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Abstract

This study constructs dynamic welfare measures for a system of futures markets that express the allocative efficiency of a particular market as a function of its accuracy and speed of adjustment following a shock to the system. The system comprises futures prices for T-bills, exchange rates (German mark, British pound, Canadian dollar and yen), and agricultural commodities (corn, wheat, and cotton) for delivery in 1981 and 1982. The results suggest that, although agricultural, exchange, and financial markets all over-react to a disturbance, agricultural markets do so to a much greater degree. Owing to their much greater size, however, the welfare loss arising from the overshooting is likely to be much larger for interest rate and exchange markets.

I. Introduction

Much of the analysis conducted on commodity futures markets focuses on partial equilibrium frameworks (e.g., Stein, 1981). However, linkages among markets implied by general equilibrium representations show that such analyses can suffer from serious limitations. In particular, studies of futures market efficiency which search for single series martingale or random walk processes cannot be expected to classify markets correctly as efficient or inefficient (Rausser and Carter, 1983).

Linkages among markets mean that inefficiencies in one market may be transmitted to related markets. Nowhere is this more likely to be evident than in commodity futures markets. Because these markets reflect price expectations, differential information flows in the various markets will generally result in varying speeds of adjustment to causal forces.

Varying speeds of market adjustment have been used by Dornbusch (1976) and others to show that exchange rates can overshoot as a result of such market behavior. In Dornbusch's work, and the subsequent work by Frankel (1979), exchange rates overreact to a monetary shock in order to compensate for the disequilibrium arising in a more slowly adjusting goods market. In the Dornbusch formulation, the long-run steady state remains unchanged while the exchange rate equates (temporarily) demand and supply in both the exchange and goods markets. For an expansionary monetary shock, the exchange rate moves to a level higher than that implied by the new long-run equilibrium and falls gradually as the sticky goods market adjusts. Prices in the efficient (flexible) market overshoot their eventual equilibrium levels in order to clear the relatively inefficient (inflexible) goods market.

In addition to disequilibrium conditions arising in all sectors from monetary shocks, similar behavior can arise from other types of shocks. In the case of commodity markets, market-specific shocks can frequently result from droughts and other weather-related phenomena. In the case of exchange rate markets, political instability is one frequent source of unexpected shocks. Furthermore, attempts on the part of central banks to manage the value of their country's currency can lead to disequilibria in exchange rate markets which, in turn, spill over to related markets. In fact, in many agricultural commodity markets, interest rate markets, and exchange rate markets, unanticipated government policy is a likely source for shocks that arise in a specific market.

Allowing different degrees of flexibility across markets raises the possibility of overshooting in spot markets for interest rates, exchange rates, and commodity markets due to monetary shocks (Rausser, Chalfant, and Stamoulis, 1985). Other types of disequilibrium can result from shocks that emerge in individual markets which may, in turn, lead to disequilibrium in other markets due to the linkages among markets. In this paper, we examine the linkages among three groups of markets: interest rates, exchange rates, and commodity markets. Price expectations as represented by futures markets are emphasized. To the extent that disequilibria exist, do they carry over to the formation of expectations as reflected by futures markets? If resource allocation decisions are based on these expectations, what are the welfare implications of the disequilibria? These questions are investigated by quantifying the dynamic linkages among U.S. Treasury bills (T-bills), the British pound, the Canadian dollar, the German mark, the Japanese yen, and three agricultural commodity markets: corn, cotton, and wheat.

A vector autoregressive moving average (ARMA) model is estimated for a specific period of tight monetary policy, viz., 1980 through the spring of 1982. Pricing efficiency, defined here as the accuracy and speed of convergence of the price series following a shock, is calculated from the dynamic adjustment paths estimated over this period, and the pricing efficiency estimates are used to compute dynamic welfare measures. The accuracy measure is the total absolute deviation from final equilibrium levels of each price series during the adjustment period. The speed measure is the number of trading days required for some percentage of the total deviation to occur.

II. Basic Model

A full understanding of the allocative efficiency loss arising from the joint adjustment of all prices to some new stationary state requires the development of general equilibrium welfare measures (Rausser and Just, 1981). To develop these measures, consider the supply and demand for a market:

$$S_t = A_0 + A_1 \hat{p}_t \qquad A_1 \geq 0 \tag{1}$$

$$D_t = B_0 - B_1 p_t \qquad B_1 \geq 0 \tag{2}$$

$$\hat{p}_t = h' [A^{-1}(L) \quad B(L) \quad Z_t] \qquad Z_t \sim N(0,\Omega) \tag{3}$$

$$h' = [1,0,0, \ldots.]$$

$$S_t = D_t, \quad (4)$$

where p_t is the price of the commodity at time t; $\hat{p}_t$ is the expected futures price at time $t - 1$; A_0, A_1, B_0, and B_1 are positive parameters of the supply and demand relationships; and $A(L)$ and $B(L)$ are polynomials in the lag operator that reflect the dynamic interactions of the flexible price markets and are assumed to be stationary and invertible.

The price expectation substitute for $\hat{p}_t$ in equation (1) will be determined by the vector autoregressive moving average (ARMA) representation of the dynamic interactions of the price series (3). If the vector ARMA model represents the price series adequately, then this approach approximates a rational expectations formulation of expectations, with the error in the approximation caused by transactions costs, risk aversion of agents, etc. (Rausser and Carter, 1983). Note that the supply (equation 1) is determined by expected prices, and following Stein (1981), Feder, et al. (1979), and Holthausen (1979) this quantity is assumed to be sold, determining the market price via the demand relationship (equation 2). Thus the effects of any risk premia that may be embedded in the price dynamics are reflected by the supply equation. Equations (1) through (4) yield a price path as a function of structural parameters and futures prices,

$$p_t = B_0 / B_1 - \left[B_1 (A_0 + A_1 \hat{p}_t) \right]. \quad (5)$$

Assume an initial steady-state level of prices, $\bar{p}$, exists and there is a shock, Z_0, at time 0. Because $\bar{p}$ represents the net effect of all past adjustments, $\hat{p}_t$ for any time after time 0 is:

$$\hat{p}_t = \bar{p} + Q_t Z_0 \tag{6}$$

where:

$$Q_t Z_0 = h' \left[A^{-1}(L) \quad B(L) \right]_t Z_0 .$$

If there are no subsequent shocks, the effect of Z_0 at any time may be expressed as the initial steady state, $\bar{p}$, plus the net effect of Z_0 to that time. The deviation of prices from the eventual long-run equilibrium changes over time; therefore, the amount of welfare loss also changes over time.

