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A SIMPLE MODEL OF USELESS SPECULATION

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ABSTRACT

The paper presents a general equilibrium model of a pure exchange economy with stochastic endowments in which speculation is profitable and stabilizes prices, but is useless from a welfare point of view. Reconciling the Siegel paradox with the theory of incomplete markets we show that banning speculation by closing the forward exchange market may increase social welfare.

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I. INTRODUCTION

It is widely held that speculation is a dubious economic activity which can be very profitable but is useless from the viewpoint of the society as a whole. In sympathy with this view, authors of UNCTAD's (1990) Trade and Development Report have recently deplored the excessive growth of international financial markets and demanded tighter regulations to limit the volume of speculative trade.

Economists on the other hand have traditionally emphasized the beneficial roles of speculation. Following Lerner (1944) and Friedman (1953), they have pointed out that profitable speculation stabilizes prices and creates welfare gains by narrowing the gaps between marginal costs and benefits at different points in time or different locations.

In the present paper, UNCTAD's view is rationalized in terms of economic theory.[1] The paper offers a very simple general equilibrium model of pure exchange with stochastic endowments and demonstrates that, for that model, speculation is profitable and stabilizes prices but fails to generate welfare gains.[2] It is shown further that if the model is extended to accommodate transaction costs then speculative profits and stabilized prices may coexist with welfare losses. Speculators gain from the mechanics of Jensen's inequality but create strong negative externalities which, from a social perspective, may outweigh the private gains. In short, it is shown that there are circumstances in which profitable and price-stabilizing speculation is a useless rent-seeking activity. In those circumstances, the closing down of the forward market may increase social welfare.

The model lacks a full set of markets; in fact, it contains only a single forward market and a single spot market. Speculators buy non-preferred commodities on the forward market to resell on the future spot market. Thus the model links the emerging theory of incomplete markets [Hart (1975) and Geanakoplos (1990)] to the Siegel paradox of the finance literature [Siegel (1972, 1975), Roper (1975)].

The Siegel paradox has received mixed reactions in the economic literature. Some authors dismiss it as a "partial analytic illusion" that vanishes once the necessity of "settling all accounts"

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1) The paper supports UNCTAD's evaluation of the role of speculation, but does not attempt to replicate or defend the arguments which are presented in the Trade and Development Report.

2) The model has no similarity with the earlier literature on the Lerner-Friedman proposition which clarified why destabilizing speculation can be profitable and did not focus on the welfare implications. See Baumol (1957), Kemp (1963), Stein (1961) and Telser (1959).

is considered [McCulloch (1975)]; as a purely nominal phenomenon with no significance for the real allocation of resources [Boyer (1975), Beenstock(1985)]; or "a trivial mathematical inconvenience without economic or empirical significance" [Adler and Dumas (1983, p. 955, n. 60)]. Others take a more affirmative view, seeing the paradox as an incentive to hold perverted international wealth portfolios or as an explanation of the observed bias between forward and spot exchange rates [Krugman (1981), Sibert (1989), Sinn (1989)]. However, it seems fair to say that the general equilibrium and welfare implications of the paradox are largely unexplored. Typically, the paradox is relegated to footnotes and treated as a mathematical curiosity of dubious economic significance.

In our opinion such a verdict is premature. In our model risk averse speculators might be induced to stake substantial proportions of their endowments to capture profits of Siegel type. There is no illusion, monetary or otherwise; indeed, the model contains no money, and the model is general equilibrium in scope, so that all "accounts" are "settled". It is a distinguishing feature of the model that randomness relates to *relative* prices and that those prices are *endogenously* determined. In common with earlier contributors, we distinguish groups of speculators with disparate preferences. For the sake of convenience, the discussion is phrased in the terminology of international trade theory; however it is straightforward to reinterpret the results in a closed economy setting. We shall demonstrate that the Siegel paradox plays an important role in stochastic equilibria with imperfect markets and has strong, but unfortunate implications for the functioning of a market economy.

