International Economics Division
Economic Research Service
United States Department of Agriculture

Staff Report # AGES861215
1987

Agricultural Trade Modeling – The State of Practice and Research Issues

Liu, K. and R. Seeley, eds.

Proceedings of a Meeting of the
International Agricultural Trade Research Consortium
December, 1985, Vancouver, British Columbia, Canada

AN APPROACH TO MODELING MACROECONOMIC LINKAGES IN TRADE MODELS: WITH AN APPLICATION TO AGRICULTURE

Douglas McTaggart

Comparing the agricultural sector with the nonagricultural sector of the U.S. economy since the late forties reveals that agricultural prices and nominal income are much more variable than nonagricultural prices and nominal income (21). 1/ An open question is the extent to which these sectoral differences are caused by changing macroeconomic policies rather than being the result of idiosyncratic real disturbances within each industry. An analysis of the sectoral effects of macroeconomic policies, therefore, must first identify distinguishing sectoral characteristics that might induce differential responses to various aggregate policies and exogenous shocks. Having done this, one can reasonably talk about the distributional effects associated with such policies in the context of a well-developed and acceptable macroeconomic model of the economy. Unfortunately, the particular aspects of agricultural industries are such that current macroeconomic models have little to say along sectoral lines. In this paper, I propose a modeling approach for the analysis of macroeconomic policy that will readily disaggregate sectors while directly addressing the issues of interest.

Agriculture and Macromodels

The distinguishing characteristics of agricultural industries are the following:

- They tend to be relatively capital intensive, with producers heavily involved in capital markets to finance production. Farm assets--primarily land and machinery--are fixed and illiquid, but their prices, as with most asset prices, are flexible, exhibiting wide fluctuations in their nominal value. Farm debts are usually fixed in nominal terms. The debt-asset ratio of agricultural enterprises is, therefore, subject to wide variation, falling in good times as rising farm incomes are capitalized into rising land values, and rising in poorer times. The eighties have been characterized by falling farm incomes and land prices and, consequently, an increase in bankruptcies. Of importance might be the rapid integration of international assets markets over the seventies, which may have introduced new sources of uncertainty into the calculus of optimal behavior in agricultural industries (21).

- They are heavily dependent on export markets, and so are exposed to sources of uncertainty not always experienced in more insulated industries. These sources of uncertainty include fluctuating foreign demand, foreign competition, the vagaries of foreign government intervention via trade barriers, and subsidies to foreign production. More important, the effect of domestic policies on the

---

Douglas McTaggart is with the Virginia Polytechnic Institute and State University, Blacksburg. This is a shorter version of paper prepared for the meeting of the USDA Universities Agricultural Trade Research Consortium, Dec. 18, 1985, held in Vancouver, B.C. Tom Grennes and David Orden provided useful comments. Support from USDA is gratefully acknowledged.

1/ Underscored numbers in parentheses refer to sources cited in the References following this article.

exchange rate in floating exchange rate regimes has become a powerful influence over the fortunes of export industries. The rising U.S. dollar in the eighties is often believed to have caused the fall in farm incomes that is creating the current spate of bankruptcies in the agricultural sector.

- o They have widely varying production circumstances, depending on the farm output. In particular, the necessity of long-range planning over the production cycle places a greater emphasis on accurately forecasting future prices. These effects were typically modeled in "cobweb" or "hog-cycle" model with ad hoc expectations formation mechanisms (5, 9, 23). A natural interpretation, one that can exploit more modern theoretical tools, is to suppose that agricultural output decisions are based on rational forecasts made using smaller information sets than are available in other industries where output decisions are made with (perhaps) full current information. The point here is that in an environment with rapidly evolving and changing government policies (which might be quite unpredictable), agricultural industries will exhibit greater relative and nominal price variability than other industries where quantity adjustments, made contemporaneously with policy changes, mitigate the price response. This may give the false impression that agricultural industries can be characterized as flexible price industries, while others are, in contrast, fixed-price.

- o Their products' price and income elasticities of demand and supply obviously differ from economy-wide values.

These distinguishing characteristics of agricultural industries capture the important channels of influence--primarily through expectations, assets markets, and international linkages. What is required, therefore, is an understanding of the mechanisms inducing asset market equilibrium and the linkages between these markets and domestic product markets and foreign markets. This point cannot be overemphasized as both the major policy tools of the government--fiscal and monetary policies--act directly through assets markets. Monetary policy is accomplished by open market operations (irrespective of the goals of the monetary authorities) and fiscal policies resulting in deficit or surpluses are financed by direct government borrowing (or lending) through the assets markets. If we fully understood these interactions, then it would seem a simple task to generalize the discussion to account for the effects of such a policy change on agriculture and other sectors. However, this is not the case.