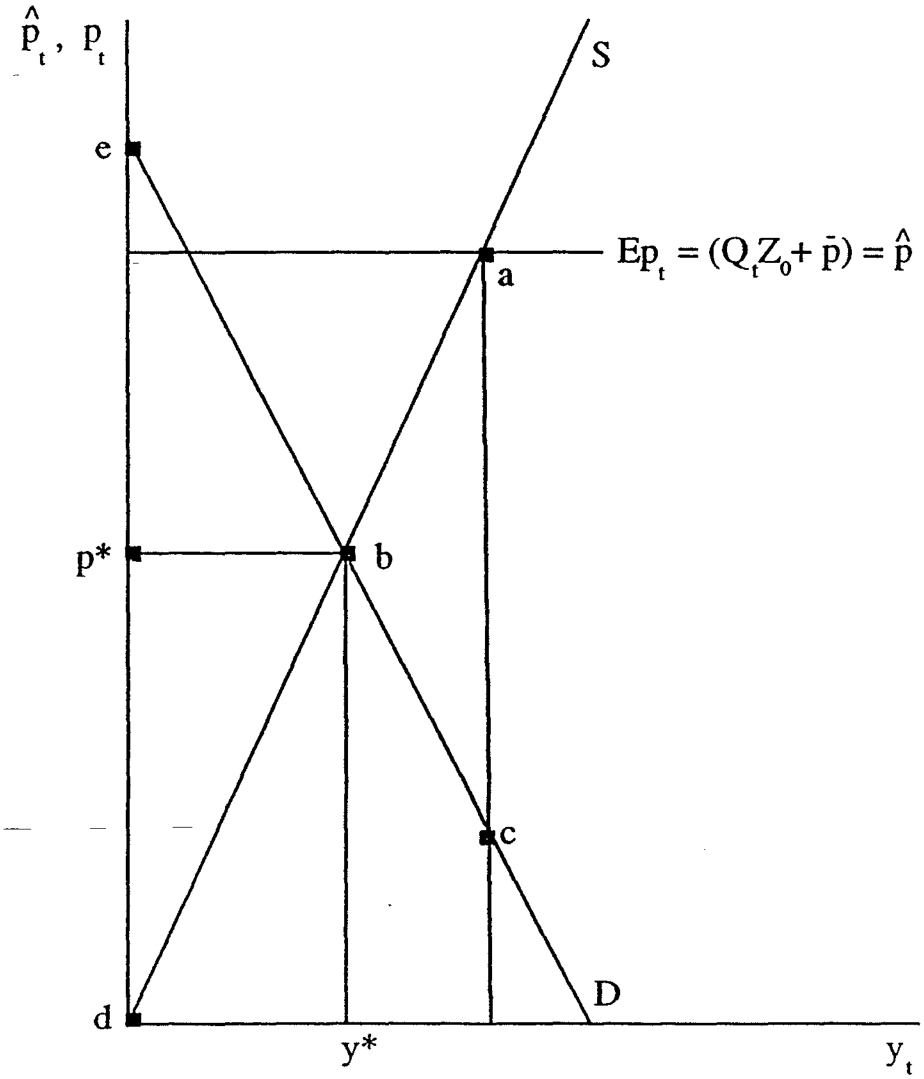
To determine the welfare loss in a market at any time during the adjustment period, consider the static welfare analysis depicted in figure 1. The long-run steady state is p^* following the shock, and y^* is the corresponding quantity. Given a stationary and invertible model, $A(L)p_\infty = B(L)Z_\infty \rightarrow p^*$; that is, given no other shocks, the price path converges to its equilibrium level. The expected level of prices for t periods following the shock is $Ep_t = (Q_i Z_0 + \bar{p})$.

It is clear that the welfare loss at p_t, relative to p^* is given by triangle abc. This area is given algebraically by halving the product of the base and height of abc:

$$WL_t = \frac{1}{2} \left[S(\hat{p}) - S(p^*) \right] \left[\hat{p} - D^{-1} \left[S(\hat{p}) \right] \right]. \tag{7}$$

Figure 1

Static Welfare Analysis



Adding and subtracting $S(p^*) = D(p^*)$ and taking a first-order Taylor series expansion about p^*, the welfare loss at any time t is:

$$WL_t = \frac{1}{2} \frac{A_1}{B_1} (B_1 + A_1) (\hat{p} - p^*)^2 . \tag{8}$$

Note that this measure depends on the squared deviation of the price from its eventual equilibrium level and the parameters of the supply and demand functions. This result is similar to Stein's partial equilibrium measure for welfare losses due to futures market price inaccuracies. Because A_1 and B_1 represent $\partial S/\partial p$ and $-(\partial D/\partial p)$, respectively, the welfare loss expressed in terms of the supply and demand elasticities at (p^*, y^*) is:

$$WL_t = \frac{1}{2} \frac{y^*}{p^*} \frac{\eta_s}{\eta_d} (\eta_d - \eta_s) (\hat{p} - p^*)^2 \tag{9}$$

where η_s, η_d define the supply and demand elasticities, respectively. The total consumer and producer surplus at (p^*, y^*) is given by the area of triangle deb in figure 1, which, when expressed in terms of elasticities, is:

$$TS = \frac{1}{2} p^* y^* \left[\frac{A_1 (p^*/y^*) + B_1 (p^*/y^*)}{B_1 (p^*/y^*) \; A_1 \; p^* \; /y^*} \right] = \frac{1}{2} p^* y^* \left[\frac{\eta_d - \eta_s}{\eta_s \, \eta_d} \right] . \tag{10}$$

Dividing equation (9) by equation (10) gives the percentage of total surplus lost as a result of the deviation of futures prices, i.e.,

$$\frac{WL}{TS} = \eta_s^2 \left[\frac{1}{p^*} \right]^2 (\hat{p} - p^*)^2 . \tag{11}$$

Representation (11) has several advantages. First, the expression is solely in terms of the elasticity of supply, the steady-state price, and the squared deviation of prices during the adjustment period. The last two variables are known for each market; therefore, the percentage welfare loss may be expressed in terms of one parameter, the elasticity of supply. Another advantage is the lack of scale for this loss measure. This allows various markets to be compared regardless of their size.