The paper has five sections. Section II derives the general equilibrium with speculative behavior of Siegel type. Section III develops an example that may help clarify the nature of the equilibrium and the magnitude of the effects described. Section IV discusses the welfare implications of the model and Section V offers some conclusions.

II. A SIMPLE GENERAL EQUILIBRIUM MODEL

Consider a pure-exchange economy with random endowments.[3] There are two countries, America and Germany, two commodities, beef and kraut, and two periods, the present and the future. Each country has non-negative future endowments of both commodities, but Americans

[3] Of course, it is possible to interpret the endowments as outputs from fixed factor inputs in alternative country-specific states of nature.

eat only beef and Germans only kraut. All endowments of a particular commodity in a particular country are perfectly correlated, but there is stochastic independence across commodities and countries. Within each country, all households have the same preferences and endowments.

There is a spot market and a one-period forward market on which kraut and beef can be traded, the forward market opens in the present, the spot market in the future. The forward market allows an exchange of unconditional delivery promises that do not depend on the state of nature (no Arrow-Debreu markets) and must be fulfilled once the spot market has opened. Let p and p^f denote the spot and forward prices of kraut in terms of beef.

A typical American household seeks to maximize its expected utility from beef consumption. Essentially, its problem is to determine the amount of beef to be traded against kraut in the forward market. Together with the future domestic endowment of kraut, the kraut received from the forward contract determines the total amount of kraut that can be traded against beef in the future spot market. Let c be the amount of beef consumed by the representative American household ($c \geq 0$), s its forward sales of beef ($s \gtreqless 0$), b its endowment of beef ($b \geq 0$), k its endowment of kraut ($k \geq 0$), and $U, U' > 0$, $U'' < 0$, its von Neumann-Morgenstern utility function. Then the household's problem is to find

$$\max_s E[U(c)] \qquad s.t.\ c = b - s + \left(\frac{s}{p^f} + k\right) p \ . \tag{1}$$

The first-order condition for an interior solution is

$$E[U'(c)r] = 0 \tag{2}$$

where

$$r \equiv \frac{p}{p^f} - 1 \tag{3}$$

is the rate of return on a short position in beef. The second-order condition $E[U''(c)r^2] < 0$ is satisfied because of $U'' < 0$.

Note that problem (1) is algebraic. It allows not only the strategy of selling a positive amount of beef in the forward market ($s > 0$), but also that of buying beef and selling kraut ($s < 0$). The net amount of kraut that remains for sale in the spot market is $\frac{s}{p^f} + k$, and the amount of beef received in exchange is $[\frac{s}{p^f} + k]p$. This amount, plus the domestic endowment of beef, b, plus the beef bought in the forward market, $-s$, is the total amount of beef available for consumption. In the optimum described by equation (2), s is chosen so that the expected increase in utility resulting from a marginal increase in s, i.e., the expectation of marginal utility weighted by the rate of return on a short position in beef, is zero.

The problem of the German household is analogous to that of its American counterpart. Let us distinguish German variables by asterisks, so that s^* denotes the German forward sales of kraut ($s^* \gtreqless 0$), k^* the German endowment of kraut ($k^* \geq 0$), b^* the German endowment of beef ($b^* \geq 0$), c^* the German consumption of kraut ($c^* \geq 0$), and U^* the German utility, with $U^{*\prime} > 0$, $U^{*\prime\prime} < 0$. Then we have, instead of (1),

$$\max_{s^*} E[U^*(c^*)] \qquad s.t.\ c^* = k^* - s^* + \frac{s^* p^f + b^*}{p}, \tag{4}$$

and the optimality condition for the German household is

$$E[U^{*\prime}(c^*)r^*] = 0 \tag{5}$$

where

$$r^* \equiv \frac{p^f}{p} - 1 \tag{6}$$

is the rate of return on a short position in kraut. Again, the second-order condition $E[U^{*\prime\prime}(c)r^{*2}] < 0$ is satisfied.