What inhibits our understanding and causes an inability to provide useful quantitative assessments of the impacts of different policies is the current confused state of macroeconomic theory. The predominant Keynesian and Monetarist theories of the sixties were overturned by rational expectations theorists in the seventies using arguments that severely eroded confidence in traditional theoretical and econometric methods (19). The discredited paradigm however, has yet to be replaced with a theoretical structure rich enough to answer questions regarding the conduct of government policy; answers to which are essentially conditional forecasts based on models of rational behavior. The current generation log-linear rational expectations models analyze monetary policy in a framework that ignores reasonable asset market interactions (monetary policy essentially amounts to transfers of cash balances from the Federal Reserve (Fed) to private agents) (3, 7, 14, 17). On the other hand, equilibrium models based on first principles of explicitly maximizing utility functions subject to budget constraints--primarily overlapping generations models, two-period models (15, 16) and cash-in-advance models (1)--are sufficiently difficult so that even modest complications render these models quite intractable.

This paper takes an approach intermediate between specifying an arbitrary linear model and beginning from first principles. The structure is rich enough to capture the important feedback effects from assets markets to product markets, and vice-versa, yet is specified so that solution techniques developed in conjunction with the linear rational expectations models can be applied. Moreover, the resulting quasi-linear structure is suited to empirical application. We begin by specifying the budget constraints of all agents in the economy, consistent with Walras Law, and then analyze implied supply and demand curves along with the necessary market-clearing conditions. A solution is specified as a set of relative prices and asset demands that can be expressed as approximately linear functions of observable variables.

The Budget Constraints

We consider a medium to large economy producing a single output good that is traded with the rest of the world. For clarity of exposition, the model will focus on a single sector. Extensions to a disaggregated model are briefly discussed later (Extensions of Agriculture). The economy comprises the action of four types of agents: domestic households; the government or administration/treasury; the monetary authority (called the Fed); and foreigners. The goods in the model are domestic and foreign output, domestic money, and domestic and foreign bonds. Only four markets are explicitly considered: domestic output, money, bonds, and the market for foreign exchange. The markets for foreign goods, money, and bonds are not explicitly modeled, but are presumed to be governed by the same types of market-clearing forces as are the domestic markets. At this point, no particular assumptions are made with respect to the substitutability of domestic and foreign output or bonds (capital) or to the degrees of commodity and capital mobility.

The economy operates according to the following sequence of events. At the beginning of every period, outstanding financial assets are held by the relevant agents in the economy. Then, the government decides on a spending-tax (fiscal) policy, which requires a certain financing effort. The Fed decides on an open market (monetary) policy and an exchange rate policy. Households decide on demand supply policies for output and assets. Markets clear according to some tatonnement process and relative prices are determined. These relative prices determine the distribution of assets (portfolio choices) that start the beginning of the next period.

The type of bond considered is a one-period discount bond. If P_t^b is the price of a bond with a \$1 face or redemption value, then the nominal yield on that bond is $i_t = (1-P_t^b)/P_t^b$.

We can now proceed to specify the budget constraints implied by the behavior discussed above using the following notation:

$Y_t \equiv$ real output

$Y_t^D \equiv$ real disposable income

$D_t \equiv$ real domestic demand for domestic output

X_t ≡ real exports (foreign demand for domestic output)

N_t ≡ real imports (domestic demand for foreign output)

G_t ≡ real government consumption of domestic output)

T_t ≡ real government tax collections from domestic residents

B_t^h ≡ domestic household holdings of domestic bonds

F_t^h ≡ domestic household holdings of foreign bonds

M_t ≡ domestic nominal cash balances

W_t ≡ nominal domestic wealth

P_t^* ≡ nominal foreign price of foreign output (£)

S_t ≡ spot exchange rate (the domestic price of foreign currency, \$/£)

i_t ≡ domestic nominal interest rate

i_t^* ≡ foreign nominal interest rate

B_t^s ≡ net supply of domestic bonds, all from the government

B_t^* ≡ foreign demand for domestic bonds

B_t^f ≡ Fed holdings of domestic bonds

C_t^* ≡ Fed holdings of foreign currency (foreign reserves)

A superscript d denotes a demand on planned quantity. A superscript s denotes a planned supply. Because of the Walrasian recontracting assumption, plans are always realized at the time trading occurs.

Households

Households supply output (through firms that are considered a "veil" in this formulation), demand both domestic and foreign output (imports), domestic and foreign bonds, and domestic money. Households do not hold foreign money (such as no currency substitution), but exhibit a derived demand for foreign exchange that finances the purchase of imports and foreign bonds. Accordingly, the budget constraint of the household can be expressed:

$$(B^h_{t-t} + S_T F_{t-1} + M_{t-1}) + (P_t Y_t^D - P_t D_t - S_t P_t^* N_t) = \frac{1}{(1+i_t)} B_t^{dh} + M_t^{dh} + S_t \frac{1}{(1+i_t)^*} F_t^{dh}, \tag{1}$$

where

$$P_tY_t^D \equiv \text{disposable income, in dollars}$$

$$= P_t(Y_t - X_t) + P_tX_t - P_tT_t. \tag{2}$$

The term $(B_{t-1}^h + S_tF_{t-1}^h + M_{t-1})$ represents the current dollar value of household wealth carried over from last period. Because each bond has a \$1 or £1 face value, B_{t-1} and F_{t-1} represent the number of domestic and foreign bonds held by households. Nominal disposable income, $P_tY_t^D$, comprises sales to domestic residents, $P_t(Y_t - X_t)$, plus sales to foreigners, P_tX_t, less tax collections. Defining nominal domestic wealth

$$W_{t-1} = B_{t-1}^h + S_tF_{t-1}^h + M_{t-1}, \tag{3}$$

as it should be apparent that supply and demand curves derived from maximizing a utility function subject to (1), (2), and (3) will have as arguments W_{t-1}, S_t, P_t, P_t^*, $(1+i_t)$, $(1+i_t^*)$ and T_t, as well as the parameters specifying the utility function. 2/

