An Economic Concept for Measuring Price Uncertainty: The Case of the World Coffee Market

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Abstract: World markets for agricultural commodities are faced with increasing price fluctuations. When measuring these fluctuations, most researchers have focused on the construction of instability indicators not directly related to economic theory. In this article, a concept for measuring price uncertainty is presented that is explicitly based on economic reasoning. The economic meaning of price uncertainty is elaborated theoretically. The extent of price uncertainty is then measured for the world coffee market. An econometric market model is used for estimating the deterministic part of the coffee price series. The paper shows that price uncertainty cannot be measured objectively but is dependent on the particular knowledge of the market analyst about the deterministic structure of the market considered.

Introduction

The world coffee market is characterized by considerable price fluctuations, which point to the problem of price uncertainty facing the participants in this market. Price fluctuations, however, may not only be due to uncertainty but may also reflect changes in the deterministic components of a market. The basic problem for this paper, therefore, is to discuss how price uncertainty can be inferred from price variability in the world coffee market.

This problem is closely related to the instability measurement literature. Instability in the world coffee market has been analyzed by Parikh (1971), Edwards and Parikh (1976), and Edwards (1977). In none of these studies, however, were the meaning of price uncertainty and its relationship to the actual price variability in this market explicitly discussed. Traditional instability analysis has been criticized for emphasizing indicator construction and neglecting economic interpretation (Wilson, 1977). This paper's purpose is to concentrate on the economic meaning of price uncertainty. The theoretical considerations are supplemented by a discussion of the empirical evidence of price uncertainty, using an econometric model for the world coffee market. This model appropriately describes the deterministic part of time series variability and, hence, should be incorporated into price uncertainty measurement in this market.

Theoretical Considerations of Uncertainty Measurement

Price uncertainty may simply be described by the existence of stochastic variables in a price function. Such a function may be defined as:

$$(1)\quad p(x,\theta)\,,$$

where p is price, x is a vector of deterministic variables, and θ is a vector of stochastic variables.

Hence, price is a stochastic variable itself. The distribution of this variable is determined by deterministic and stochastic variables. Price uncertainty measurement may, then, be interpreted as obtaining empirical information on a hypothetical distribution of price, keeping the deterministic part of the function constant (Kirschke, 1985). This may be described formally as indicating the distribution of:

$$(2)\quad p'(\bar{x},\theta)\,,$$

where p' is the corrected price and the bar indicates that x is constant.

Based on this interpretation of price uncertainty, the relationship between time series variability and the extent of uncertainty involved should be obvious. Analytically, prices at different points of time have to be seen as realizations of different distributions. Hence, actual prices have to be modified such that the corrected values may be interpreted as realizations of the same hypothetical distribution. Uncertainty measurement, therefore, has to solve four problems:

- determine the point in time for which the price distribution is to be considered,
- choose an appropriate deterministic part of a system according to ones view of a market,
- statistically infer from actual time series data to the unknown price distribution, and
- trace out this price distribution and/or calculate suitable statistics.

The relevant procedure for the world coffee price is visualized in Figure 1. The series $p(x,\theta)$ marks the actual price development, whereas $p^d(x,\theta^-)$ characterizes the deterministic series as estimated by the econometric model.[2] To construct the hypothetical time series $p'(x^-,\theta)$, deviations of individual deterministic values from the 1982 deterministic values have been added to the actual prices. Hence, $p'(x^-,\theta)$ shows realizations of the stochastic price variable for the 1982 situation. Based on this corrected time series, suitable indicators for price uncertainty can be calculated.

Hence, the correction of the price series may be interpreted as a decomposition of the price variable according to the following equations:

