overshooting. The excess adjustment is reversed in the period after the money-shock, however, under our specific assumptions about positive serial correlation of expenditure and money disturbances.

Even when all agents are not fully informed about current disturbances, equilibrium was seen to depend on the ability of uninformed agents to infer what they could about these disturbances, however imperfectly, from observable market signals. The informativeness of market signals depended on the relative variances of the underlying disturbances. An incentive to purchase information exists as long as the market signals alone do not fully reveal to those yet uninformed all the information about current disturbances they would like to obtain. The presence of an error in the international financial market equilibrium condition was seen to be crucial for overcoming a potential free-rider problem in the information market. We interpret this error as arising either from a market imperfection or lack of knowledge by the uninformed about the expectation formation of relatively informed agents with the consequence that the financial market does not fully reveal the expectations of those acquiring costly information. The incentive to purchase information that exists under these circumstances increases with the variance of all disturbances, and the relative variance of different shocks.

The 'excess' adjustment relative to full information adjustment decreases when the variances of *all* disturbances increase proportionately. If there is sufficient variance in expenditure, money, and relative demand disturbances and the cost of information is not prohibitive, then excess adjustment in response to money and expenditure disturbances is relatively small when the signal from international financial markets contains sufficient noise for the free-rider problem in information markets to be just barely overcome. If all variances become sufficiently large, all agents are induced to acquire information and there is no excess adjustment.

Our analysis should not be seen as normative in the sense that noise should be introduced in financial markets in order to create incentives for information acquisition. Information acquisition is costly and the larger the number of firms acquiring information, the higher is the social cost. In a welfare analysis increased costs of information acquisition must be traded off against the potential social gains of basing macroeconomic adjustment on improved information.

Appendix I

In this appendix we describe the derivation of the quasi-reduced form coefficients of relative price and exchange rate adjustment in equations ⟨10⟩ and ⟨21⟩ presented in Tables 1 and 2.

The relative price coefficients are obtained by first noting that ⟨11⟩–⟨13⟩ imply

$$E_{t-1}^{\,i} R_t = \bar{R} + B_{r1} w_{t-1} + (\lambda B_{r1}' - (1-\lambda) B_{r1}) \Delta\varepsilon_{w,t-1}$$

Substituting in ⟨7⟩, and the forward-dated equivalent for $E_t^{I} R_{t+1}$ and rearranging gives

$$
\begin{aligned}
R_t(1-cb) = {} & [b_0 + (b-c)k(k_0 - \delta\bar{R}] + [B_{r1}\delta k(c\rho_u - b) + c\rho_u]w_{t-1} \\
& + [c + c\delta k B_{r1}]\varepsilon_{u,t} + \varepsilon_{d,t} \\
& - [b\delta k(\lambda B'_{r1} - (1-\lambda)B_{r1})]\,\Delta\varepsilon_{u,t-1} + [c\delta k(\lambda B'_{r1} - (1-\lambda)B_{r1})]\,\Delta\varepsilon_{u,t}
\end{aligned}
$$

Dividing through by $1-cb$ and comparing the coefficients with those in expression ⟨10⟩ permits solution for the values of the B_r coefficients in Table 1.

The exchange rate coefficients are obtained by substituting in ⟨20⟩ for Y_t, R_t, $E_t^I s_{t+1}$, and $E_t^I R_{t+1}$ by ⟨3⟩, ⟨10⟩, ⟨24⟩, and ⟨12⟩, respectively, and obtaining

$$
\begin{aligned}
s_t(1+\gamma) = {} & [\bar{m} + (1-a)/a + \beta k(k_0 - \delta\bar{R}) + \gamma\bar{s} - \zeta\bar{R}] \\
& + [\gamma B_{s1}\rho_w - \zeta B_{r1} - \beta k\delta\rho_u B_{r1} - \beta\rho_u]w_{t-1} \\
& + [\gamma B_{s1} - \zeta B_{r2} - \beta k\delta B_{r1} - \beta]\varepsilon_{u,t} \\
& - \zeta B_{r3}\varepsilon_{d,t} + [\rho_v(1+\gamma B_{s4})]v_{t-1} + [1 + \gamma B_{s4}]\varepsilon_{v,t} + \gamma\varepsilon_{i,t} \\
& - \zeta B'_{r1}\,\Delta\varepsilon_{u,t-1} + [\gamma(\lambda B'_{s1} - \zeta B'_{r2} - \beta k\delta(\lambda B'_{r1} + (1-\lambda)B_{r1})]\,\Delta\varepsilon_{u,t} \\
& + \gamma B'_{s4}\,\Delta\varepsilon_{v,t}
\end{aligned}
$$

where $\zeta = \beta b + (1-a)/a$. Dividing through by $1+\gamma$, comparing coefficients with those in expression ⟨21⟩, and using the previously obtained B_r coefficients yields the values of B_s coefficients presented in Table 2.