In market equilibrium, the plans of American and German households are compatible. Equilibrium in the forward market requires equality between the American forward demand for, and the German forward supply of, kraut:

$$\frac{s}{p^f} = s^*. \tag{7}$$

The condition for equilibrium in the spot market is equality between the American spot demand for, and the German spot supply of, beef:

$$p\left(\frac{s}{p^f} + k\right) = s^* p^f + b^*. \tag{8}$$

Condition (7) implies that

$$p^f = \frac{s}{s^*} \tag{9}$$

which, together with (8), gives

$$p = \frac{s + b^*}{s^* + k} \tag{10}$$

Because of (1), (4), (7), and (10), market clearing also implies that, eventually, American households consume all the beef,[4)]

$$c = b + b^*, \tag{11}$$

and German households all the kraut,

$$c^* = k^* + k. \tag{12}$$

Substituting (11) and (12) into the first order conditions (2) and (5) gives

$$E\left[U'(b + b^*)\, r\right] = 0 = E\left[U^{*\prime}(k + k^*)\, r^*\right] \tag{13}$$

where, from (3), (6), (9), and (10),

$$r = \frac{s^*(s + b^*)}{s(s^* + k)} - 1, \qquad r^* = \frac{s(s^* + k)}{s^*(s + b^*)} - 1. \tag{14}$$

Equations (13) and (14) are to be solved for the optimal values of s and s^*.

Let us simplify the problem by assuming that American and German utility functions are identical and that domestic endowments of the preferred commodities (respectively, the non-preferred commodities) are identically and independently distributed (i.i.d.):

$$U'(c) = U^{*\prime}(c^*) \quad \text{for all} \quad c = c^* \geq 0,$$

$$b, k^* \quad \text{i.i.d.} \; ,$$

$$k, b^* \quad \text{i.i.d.} \; .$$

Under these symmetric assumptions, $s = s^*$; thus (14) becomes

$$r = \frac{s + b^*}{s + k} - 1, \quad r^* = \frac{s + k}{s + b^*} - 1. \tag{15}$$

Since b^* and k are stochastically independent, but identically distributed, it is clear[5)] from these expressions that, in a market equilibrium,

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[4)] Equations (11) and (12) show that, in (1) and (4), it is not necessary to restrict the size of s or s^* in order to avoid bankruptcy problems. It is sufficient to assume that the endowments are non-negative. In equilibrium, traders would even be able to satisfy a forward commitment to deliver more of the preferred commodity than they "produce"; they can always buy the required quantities in the spot market, which will be open when the forward contract must be fulfilled.

[5)] Note that the stochastic independence of b^* and k implies stochastic independence of $s + b^*$ and $1/(s + k)$ which makes it possible to write $E(r) = E\left(\frac{s+b^*}{s+k}\right) - 1 = E(s + b^*) \cdot E\left(\frac{1}{s+k}\right) - 1 = \frac{E(s+b^*)}{H(s+k)} - 1$. Analogous reasoning applies to $E(r^*)$.

$$E(r) = \frac{E(s+b^*)}{H(s+k)} - 1 > 0 \tag{16}$$

and

$$E(r^*) = \frac{E(s+k)}{H(s+b^*)} - 1 > 0 \tag{17}$$

where $H(x) \equiv 1/E(1/x)$ is the harmonic mean of a random variable x. From Jensen's inequality, $E(x) > H(x)$ whenever x is positive and has a positive variance.

Equations (16) and (17) reflect the Siegel paradox. Obviously, price randomness *per se* can be profitable for both parties. The forward exchange rate between beef and kraut, given by (9), is unity and both the expected spot price of kraut, $E(p)$, and the expected spot price of beef, $E(1/p)$, are greater than one. There is scope for mutually attractive speculative commitments that consist in taking a short position in the preferred commodity (beef for Americans, kraut for Germans).[6)]

Whether the expected profits are large enough to imply a speculative equilibrium with $s > 0$ depends on the degree of risk aversion. Since a short position in the preferred commodity entails risks that are positively correlated with the existing exchange risk for the non-preferred commodity, we cannot rule out the possibility that $s \leq 0$ for sufficiently high risk aversion. However, the interesting question is whether equilibria with $s > 0$ are possible at all.