The form of this welfare measure depends upon several assumptions of the basic model, (1) through (4). First, the results hold only to the extent that the linear representation approximates the supply and demand relationships. Note that, in this measure, futures prices affect welfare through expectations, and the critical parameters are those appearing in the spot market supply and demand relationship. The dependence of (11) on the supply elasticity rather than both supply and demand elasticities occurs because of the linear structure and because $\hat{p}$ in the supply equation (1) determines the quantity in any period. Once one component of the supply and demand relationships determining the surplus measure is fixed (i.e., the supply elasticity at (p^*, y^*)), any change in the other component has offsetting effects on total surplus and welfare loss. That is, rotating the demand curve clockwise around (p^*, y^*) in figure 1 proportionately increases both the welfare loss (9) and the total surplus (10), leaving their ratio unchanged. The supply elasticity becomes the scaling factor in (11) because the expected price determines the quantity via supply.

Of course, to obtain the total welfare loss for the adjustment period, one should discount losses at future dates by some discount rate. Specifying the number of periods for an arbitrary amount of the total adjustment to occur, the total welfare loss due to the deviation of prices is a function of the discount rate, elasticities of the supply and demand functions, the number of periods for the adjustment to occur, the new steady-state level of prices and quantities, and the squared deviations of futures prices from the new steady state following a shock. The first three parameters are assumed to be constant over the adjustment period, so welfare loss may be viewed as a function of the dynamic adjustment path of prices. In other words, the welfare loss depends on the accuracy (squared deviations) and the speed of convergence of the price series.

A crucial assumption for this view of the efficiency of observed price series is the nature of the long-run equilibrium in an environment of slowly adjusting prices. Futures markets clear each day, and allocative decisions involving futures prices may be made during the adjustment of prices to their equilibrium levels. If the final equilibrium is affected by the series of temporary equilibria of all related markets, any measure of welfare loss based upon the final equilibrium which obtains must be incorrect. The long-run equilibrium which would exist in the absence of lagged adjustment of prices is unobservable; so the new efficiency measures developed in this paper, while correcting for some of the possible misspecification of previous studies, may remain only partial evaluations of total efficiency.

Although the loss measure in equation (11) provides a convenient comparison of the relative efficiency of various markets, the absolute levels of welfare loss remain informative. The measurement problem that arises for the absolute welfare loss (10) is the absence of observations of y^*, the equilibrium quantity. Although some approximations of y^* are used in the empirical section, the approximations may be crude. A loss measure consisting of the forecast error weighted by the particular market's importance to the economy is both easily determined from available data and useful in assessing the total welfare loss in each market.

Dividing both sides of equation (9) by (p^*, y^*) yields:

$$\frac{WL}{y^* p^*} = \frac{1}{2} \frac{\eta_s}{\eta_d} (\eta_d - \eta_s) \left[\frac{\hat{p} - p^*}{p^*} \right]^2 . \tag{12}$$

This value expresses the welfare loss scaled by the total sales in the market or, in other words, the welfare loss per unit of revenue. An attraction of this measure is the absence of unobserved equilibrium quantities from the right-hand side of the expression. The scaled welfare measure depends only on the elasticities of supply and demand, the steady-state price level, and the squared deviation of prices.

III. Methodology, Data, and Empirical Results

To capture empirically the dynamic price linked paths, a multivariate time series model is specified for an eight-market system. As shown in numerous places (Zellner and Palm, 1974; Rausser and Carter, 1983), if a set of endogenous variables is generated by a dynamic simultaneous equation model, then it is often possible to solve for the transfer function of individual endogenous variables (such as exchange rates, interest rates, etc.) through algebraic manipulation. In essence, each endogenous variable in a structural form model has associated with it an explicit and unique transfer function equation which expresses the endogenous variable as a linear combination of current and past values of the exogenous variables and an ARMA error term. Similarly, given that each exogenous variable can be expressed in terms of an ARMA process, it is possible to respecify the transfer function equation as an ARMA process for each endogenous variable. Accordingly, it is possible to represent the basic model presented in section II as a multivariate time series model as long as the relevant error terms in each exogenous variable can be represented as an ARMA process.

The model incorporates the relationships of T-bills and exchange rates (British pound, Canadian dollar, German mark, and Japanese yen--all in cents per unit of foreign currency) with corn, cotton, and wheat prices. As mentioned earlier, the dynamic interactions of the price series depend on the structural relationships of the underlying supply and demand functions. The existence of these interactions among agricultural commodities, as well as the relationship of agricultural commodities to interest and exchange rates, has been documented in numerous studies (Rausser, 1985).

The accuracy of the estimated efficiency for each market and for the system depends critically upon expressing the dynamic interactions adequately by identifying a suitable time-series representation. We chose vector ARMA representations because of their parsimony relative to the more widely used vector autoregressive models. Nevertheless, large vector

ARMA models still fall into the general class of overparameterized models, implying that some sort of restrictions other than identifying the order of the autoregressive and moving average polynomials may become necessary (Sims, 1980).[1]

The data used to estimate the vector ARMA consist of 205 observations for the March 1981, delivery contracts of the eight variables mentioned above and 195 observations for March 1982. These data span the period beginning in the spring of 1980 through the spring of 1982, a period during which financial markets adjusted to the new Federal Reserve (Fed) policy of targeting the money supply rather than interest rates. The two sets of observations provide estimates of pricing and allocative efficiency immediately following the Fed policy change (1981 delivery contracts) and much later (1982 delivery contracts).