(3) $p(x,\theta) = p^d(x,\theta^-) + p^s(\theta)$, and

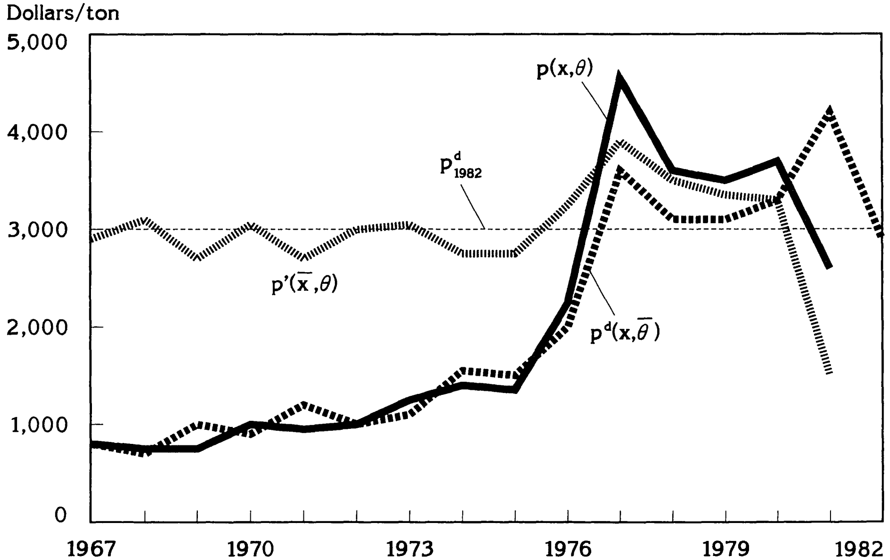
(4) $p'(x^-,\theta) = p(x,\theta) + p_n{}^d(x,\theta^-) - p^d(x,\theta^-) = p_n{}^d(x,\theta^-) + p^s(\theta)$.

where $p^s(\theta)$ marks the stochastic part of the price series and $p_n{}^d(x,\theta^-)$ the deterministic norm level. The hypothetical series $p'(x^-,\theta)$ has been constructed on the basis of 1982 to determine the actually relevant degree of price uncertainty.

Most important for the measurement of uncertainty is the knowledge of the deterministic part of a system. The degree of uncertainty is no fixed figure but depends on the person considered, the person's information level, and the point in time. For God, the whole world is deterministic. Hence, no uncertainty exists at all. On the other hand, a fool may not see any deterministic structure at all. The variability of a time series automatically characterizes ones degree of uncertainty. Hence, a unique, objective measure of the degree of uncertainty does not exist (Kirschke, 1984).

In most studies of instability measurement, simple trend estimates take care of the deterministic part of the system.[3] From an economic viewpoint, this is a rather simplistic and unsatisfactory view of the world. The problem is that potentially available information on economic relationships is lost in this approach. To avoid this problem, structural economic models could be used to generate corrected time series. An interesting alternative is to use ARIMA-type time series models taking estimated "white noise" as a means to correct actual values.[4] Our approach in this paper is purely economic in the traditional sense. Using economic theory, we formulate and estimate a structural

Figure 1—Coffee Price Uncertainty



world coffee market model. Based on this econometric model, the hypothetical coffee prices are derived, and indicators for their distributions are calculated. Hence, price uncertainty in the world coffee market is seen from the viewpoint of an economist who has done some theoretical and empirical work on this market.

Empirical Evidence of World Coffee Price Uncertainty

The econometric world coffee model consists of an import demand function, an export supply function, and an equilibrium condition. The import demand quantity is assumed to depend on the world market price and an income variable. The export supply quantity depends on the world market price and on a variable indicating the availability of coffee in the world. Both functions are estimated for the 1966-81 period, with a 2SLS approach (Pindyck and Rubinfeld, 1982). The results are:[5]

$$(5)\quad \ln QID = \underset{(108.3)}{13.6310} - \underset{(7.2)}{0.2678} \ln \hat{PW} + \underset{(9.0)}{0.4926} \ln Y(t-1)$$

$$[R^2 = 0.91; F = 60.72; DW = 2.69; \hat{\rho} = \underset{(2.6)}{-0.5739}], \text{ and}$$

$$(6)\quad \ln QES = \underset{(4.9)}{5.1789} + \underset{(4.0)}{0.0353} \ln \hat{PW} + \underset{(9.0)}{0.6293} \ln PR(t-1)$$

$$[R^2 = 0.91; F = 60.72; DW = 2.69; \hat{\rho} = \underset{(2.6)}{-0.5739}],$$

where *QID* and *QES* are the import demand and export supply quantities, *PW* is the world market price, *PR(t-1)* is world coffee production in the previous period, and *Y(t-1)* is a weighted income variable for the main importing countries: USA, FRG, and Japan. The GNP data from these countries are weighted with their respective import shares in the 1969-72 period. R^2 is the corrected coefficient of determination, *F* is the *F*-value. *DW* is the Durbin-Watson coefficient, and ρ is the Cochrane-Orcutt coefficient. ^ indicates estimated values, and the values in parentheses are *t*-values. Inserting equations *(5)* and *(6)* into:

$$(7)\quad \ln QID = \ln QES,$$

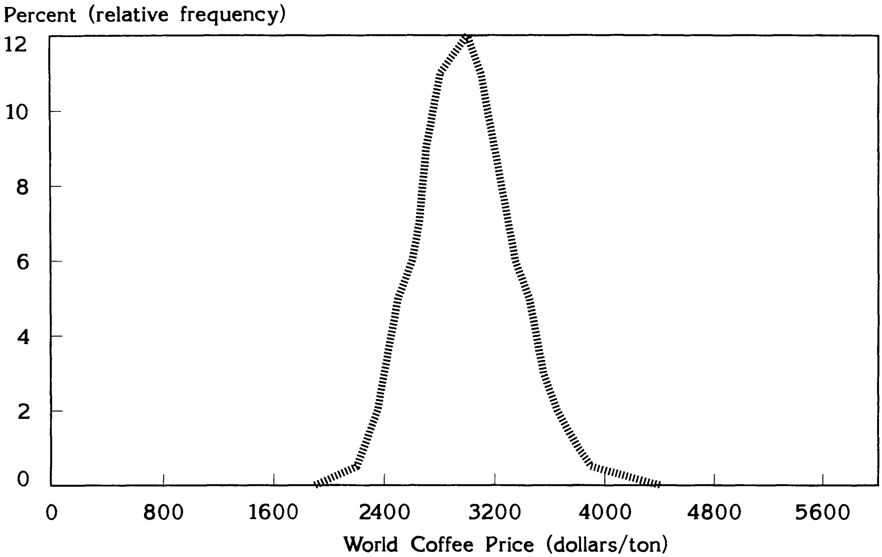
and solving for *ln PW* yields the reduced form of the world coffee model. This reduced form[6] was used to measure the deterministic part of the price series in equation *(4)*, $p^d(x,\bar{\theta})$. By inserting $p^d(x,\bar{\theta})$ into equation *(4)* and choosing the deterministic price for 1982 as a deterministic norm level, the corrected series $p'(\bar{x},\theta)$ shown in Figure 1 was constructed.

This price series characterizes the relevant distribution of coffee prices in the world market the analyst was faced with in 1982. Using the derived data, some descriptive statistics can be calculated. An alternative is to use the estimation results and explicitly trace out the price distribution by stochastic simulation. This is done in Figure 2 (page 308).[7] In particular, the curve visualizes the relatively high degree of price uncertainty in the world coffee market. Furthermore, the distribution is slightly skewed to the right. Some figures, finally, were calculated to characterize the simulated distribution. In particular, the coefficient of variation is 11.5 percent, which is much higher than the 5.6 percent calculated for price uncertainty on the world wheat market (Kirschke, 1985).

Conclusions

Price uncertainty is characterized by the distribution of a price variable facing the market analyst. Hence, the degree of uncertainty depends crucially on the analyst's view of the deterministic part of a market. The approach presented of measuring price uncertainty may be used to identify uncertainty involved in various economic and policy variables.

Figure 2—Simulated Price Distribution*



[*Based on mid-points of the calculated histogram with 100 $/t price steps: mean—2989.70 $/t, standard deviation—343.80 $/t, coefficient of variation—11.5 percent, highest value—4558.50 $/t, smallest value—1905.30 $/t, and skewness—0.339. On the measurement of skewness, see Freund and Walpole (1980, p. 148).]

Notes

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[2]The actual procedure will be discussed later.

[3]Actually, linear and exponential trends, moving averages, and polynomial models were estimated. For a discussion of frequently used instability indicators, see Diakosavas (1983), Blom and Oskam (1984), Murray (1978), and Cuddy and Valle (1978).

[4]Whether such a purely statistical interpretation of the deterministic part of a system may be accepted in the context of the problem discussed here facing the forecasting properties of such models is open to discussion (see Herrmann, 1984; and Parikh, 1971).

[5]The Cochrane-Orcutt procedure was used to cope with autocorrelation. The trade data are taken from FAO, *Trade Yearbook*, various years; the production data from FAO, *Production Yearbook*, various years; and the GNP data from IMF, *International Financial Statistics*, various issues. The prices are import unit values.

[6]Although turning points in actual coffee prices were not detected in each case, the model was chosen due to its relatively low simulation errors. The root-mean-square simulation error is clearly lower for the presented econometric model than for various trend estimations. Moreover, Theil's inequality coefficient (U) for the econometric model (0.11) is relatively low and consists of the following proportions of inequality: $UM = 0.007$, $US = 0.052$, and $UC = 0.94$. This indicates that the simulation error contains no bias but is mainly unsystematic. For these measures, see Pindyck and Rubinfeld (1982, pp. 360-367).