To answer this question note that, from the definition of a covariance, $E(x \cdot y) = \text{cov}(x, y) + E(x)E(y)$, and that $\text{cov}(x, y + z) = \text{cov}(x, y)$ when $\text{cov}(x, z) = 0$. Using (15) and normalizing the utility function so that $E[U'(b + b^*)] = E[U'(k + k^*)] = 1$, we can then write (13) in the form

$$\text{cov}\left[U'(b+b^*), \frac{b^*}{s+k}\right] + E(r) = 0 = \text{cov}\left[U'(k+k^*), \frac{k}{s+b^*}\right] + E(r^*). \tag{18}$$

The covariance terms in this expression are negative, their exact magnitudes depending on, among other things, the degree of concavity of the utility function $U(\cdot)$. With any given value $s > 0$ and hence a given positive value of the expected returns $E(r)$ and $E(r^*)$ [cf. (16) and (17)] it is

6) The Siegel paradox which drives our results should not be confused with the paradox of Waugh (1944) and Oi (1961). The latter results from the convexity of the indirect utility and profit functions, implying that both firms and households prefer price variations around a given mean. The former results from the fact that price variations increase the mean, not from a preference for such variations. The Waugh-Oi paradox is a normative proposition which Samuelson (1972) showed to be incompatible with the requirements of a general equilibrium framework. The Siegel paradox is a positive result which this paper shows to be compatible with such requirements.

clearly possible to find a degree of concavity that makes the covariance terms sufficiently strongly negative to satisfy (18). This shows that there is a large class of utility functions for which the Siegel paradox harmonizes with the conditions of a market equilibrium.

An interesting limiting case is that of vanishing risk aversion where $U''(c) = 0$ for all c. As in this case the covariances are zero it is necessary that the expected rates of return $E(r)$ and $E(r^*)$ also equal zero. Using (16) and (17), it is obvious that this in turn occurs when s equals infinity. Thus, without risk aversion, there would be an incentive to hold infinitely large short positions in the preferred commodities, and an equilibrium would not exist.

We summarize this section with

Proposition 1: *In the symmetrical model specified above, with strictly concave utility functions, there exists a class of speculative equilibria in which each party sells its preferred commodity in the forward market in order to participate in Siegel profits.*

III. AN EXAMPLE

It may be useful to construct a special example to further illustrate the nature of the solution.[7] Suppose that

(i) $b, k^* = A > 0$, non-stochastic;

(ii) k, b^* are i.i.d. with equal probability of $k = 1, 2$; and

(iii) $U'(c) = c^{-\varepsilon}$, $U^{*'}(c^*) = c^{*-\varepsilon}, \varepsilon > 0$.

Assumption (i) says that, in each country, the endowment of the preferred commodity is non-stochastic. Assumption (ii) reduces the number of states of nature to four: the endowment vector (b^*, k) attains one of the four variates $(1,1), (1,2), (2,1)$, and $(2,2)$ with probability $\frac{1}{4}$ each.[8] Assumption (iii) requires the utility functions to display constant relative risk aversion, where ε is the degree of relative risk aversion according to the Pratt-Arrow definition. Given these simplifying

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[7] A non-symmetrical example where
(i) $(b, b^*) = A > 0$, non-stochastic, and
(ii) $(k, k^*) = (1,1), (1,2), (2,1)$, and $(2,2)$ with probability $\frac{1}{4}$ each
was communicated to us by Syed Ahsan in a comment on this paper.

