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Futures Markets, Real Income, and Spot Price Variability: A General Equilibrium Approach

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Abstract

The effect of opening a futures market on price stability has been investigated in a two sector, two good, two state general equilibrium model. It is assumed that in equilibrium agents have rational expectations. The circumstances in which a futures market is stabilizing or destabilizing are characterized in terms of such familiar parameters as substitution elasticities, marginal propensities to consume and degrees of risk aversion. Some general presumption in favour of stabilization is found. This presumption is strengthened the less risk averse the agents are, contrary to previous findings.
The central issue addressed in this paper has long been a subject for debate, both practical and academic. It concerns the effect of futures trading in commodities on the stability of spot prices. In the real world this issue is of obvious importance; some active futures markets have been closed on the grounds of their alleged destabilizing effect on prices.\(^1\) It is therefore no surprise that this topic has been the subject of extensive empirical research.\(^2\) However, the underlying theoretical issues have received much less attention. In those studies which do exist, the treatment of optimization behavior is far less general than that commonly considered in standard microeconomic theory. It is the purpose of this study to investigate the issue of stabilization, considering fully general optimization behavior.

Only recently have there appeared papers which make specific comparisons of spot price variability with and without futures markets (see Peck (1976), Turnovsky (1979, 1983), Sarris (1980), and Kawai (1984)). These studies are however limited to partial equilibrium analysis and, in so far as they consider optimization behaviour, are fairly restrictive in their treatment.

Turnovsky (1983) and Kawai (1984) adapt the framework of macroeconomic rational expectations models with an infinite time horizon, where demand and supply behavior is based upon explicit optimization processes. A disadvantage of using such models is that rather special preference structures have to be assumed so that the resulting demand and supply functions have linear forms.

This study approaches the problem along microeconomic rational expectations lines as originally exemplified in the work of Arrow on securities markets (1963). We consider spot markets for various goods
which open after the realization of a state of nature. We then introduce the futures market for a good whose output levels are random. In order to evaluate the effect of the futures market on the stability of spot prices, we compare spot price variability before and after opening the futures market.

This requires us to compare equilibria in two different general equilibrium models. For this purpose, we generalize the method of comparative statics developed in the field of international trade into a model under uncertainty. The novelty of our analysis is to extend such a method to a general equilibrium rational expectations model, where expected utility is maximized by agents whose utility functions depend upon more than one physical commodity. Despite the generality of our model, we are able to characterize the effect of opening a futures market in terms of such familiar parameters as substitution elasticities, marginal propensities to consume, and degrees of risk aversion.

Transactions on the futures market result in subsequent capital gains and losses which transfer purchasing power between agents in spot markets. The effect of opening a futures market therefore appears through these transfers. In the literature on transfers in international economics, it is emphasized that taste differences between agents, or the difference in their marginal propensities to consume, play a key role in determining the terms of trade and other economic variables (see Samuelson (1952) and Jones (1970, 1975). We find also that differences in tastes are an important factor in our analysis because of the income transfer effect referred to above.

The structure of this study follows. Section I describes the basic model. Section II states an outline of our analysis. Section III
carries out comparative statics in the market system with a futures market. Section IV considers the effect of a futures market on the stability of spot prices. Section V makes some remarks on the effect of a futures market on real income. Section VI summarizes the main conclusions of this study.
I. Model

In order to abstract from unnecessary complexity, we work with a two-good, two-agent exchange model. The output level of one of the goods, call it $A$, depends upon random factors; the output of the other good, good $M$, is non-random. Input decisions are not considered. We assume that the entire output of good $A$ is owned by an agent, call it sector $A$, and that the entire output of good $M$ is owned by the other agent, call it sector $M$. Good $A$ is to be thought of as an agricultural good whose production process is affected by random factors such as weather. Good $M$ may be thought of as money, or an aggregate of all other goods. There are only two states of nature; state $i$ ($= 1, 2$) is realized with probability $\phi_i$. When state $i$ occurs, sectors $A$ and $M$ produce $X^*_A$ units of good $A$ and $X^*_M$ units of good $M$, respectively. The preferences of each sector are represented by von Neumann-Morgenstern utility functions: $\Sigma_1 \phi_i u^*(D^*_A, D^*_M)$ for sector $A$ and $\Sigma_1 \phi_i u(D^*_{A1}, D^*_{M1})$ for sector $M$, where $D^*_{A1}$ and $D^*_{M1}$ are sector $A$'s ($M$'s) consumption of goods $A$ and $M$ in state $i$. (Since we shall analyse complete information rational expectations equilibria, the sectors are assumed to know the correct probability distribution over states.) Let $p$ be the relative price of good $A$ in terms of good $M$. We define the indirect utility function $v(Y, p) = \max u(D^*_A, D^*_M)$ subject to $pD^*_A + D^*_M = Y$. $v^*(Y^*, p)$ is defined in the same way.

The futures market for good $A$ opens before the state of nature is realized; trading on the spot market for goods $A$ and $M$ occurs after the state is realized. A futures contract stipulates that one unit of good $A$ is to be delivered when the spot market opens. Each agent enters the
futures market with expectations about the distribution of the spot relative price of good A. Let \( p^a_1 \), \( i = 1, 2 \), be sector A's expected price distribution. Then, the sector anticipates the income from its endowment to be \( p^a_1 X^*_A \) if state 1 is realized. Let \( q \) be the price of a futures contract in terms of the numeraire (good M), and denote sector A's supply of futures contracts by \( X^* \). (\( X^* \) can be negative.) Then, \( (q - p^a_1)X^* \) is its capital gain after state 1 is realized. (This value can also be negative. A negative capital gain is a positive capital loss.) 

Thus, sector A expects to have an income \( Y^*_1 = p^a_1 X^*_A + (q - p^a_1)X^* \) after state 1 is realized. In the futures market sector A supplies (or demands) futures contracts, choosing \( X^* \) so as to maximize its expected utility. Thus, sector A's optimization problem is

\[
\text{(1)} \quad \max_{X^*} \sum_i \phi_i v^*(Y^*_i, p^a_i)
\]

s.t. \( Y^*_i = p^a_1 X^*_A + (q - p^a_1)X^* \), \( i = 1, 2 \).