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Discussion Opening–*John Kitchen*

To provide a frame of reference, examine a simple yet informative import demand function:

$$(1)\ M = M(\rho,Y)\,,$$

where M is home import demand, Y is home income, and:

$$(2)\ \rho = eP^*/P\,,$$

where e is the home currency price of foreign currency (the exchange rate), P is the home price, and P^* is the foreign price. ρ is the terms of trade or relative price of domestic goods in terms of import goods. Totally differentiating equation *(1)* gives:

$$(1')\ dM = (\delta M/\delta\rho)d\rho + (\delta M/\delta Y)dY\,,$$

and totally differentiating equation *(2)* and substituting into equation *(1')* gives:

$$(3)\ dM = (\delta M/\delta\rho)[(e/P)dP^* + (P^*/P)de + eP^*(-1/P^2)dP] + (\delta M/\delta Y)dY\,,$$

or, in dynamic expectations format (where dx^e represents the expectation of dx):

$$(3^e)\ dM^e = (\delta M/\delta\rho)[(e/P)dP^{*e} + (P^*/P)de^e + eP^*(-1/P^2)dP^e] + (\delta M/\delta Y)dY^e\,.$$

By using *(3)* and (3^e), we have a framework (albeit a simple partial equilibrium framework) that we can use to organize a discussion on the three papers.

Peterson in effect asks what happens if P^* is suddenly set higher by government action (i.e., $(1+t)P^*$). His results indicate that, for M being French soyabean imports, the partial derivative $(\delta M/\delta\rho)$ is "small," since the substitution effects by other commodities (which are not explicit in the present framework) are small and dM will thus be small.

Frohberg *et al.* examine with the BLS general equilibrium model the implications for world agricultural trade of a reallocation of income (through income transfers) so that $dY^T > dY^B$, where T is the value with transfers and B is the base case value. In the present framework, their case is one in which the foreign country is the representative aid giver, while the home country is the representative aid receiver. Frohberg *et al.* show from model results that, in a reciprocal relationship, the increase in exports of the foreign country (resulting from the real growth impacts of the aid programme) is nearly sufficient to offset the costs to the foreign country of the aid programme. Their results hold in a general equilibrium, multiple country setting. Agriculture is shown to receive a disproportionately large share of the benefits of increased trade from such transfer programmes.

Herrmann and Kirschke examine the construction of dP^e measures and the sources of price uncertainty $(dP^e - dP^A)$, where A represents the *ex post* actual value for the world coffee market.

So we have seen in this session how income and prices (and expectations or errors in expectations about their future values) can have an impact on agricultural trade in our integrated world economy.

One variable that has not been dealt with—and yet one that will always have a strong impact on agricultural trade—is the exchange rate. I am speaking of the e, de, and de^e terms in my simple import equations above. To the extent that the exchange rate does not have an impact on *real* agricultural trade, it would (at a minimum) have nominal impacts through domestic price effects (i.e., increases in domestic real interest rates and currency exchange values will lead to falling commodity prices through arbitrage). Since the breakdown of the Bretton Woods accord, we have observed substantial volatility in bilateral (and, in a trade-weighted sense, multilateral) exchange rates. Much uncertainty exists and will continue to exist about the dynamics of exchange rate adjustments. For example, increasing evidence exists that large and variable risk premiums exist in the foreign exchange forward premium, and, as a result, forward exchange rates are poor predictors of future spot exchange rates. For our purposes, we should realize that, since increased uncertainty exists about exchange rates, trade will be negatively affected. And we should remember that, in this context, the BLS results of Frohberg *et al.* showed that agricultural trade is disproportionately sensitive to changing volumes of trade. As the world economy becomes increasingly integrated, exchange rate variations will become all the more important. Further research on these issues is suggested and required.

Discussion Opening – *Hiroshi Yamauchi*

While all three papers in this session are related to international trade in agricultural products, no other obvious link exists among them. A useful common theme could be developed on a topic absent from all three papers: the influence of well-developed international capital markets on foreign exchange rates and trading patterns and the attendant adjustment challenges that confront decision makers at all operating, institutional, and policy levels in the trading countries.

In Peterson's paper, more important areas of research ought to be considered. GATT's binding restriction on import taxes (such as for soyabeans) and the possibility of retaliation raise the question of the social costs of such measures. What about possible countereffects of price and interest rate changes due to shifts in exchange rates and international capital flows? Fruitful discussion on this paper could be directed at alternative designs for further research. Any design that does not account for changes in international capital flows and exchange rates would appear to be seriously lacking.