[8] Since there are two commodities and four states of nature, an Arrow-Debreu model would have seven contingency markets under these circumstances.

assumptions, it is again true that $s = s^*$, and it follows from equations (13) and (14) that

$$(A+1)^{-\varepsilon}\cdot\frac{1-1}{s+1}+(A+1)^{-\varepsilon}\cdot\frac{1-2}{s+2}+(A+2)^{-\varepsilon}\cdot\frac{2-1}{s+1}+(A+2)^{-\varepsilon}\cdot\frac{2-2}{s+2}=0$$

or

$$\left(\frac{A+2}{A+1}\right)^{\varepsilon}=\frac{s+2}{s+1}\,. \tag{19}$$

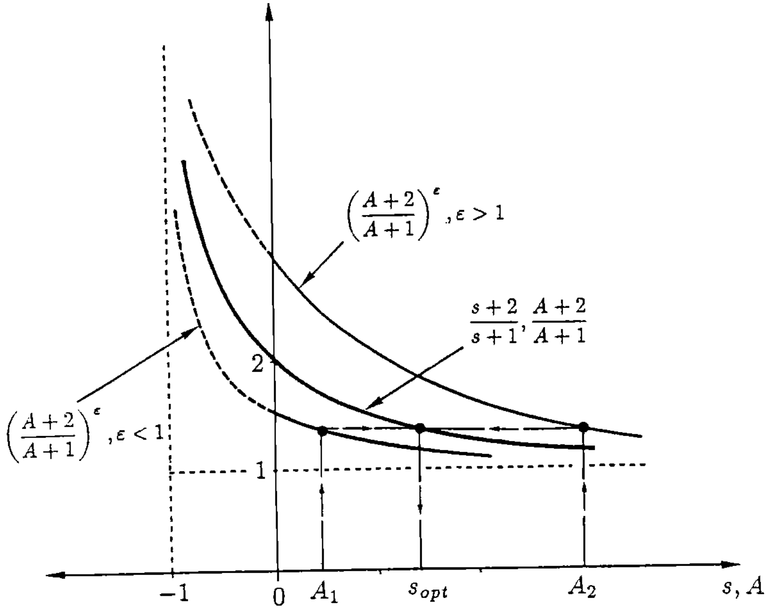

Figure 1: *Relative risk aversion* (ε) *and the optimal forward supply of the preferred commodity* (s)

Figure 1 helps to interpret equation (19). The heavy curve depicts the values of $(s+2)/(s+1)$ for alternative values of s, the two other curves depict $[(A+2)/(A+1)]^{\varepsilon}$ for alternative values of A where the upper curve is typical for $\varepsilon > 1$ and the lower one for $\varepsilon < 1$. Given A (the domestic output of the preferred good) the corresponding optimal value of s can be found in the manner illustrated for the two values $A = A_1$ and $A = A_2$. It is obvious that

$$s_{opt}\begin{Bmatrix} > \\ = \\ < \end{Bmatrix} A \iff \varepsilon \begin{Bmatrix} < \\ = \\ > \end{Bmatrix} 1.$$

The following proposition expresses the finding in words.

Proposition 2: *With relative risk aversion less than or equal to one and under the conditions of the example specified above, people sell short at least their endowment of the preferred commodity. When relative risk aversion exceeds unity, forward sales fall short of the endowment but remain positive provided the excess of relative risk aversion over unity is not too large.*

IV. WELFARE IMPLICATIONS

We have set up a very simple model of speculation and, in terms of that model, have provided an interpretation of UNCTAD's views. Thus, speculation does generate private gains. In the speculative equilibrium ($s > 0$) each individual household attains a higher level of utility than if it chose a lower speculative commitment or decided not to speculate at all. This follows from the first order conditions (2) and (5) and the fact that expected utilities are strictly concave in s and s^*: i.e. $E[U''(c)r^2] < 0$ and $E[U^{*\prime\prime}(c^*)r^{*2}] < 0$. However, everyone ends up with the same vector of consumption possibilities as when only spot contracts are allowed. In both cases, American households consume $b + b^*$ and German households $k + k^*$. The introduction of a forward market brings in speculative activities, but leaves unchanged the expected and realized utilities of both countries. Speculation is individually profitable, but socially useless. It is a rent seeking activity.