The choice of the steady-state vector of prices used in the dynamic analysis influences all of the subsequent results. The welfare measures developed in section II depend on the steady-state level of prices. In addition, because the models all have autoregressive terms, the new equilibrium price levels, as well as the dynamic adjustment paths, depend upon the initial steady state chosen.

1. One option is to use t-tests to set individual elements of parameter matrices to zero (Tiao and Box, 1981), reducing the degree of overparameterization. The undesirable decrease in statistical power due to the extra coefficients, therefore, may be reduced by constraining particular values to zero. The increase in power is achieved, of course, at the risk of biasing the remaining parameter estimates. Since there is little prior information concerning parameter values used in the vector ARMA models (in particular, whether or not to include variables in certain equations), the possibility of biased parameter estimates is high. One should, thus, avoid selecting extremely low significance levels for any tests. The major concern in this study is not hypothesis testing but in reflecting as much of the dynamic adjustment as possible.

The initial equilibrium of each series is obtained by forecasting from the end of the time series until no further change in the variables is observed. This approach, of course, provides only one of many possible steady-state levels for the vector of series. At any point in the sample, one could assume that there are no further shocks and find a different steady-state level. Any one of these steady states is preferable to some ad hoc level, such as the mean for each series, because the simultaneous observation of all series at their mean level may be highly unlikely. There is no definite trend in the price series, so the choice of the last observation rather than another simultaneously observed set of prices will not affect the results.

The degree of correlation among the series in this study may be highly positive or negative, so a simultaneously observed set of prices was chosen--the last observation vector. Then, assuming no further disturbance, the estimated parameters are used to compute successive forecasts until there is no change in the forecast price. The estimated models are stable and invertible, so the forecasts converged to the equilibrium level, p^*--usually in about 25 periods.

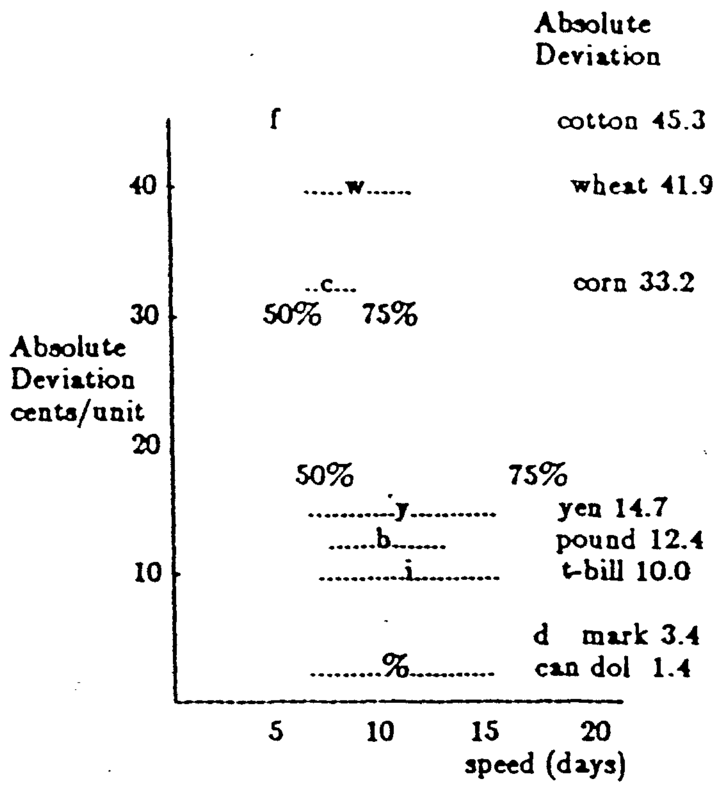
The proper type of shock to consider when calculating the multipliers is an interesting question relating to the selection of the initial steady state. Most authors who construct vector autoregressive systems analyze the dynamic properties of their models by using one standard deviation of a single series as a shock. In other words, one element of the shock vector is the standard deviation of the corresponding error series, and all other elements are zero. The probability of observing this particular shock may be extremely low, especially when the residual error terms are correlated. For example, given positive expected correlation of interest rate and the costs of storage, one might not expect to see large positive shocks both in T-bills and all commodity prices. Even if all the series are positively correlated, adjustment by the correlation matrix will reflect the relationships among errors.

The plausibility of the shock is very important because the resulting dynamic patterns are used to construct empirical measures. As mentioned earlier, positive shocks in one market or set of markets might be associated with a particular type of shock in a related market. An arbitrary choice of a particular shock might obscure this empirical relationship in the efficiency measure.

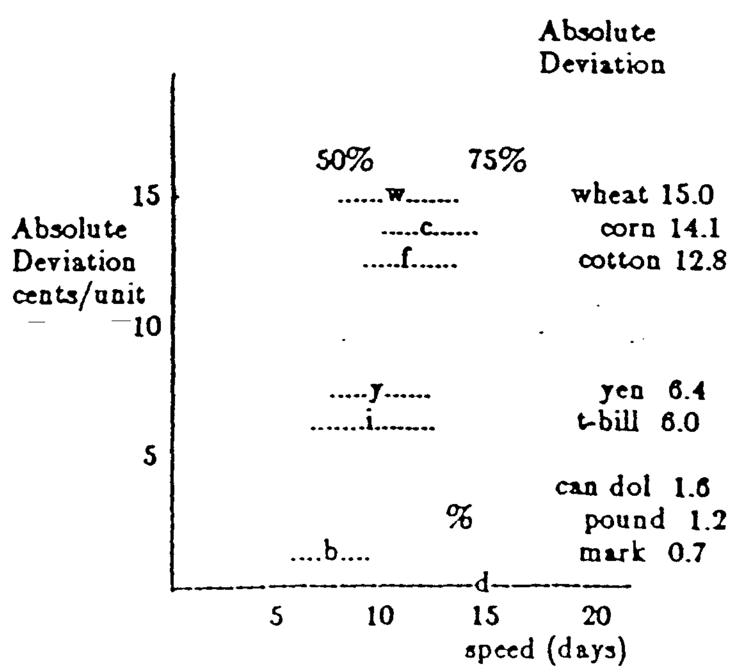
Consideration of a large positive shock in one leading market and none in another should yield a different adjustment pattern than a simultaneous shock in several markets. If some particular type of shock rarely occurred and, therefore, hardly affected the estimated relationships among the price series, then one should not use it to calculate the efficiency measure for the entire sample. In other words, the most likely shock during the sample period should be used to summarize the relative efficiency of the markets. Accordingly, a multimarket shock is employed here. It is generated by a one-standard deviation vector of errors from the fitted ARMA model multiplied by the empirical correlation matrix of the errors. This procedure yields the best estimate of the signs and relative magnitudes of the elements of the shock vector given the observed data. Multiplication by the correlation matrix adjusts each standard deviation by its correlation with all other series times the standard deviation of that particular series. This perturbation helps to demonstrate the dynamic interactions of the series and allows calculation of the empirical efficiency measures resulting from the single shock.