Administration/Treasury

The government demands domestic output; we ignore the possibility that some government consumption may be imported. Domestic government consumption is financed primarily through taxation. Any surplus or deficit is financed by direct borrowing or purchasing of bonds from the other agents in the economy (the Treasury does not hold cash balances). Thus, a budget constraint for the government is:

$$\frac{B_t^s}{(1+i_t)} = P_t(G_t - T_t) + B_{t-1} \tag{4}$$

The LHS (left-hand side) represents the current nominal value of bond sales used to retire old debt, B_{t-1}, and to finance the deficit, $P_t(G_t - T_t)$. Notice that we have two definitions of a "balanced budget." First a balance on the "current account," $G_t = T_t$, represents a zero deficit. But if at any time in the past a deficit had been run so that $B_{t-1} > 0$, then current bond sales will be required to finance the retirement of old debt and the stock of outstanding government debt will increase exponentially over time. For debt with a longer maturity, this is analogous to creating new debt to finance the interest payments. A truly balanced budget might be defined as one where the stock of outstanding government debt remains constant, which will generally require a surplus on the current account, $G_t < T_t$, to finance the interest payments on outstanding debt.

As with our discussion of the household, we can think of G_t, T_t, and B_t^s as emerging from some utility maximization problem subject to the budget constraint of equation 4.

2/ Turnovsky (28) is one of the few who has emphasized the fact that beginning period wealth is the relevant variable entering supply and demand curves.

Federal Reserve

The Fed supplies domestic currency and demands domestic bonds via open market operations. Only the Fed can hold foreign currency in the form of foreign reserves. The Fed's budget constraint is given by:

$$(M_t^s - M_{t-1}) + B_{t-1}^f = \frac{1}{(1+i_t)} B_t^{df} + S_t(C_t^* - C_{t-1}^*). \qquad (5)$$

The Fed's purchases of domestic bonds, B_t^{df}, and foreign currency, $C_t^* - C_{t-1}^*$, are financed by interest earnings on old debt, B_{t-1}^f, and the creation of new money. The Fed chooses a money supply rule, M_t^s, an exchange rate policy, and an open market operation policy by maximizing its utility function subject to equation 5.

Walras Law

Adding up the budget constraints of equations 1, 4, and 5, making use of equations 2 and 3, yields

$$P_t\{Y_t - D_t - X_t - G_t\} + \{M_t^s - M_t^d\} + \frac{1}{(1+i_t)}\{B_t^s - B_t^{dh} - B_t^{df} - B_t^*\} \qquad (6)$$

$$+ \{(S_t F_{t-1} + P_t X_t + S_t C_{t-1}^* + \frac{1}{(1+i_t)} B_t^*) - (S_t \frac{1}{(1+i_t)^*} F_t^{dh} + S_t P_t^* N_t$$

$$+ S_t C_t^* + B_{t-1}^*)\} = 0,$$

where B_t^* is the foreign holdings of domestic bonds. Equation 6 says that the sum of excess supplies across all markets in the economy is zero. It tells us that when considering economy-wide equilibrium we need only account for <u>three</u> independent market-closing conditions. Consequently, with four markets, only three of which are independent, we have three relative prices to consider: P_t, the aggregate price level; i_t, the nominal interest rate; and S_t, the spot exchange rate. 3/

All are relative prices expressed in terms of dollars which is the numeraire good in the model.

The supply of foreign exchange has four sources: interest earnings on domestically held foreign bonds, export earnings, current holdings of foreign exchange, and earnings from the foreign demand for domestic bonds. Conversely, the demand for foreign exchange derives from the domestic demand for foreign bonds, imports of foreign output, increases in holding of foreign reserves, and interest payments to foreigners on the domestic debt they hold. It is usual in the international trade literature to simply consider the excess supply of foreign exchange, rewriting it as

---

3/ Note that Fair's (10) claim that the exchange rate is not a relative price is wrong.

$$XS_{FE} = (P_tX_t - S_tP_t^*N_t) - S_t(C_t^* - C_{t-1}^*) + (\frac{1}{(1+i_t)} B_t^* - B_{t-1}^*$$

$$- S_t(\frac{1}{(1-i_t)^*} F_t^{dh} - F_{t-1}^h).$$

If all other markets clear, then from equation 6, $XS_{FE} = 0$. This gives the usual definition of the balance of payments,

$$S_t(C_t^*-C_t^*-1) \equiv \text{change in foreign reserves}$$

$$= (P_tX_t - S_tF_tN_t) + \{(\frac{1}{1+i_t} B_t^* - B_t^*-1)$$

$$- (S_t\frac{1}{(1+i_t)^*} F_t^{dh} - f_{t-1}^h)\}. \qquad (7)$$

The first term on the RHS (right-hand side) of equation 7 is the balance on the current account, while the second term is the balance on the capital account. The arbitrariness of defining the balance of payments in terms of changes in holdings of foreign reserves is apparent.