While speculation is neither good nor evil in the model as set up above, it becomes an evil when transaction costs are introduced. Suppose that participation in forward contracts involves strictly positive rent seeking costs ε and ε^* for the two groups of speculators, measured in terms of beef for Americans and kraut for Germans.[9] If we assume that the American endowment of beef, b, and the German endowment of kraut, k^*, are defined net of the rent seeking costs, then the speculative equilibrium described in our model would not be affected provided only that ε is small enough to not reverse the individual's decision to participate in speculative profits. However, if no forward market were available everybody would be strictly better off, since the cost of rent seeking would be saved. Americans would consume $b + b^* + \varepsilon$ and Germans $k + k^* + \varepsilon^*$. Obviously, this is a case where policy measures against speculation, such as the closure of the forward market, are welfare enhancing.

[9] The rent seeking costs may be salaries for agents consulted and employed. See Tullock (1967) and Varian (1989) for details and further references.

The result is a typical example of the theory of second best. There is no set of Arrow-Debreu markets to begin with, and as in Hart (1975) the subtraction of a market from an incomplete set of markets may increase social welfare. The novelty of the result is that it is based on the Siegel paradox and may illuminate a particular aspect of forward speculation.

The diagram in Figure 2 illustrates the welfare effects of speculation from the viewpoint of an individual American household. The graph shows the household's expected utility as a function of its own forward sales of beef, s, assuming that the commitments of all other German and American speculator households are constant at the equilibrium level $\bar{s}$. The household's best strategy is to follow the general pattern and equate s to $\bar{s}$, for then it reaches point A where its expected utility is maximized.

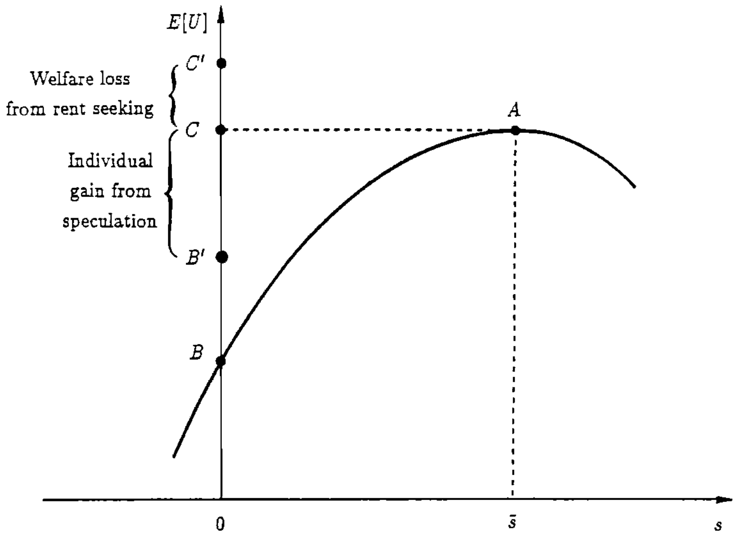

Figure 2: *The welfare economics of speculation*

If there are no costs of rent seeking and the household alone decides not to enter forward contracts it can only reach point B which, because of the concavity of $E[U]$ is strictly below A.

However, if all households decided to abstain from speculation or were forced to do so, then everyone would be at point C, enjoying the same level of expected utility as in A.

With costs of rent seeking the individual pre-speculative position can be on a point such as B' and the attainable position without a forward market may be C'. Provided the transaction costs are small enough to keep B' below C, neither the individual's incentive to speculate nor the nature of the market equilibrium is affected. However, the speculative equilibrium now implies a welfare loss equal to the distance between[10] C' and C.

As it is generally believed that profitable and price-stabilizing speculation is socially beneficial, one might suspect that, in the present model, the welfare loss results from the destabilizing role of speculation. However, it is easy to see that this suspicion is unfounded. Because of (10) and the properties of the symmetrical equilibrium, the spot price of kraut in units of beef is endogenously determined by

$$p = \frac{s + b^*}{s + k} \quad . \tag{20}$$

This equation shows that speculation is indeed stabilizing. Speculation reduces the price variance because it adds to both sides of the market non-random supplies of the non-preferred commodities received from the forward contracts:

$$\frac{\partial \mathrm{var}(p)}{\partial s} = \frac{\partial \mathrm{var}(1/p)}{\partial s} < 0 \quad .$$