Sector M's expectations about spot prices are denoted by \( p^a_i \), \( i = 1, 2 \). Let \( D \) be its demand for futures contracts. Then, \( (p^a_1 - q)D \) represents its expected capital gain on a futures transaction in state 1. Sector M therefore expects to have an income \( Y = X_1 + (p^a_1 - q)D \) when state 1 occurs. In the futures market sector M demands (or supplies) futures contracts, choosing \( D \) so as to maximize its expected utility. Sector M's optimization problem is

\[
\text{(2)} \quad \max_D \sum_i \phi_i v(Y_i, p^a_i)
\]

s.t. \( Y_i = X_M + (p^a_1 - q)D \), \( i = 1, 2 \).

In the futures market the price of a futures contract \( q \) is established so
as to clear the market, or to have

\[ D = X^*. \]

After the state of nature is realized, the spot markets for goods A and M open. Suppose that \( p_1 \) is the spot relative price of good A after state 1 is realized. Let \( B_1^* \) and \( B_1 \) be the capital gains for sectors A and M, respectively; that is, \( B_1^* = (q - p_1)X^* \) and \( B_1 = (p_1 - q)D \). In the spot market each sector trades goods A and M so as to maximize its utility. Thus, the optimization problems of sectors A and M are

\[ \max \quad u(D_{A1}, D_{M1}) \]

s.t. \( p_1 D_{A1} + D_{M1} = p_1 X_{A1} + B_1^* \),

and

\[ \max \quad u(D_{A1}, D_{M1}) \]

s.t. \( p_1 D_{A1} + D_{M1} = X_{M} + B_1 \),

respectively. The spot relative price is established to clear the market, or to have

\[ D_{A1} + D_{A1}^* = X_{A1}^*, \quad i = 1, 2. \]

We consider a rational expectations equilibrium. In other words, each agent enters the futures market, anticipating the correct distribution of the spot relative price. That is,

\[ p_1 = p_{1}^a = p_{1}^a. \]

We call the system described by conditions (1) - (7) the futures-spot market system. The system simultaneously determines futures and spot prices \( q, p_1, \) and \( p_2 \). If we set \( B_1^* \) and \( B_1 \) identically equal to zero in conditions (4) - (6), the conditions describe a spot market system with no futures market. We call this system the pure spot market system. The main purpose of this study is to compare the variability in spot prices and in income in these two market systems.
We are concerned with a one period static model. Goods storable for more than one period are ignored. Many agricultural goods are however storable for at most one crop cycle, economically or physically. Thus, our analysis applies to all such goods if a period is considered to be a crop cycle. In reality, futures transactions in these goods are often carried out sequentially within a crop cycle. Our equilibrium may be thought of as a natural simplification of this sequential structure, given our concern with the long run economy. Thus, some agricultural products which are usually thought to be storable (for example, wheat, rice, etc.) are suitably treated within our model, not to mention such non-storables as eggs, onions, etc.

In this study, storage decisions are therefore not explicitly considered. Their role is certainly an important factor in the operation of futures markets, if many periods are considered in one crop cycle. For such a case, however, the structure of a general equilibrium rational expectations model seems too complicated in order to obtain any meaningful results. In contrast, the line of an approach taken by Turnovsky (1983) and Kawai (1984) successfully takes storage decisions into account.

Forward transactions of an actual good and trading in the organized futures market for the good are not differentiated in this study. This treatment is natural since we are concerned with the long run effect of a futures market in the framework of a rational expectations model.
II. Outline of the Analysis

When a futures market opens, the initial equilibrium in the pure spot market system makes a discrete shift. As is well known, it is an intractable problem to try to analyze the nature of such a discrete shift with a fully general preference structure. The basic idea of our approach is as follows. First, we consider a hypothetical economy where there is no output risk. If the magnitude of output risk is small in the economy with which we are concerned, equilibria in both the pure spot market system and the futures-spot market system lie near an equilibrium in the hypothetical economy. We describe the shift from an equilibrium before the opening of a futures market to one after by comparing each of those equilibria with the equilibrium in the hypothetical economy. A more detailed outline of our analysis follows.

The basic role of a futures market is to transfer purchasing power between agents in the spot market. This transfer of purchasing power is achieved by the incurring of capital gains and losses \( B^* \) and \( B_1 \). Let us introduce a new variable \( r = (p_2 - q)/(q - p_1) \). Then, the first order conditions of optimization problems (1) and (2) together with condition (7) imply

\[
\frac{r}{\phi_2} \frac{\phi_1 Y_1}{\phi_Y^*} = \frac{\phi_1 Y_1}{\phi_Y^*} = \frac{\phi_1}{\phi_2} \frac{\phi_Y^*}{Y_2}
\]

where \( \phi_Y^* = \phi_Y(Y_1^*, p_1) = \phi_Y(Y_1^*, p_1) / \phi_Y^* \) (\( \phi_Y^* \) is defined similarly). Thus, \( r \) may be interpreted as the relative price of state 1 income in terms of state 2 income.

Using \( r \), we may rewrite optimization problems (1) and (2) as follows.
\[
\begin{align*}
(1') & \quad \max \; \Sigma_1 \phi_i v^*(Y^*_i, p_i) \\
& \text{s.t.} \quad r \; Y^*_1 + Y^*_2 = r \; p_1 \; x^*_A_1 + p_2 x^*_A_2 \\
& \quad \max \; \Sigma_1 \phi_i v(Y^*_1, p_i) \\
(2') & \quad \text{s.t.} \quad r \; Y_1 + Y_2 = r \; X_M + X'_M.
\end{align*}
\]

This suggests that trading futures contracts may be regarded as trading state contingent incomes spent in spot markets. Since \( B_1^* = Y^*_1 - p_1 x^*_A_1 \) and \( B_1 = Y_1 - X_M \), \( B_1^* \) and \( B_1 \) can be thought of as 'import' demands for state contingent incomes, by analogy with the theory of international trade. Then, the market clearing condition (3) together with the definitions of \( B^* \) and \( B \) imply

\[(3') \quad r \; B_1^* = B_2^*.
\]