The Walras Law condition (equation 6) provided a useful framework for discussing the various approaches to the determination of the balance of payments or exchange rate found in the literature. If we assume that the domestic output, money, and bond markets always clear and if capital is immobile, ($B_t^* = B_{t-1}^* = F_t^{dh} = F_{t-1}^h = 0$, then equation 6 becomes

$$S_t(C_t^* - C_{t-1}^*) = P_tX_t - S_tP_t^*N_t,$$

which provides the foundation for the elasticities approach. Or, again assuming zero capital mobility and continuously clearing money and bond markets, we can rewrite equation 6 as

$$S_t(C_t^* - C_{t-1}^*) = P_t(Y_t - A_t)$$

where $A_t = D_t + G_t + \frac{S_tP_t^*}{P_t} N_t$ is domestic absorption. This equation forms the basis of the absorption approach. Finally, if the goods and bond markets clear, and under flexible exchange rates (the change in international reserves is zero), equation 6 becomes

$$M_t^s - M_t^d = -(P_tX_t-S_tP_t^*N_t) - \{(\frac{1}{(1+i_t)} B_t^* - B_{t-1}^*) - S_t(\frac{1}{1+i_t^*} f_t^{dh}- f_{t-1}^h)\}.$$

That is, excess supply in the money market will generate adjustments in either or both of the current and capital accounts. These trade and capital flows will then determine the exchange rate. Similarly, the monetary approach to the balance of payments emphasizes disequilibrium in the money market. It should be apparent that these different "approaches" to the determination of the exchange rate or balance of payments depend on very different sets of assumptions regarding which markets always clear first and the degree of capital mobility. 4/ Each approach can be thought of as a partial equilibrium approach emphasizing different aspects of international trade, but since all in some way derive from equation 6, all are fundamentally consistent. Since the model in this paper is based on equation 6, the approach taken here is a synthesis of the various approaches found elsewhere.

Specification of the Model

This section describes the various behavioral assumptions in the form of supply and demand curves. A log-linear version is as follows:

$$y_t = k_y + \alpha_1^s r_t - \alpha_2^s w_{t-1} - \alpha_3^s \hat{t} + \varepsilon_t^s \tag{8}$$

$$d_t = k_d - \alpha_1^d r_t + \alpha_2^d w_{t-1} - \alpha_3^d (p_t - p_t^* - s_t) + \varepsilon_t^d \tag{9}$$

$$b_t^{dh} - q_t = k_b + \phi_1 w_{t-1} + \phi_2 (i_t - i_t^* - E_t s_{t+1} + s_t) - u_t^1 \tag{10}$$

$$f_t^{dh} - s_t - q_t = k_f + \psi_1 w_{t-1} - \psi_2 (i_t - i_t^* - E_t s_{t+1} + s_t - \psi_3 \hat{t} + U_t^2 \tag{11}$$

$$m_t^d - p_t = km + \eta_1 w_{t-1} - \eta_2 i_t - \eta_3 \hat{t} + u_t^3 \tag{12}$$

$$n_t = k_n - \gamma_1 r_t + \gamma_2 w_{t-1} + \gamma_3 (p_t - p_t^* - s_t) + \varepsilon_t^n \tag{13}$$

$$x_t = k_n + \theta_1 y_t^* - \theta_2 (p_t - p_t - s_t) + \varepsilon_t^n \tag{14}$$

$$b_t^* - s_t - p_t^* = k_b^* + \theta_3 y_t^* + \theta_4 (i_t - i_t^* - E_t s_{t+1} + s_t) + u_t^* \tag{15}$$

4/ The assets approach to the exchange rate, currently popular in the literature, is unusual in that it does not directly derive from the Walras Law condition (equation 6). Instead, it utilizes certain arbitrage conditions--purchasing power parity and interest rate parity--that hold only under restrictive assumption concerning goods and capital mobility and substitutability with foreign goods and capital.

$$b_t^s - i_t = (1/\sigma_1)\{\sigma_2(g_t+p_t) - (y_t+t+p_t) + \sigma_3 b_{t-1}\} \tag{16}$$

$$b_t^{df} = \beta_1 m_t^s - \beta_2 m_{t-1} + \beta_3 b_{t-1}^f + i_t \tag{17}$$

$$y_t = \delta_1 d_t + \delta_2 n_t + \delta_3 g_t \tag{18}$$

$$b_t^s = \rho_1 b_t^{dh} + \rho_2 b_t^{df} + \rho_3 b_t^* \tag{19}$$

$$m_t^s = m_t^d \tag{20}$$

$$\begin{aligned} 0 = {} & \lambda_1(x_t+p_t) - \lambda_2(n_t+p_t^*+s_t) + (b_t^*-i_t) - \lambda_3(f_t^{dh}+s_t-i_t^*) \\ & - \lambda_4 b_{t-1}^* + \lambda_5(f_{t-1}^h+s_t) \end{aligned} \tag{21}$$

$$g_t = k_1 + y_t \tag{22}$$

$$\ln(T_t) = t + y_t \tag{23}$$

$$m_t^s = k_2 + m_{t-1} \tag{24}$$

$$r_t = i_t - (E_t q_{t+1} - q_t) \tag{25}$$

$$q_t = \pi p_t + (1-\pi)(p_t^*+s_t) \tag{26}$$

$$w_{t-1} = \nu_1 b_{t-1}^h + \nu_2(f_{t-1}^h+s_t) + \nu_3 m_{t-1} - q_t. \tag{27}$$

r_t is the real interest rate, w_t is current real value of household wealth, t is the marginal rate of income tax, s_t is the current spot exchange rate, and $E_t s_{t+1}$ is the current expected future spot rate or the forward rate. 5/ E_t represents the conditional expectation operator--conditioned on