Fitting an (AR(1) MA(6,13,18)) model to the differenced 1981 data and an (AR(1) MA(5,6,8,14,15)) model to the differenced 1982 data yield the parameter estimates necessary for constructing the efficiency measures. Graphs of eight markets in terms of these efficiency measures, accuracy and speed, are given in figures 2 and 3. Figure 2 effectively summarizes the previous comparison of the dynamic behavior of each market from the perspective of the absolute deviation measure of accuracy. Figure 3 displays a similar summary for a total deviation measure. In both graphs, the furthermost point on the left for each series represents the number of periods following a shock required for 50 percent of the total response to occur. Similarly, the furthermost point on the right represents the number of periods required for 75 percent of the total fluctuations to occur. The 1981 Canadian dollar series in figure 2, for example, achieves 50 percent of the total adjustment by period 7 and 75 percent by period 17. The German mark, in contrast, achieves both 50 percent and 75 percent of its adjustment at period 18. When the deviation measures for two series overlap, parentheses indicate differing values of the speed measure. To illustrate, in figure 3, the British pound and Canadian dollar have total deviation values of -1.28 and -1.05, respectively, which are too close to distinguish on the graph. The parentheses surrounding the symbol for the pound indicate that its speeds for 50 percent and 75 percent adjustment were 9 and 15 days, respectively. The vertical axes for figures 2 and 3 measure the total absolute deviation

Figure 2. Accuracy in Terms of Total Absolute Deviations and Speed 1981

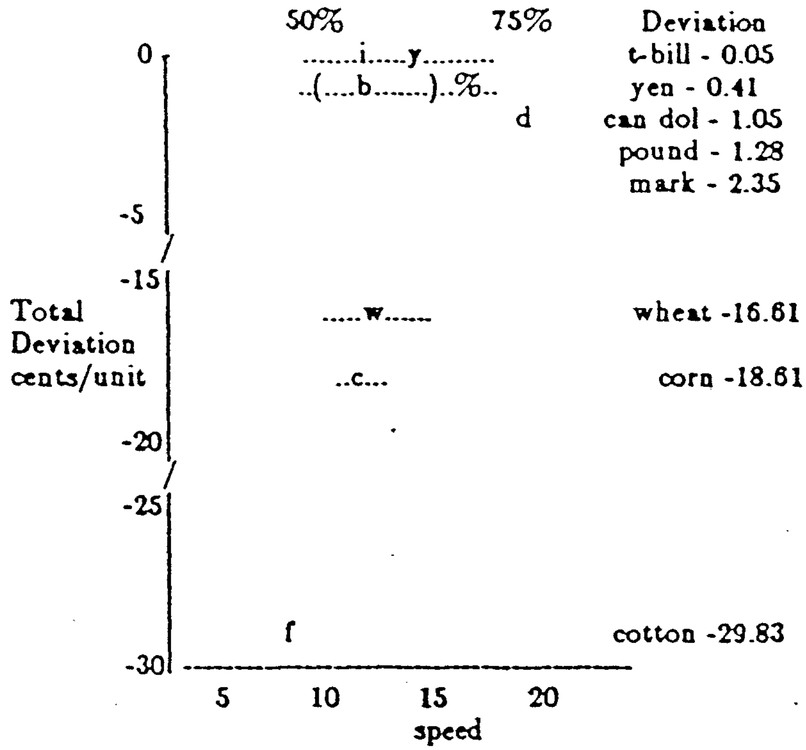


Accuracy in Terms of Total Absolute Deviations and Speed 1982

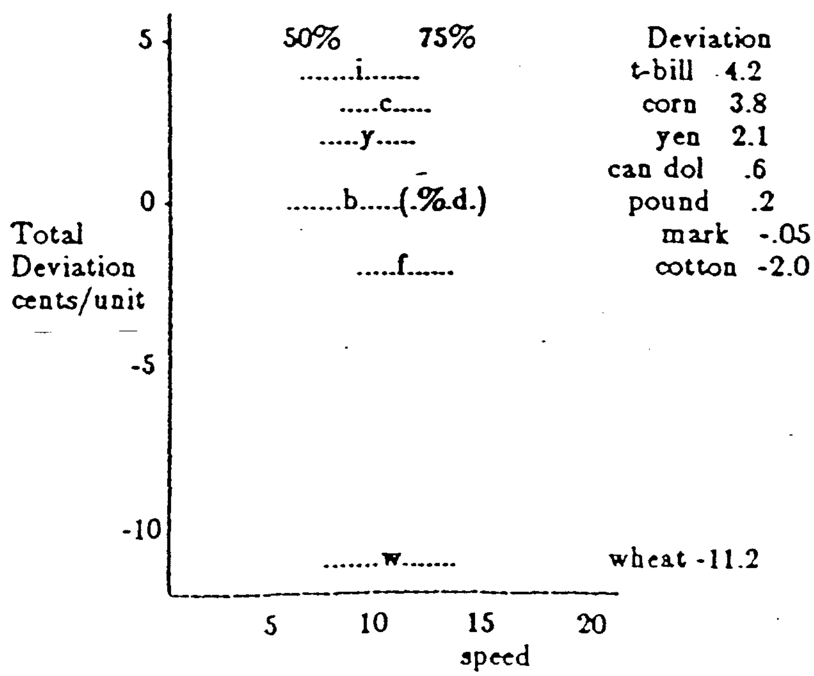


i denotes T-bills, b the British pound; % of the Canadian dollar; d the German mark; y the Japanese yen; c = corn; f = cotton; and w = wheat.