Appendix II

Expression ⟨28⟩ for $E^U\varepsilon_{u,t}$ conditional on the three signals

⟨25⟩ $$Z^M = \varepsilon_{v,t} - \beta(1 + \delta k\lambda(B_{r1} + B'_{r1}))\varepsilon_{u,t},$$

⟨26⟩ $$Z^B = [(B_{s1} + B'_{s1})\varepsilon_{u,t} + B_{s4}\varepsilon_{v,t}] + \varepsilon_{i,t}, \qquad \text{and}$$

⟨27⟩ $$Z^G = [c(1 + \delta k\lambda(B_{r1} + B'_{r1}))\varepsilon_{u,t} + \varepsilon_{d,t}]/(1-cb)$$

is obtained by using the following formula for information extraction:

$$
\begin{aligned}
E^U[\varepsilon_u | Z^M, Z^B, Z^G] = {} & E^U[\varepsilon_u | Z^M] \\
& + E^U[(\varepsilon_u - E^U[\varepsilon_u | Z^M])|(Z^B - E^U[Z^B | Z^M])] \\
& + E^U[(\varepsilon_u - E^U[\varepsilon_u | Z^M, Z^B])|(Z^G - E^U[Z^G | Z^M, Z^B])],
\end{aligned}
$$

where t subscripts have been suppressed. The relatively tedious details of derivation can be obtained from the authors upon request. Note that expressions ⟨28⟩ and ⟨8⟩ imply

$$
\begin{aligned}
\Delta\varepsilon_u &= \varepsilon_u - E^U[\varepsilon_u | Z^M, Z^B, Z^G] \\
&= \varepsilon_u\theta_v\theta_i\theta_d + \varepsilon_v\frac{1}{\beta'}(1-\theta_v)\theta_i\theta_d - \varepsilon_i\frac{1}{\beta''}(1-\theta_i)\theta_d \\
&\quad - \varepsilon_d\frac{\beta}{\beta' c}(1-\theta_d)
\end{aligned}
$$

In deriving ⟨28⟩ it is useful to observe the following. Expression ⟨30⟩ for θ_i is a simplified form of

$$\theta_i = \frac{\sigma^2_{\varepsilon i}}{(\beta'')^2\theta_r\sigma^2_{\varepsilon u} + (\beta''/\beta')^2(1-\theta_r)^2\sigma^2_{\varepsilon r} + \sigma^2_{\varepsilon i}}$$

Expression ⟨31⟩ for θ_d is a simplified form of

$$\theta_d = \frac{\sigma^2_{\varepsilon d}}{(c\beta'/\beta)^2[\theta_i^2\theta_r^2\sigma^2_{\varepsilon u} + (1-\theta_r)^2\theta_i^2\sigma^2_{\varepsilon r}/(\beta')^2 + (1-\theta_i)^2\sigma^2_{\varepsilon i}/(\beta'')^2] + \sigma^2_{\varepsilon d}}$$

where β' and β'' are defined by ⟨32⟩ and ⟨33⟩, and it should be noted that

$$(1-\theta_r)\sigma^2_{\varepsilon r}/(\beta')^2 = \theta_r\sigma^2_{\varepsilon u} \qquad \text{from } \langle 29\rangle$$

$$(1-\theta_i)\sigma^2_{\varepsilon i}/(\beta'')^2 = \theta_r\sigma^2_{\varepsilon u} \qquad \text{from } \langle 30\rangle$$

To derive ⟨42⟩ note first that

$$\sigma^2_{\Delta\varepsilon u} = \theta_d^2\{\theta_r^2\theta_i^2\sigma^2_{\varepsilon u} + (1/\beta')^2(1-\theta_r)^2\theta_i^2\sigma^2_{\varepsilon r} + (1/\beta'')^2(1-\theta_i)^2\sigma^2_{\varepsilon i}\}$$
$$+ (1-\theta_d)^2(\beta/(\beta'c))^2\sigma^2_{\varepsilon d}$$

Using ⟨29⟩, ⟨30⟩, and ⟨31⟩ the term within brackets can be expressed solely in terms of $\sigma^2_{\varepsilon u}$. Further simplification gives ⟨42⟩.