5/ In the absence of a risk premium, the current forward rate equals the expected future spot rate.

period t information. Equation 8 says that the supply of real output depends positively on the real interest rate (capturing an intertemporal substitution effect) 6/, negatively on real wealth (an income effect--consumption and leisure are both normal goods), and negatively on the rate of taxation--a "disincentive" effect which is really another substitution effect, reflecting the consumption-leisure tradeoff. Nominal wealth (and other nominal variables) is deflated by an aggregate price index Q_t, defined below. Equation 9 describes domestic demand for domestic output, which also involves an intertemporal substitution effect (the real interest rate represents the opportunity cost of future consumption in terms of current consumption) and an income effect. Demand for domestic output also depends negatively on the real exchange rate (the opportunity cost of current domestic output in terms of foreign output), representing an additional contemporaneous substitution possibility. Equation 13 similarly describes the demand for imports. Asset demands are given by equations 10-12, which are the domestic demand for domestic bonds, foreign bonds, and money. Each depends positively on real wealth, but responds differently to deviations from uncovered interest rate parity, which represents the opportunity cost of domestic bonds in terms of income foregone on foreign bonds.

The degree of substitutability between domestic and foreign goods and bonds, and possibly the degree of mobility of each, can be parameterized by α_3^d, γ_3, ϕ_2 and ψ^2. If the different outputs are highly substitutable and highly mobile, then the responses to deviations in purchasing power parity (deviations in the real exchange rate) will be large; likewise with bonds and deviations from interest rate parity. Note also that the effects of taxation are such that an increase in the rate of taxation provides an immediate disincentive effect in product markets, but does not immediately have an impact on consumption. The income effects of taxation occur through asset demands, which affect the next period's consumption opportunities.

Foreign households demand domestic bonds (equation 15) and output (equation 14), where y_t^* is foreign real income. The various exogenous disturbances ε_t^d, ε_t^s, ε_t^n, ε_t^*, u_t^1, u_t^2, u_t^3, and u_t^* are stochastic shifts in tastes and preferences. Their precise nature is specified below. Also note the various restrictions placed on linear combinations of parameters by the different budget constraints.

The Treasury/Administration selects the fiscal policy regime (spending and taxation policies--equation 22 and 23), which, together with the government budget constraints (equation 4), determines a borrowing policy or a supply of domestic bonds (equation 16). Similarly we need to specify the monetary regime chosen by the Fed. Reasonable monetary rules are from K% growth rules, rules inducing interest rate and price stability and rules determining the extent to which the Fed monetizes existing government debt. For simplicity, assume a constant monetary growth rule (equation 24). The Fed also chooses an exchange rate regime. In this formulation, we assume a free float. Given these policy choices, (equation 17) specifies the implied open market operations of the Fed.

Next we have the market clearing conditions, (equations 18-21). The following definitions also hold: equation 25 is the Fisher relationship connecting

6/ It is more worthwhile to work today and then invest the earning at the higher interest rate and be able to consume more tomorrow.

nominal and real interest rates via the expected rate of inflation; equation 26 is the price index relevant for domestic demand and supply decisions; and equation 27 is a definition of real wealth.

There are a total of 20 equations in 19 variables: y_t, d_t, b_t^{dh}, f_t^{dh}, n_t, x_t, b_t^*, b_t^s, b_t^{df}, m_t^s, m_{td}^d, w_{t-1}, g_t, t_t, $(1+i_t)$, $(1+r_t)$, p_t, s_t, q_t. By Walras Law, however, only three of the four market- clearing conditions are independent. The model so specified is a log-linearized version of a more general dynamic nonlinear model. As such it involves a number of approximations. The general solution procedure adopted is to solve the linearized version using methods developed in the macroeconomic literature, update the various "constants" in the model, resolve, and so on. This allows us to track or simulate the evolution of the economy following different policy experiments. To solve the linear version, define the following vectors:

$$\underset{\sim}{P}_t^T = [p_t \quad s_t \quad i_t \quad b_t^h \quad f_t^h \quad b_t^f \quad m_t \quad b_t^*]$$

$$\underset{\sim}{P}_t^{*T} = [p_t^* \quad i_t^* \quad y_t^*]$$

$$\underset{\sim}{V}_t^T = [\varepsilon_t^s \quad \varepsilon_t^d \quad \varepsilon_t^x \quad \varepsilon_t^n \quad u_t^1 \quad u_t^2 \quad u_t^*].$$