Conditions (1') - (3') and (4) - (6) are therefore an alternative representation of the futures-spot market system. It turns out to be illuminating to proceed with the analysis in this framework. Based upon optimization problems (1') and (2'), 'import' demands for state contingent incomes are clearly functions of \( r, p_1, p_2, x^*_A_1, x^*_A_2, \) and \( X_M \); that is

\[
B_1^* = B_1^*(r, p_1, p_2, x^*_A_1, x^*_A_2)
\]

(9)

\[
B_2 = B_2(r, p_1, p_2, X_M).
\]

Ex-post, a positive \( B_1^* (= -B_1^*) \) operates in the same way as a transfer from sector \( M \) to sector \( A \) in the spot market which opens when state 1 occurs. Thus, the spot market clearing condition (6) may be expressed as

\[
p_1 D_{A_1} = D^*_M - B_1^*
\]

(10)

\[
p_2 D_{A_2} = D^*_M + B_2^*.
\]

since \( B_1^* = -B_1^* \).
Moreover, (import) demands for state contingent goods depend variously upon \( p_1, p_2, B_1^*, \) and \( B_2^* \); that is,

\[
\begin{align*}
D_{M1}^* &= D_{M1}^*(p_1, B_1^*) \\
D_{A1}^* &= D_{A1}^*(p_1, B_1^*) \\

D_{M2}^* &= D_{M2}^*(p_2, B_2^*) \\
D_{A2}^* &= D_{A2}^*(p_2, B_2^*).
\end{align*}
\]

(11)

This system of equations (3'), (9), (10), and (11) determines equilibrium prices \( r, p_1, \) and \( p_2. \)

As discussed above, we consider the hypothetical economy where there is no output risk; i.e., \( X_{A1}^* = X_{A2}^* = X_A^* \). Differentiating the equilibrium conditions (1') - (3') and (4) - (6) of the futures-spot market system above with respect to output levels \( X_{A1}^* \) and \( X_{A2}^* \), and evaluating the result at an equilibrium in the hypothetical economy, we may characterize an equilibrium in the futures-spot market system given output risk of small magnitude. It can be shown that if there is no output risk, the spot market allocation and price established in the futures-spot system is also an equilibrium in the pure spot market system.\(^3\) Therefore, differentiating the equilibrium conditions in the pure spot market system (with respect to output levels), and evaluating the result at the spot market allocation and price above, we may characterize an equilibrium in the pure spot market system given output risk of small magnitude. We are then able to compare equilibria in the two market systems, assuming that the risk introduced into the two systems is of the same magnitude.

It is known that if there is no output risk, a change in the probability distribution over states does not affect an equilibrium allocation in the futures-spot market system.\(^4\) Thus, without
loss of generality we may assume that $\phi_1 = \phi_2$. Moreover, we introduce a small magnitude of risk, keeping the expected output of good A constant; i.e., $dX_{A1}^* = -dX_{A2}^* > 0$. This assumption also has no effect on the generality of our analysis. Due to these assumptions, we have $r = 1$ if there is no output risk.

A few remarks have to be made. First, any equilibrium in the futures-spot market system described by conditions (1) - (7) is represented by an equilibrium in the system described by conditions (1') - (3') and (4) - (6), but not vice versa. The difference is that in the latter system agents can trade state-contingent incomes in the ex-ante market even if the spot relative price is state-independent. In the former system the price of a futures contract must always lie between the two state-contingent spot prices. Thus, if there is no spot price differential between the two states, the transaction of futures contracts does not allow agents to trade state-contingent incomes. As one may have noticed already, the system described by conditions (1') - (3') and (4) - (6) is the system with Arrow securities, which we shall call the Arrow-security market system. As argued above, we consider an initial equilibrium which is established in the Arrow-security market system, and where there is no risk. Since there are no transactions of state-contingent incomes, this is also an equilibrium in the futures-spot market system (in which there is no trade on the futures market).
III. Comparative Statics

a. Demand for state contingent income

At the first stage of our comparative statics, we examine the responses of $B_1^*$, $B_2^*$, $D_{A1}^*$, and $D_{A1}$ induced by changes in $r$, $p_1$, $p_2$, $X_{A1}^*$, and $X_{A2}^*$. Although the responses of $D_{A1}^*$ and $D_{A1}$ (induced by changes in $p_1$, $X_{A1}^*$, $B_1^*$, and $B_1$) will be familiar from the literature of International trade theory, those of $B_1^*$ and $B_1$ have not been examined and are considered in this section.

Recall that $Y_i = p_1 D_{A1} + D_{M1}$ is sector $M$'s state $i$ income. Define $dy_i = p_1 dD_{A1} + dD_{M1}$. As is well known, the optimization of sector $M$ in the spot markets implies that $dy_i > 0$ if and only if $d u(D_{A1}, D_{M1}) > 0$. In this sense $dy_i$ is regarded as a change in state $i$ real income. Since state $i$ income is an ex-ante choice variable in the futures market, we may think of a sector as expressing demands for state $i$ real income.