Figure 3. Accuracy in Terms of Total Deviation and Speed 1981



Accuracy in Terms of Total Deviation and Speed 1982



and the total deviation, respectively. The values of these deviations are printed along the right side of each group.

These results indicate that agricultural markets for 1981 delivery tended to adjust more quickly and to deviate more than either interest rate or exchange rate markets. As shown in figure 2, the agricultural markets achieved 50 percent of the total absolute deviation by period 7 in 1981. Furthermore, 75 percent of the total absolute adjustment occurred by period 7 for cotton, period 10 for corn, and period 14 for wheat. In contrast, both interest rates and exchange rates generally took much longer to reach either 50 percent or 75 percent adjustment.

The total deviation values in figure 3 show that the agricultural series dropped to their final levels while the other markets oscillated about their initial levels. The combination of large negative total deviations and large positive absolute deviations of the agricultural markets suggests that they generally fell after the period 0 reaction to the shock. The agricultural markets overshoot to the greatest degree followed by exchange rates. The empirical results indicate that agricultural markets exhibited both greater net overshooting and a faster speed of convergence in 1980-1981.

For March 1982, delivery contracts, the German mark continued to show little deviation and to adjust slowly. The agricultural markets continued to deviate substantially more in absolute value than exchange rates or interest rates, but the speed was much more similar to the financial markets than previously. Indeed, the British pound achieved both 50 percent and 75 percent of its total adjustment faster than any other series, while the speed for the agricultural series was similar to that of the Japanese yen and T-bills.

The total deviation measures in 1982 are markedly different from 1981. In contrast to the -.05 to -30.0 range for 1981, the total deviation varied from 4.2 for T-bills to -11.2 for wheat; and the distinct difference between agricultural and financial contracts observed in 1981 is less clear.

The empirical dynamic adjustment paths can be used to compute the welfare measures developed in section II. Figures 4 and 5 express the percentage of total welfare lost as a result of the dynamic path of prices for 1981 and 1982, respectively. The percentage of total welfare lost as a function of squared elasticity of supply are represented along the vertical axis in these figures.

The figures show clearly that a much greater percentage of total welfare in the cotton and Japanese yen markets is lost in both 1981 and 1982. The other series have values markedly smaller, suggesting that, relative to total trade of the commodities, the cotton and Japanese yen markets were inefficient allocatively. Of course, this observation depends upon an assumption that the elasticity of supply for yen and cotton is nonzero and not drastically different from the other exchange rates and agricultural commodities, respectively.

The elasticity of supply for both yen and cotton in 1981 must be approximately $\sqrt{.25}$, while the elasticity of supply for the other commodities must be approximately $\sqrt{3}$ for there to be a roughly comparable percentage welfare loss in all the markets. Although there are no