Next, reduce the model to the quasi-reduced form

$$a\underset{\sim}{P}_t = k + b\underset{\sim}{P}_{t-1} + cE_t\underset{\sim}{P}_{t+1} + d\underset{\sim}{P}_t^* + e\underset{\sim}{P}_{t+1}^* + f\underset{\sim}{V}_t. \qquad (28)$$

P_t is the vector of endogenous variables. $\underset{\sim}{P}_t^*$ is the vector of disturbances emanating from the foreign country. $\underset{\sim}{V}_t$ is the vector of unobservable taste shift disturbance. Equation 28 is a "quasi-reduced" form solution because it involves unobservable expected variable as well as exogenous and predetermined variables. Supposing that

$$\underset{\sim}{P}_t^* = g\underset{\sim}{P}_{t-1}^* + \underset{\sim}{V}_t^*, \qquad (29)$$

that is, domestic residents perceive that the foreign price level, interest rate, and output follow some first-order Markov process, then solution to the model is given by

$$\underset{\sim}{P}_{t+1} = B_o + B_1\underset{\sim}{P}_t + B_2\underset{\sim}{P}_{t-1} + B_3\underset{\sim}{P}_{t+1}^* + B_4\underset{\sim}{P}_t^* + B_5\underset{\sim}{V}_{t+1} + B_6\underset{\sim}{V}_t. \qquad (30)$$

The elements of the matrices B_i are, in general, complicated nonlinear functions of the underlying structural parameters and of the policy parameters. The dependence of the solution of the model on the particular policy regimes is a manifestation of the Lucas critique (18), namely, the parameters of reduced form rational expectations models will not generally be invariant to policy changes. This point not only complicates theoretical discussions of policy changes but also has very important implications for econometric analyses of models such as equation 30. Identification is achieved only when we have isolated periods of stable policies, in this case, periods where (1) monetary policy, (2) fiscal policy, and (3) exchange rate policy remain unchanged. Then we can estimate the implied reduced-form model solved for these policies over that particular time period. This consideration places severe constraints on our ability to successfully estimate large-scale models in periods when different policies are observed. Not the least problem is actually identifying periods where policy rules remained unchanged.

Impact Effects of Policy Changes

One can calculate the shortrun or impact effects of policy changes on the relative prices holding expectations constant and deduce the types of portfolio adjustments they will cause. These portfolio adjustments will, of course, be important for the future evolution of the economy. A summary of the impact effects is given in table 1.

Many of the results are as expected, for example, an increase in domestic output supply (k_y^s) due, for instance, to an increase in economy-wide productivity, reduces domestic prices. It also increases disposable income and so directly increases the demand for domestic and foreign bonds. This drives bond prices up and the interest rate down. The reduction in the interest rate reduces the foreign demand for domestic bonds and increases domestic demand for foreign bonds. The net effect in the foreign exchange market is an excess demand for foreign exchange, which causes a domestic depreciation of the exchange rate. The next period will see an increase in wealth carried over, which will reduce domestic output supply, increase demand, and increase the demand for imports. The future current account effects could well reverse some of these impact effects.

A domestic increase for domestic bonds causes the interest rate to fall as bond prices rise. The falling interest rate reduces the supply of output and increases demand. Goods prices rise. The rise in good prices and the rise in domestic bond prices both act to increase the supply of foreign exchange. Hence, the exchange rate strengthens.

An increase in the money supply has similar effects to an increase in the demand for domestic bonds because it entails open market operations. Now, however, because the supply of dollars rises relative to foreign exchange, the exchange rate falls (the dollar weakens).

Table 1--Effect of increases in constants on the relative prices

Item	k_y^s	k_y^d	k_x	k_b	k_m	k_b^*	k_1	k_2	t
p_t	↓	↑	↑	↑	↓	↑	↓↑	↑	↓↑
s_t	↑	↓	↓	↓	↓	↓	↓↑	↑	↑↓
i_t	↓	↑	↑	↓	↑	↓	↑	↓	↑↓

Interestingly, increases in government spending have indeterminate effects. The increase in aggregate demand puts pressure on the domestic price level, but since the deficit is financed by borrowing, the price of bonds falls and interest rates rise, increasing supply and reducing demand. The net effect on domestic prices, and consequently on the exchange rate is ambiguous.

Finally, notice that the exchange rate and interest rate do not always move in opposite directions. This should be a concern to modelers who take the interest rate and exchange rate as exogenous as it is not clear now how to introduce these elements in a determinate way.

Extensions to Agriculture

This paper began with a discussion of the characteristics of agricultural industries that might induce responses in agricultural prices and output different from those observed in the rest of the economy. We posited that the capital intensity, openness, and possibly different production circumstances of agriculture made that sector particularly sensitive to disturbances in assets markets and exchange rate movements. The analysis in the earlier sections developed a framework for analyzing a single-sector aggregate open economy. This section discusses a generalization of the approach to incorporate sectoral differences in the analysis. In particular, we want to isolate the characteristics peculiar to agriculture.

One approach might be to introduce firms explicitly into the analysis, so that the economy consists of households, manufacturing firms, agricultural firms, the government, and the Fed. A somewhat simpler approach, the one adopted here, is to consider different households (manufacturing and agricultural) and once more to subsume the explicit analysis of firms.