Now we totally differentiate the expression $v_{Yi} = v_Y(Y_i, p_1)$. to obtain

$$
\hat{v}_{Yi} = -\rho_i dy_i - m_{A1} \hat{p}_i,
$$

where $\rho_i = v_{YY}(Y_i, p_1) / v_Y(Y_i, p_1)$ is the degree of absolute income-risk aversion ($v_{YY} = \frac{\partial^2 v}{\partial Y^2}$), and where $m_{A1}$ is the marginal propensity to consume good $A$. Since the first order condition (8) implies $\hat{v}_{Y1} = \hat{v}_{Y2} = \hat{r}$, by equation (12) we have

$$
\rho_i dy_1 - \rho_2 dy_2 = - \hat{r} - m_{A1} \hat{p}_1 + m_{A2} \hat{p}_2.
$$

Let us introduce a natural definition for $dy$ as follows.

$$
r \ dy_1 + dy_2 = dy.
$$
Then, the first order condition (8) implies that \( \text{dy} > 0 \) if and only if
\[
d \sum_1 \phi_i u(D_{A1}^*, D_{M1}^*) > 0.7
\]
In this sense we interpret \( \text{dy} \) as a change in expected real income. Equations (13) and (14) describe the response of sector \( M \)'s demand for state contingent real income to changes in \( r, \rho_1, \rho_2, \) and \( y \). Equations parallel to equations (13) and (14) can be obtained for sector \( A \), if we define \( \text{dy}_1^*, \text{dy}_2^*, \rho_1^*, \) and \( m_1^* \) in the same way. Thus, we may expand sector \( A \)'s demand for state 1 real income and sector \( M \)'s demand for state 2 real income in the following way.

\[
dy_1^* = -\sigma^* \hat{r} - \sigma m_1^* \hat{p}_1 + \sigma m_2^* \hat{p}_2 + \sigma^* \text{dy}^*
\]

\[
dy_2 = \sigma \hat{r} + \sigma m_1^* \hat{p}_1 - \sigma m_2^* \hat{p}_2 + \sigma (\rho_1/r) \text{dy},
\]

where \( \sigma^* = 1/(\rho_1^* + r \rho_2^* ) \) and \( \sigma = r/(\rho_1 + rp_2) \).

The interpretation of equations (15) accords with intuition. Observe that \( r \), the relative price of state one-contingent income, is also the relative price of state one real income if spot prices do not change. Hence the coefficients on \( r \), which give changes in state-contingent demand for real income induced by a change in \( r \) when
\[
\hat{p}_1 = \hat{p}_2 = \text{dy} = \text{dy}^* = 0,
\]
are straightforward substitution terms. The coefficients on \( \hat{p}_1 \) and \( \hat{p}_2 \) can be explained as follows. If the spot price of good \( A \) in state 1 increases, the same amount of nominal income in state 1 guarantees a lower level of utility (real income) in state 1. Given that expected utility is compensated, this leads an agent to substitute utility in the other state for state 1 real income.

A change in production risk in sector \( A \) changes the levels of \( X_{A1} \) and \( X_{A2} \). Thus, using budget constraints in the spot markets, we have
\[
dy^*_1 = - p_1 (D^*_A - X^*_A) \hat{p}_1 + dB^*_1 + p_1 \hat{dX}^*_A
\]

(16)
\[
dy^*_1 = - p_1 D^*_A \hat{p}_1 + dB^*_1.
\]

Since the constraints of the optimization problems (1) and (2) in the futures market imply \( rB^*_1 + B^*_2 = 0 \) and \( rB^*_1 + B^*_2 = 0 \), the expressions for \( dy^*_1 \) and \( dy^*_1 \) imply
\[
dy^* = - rB^*_1 \hat{r} - rp_1 (D^*_A - X^*_A) \hat{p}_1 - p_2 (D^*_A - X^*_A) \hat{p}_2
\]
\[
+ rp_1 \hat{dX}^*_A + p_2 \hat{dX}^*_A
\]

(17)
\[
dy = B^*_2 \hat{r} - rp_1 D^*_A \hat{p}_1 - p_2 D^*_A \hat{p}_2.
\]

As noted in the previous section, we have \( r = 1 \) and \( B^*_1 = B^*_2 = 0 \) in the initial equilibrium. Thus, setting \( p^* = p^*_1, \hat{r} = \hat{p}_1, p = p_1, D^*_M = D^*_M, \)
\( D_A = D^*_A, m^*_A = m^*_A, m_A = m^*_A \), and \( dX^*_A = dX^*_A = -dX^*_A \), and using condition (10), we have
\[
\frac{dB^*_1}{D^*_M} = - \frac{\sigma^*}{D^*_M} \hat{r} + \frac{\sigma^*}{D^*_M} (m^*_A + p^* \hat{p}_A) (\hat{p}_2 - \hat{p}_1) - \frac{p}{D^*_M} \hat{dX}^*_A
\]

(18)
\[
\frac{dB^*_2}{pD^*_A} = \frac{\sigma}{pD^*_A} \hat{r} - \frac{\sigma}{pD^*_A} (m_A - p \hat{p}_A) (\hat{p}_2 - \hat{p}_1),
\]

In (18) we have summarized how demand for state-contingent income transfers through the futures market will react to changes in prices and endowment income.

b. **Market equilibrium**

Since \( B^*_1 = B^*_2 = 0 \) initially, conditions (3') and (10) imply
\[
\frac{dB^*_1}{D^*_M} = dB^*_2 / pD^*_A.
\]
Therefore, by equations (18), we have
(19) \[ \tilde{r} = \frac{D^*_M}{\sigma^{*}} (\sigma^{*}(m^*_A + \rho^*pD^*_A) + \sigma(m^*_A - \rho pD^*_A))(\hat{p}_2 - \hat{p}_1) - \frac{1}{\sigma^{*}} \rho \frac{p}{D^*_M} dX^*_A \]

Therefore, using (18), (19), \( \sigma^{*} = 1 / 2\rho^{*} \) and \( \sigma = 1 / 2\rho \), we have

(20) \[ \frac{dB^*_i}{D^*_M} = \frac{dB^*_2}{pD^*_A} = \frac{1}{2pD^*_A(\rho^{*} + \rho)}(m^*_A - m^*_A + (\rho^{*} + \rho)D^*_A)(\hat{p}_2 - \hat{p}_1) - \frac{\rho}{\rho^{*} + \rho} \frac{p}{D^*_M} dX^*_A. \]