Frohberg *et al.* have packed into six pages the results of two scenarios from the basic linked system (BLS) of national and regional models. Unfortunately, not enough space exists to present the structure of the models, and we are referred to an article published elsewhere. For those of us who have not yet read that article, some questions that might be discussed are as follows:

- How do the models reflect the fact that today's flexible exchange rate régime no longer maintains "purchasing power parity" and that commodity traders are not necessarily the major actors responsible for the growth of international economic interdependence?
- How are short-run financial effects of international capital flows on exchange rates and interest rates translated into long-run adjustments in trade?
- Since development aid is now only a minor portion of total international capital flows, how can the BLS models help to evaluate the potential effects of tripling compensatory-type aid on the growth of international credit to developing countries?

The basic problem of Herrmann and Kirschke's paper is to discuss how price uncertainty can be inferred from price variability in the world coffee market. Since prices at different points in time are realizations of different distributions, actual prices must be modified such that the corrected values may be interpreted as realizations of the same hypothetical distribution.

The authors have been trying to forge new frontiers in this highly specialized topic. Opportunity exists for fruitful discussion along both conceptual and empirical lines. They reject purely statistical interpretations of the most important "deterministic" component of price systems because potentially useful information on economic relations would be lost in the measurement of price uncertainty through statistical trend analyses and ARIMA-type models. Thus, their estimate of the "deterministic" component of world coffee prices is derived from the reduced form of an econometric model consisting of both import demand and export supply functions in equilibrium. Theirs is, for the most part, a clear and concise presentation.

What is not clear, however, is the economic rationale for equation *(4)*, which describes the derivation of the hypothetical distribution $p'(\bar{x},\theta)$ relative to a selected "deterministic" norm level. The algebraic manipulation is clear, but some discussion of the intuitive logic underlying the formulation would be useful.

Also, their 1968-81 time series data cover a period over which both fixed and flexible foreign exchange rate régimes operated. Can the model measure the increase in price uncertainty resulting from the shift to flexible exchange rates? Would it be possible to do this by comparing the results of different "deterministic" norm levels selected for years under both fixed and flexible exchange régimes? What is the potential for extending the method to measuring changes in interest rate uncertainty as a result of flexible exchange rates and growth of international capital markets?

General Discussion – *Manuel Vanegas*, Rapporteur

Peterson was asked if his model could predict what would happen to the pattern of production as a result of changes in price support policies in the western countries, since no significant changes took place.

Peterson replied that the main implication of his paper is for further research on the demand for compound feed, the relation of feed prices to production of livestock products, and on more accurate estimates of feed demand elasticities. Also, and of greatest importance, the scope of the study must be expanded to include other EC countries. GATT's binding restriction on such import taxes for soyabeans and the possibility of retaliations are barriers to implementing such duties because of the social costs. He agreed that any further study should take into account changes in international capital flows and exchange rates.

Regarding Frohberg *et al.*'s paper, one observes a strong upward trend in food imports and food supplies by developing countries but with respect to the share of raw materials in world trade and the amount supplied by developing countries, one notes a strong downward trend since 1975. In addition, is the role of food aid mainly one of giving to Africa? Does the model consider the breakdown of aid (cash, concessional, and grants)? Because aid is only a small portion of foreign exchange earnings, what is the real meaning of evaluating the potential effects of tripling aid?

Frohberg replied that demand would surpass production, more aid would be needed, and that the GDP of the donors would increase as a result. The study did not consider food aid explicitly. Most food aid goes to Africa now, and that helps the trade component of many African countries. Changes in trade of raw materials were not considered but they could be integrated into the model.

Would the information obtained in Herrmann and Kirschke's paper not be lost in the measurement of price uncertainty through statistical trend analysis? In discussing price variability on the world coffee market, one should take into consideration the effects of the coffee agreement on prices because some significant adjustment can be obtained from the results.

Kirschke replied that they have been trying to forge new frontiers in this topic, and an opportunity exists for future fruitful discussion along both conceptual and empirical lines. They agreed that more discussion is needed on the logic underlying the formulation of the model. They went on to say that the implementation of the coffee agreement did not exert any significant disturbance, thus, they did not try to measure its effects. Nor did their 1968-81 time series analysis include the flexible foreign exchange rate régimes that operated after 1973. For future extensions of the model, they can do this. The potential use of the results can be extended to traders, professionals, and users of probabilistic analysis.

Participants in the discussion included J. Berthelot, K. Burger, and H.S. Dillon.