Manufacturing households are assumed to be the same as before: they are net holders of the debt of others, they produce manufactured goods, but consume both manufactured and agricultural goods.

Agricultural households, on the other hand, produce agricultural goods and consume only manufactured goods. We can think of agricultural households consuming some of their own output, so we observe zero agricultural household consumption of market agricultural goods. Furthermore, agricultural households are a new source of debt in the economy; they issue short-term liabilities every period to finance current production. Revenues from sales of that output are used to pay off past debt and to finance current consumption of manufacturing goods. Agricultural debt will generally not be perfectly substitutable with government debt (which is usually though of as default free) and, for simplicity, we assume that foreigners hold only government debt.

We further assume that some agricultural goods are exported, while some manufactured goods are imported. These considerations imply the following budget constraints.

Manufacturing Households

$$(B^{h}_{t-1} + A^{h}_{t-1} + S_tF^{h}_{t-1} + M_{t-1}) + (P^{m}_{t} Y^{Dm}_{t} - P^{m}_{t} D^{mm}_{t} - S_tP^{*m}_{t} N^{m}_{t} - P^{a}_{t} D^{ma}_{t})$$

$$= \frac{1}{(1+i_t)^g} B^{dh}_{t} + \frac{1}{(1+i_t)^a} A^{dh}_{t} + S_t \frac{1}{(1+i_t)^*} F^{dh}_{t} + M^{dh}_{t}. \tag{32}$$

where

$$Y^{Dm}_{t} = Y^{Sm}_{t} - T^{m}_{t}. \tag{33}$$

Agricultural Households

$$(P^{a}_{t}Y^{Da}_{t} - P^{m}_{t}D^{am}_{t}) + \frac{1}{(1+i_t)^a} A^{s}_{t} = A_{t-1} \tag{34}$$

where

$$Y^{Da}_{t} = Y^{sa}_{t} - T^{a}_{t} \tag{35}$$

Treasury/Administration

$$\frac{B^{s}_{t}}{(1+i_t)^g} = (P^{a}_{t}G^{a}_{t} + P^{m}_{t}G^{m}_{t} - P^{a}_{t}T^{a}_{t} - P^{m}_{t}T^{m}_{t}) + B_{t-1} \tag{36}$$

Federal Reserve

$$(M^{s}_{t} - M_{t-1}) + B^{F}_{t-1} + A^{F}_{t-1} = \frac{1}{(1+i_t)^g} B^{df}_{t} + \frac{1}{(1+i_t)^a} A^{df}_{t} + S_t(C^{*}_{t} - C^{*}_{t-1}) \tag{37}$$

This disaggregation of the economy permits the analysis a much richer set of policies than before. For example, we might want to consider the sectoral effects of a large increase in government spending on manufactured goods, say a large defense buildup. Or the effects of an agricultural price support scheme by letting

$$G^{a}_{t} = K(P^{a}_{t} - P^{a}_{t}),$$

where $K \to \infty$ would imply strict adherence to price supports. The Fed now has the choice of monetizing the government debt or of subsidizing agricultural debt.

As before, Walras Law must hold,

$$P_t^m(Y_t^{sm}-D_t^{mm}-D_t^{am}-G_t^m) + P_t^a(Y_t^{sa}- D_t^{ma} - G_t^a - X_t^a) + (M_t^s - M_t^{dh})$$

$$+ \quad (\frac{1}{1+i_t^g})(B_t^s - B_t^{dh} - B_t^F - B_t^*) + \frac{1}{(1+i_t^a)} (A_t^s - A_t^{dh} - A_t^{dF})$$

$$+ \quad \{(P_t^a X_t^a - S_t P_t^{*m} N_t^m) + (\frac{1}{(1+i_t^g)} B_t^* - B_{t-1}) - (S_t \frac{1}{(1+i_t^*)} F_t^{dh} - F_{t-1})$$

$$- S_t(C_t^* - C_{t-1}^*)\} = 0. \tag{38}$$

Now we have five independent market clearing conditions, with five relative prices: P_t^a, P_t^m, i_t^a, i_t^g, S_t. The model is more complicated than before, but well within the capabilities of current technology, both theoretical and computing. It enables us to consider the following types of interactions. First, since agricultural bonds will be competing with government bonds, when more of the government deficit is financed by borrowing, the induced increase in interest rates on government debt will cause i_t^a to rise. This will cause agricultural producers to go more heavily into debt and will induce a reduction in consumption by agricultural households. Any induced exchange rate effects will have an impact on the demand for agricultural exports. If export demand falls, the market-clearing price for agricultural goods will fall, reducing nominal agricultural income. Again, this will require more debt issuance by agricultural households or a reduction in consumption.

Conclusions

The primary aim of this paper has been to present an approach that, while maintaining tractability, allows for the analysis of the various interactions between domestic product and asset markets and various international linkages. Doing this introduces some ambiguity into the analysis, in that some of the results become sensitive to parametric changes in the model. But, for a wide class of parameter values, some surprising results occur because of the exchange rate effects feeding back into domestic markets. At this point, these results are tentative at best, yet they suggest that care should be taken when discussing the domestic effects of macroeconomic policy in an open economy. At the very least, further research is required to (1) verify that these results are reasonable for actual economies and (2) to detect the longer run effects of such policies.