Although we are solving the equilibrium system (1') - (3') and (4) - (6) simultaneously, the reader may find it helpful to consider the following two stage process of adjustment to equilibrium. That is, given a distribution of spot prices, \( p_1 \) and \( p_2 \) the futures market clears instantaneously, establishing an equilibrium relative price of state contingent income, \( r \). This determines the capital gains and losses for each agent in each state, \( B^*_i \) and \( B^*_1 \). After a state of nature, say, state \( i \) is realized, an equilibrium spot price is determined, given the \( B^*_i(= -B^*_1) \). If the first \( p_1 \) is inconsistent with this spot price, it is adjusted until a rational expectations equilibrium is established. When production risk is introduced into sector \( A \), it changes sector \( A \)'s demand behavior in the futures market; this is captured by the coefficient for \( dX^*_A \) in equation (18). Given the initial distribution of spot prices, the relative price of state contingent income must adjust; this is captured by the coefficient for \( dX^*_A \) in equation (19). This change in turn introduces capital gains and losses in the spot markets; this is reflected in the coefficient for \( dX^*_A \) in equation (20). This brings about an adjustment in the spot price in each state. The adjustments in spot prices cause a further change in \( r \); this is captured by the coefficient for \( (\hat{p}_2 - \hat{p}_1) \) in equation (19). This process continues until a new rational expectations equilibrium is established.
When production risk is introduced, two things occur in the spot markets in state 1. One is a change in supply, $dX_A^*$; and the other is an income transfer between agents, $dB_1^* = -dB_2^*$. The adjustment of a spot price in response to changes in endowments and transfers in a non-random environment is well known and is described by the following expressions (see Caves and Jones (1981) for derivation).

\[
\hat{p}_1 = -\frac{m_A - m^*_A}{\Delta} \frac{dB^*_1}{DM} - \frac{m^*_M}{\Delta} \frac{D^*_M}{DM} dX^*_A
\]

\[
\hat{p}_2 = \frac{m_A - m^*_A}{\Delta} \frac{dB^*_2}{DM} + \frac{m^*_M}{\Delta} \frac{D^*_M}{DM} dX^*_A,
\]

where $\Delta = e^*_M + e_A - 1$,

where $e^*_M$ and $e_A$ are the elasticities of import demand for sectors A and M, respectively, in spot markets, and where $m^*_M$ and $m^*_M$ are the marginal propensities to consume good M. The coefficients for $dB_1^*$ and $dB_2^*$ show the effect of a transfer; those for $dX_A^*$ show that of an endowment change. We assume that the spot market equilibrium is stable, or $\Delta > 0$ (the Marshall-Lerner condition).

As noted above, capital gains and losses $B_1^*$ and $B_2^*$ endogenously determine income transfers between agents in the spot market of the futures-spot market system. In other words, given a small magnitude of output risk, or given $dX_A^* > 0$, an equilibrium in the futures-spot market system is characterized by equations (20) and (21). In contrast, an equilibrium in the pure spot market system is characterized by equation (21) together with the condition $dB_1^* = dB_2^* = 0$, since in this case there can be no capital gains and losses. Therefore, equation (21) indicates that the difference in tastes between agents, or the difference in marginal propensity to consume, plays a crucial role in determining the effect of opening a futures market.
Using equations (20) and (21) together with $m_A^* + m_M^* = m_A + m_M = 1$, $e_M^* = s_M^* + m_M^*$, and $e_A^* = s_A^* + m_A^*$, we obtain

$$\hat{p}_2 - \hat{p}_1 = 2 \left( \rho \frac{m_A^* + \rho m_M^*}{\delta} \right) \frac{P}{\delta} d\hat{x}_A^*,$$

where $\delta = (\rho^* + \rho)pD_A(s_A^* + s_M^*) + (m_A^* - m_A)^2 > 0$.

Note that, by equations (21), we have $\hat{p}_2 = -\hat{p}_1 = (\hat{p}_2 - \hat{p}_1)/2$. Therefore, equation (22) indicates that the introduction of a small amount of production risk in sector A into the futures-spot market system raises the spot relative price of good A in the state where the output level of good A is decreased, or in state 2, and reduces the price in the state where the output level of good A is increased (under the assumption that all goods are normal). It is important to note that this result holds without reference to any market stability condition; in fact, we may prove that the initial equilibrium is stable with respect to a properly defined adjustment process in our rational expectations equilibrium model. This is a consequence of the fact that there is no trade in the futures market initially. (Note that the stability condition in the spot market, or $\Delta > 0$, is not needed to determine the effect of a small amount of risk on spot prices.)

Equation (22) shows that if both agents are income risk neutral, or if $\rho^* = \rho = 0$, the spot price is state independent in the risky economy. Thus, as argued in the previous section, in this situation the spot prices correspond to an equilibrium in the Arrow security market system but not necessarily in the futures-spot market system. In contrast, if there is an Income risk averse agent, production risk is reflected in spot price risk. In this case there is a corresponding equilibrium in the futures-spot market system no matter how weak the degree of risk aversion.
IV. Spot Price Variability

The variability in the spot price is measured by the term \( \frac{p_2 - p_1}{p_1} \) in this study. This term is monotonically increasing in the coefficient of variation \( \frac{\sqrt{V(p)}}{E(p)} \) if \( \frac{p_2}{p_1} \geq 1 \), where \( E(p) \) and \( V(p) \) are the mean and variance of the spot price distribution. Let \( V_f \) be the spot price variability in the futures-spot market system, given a small amount of production risk. Then, \( V_f \) is equal to the term \( \hat{p}_2 - \hat{p}_1 \) in equation (22). (More precisely, \( V_f = \hat{p}_2 - \hat{p}_1 \) at the level of first order approximation. However, we ignore the higher order error for the sake of simplicity.) In the pure spot market system, income transfers associated with the capital gains and losses on future contracts cannot be made; the effect of a change in output level on spot price is obtained by setting \( dB_1 = dB_2 = 0 \) in equations (21). Let \( V_s \) be the spot price variability in the pure spot market system, given a small amount of production risk. Then, by equations (21) we have

\[
(23) \quad V_s = 2 \sum_{i=A}^{M} \frac{P}{M} \Delta x_i^* \]

Equations (22) and (23) indicate that both \( V_s \) and \( V_f \) are positive.