Figure 4. 1981 PERCENTAGE WELFARE LOSS

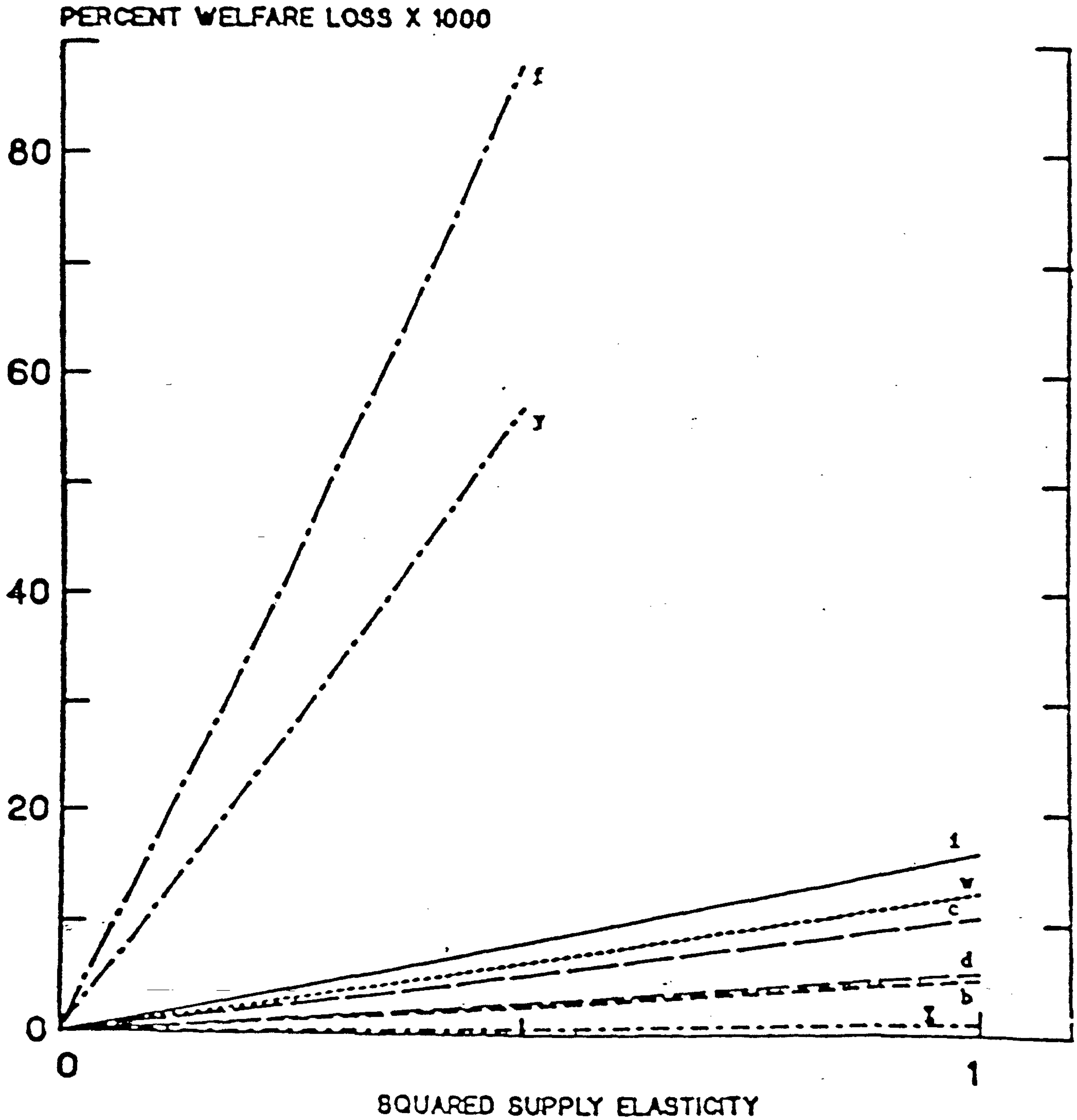
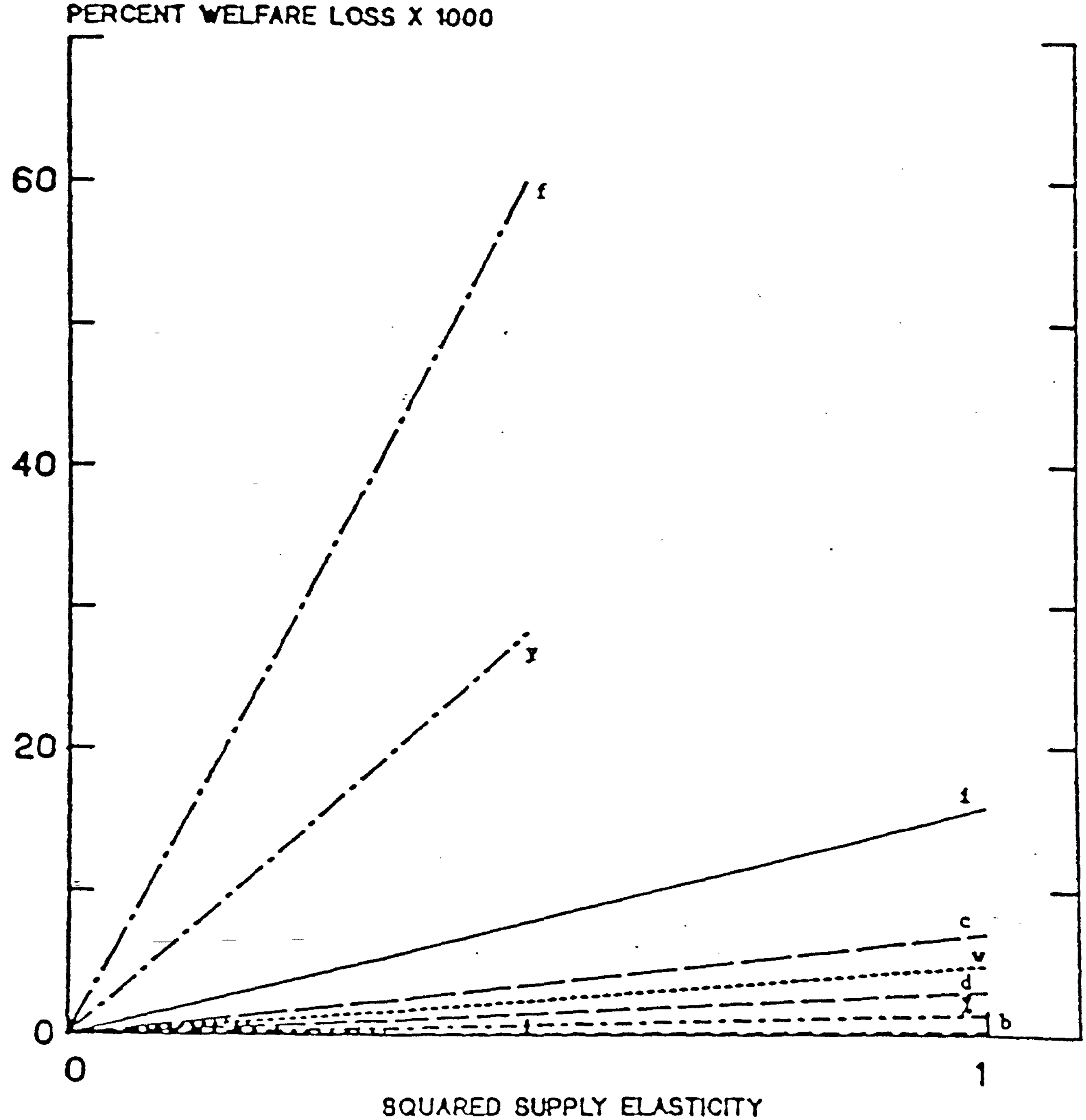


Figure 5. 1982 PERCENTAGE WELFARE LOSS



empirical estimates of daily supply-and-demand elasticities, general assumptions regarding relative elasticities may be made. It seems reasonable to assume that there is some degree of price responsiveness, even on a daily basis. The difference in the loss measure becomes more pronounced if all series have roughly similar elasticities of supply. The similarity of the relative values in 1981 and 1982 suggests that greater welfare loss may be endemic to the yen and cotton markets.