The true reason for the welfare loss is not that speculation destabilizes prices but that, in the face of stochastic elements imposed by Nature, it stabilizes them. The stabilization reduces the scope for profits of Siegel type and causes external losses that may overcompensate the speculative profits from a welfare point of view. This follows from equation (20). As this equation implies that[11] $E(p) = E(s + b^*)/H(s + k)$ and $E(1/p) = E(s + k)/H(s + b^*)$ and since $E(\cdot)$ and $H(\cdot)$ approach one another as s increases, it is clear that

$$\frac{\partial E(p)}{\partial s} = \frac{\partial E(1/p)}{\partial s} < 0 \quad .$$

Thus price stabilization takes place not around a given mean spot price but around a mean which declines with the extent of speculation. In itself, independently of changes in the variance, the

[10] In a richer model with competition for entry, the equilibrium cost of rent seeking may eliminate the total private profit BC.

[11] Cf. the step from (15) to (16) and (17).

decline in the mean reduces the revenue from selling the endowments of non-preferred commodities and the returns to speculation $r = E(p) - 1$ and $r^* = E(1/p) - 1$.

The net effect of the decrease in the expectation and riskiness of the spot price can be seen in Figure 2. If all households abstain from speculation they are all at point C'. If all but "one" speculate[12], this one household is pushed down to B'. The distance $C'B'$ (or CB in the case without rent seeking costs) therefore measures the size of the negative external effect which the others households' speculation imposes on the one household considered.

We summarize this section with a proposition.

Proposition 3: *In the model set up in this paper speculation is individually profitable and stabilizes the spot price, but this stabilization is a negative external effect because it reduces other agents' scope for profit of Siegel type. Speculation is a rent seeking activity that may lower social welfare.*

IV. CONCLUSIONS

UNCTAD's demand for stricter regulation of speculation in international financial markets cannot be founded on the present model alone. However we have shown that there are conditions under which the rent seeking interpretation of speculation is compatible with the requirements of a fully specified general equilibrium model.

The source of the potentially harmful role of speculation is to be found not in illusion, monetary or otherwise, nor in deviations from purchasing power parity, nor in incompatible expectations. It is to be found in the inherent randomness of relative prices and the disparity of preferences across countries. The variance of relative spot prices gives rise to the Siegel paradox. It induces the residents of each country to take speculative positions, although transaction costs are involved. This lowers the variance of spot prices and the profits resulting from it. In equilibrium everyone who decides not to speculate suffers a loss in expected utility, but everyone who speculates has less expected utility than he would if the forward market were closed. The economy is trapped in an inefficient speculative equilibrium where speculators enjoy private gains and effect social losses.

This is very much against the traditional economic view that profitable and stabilizing speculation is a socially useful activity. The traditional view is that speculators earn profits from

12) To make this argument precise we would have to specify a continuum of households where "one" agent has a measure of zero.

eliminating scarcities and leveling prices over time and space. In our model, speculators level prices over different states of nature. This activity is not necessarily welfare enhancing.

Closing the forward market is one policy option the model suggests. This option is rather crude and unlikely to remain optimal in richer models that would also allow for a more useful role of the forward market. Another option is the transaction tax which UNCTAD (1990, p. 12) proposed. An ad-valorem tax on forward trade would help reduce the level of speculative trade and might be an appropriate tool for steering the economy towards a second-best equilibrium. UNCTAD's call for "considerable policy innovation in this area" should challenge economic theorists.

To what extent it will be worth pursuing along the lines suggested in this paper remains to be seen. It partly depends on the magnitude of the effects described which ultimately will have to be clarified by empirical research. From a purely theoretical point of view there is some indication that the incentive to speculate may be large. With plausible utility functions and the example considered in section III, it is possible that households stake their entire endowments of the preferred commodities. When relative risk aversion is less than one, it is even optimal to buy the preferred commodity in the spot market in order to meet the forward commitment to deliver more of this commodity than is "produced". These observations suggest to us that the question of what fraction of observable speculative activities fall under the category investigated in this paper may be worth exploring further.

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