Therefore, both in the pure spot market system and in the futures-spot market system, the spot relative price of good A is higher when the output level is lower. Thus, opening a futures market can never reverse the pattern of price variability. In this sense, there is no possibility of over-stabilization.
We shall say that the futures market is price-stabilizing (price-
destabilizing) if $V_f$ is smaller (larger) than $V_s$. Since $V_f = \hat{p}_2 - \hat{p}_1$, 
equations (21) and (23) imply 

(24) \hspace{1cm} V_f - V_s = 2 \frac{m_A^* - m_A^*}{\hat{p}_1} \frac{dB^*_1}{\hat{p}_M^*} .

Since equations (20) and (22) imply 

(25) \hspace{1cm} \frac{dB^*_1}{\hat{p}_M^*} = (pD_A (pm^*_M + \rho^* m^*_M - \rho^* (s_A^* + s_M^*)) + m^*_A (m^*_A - m_A^*)) \frac{dX_A^*}{\delta D_A^*} ,

equations (24) and (25) imply 

(26) \hspace{1cm} V_f - V_s = 2 (-m^*_M (m^*_A - m_A^*))^2 + pD_A (m^*_A - m_A^*) (pm^*_M + \rho^* m^*_M - \rho^* (s_A^* + s_M^*)) \frac{dX_A^*}{\delta D_A^*} .

This shows that it is in general ambiguous whether the futures market has 
a stabilizing or destabilizing effect on spot prices.

Equation (26) indicates that the effect of opening a futures market 
is a combination of the effects in the following two polar cases. The 
first is that where both agents are income-risk neutral, which implies 
$\rho^* = \rho = 0$. Since $V_f = \hat{p}_2 - \hat{p}_1$, equation (22) implies that even if there 
is production risk, the resulting spot price variability is zero.

We have already argued that in this case the equilibrium will not in 
general be sustainable in the futures-spot market system. However, it 
will be true that if the degree of absolute risk aversion of each agent 
is small, then the resulting spot price variability in the futures-spot 
market system will be small.

If the agents are income-risk neutral, only spot price risk matters 
to them. This implies that all agents choose to have the same market 
position in the Arrow-security market since all agents face the same 
price risk. Therefore, as long as spot price risk exists, the market is
not in equilibrium. An equilibrium is established when capital gains and losses are allocated to agents so as to absorb price risk completely.

The second polar case is that where the agents' marginal propensities to consume the good traded on the futures market are equal. As we see from equations (21), opening a futures market has an effect on the terms of trade only if the income transfers due to capital gains and losses affect spot prices. If \( m_A^* = m_A^* \), an income transfer has no effect on spot prices. Therefore, in this case, opening the futures market has no effect on spot price variability, or \( V_f - V_s = 0 \).

As equation (26) shows, \( V_f - V_s \) is the sum of a negative term and a term whose sign is ambiguous. In this sense then, there is a presumption in favor of the situation in which the futures market is price-stabilizing. Since the degree of absolute risk aversion has no impact on spot price variability in the pure spot market system, our discussion above indicates that the presence of a futures market is more likely to stabilize prices if risk aversion is small. This result is clearly apparent in equation (26). However, our analysis also demonstrates that we cannot conclude that if risk aversion is strong, then the reverse presumption holds.

Suppose that risk aversion is strong. Then equation (26) shows that a futures market may destabilize spot prices. If, in fact, it is destabilizing, the following observation can be made. If the sector producing the random output has a stronger taste bias in favor of (or a larger marginal propensity to consume) its own output, the aggregate substitution effect has to be larger than a weighted sum of the marginal propensities to consume the non-random output. On the other hand, suppose that one agent is risk averse, and that the other is risk
neutral. If sector A is risk neutral, that the futures market is destabilizing implies that sector M has a stronger taste bias in favor of good A. However, if sector M is risk neutral, a parallel statement cannot be made.

In the literature on futures trading, agents who enter a futures market to reduce their income risk are called hedgers, and those who by trading in futures increase income risk are called speculators. In our model sector A is therefore identified as engaging in hedging, whereas sector M engages in speculation. If hedgers are risk neutral \( (\rho^* = 0) \), and if speculators are not \( (\rho > 0) \), it is possible for the futures market to be destabilizing only if speculators have a stronger taste bias in favor of good A than hedgers \( (m_A^* > m_A^*) \). If speculators are risk neutral, and if hedgers are not, it is possible for the futures market to be destabilizing only if \( (m_M^* - m_M^*)(m_M^* - s) > 0 \), where \( s = s_A^* + s_M^* \) is the aggregate substitution elasticity.

It is often said that in normal circumstances there is a predominance of short hedging in the futures market. In other words, hedgers are net sellers of futures contracts.\(^9\) Since \( p_2 > q > p_1 \) in the new equilibrium after the introduction of production risk, and since \( B_1^* = (q - p_1)X^* \), sector A (a hedger) is short if and only if \( B_1^* > 0 \) in the new equilibrium. The sign of \( B_1^* \) in the new equilibrium is determined by equations (20) and (22); short hedging occurs if and only if \( dB_1^* > 0 \). As equation (25) shows, our analysis does not support a presumption either for or against the predominance of short hedging. If the hedging sector is in fact short, equation (24) implies that the futures market is price-stabilizing if and only if that sector (sector A) has a stronger taste bias in favor of good A than the speculating sector.
(sector M).

Turnovsky (1983) concludes that in the limiting case where producers and speculators are both risk neutral, the presence of a futures market has no effect on spot price variability. This result sharply contrasts with our conclusion. In our model the futures market equilibrium disappears in the limit, but as agents become less risk averse there is progressively more price stabilization associated with the existence of the futures market. Although our models are very different, we feel that our result identifies an important factor necessarily absent in a partial equilibrium approach. One should note that Turnovsky finds that if one or other group in the market is risk-neutral, then a futures market is price stabilizing. This is consistent with our own findings.