References

(1) Abel, A. B. "Dynamic Behavior of Capital Accumulation in a Cash-in-Advance Model," Journal of Monetary Economics, Vol. 16 (June 1985).

(2) Aoki, M., and M. Canzoneri. "Reduced Forms of Rational Expectations Models," Quarterly Journal of Economics, Vol. 93, (Feb. 1979), 47-71.

(3) Barro, R. J. "Rational Expectations and the Role of Monetary Policy," Journal of Monetary Economics, Vol. 2 (Jan. 1976).

(4) Chambers, R. G., and R. E. Just. "An Investigation of the Effect of Monetary Factors on Agriculture," Journal of Monetary Economics, Vol. 9 (Mar. 1982), 235-47.

(5) Cochrane, W. "Farm Price Gyrations--An Aggregative Hypothesis," Journal of Farm Economics, Vol. 29 (1947), 383-408.

(6) Dornbusch, R., and S. Ficher. The Open Economy: Implications for Monetary and Fiscal Policy. Working paper 1422. National Bureau of Economic Research, Cambridge, Mass., Aug. 1985.

(7) Dotsey, M., and R. G. King. "Monetary Instruments and Policy Rules in a Rational Expectations Environment," Journal of Monetary Economics, Vol. 12 (Sept. 1983), 357-82.

(8) Duncan, M. "Current Macroeconomic Policies and U.S. Agriculture: Discussion," American Journal of Agricultural Economics, Vol. 64 (Dec. 1982), 872-73.

(9) Ezekiel, M. "The Cobweb Theorem," Quarterly Journal of Economics, Vol. 52 (1938), 255-80.

(10) Fair, R. "A Model of the Balance of Payments," Journal of International Economics, Vol. 9 (Feb. 1979).

(11) Feldstein, M. "The Fiscal Framework of Monetary Policy," Economic Inquiry, Vol. 21 (Jan. 1983), 11-23.

(12) Frenkel, J. A., and A. Razin. Fiscal Policies, Debt, and International Economic Dependence. Working paper 1266. National Bureau of Economic Research, Cambridge, Mass., Jan. 1984.

(13) Giddy, I. H. "An Integrated Theory of Exchange Rate Equilibrium," Journal of Financial and Quantitative Analysis (Dec. 1976), 883-92.

(14) Hirschhorn, E. "Rational Expectations and the Effects of Government Debt," Journal of Monetary Economics, Vol. 14 (July 1984), 55-70.

(15) Kimbrough, K. Inflation, Employment and Welfare in the Presence of Transactions Costs. Working paper 85-11. Department of Economics, Duke University, Durham, Oct. 1985.

(16) ____________. Foreign Aid and Optimal Fiscal Policy. Working paper 85-12. Department of Economics, Duke University, Durham, Sept. 1985.

(17) King, R. G. "Monetary Policy and the Information Content of Prices," Journal of Political Economy, Vol. 90 (Apr. 1982), 247-79.

(18) Lucas, R. E., Jr. "Econometric Policy Evaluation: A Critique," The Philips Curve and Labor Markets, Ed. by K. Brunner and A. Meltzer, Amsterdam, North Holland, 1976.

(19) ____________, and T. J. Sargent. "After Keynesian Macroeconomics," After the Philips Curve: Persistence of High Inflation and High Unemployment. Boston: Federal Reserve Bank, 1979.

(20) Mayer, L. V. "Current Macroeconomic Policies and U.S. Agriculture: Discussion," American Journal of Agricultural Economics, Vol. 64 (Dec. 1982), 869-71.

(21) McCalla, A. F. "Impact of Macroeconomic Policies upon Agricultural Trade and Agricultural Development," American Journal of Agricultural Economics, Vol. 64 (Dec. 1982), 861-68.

(22) Mussa, M. "A Model of Exchange Rate Dynamic," Journal of Political Economy. Vol. 90 (Feb. 1982), 74-104.

(23) Nerlove, M. The Dynamics of Supply: Estimation of Farmer's Response to Price. Baltimore, MD: Johns Hopkins Press, 1958.

(24) Pick, D. H. and A. F. McCalla. Do Macroeconomic Variables Affect the Agricultural Trade Sector? An Elasticities Analysis. Working paper 85-1. International Agricultural Trade Research Consortium, University of California, Davis, Nov. 1985.

(25) Rausser, G. C. Macroeconomics and U.S. Agricultural Policy. Working paper 358. Division of Agricultural Sciences, University of California, Davis, Mar. 1985.

(26) Stamoulis, K. G., J. A. Chalfant, and G. C. Rausser. Monetary Policies and the Overshooting of Flexible Prices: Implications for Agricultural Policy. Working paper. Division of Agricultural Sciences, University of California, Davis, 1985.

(27) Starleaf, D. R. "Macroeconomic Policies and Their Impact on the Farm Sector," American Journal of Agricultural Economics, Vol. 64 (Dec. 1982), 854-60.

(28) Turnovsky, S. J. Macroeconomic Analysis and Stabilization Policy. Cambridge, England: Cambridge University Press, 1977.