Appendix III

To obtain ⟨41⟩ note that inserting ⟨12⟩ and ⟨11⟩ forward-dated individually into ⟨39⟩ gives:

$$\left(\frac{2n}{k}\right) E_t^I\Pi_t^i = (\delta E_t^I R_{t-1} - k_0)^2 = (\delta(\bar{R} + B_{r1}\rho_u w_{t-1} + B_{r1}\varepsilon_{u,t} + B'_{r1}\,\Delta\varepsilon_{u,t}) - k_0)^2$$

$$\left(\frac{2n}{k}\right) E_t^U\Pi_t^i = (\delta E_t^U R_{t+1} - k_0)^2 = (\delta(\bar{R} + B_{r1}\rho_u w_{t-1} + B_{r1}\varepsilon_{u,t} - B_{r1}\,\Delta\varepsilon_{u,t}) - k_0)^2$$

Since expected disturbances and perception errors are zero:

$$\left(\frac{2n}{k}\right) E_t E_t^I\Pi_t^i = (\delta(\bar{R} + B_{r1}\rho_u w_{t-1}) - k_0)^2 + \delta^2 B_{r1}^2\sigma^2_{\varepsilon u} + \delta^2(B'_{r1})^2\sigma^2_{\Delta\varepsilon u}$$
$$+ 2\delta^2 B_{r1}B'_{r1}\operatorname{cov}[\varepsilon_{u,t}\,\Delta\varepsilon_{u,t}]$$

$$\left(\frac{2n}{k}\right) E_t E_t^U\Pi_t^i = (\delta(\bar{R} + B_{r1}\rho_u w_{t-1}) - k_0)^2 + \delta^2 B_{r1}^2\sigma^2_{\varepsilon u} + \delta^2(B_{r1})^2\sigma^2_{\Delta\varepsilon u}$$
$$- 2\delta^2(B_{r1})^2\operatorname{cov}[\varepsilon_{u,t}\,\Delta\varepsilon_{u,t}]$$

With rational expectations $\operatorname{cov}[\varepsilon_{u,t}\,\Delta\varepsilon_{u,t}] = \sigma^2_{\Delta\varepsilon u}$. Thus the difference between the above two expressions reduces to

$$\left(\frac{k\delta^2}{2n}\right)\{[(B'_{r1})^2 - (B_{r1})^2]\sigma^2_{\Delta\varepsilon u} + 2B_{r1}(B'_{r1} + B_{r1})\sigma^2_{\Delta\varepsilon u}\}$$

which implies ⟨41⟩ in the text.

Notes

1. One may argue that the discount factor depends on the productivity of capital as well as the stochastic structure of the economy. We treat this factor as a constant, however, and do not

consider investment decisions which would otherwise be influenced by and influence the discount rate.