As noted above, if the two sectors have the same marginal propensity to consume a good, a futures market has no impact on the spot price distribution. A special case of this is that where the marginal propensity to consume good A is equal to zero for both sectors, as is the case in partial equilibrium analysis. Therefore, our model may be considered as an natural extension of the basic partial equilibrium model of futures trading developed by Keynes (1930) and Kaldor (1939).
V. Income Variability

Recall that changes in expected real income in the futures-spot market system are given by equations (17). Since we have $r = 1$, $p(D^* - X^*) = p(D^*_A - X^*_A)$, $pD_A = pD_A$, and $B^*_1 = B^*_2 = 0$ in the initial equilibrium, and since equations (21) imply $\hat{p}_2 = -\hat{p}_1$, we have

\[(27) \quad dy^* = dy = 0\]

in the futures-spot market system. This demonstrates that introducing a small amount of production risk while holding expected output constant does not affect the expected real income of either sector.

In the pure spot market system, changes in expected real income and spot prices are obtained by setting $dB^*_1 = dB^*_2 = 0$ in equations (16) and (21), respectively. Since equations (21) imply $\frac{\hat{p}_2}{dB^*_2 = 0} = -\frac{\hat{p}_1}{dB^*_1 = 0}$, we have

\[(28) \quad dy^*|_{dB^*_1 = dB^*_2 = 0} = dy|_{dB^*_1 = dB^*_2 = 0} = 0.\]

Thus, at least at the level of first order approximation, we observe no differential welfare effect. This is explained by the fact that our initial equilibrium is one with no risk.

It is often suggested that farmers are worse off when the harvest is good than when it is bad. We call such a phenomenon "good harvest poverty". As noted above, we may identify good A as an agricultural product. Then $dX^*_A (= dX^*_A = -dX^*_A) > 0$ implies that states 1 and 2 are
the good and bad harvest states, respectively. Therefore, good harvest poverty occurs if and only if \(dy_1^* < 0\), since \(dy_1^* = dy_1 + dy_2^* = 0\) by equation (27). Now, equations (17), (25), and (27) imply
\[
dy_1^* = -dy_2^* = (ppD_A(s_A + s_M^*) + m_A^*(m_A^* - m_A)) \frac{pdX_A^*}{\delta}
\]
(29)
\[
dy_1 = -dy_2 = (p^*pD_A(s_A + s_M^*) - m_A^*(m_A^* - m_A)) \frac{pdX_A^*}{\delta}.
\]
Equations (29) show that good harvest poverty occurs if and only if
\[
\frac{(m_A^* - m_A)}{ppD_A} > s_A + s_M^*,
\]
and so obviously only if \(m_A > m_A^*\).

This condition is significantly different from that obtained in the pure spot market system. As noted above, the effect of introducing production risk in the pure spot market system is obtained by setting \(dB_1^* = -dB_1 = 0\). Therefore, equations (16), (22) and (28) imply
\[
dy_1\bigg|_{dB_1^* = 0} = -dy_2\bigg|_{dB_2 = 0} = \frac{\Delta - m_A^*}{\Delta} pdX_A^*
\]
(31)
\[
dy_1\bigg|_{dB_1^* = 0} = -dy_2\bigg|_{dB_2 = 0} = \frac{m_A^*}{\Delta} pdX_A^*.
\]
In the pure spot market system, good harvest poverty occurs if and only if
\[
m_M > s_A + s_M^{11}
\]
(32)
Good harvest poverty in a pure spot market system can be viewed as resulting from the inability of the agricultural sector to insure against income risk. Thus it has been argued that the presence of futures markets should provide an opportunity to obtain such insurance. However, when the terms on which this insurance becomes available are endogenously determined, as is the case in our model, we see from a comparison of (30) and (32) that introducing a futures market may
generate good harvest poverty in circumstances where previously it was absent.

The condition in (32) is a natural generalization of the partial equilibrium requirement that demand for the agricultural good be inelastic. If substitutability between goods A and M is small, good harvest poverty becomes more likely. We see from (30) that this is still true in the presence of a futures market, with the proviso that we must also have the necessary condition $m_A > m_A^*$. What (21) tells us is that this condition ensures that a capital gain for the agricultural producer in the good harvest state will reinforce the spot price decline caused by the increase in supply.

However, perhaps the most important difference that one observes between real income patterns in the two market systems emerges from a comparison of equations (29) and (31). Whereas in the pure spot market system a good harvest must increase the welfare of sector M in that state, this is no longer the case in the futures-spot market system. (But in that case good harvest poverty as defined above will not occur.)

We shall conclude this section with some remarks on the pattern of real income variability which emerges under the two market systems. We adopt as our index of the pattern of real income variability in sector A the term $(y_2^* - y_1^*)/y_1^*$, where $y_1^* > 0$ is the real income of sector A in state i.\[12\] We use an analogous index for sector M. Let $W_f^*$ and $W_s^*$ be sector A's real income variability in the futures-spot market system and that in the pure spot market system, respectively. Since there is no risk in the initial equilibrium, we have $y_1^* = y_2^*$. Since equations (27) and (28) imply $dy^* = dy_1^* + dy_2^* = 0$ and $dy_1^*|_{dB_1=0}=dy_2^*|_{dB_2=0}=dy_2^*|_{dB_1=0}=0$, 


we have \( W_f^* = -2dy^*_1 / y^* \) and \( W_s^* = -2dy^*_1 \bigg|_{dB^*_1} = 0 / y^* \), as a first order approximation. Using equation (16) and the definitions of \( V_f \) and \( V_s \), we obtain \( W_f^* - W_s^* = (p \Delta V_f - V_s) - 2 \Delta dB^*_1 / y^* \). Therefore, equation (24) and the definition of \( \Delta \) imply

\[
W_f^* - W_s^* = -2 \left( s_A^* + s_s^* \right) y^* \Delta \frac{dB^*_1}{\Delta M}.
\]

Let us first make a comment upon how we intend the expression in (32) to be interpreted. It cannot in general be thought of as a measure of the change in income variability brought about by introducing a futures market. The reason for this is that \( dy^*_1 \) may change sign under the separate market regimes. Thus an income pattern where income is high in state 1 and low in state 2 may be reversed to one where income is low in state 1 and high in state 2. In these circumstances a simple measure of income variability may not change, or may change only a little. This obscures the fact that a dramatic reversal in income pattern has occurred. The measure in (32) does not suffer from this disadvantage, and we choose to work with it since we consider the change in income pattern to be of intrinsic interest.