Daily quantities supplied or demanded are necessary to calculate the welfare loss. Quantities supplied are readily available for agricultural markets, and the Federal Reserve Bulletin reports average daily trade in T-bills. The only source of data regarding the volume of spot market currency transactions seems to be a sampling done by the New York Federal Reserve Bank every three years. The last available data, sampled for the month of April, 1983, are given in table 1. These monthly trade volume numbers provide an estimate of the daily volume which may be used to estimate the total welfare loss in the exchange markets.[2]

The welfare measure can be rearranged to be an expression involving two multiplicands, specifically:

$$\overline{WL}_t = \left[\frac{\eta_s}{\eta_d} (\eta_d - \eta_s) \right] \left[\frac{p^* y^*}{2} \frac{(\hat{p} - p^*)^2}{p^*} \right] . \qquad (13)$$

The first term, involving elasticities of supply and demand, shall be denoted subsequently as the elasticity multiplicand. The second term, hereinafter called the deviation multiplicand, consists of the squared

2. The exchange rate volumes presented in table 1 may overstate actual volume by up to 25 percent due to double counting.

forecast error, constants, market revenues, and the squared equilibrium price.

The deviation multiplicand and its components are given in table 1. The deviation multiplicand indicates that the loss due to deviations in the agricultural markets is minuscule compared to the losses in the T-bill, German mark, and Japanese yen markets if the elasticity multiplicands are of similar magnitudes across markets. That is, if the elasticity multiplicand, $\eta_s / \eta_d \ (\eta_d - \eta_s)$, is roughly comparable, the welfare loss is much less in the agricultural markets. The greater deviation of prices for agricultural series are more than counterbalanced by the large volume of trade in the financial markets.

The deviation multiplicand indicates that the Japanese yen, followed by T-bills and the German mark, should exhibit the greatest daily welfare loss due to slowly adjusting prices. The relatively small squared deviations of T-bill prices are offset by its enormous size, causing any deviation of prices to cause a great welfare loss. The Japanese yen exhibits the highest squared deviations among the financial markets, and its relatively large volume gives it a large welfare loss. Agricultural markets have squared deviations about ten times greater than the financial markets, but their lower trade value results in a relatively low welfare loss.

Figure 6 depicts the trade-off between elasticities of supply and demand for the elasticity multiplicand. For welfare losses in agricultural markets to be as large as in the T-bill market, the elasticity multiplicand (k in figure 6) must be roughly 100 times greater for agricultural markets than for T-bills.

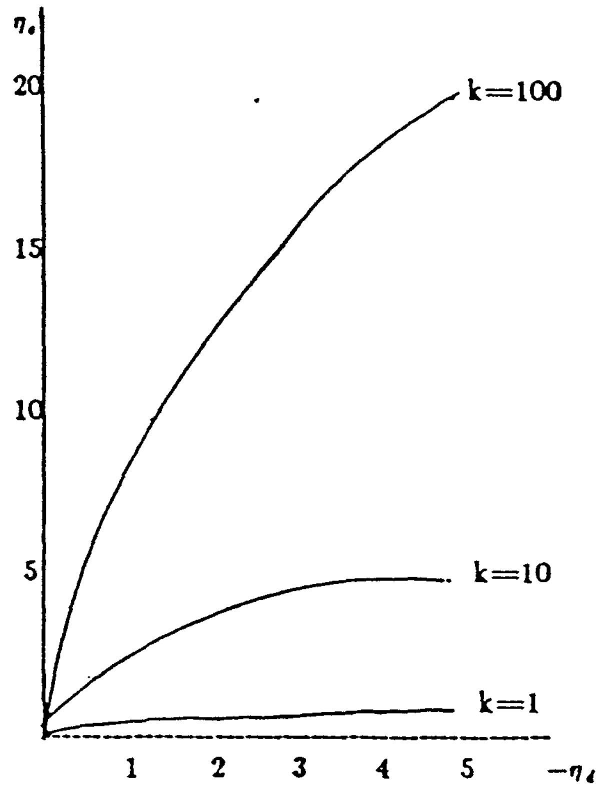
Table 1.--Welfare Loss Measure

Series	Squared deviation		Yearly volume[a]		Steady state		Yearly value		Deviation multiplicand	
	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982
	dollars				dollars		billion dollars		million dollars	
U. S. Treasury bills	.27	.56	3707.0	4618.0	.851	.869	3155.0	4013.0	.515	.634
British pound	.64	.04	b		2.21	1.84	861.0	861.0	.060	.003
Canadian dollar	.02	.04			.838	.810	318.0	318.0	.004	.006
German mark	.04	.02			.468	.416	1929.0	1929.0	.147	.078
Japanese yen	1.22	.93			.469	.421	1006.0	1006.0	3.14	1.56
Corn	2.71	1.85	8.3	9.2	3.50	2.54	29.0	23.5	.002	.001
Cotton	4.11	4.52	10.7	15.2	.847	.628	4.3	4.6	.010	.008
Wheat	6.61	2.80	3.8	4.0	4.40	3.51	16.7	14.0	.001	.0005

[a]Dollars for Treasury bills; million bushels for corn and wheat; and thousand bales for cotton.

[b]Blanks indicate no data available.

Figure 6. Elasticity Multiplicand Tradeoffs



IV. Conclusion

Allowing for varying flexibility among exchange rates, interest rates, and commodity markets and dynamic linkages among these various markets, disequilibrium is revealed as a common empirical phenomenon. For the eight futures markets investigated (T-bills, the British pound, the Canadian dollar, the German mark, the Japanese yen, corn, cotton, and wheat), disequilibrium occurs in formation of expectations for each market.

Although interest rate, exchange rate, and commodity markets are all shown by the estimated vector autoregressive moving average model to overeact to an initial shock, commodity markets (corn, cotton, and wheat) do so to a much greater degree than either exchange rate or short-term interest rate markets. However, the period length of this overreaction, for a major portion of the degree of disequilibrium, is much shorter for the agricultural commodity markets. In the context of resource allocation decisions, the dynamic welfare measures reported suggest that the cotton and yen markets have the greatest loss as a proportion of the total consumer and producer surplus in each. For comparable elasticities of supply and demand, the total welfare losses are found to be the largest in the short-term interest and Japanese yen exchange rate markets.

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