2. Note that it is also possible to express domestic demand as a function of the real interest rate as in Kimbrough (1983, 1984). Doing so in our more complex framework overly complicates the analysis.
3. A similar linear expression for aggregate expenditures is used in Flood and Hodrick (1985a and 1985b). These authors argue that the expenditure disturbance term should be negative serially correlated. This would affect the direction of some of our results.
4. Note that current disturbances and perception errors have mean values of zero.
5. In the terminology of Haltiwanger and Waldman such markets are characterized by congestion, as opposed to synergy, among agents.
6. Note that if covered interest parity holds the forward exchange premium equals the interest rate differential which in turn, according to ⟨17⟩, also equals $E_t^I s_{t+1} - s_t + \varepsilon_{i,t}$. The forward premium and the interest rate differential thus provide the same information about average exchange rate expectations of informed agents. Future markets in commodities would similarly not add an independent source of information since future prices for commodities and foreign exchange would depend on expectations about the same disturbances.
7. Equation ⟨25⟩ is obtained by first expanding expression ⟨5⟩ for X_t by forward-dating and inserting ⟨3⟩ for Y_t, forward-dating ⟨11⟩ and ⟨12⟩, and substituting for $E_t^I R_{t+1}$. Equation ⟨6⟩ is used for w_t, and ⟨8⟩ for $\Delta\varepsilon_{w,t}$. Substitution of the resulting expression into ⟨14⟩ then reveals Z^M given knowledge of v_{t-1}, w_{t-1}, i_t, p_t, R_t, $\bar{m}$, $E_t^U R_{t+1}$, $E_t^U \varepsilon_{w,t}$, and λ.
8. Equation ⟨26⟩ is obtained by first inserting ⟨24⟩ for $E_t^I s_{t+1}$ in ⟨17⟩. Substituting ⟨8⟩ for $\Delta\varepsilon_{w,t}$ then reveals Z^B given knowledge of v_{t-1}, w_{t-1}, i_t, s_t, and $E_t^U \varepsilon_{w,t}$.
9. Equation ⟨27⟩ is obtained by first using ⟨13⟩ to substitute for $E_{t-1}^I R_t$ and $E_t^I R_{t+1}$ in ⟨7⟩. Using ⟨11⟩ and ⟨12⟩ to substitute for $E_{t-1}^U R_t$ and $E_{t-1}^I R_t$, and their forward-dated equivalents, respectively, and, in turn, ⟨8⟩ for $\Delta\varepsilon_{w,t-1}$ and $\Delta\varepsilon_{w,t}$ then reveals Z^G given knowledge of v_{t-1}, w_{t-1}, $E_{t-1}^U R_t$, $E_t^U R_{t-1} \varepsilon_{w,t-1}$, and $E_t^U \varepsilon_{w,t}$.
10. Note that the weights in each of these relative variance terms are not purely exogenous but depend on adjustment coefficients and in some cases on other relative variances. The denominator of θ_i is the variance of Z^B and the denominator of θ_v is the variance of Z^M.
11. Note that the coefficients B_{r7}^*, B_{r8}^*, B_{s7}^* and B_{s8}^* for $\varepsilon_{d,t-1}$ and $\varepsilon_{i,t-1}$ appear in ⟨37⟩ and ⟨38⟩ since these lagged disturbances enter into the perception errors of expenditure disturbances in period $t-1$.
12. If domestic expenditures were posited as a function of the real or nominal interest rate, asset market disturbances might affect the relative price even under full information.
13. Treating disturbances as serially correlated for more than one period would cause the overshooting phenomenon to persist for a correspondingly longer period. Incorporating inventories into the analysis would also magnify the persistence of disturbances. (See Flood and Hodrick, 1985a, 1985b.)
14. It should be noted that in equilibrium this cost of information will equal the cost of transferring the information among agents, unless contracts between the external supplier and the original purchasers can be made that prohibit such transfers.
15. While agents can also potentially make profits by acting as arbitrageurs as long as ε_i is non-zero, we assume that they are unable to exploit these profits. If ε_i is a market inefficiency due to transactions costs, this assumption is reasonable. In Section V we note other reasons why ε_i may be non-zero even in the absence of arbitrage opportunities for the informed.
16. We do not discuss how information market equilibrium is reached, though the equilibrium presumes that each firm knows the share of all firms purchasing information simultaneously. We may interpret the cost of purchasing information as the cost to individual firms of gathering and analyzing information on their own. In this case equilibrium presumes knowledge of the share of firms with this gathering and analyzing capability.
17. Variances 'matter' even though agents are risk-neutral because expected net revenue is quadratic. The number of firms affects the incentive to acquire information, since profits depend on industry cost conditions. In Darby (1976) the incentive to buy information depends on the size of the firm. We assume that all firms are of equal size.
18. Though λ affects $\sigma^2_{\Delta\varepsilon_w}$ through its effects on θ_v, θ_i, θ_d, and β', it is convenient to treat these relative variance terms as exogenous. Taking them into account would not change our qualitative effects.
19. The equilibrium thus determined is stable since T is decreasing in λ. To see this note that $\sigma^2_{\Delta\varepsilon_w}$

and

$$(B_{r1}+B'_{r1})^2 = B_{r1}^2\left(1+\frac{b\delta k(1-\lambda)}{1-cb+b\delta k\lambda}\right)^2 = B_{r1}^2\left(\frac{1-cb+b\delta k}{1-cb+b\delta k\lambda}\right)^2$$

are both decreasing in λ.

20. From ⟨44⟩

$$\frac{dB^*_{r1}}{d\theta_i} = \tfrac{1}{2}[(2nx/(k\delta))\theta_e\theta_d]^{1/2}\beta\theta_i^{-1/2}/(\sigma_{\varepsilon u}(c\beta)) - \theta_e B_{r1} \gtrless 0$$

$$\frac{d^2 B^*_{r1}}{(d\theta_i^2)} = \tfrac{1}{2}[(2nx/(k\delta))\theta_e\theta_d]^{1/2}\beta\theta_i^{-3/2}/(\sigma_{\varepsilon u}/(c\beta')) < 0$$

21. Note that the existence of the free-rider problem does not require that those acquiring information become informed about all disturbances. If, for example, an additional disturbance in, say, money demand is introduced, then those who can buy information only about a single disturbance, such as expenditures as we have assumed, will not become fully informed about remaining disturbances. None the less, the free-rider problem would exist in the absence of a financial market error since whatever additional information they obtain becomes revealed through financial markets to the uninformed.
22. The existence of a risk premium is not sufficient to resolve the free-rider problem, since when there is imperfect substitutibility among bond markets, the different interest rates are separate market signals. Thus, there is both an additional unobservable disturbance (the risk premium) and an additional signal.

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