The major point to emerge from (32) is that differences in the pattern of real income variability depend not only on the monetary capital gains and losses experienced in the futures market but also on the aggregate substitution elasticity. If this substitution elasticity is small, we have seen that good harvest poverty is more likely to be observed in the spot market. So the introduction of a futures market can be expected to have less effect on patterns of income variability if good harvest poverty prevails in the spot market.

Now let us consider sector \( M \). Let \( W_f \) and \( W_s \) be our indices of the pattern of real income variability of sector \( M \) in the futures-spot market system and that in the pure spot market system, respectively.
Then, an argument similar to that used for the case of $W_f$ and $W^*_s$, implies that $W_f = 2\, dy_1/y$ and $W_s = 2\, dy_1|dB^*_1=0/y$, where $y = y_1 = y_2$ is the initial value of real income. Moreover, we have

\begin{equation}
W_f - W_s = -2(s_\Delta + s^*_M) \frac{D^*_M}{y\Delta} \frac{dB^*_1}{D^*_M} (= (W^*_f - W^*_s)y*/y).
\end{equation}

Since $W_s = 2\, dy_1|dB^*_1=0/y$, equation (31) implies $W_s > 0$. Therefore, opening a futures market absorbs sector M's real income risk only if $W_f < W_s$. This implies that the futures market is real income stabilizing for speculators (sector M) only if hedgers are short.

As equations (29) and (31) show, it is possible that $W^*_f$ and $W_f$ have signs opposite to those of $W^*_s$ and $W_s$, respectively. In such a case, the futures market is over-stabilizing with respect to real income risk.
VI Conclusions

We have characterized the effect of opening a futures market on spot price variability and on patterns of income variability in a general equilibrium framework. If the magnitude of risk is large, the effect of a futures market is highly complicated. In order to highlight the essential features of a futures market as simply as possible, we have considered only the case where the magnitude of risk is small.

Our major conclusions follow. There is some general presumption that a futures market has a stabilizing effect on spot prices. This agrees with the results of Turnovsky (1983) and Kawai (1984). This presumption is particularly strong if agents are close to risk neutral. This contrasts with the result of Turnovsky. The taste difference between the two sectors and the difference between aggregate income effects and substitution effects are crucial factors determining whether or not a futures market is destabilizing. If the two sectors have similar tastes (marginal propensities to consume), opening a futures market has no impact on spot prices. A futures market cannot reverse the pattern of price variability; no overstabilization can occur. We have observed the possibility that the pattern of an agent's income variability may be reversed in the presence of a future's market. This implies that a futures market can overstabilize income. In general, the effect of a futures market on income variability is ambiguous.

It is known in the deterministic theory of trade that a good harvest may result in a decline in the real income of the agricultural sector. We have found that the condition for this to occur in the presence of a futures market is a natural extension of that obtained in the deterministic case.
We have not attempted to model the supply response of producers in the presence of a future market in order to simplify our analysis. The incorporation of this aspect is an important subject for future investigation. It happens to be the case that our market structure with future trading is complete. It is an interesting open question to investigate to what extent our results carry over to the case of an incomplete market structure. Our model is based upon the static general equilibrium model with rational expectations, whereas Turnovsky (1983) and Kawai (1984) apply the techniques developed in macroeconomic rational expectations models. As discussed above, these two approaches have different limitations and provide different insights into the issue addressed here. In this sense we regard our study as complementary to those of Turnovsky and Kawai.
Footnotes

1. An example is the closing of the onions futures market in the U.S. in 1958.

2. See Turnovsky (1983) for a list of such studies.

3. If there is no output risk, the futures-spot market system above always establishes an equilibrium where the spot market allocation and prices are independent of states of nature. (See Malinvaud (1974) and Cass and Shell (1983).) This implies that an agent has neither capital gains nor losses in the spot market regardless of state. Thus, the spot market allocation and prices may be attained in the pure spot market system.


5. This concept of real income is often used in trade theory (see Caves and Jones (1981)). A proof follows. \( du = u_{AI} dA_I + u_{MI} dM_I = u_{MI}(p_I dA_I + dM_I) = u_{MI} dy_I \), where \( u_{GI} = \delta u / \delta DGI, G = A, M. \)

6. The notation "\( \cdot \)" on an argument is the hat operator well known in trade theory. \( x \) means \( dx / x \). A derivation of equation (12) follows. Note that \( dy_I = dY_I - DA_I dp_I \), and that \( y_I = u_{MI}. \)

These facts together with the discussion in footnote 5 imply that \( du = v_{Y_I} dy_I = v_{Y_I} dY_I - DA_I v_{Y_I} dp_I \). Thus, \( v_{p_I} = \delta v(Y_I, p_I) / \delta p_I = -DA_I v_Y(Y_I, p_I) \). This implies \( p_I v_{Yp_I} = v_{Y_I} m_A - p_I DA_I v_{YY_I}, where v_{YY_I} = \delta v_Y(Y_I, p_I) / \delta Y_I \) and \( v_{Yp_I} = \delta v_Y(Y_I, p_I) / \delta p_I \). This fact implies equation (12).

7. As seen in footnote 6 \( dv(Y_I, p_I) = v_{Y_I} dy_I \). Therefore, \( \frac{1}{2} \phi_1 u(DA_I, DM_I) = \frac{1}{2} \phi_2 (rdy_1 + dy_2) = \frac{1}{2} v_{YY} dy, where the third equality follows from condition (8). \)

8. It has been pointed out in the theory of deterministic trade that given the stability of an equilibrium taste differences play a major role in determining the terms-of-trade effect of a transfer (see Samuelson (1952) and Jones (1970, 1975)).

9. This argument originates from Keynes (1930) and Kaldor (1939).

10. Good harvest poverty is analytically identical to immiserizing growth, often considered in the deterministic theory of trade. Since no long run trend rate of growth is implied in our model we adopt the former term.


12. State 1 real income \( y_1 \) is defined implicitly by the definition of a change in state 1 real income \( dy_1 \), which is introduced in Section III.
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