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by
Mark Pingle and Leigh Tesfatsion

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INTERMEDIATION IN OVERLAPPING GENERATIONS ECONOMIES

By MARK PINGLE AND LEIGH TESFATSION*

Abstract

Do active earnings-driven intermediaries have a significant role to play in dynamic economies, even in the absence of transactions costs and asymmetrical information? This paper shows that the answer is "yes" for the overlapping generations (OG) economy. This role is not recognized in traditional OG models because an overly restrictive definition of equilibrium is used which rules out the possibility of positive earnings for intermediaries *a priori*. Using a simple illustrative OG model, it is shown that positive earnings are possible for intermediaries when the definition of equilibrium is relaxed to that which is standard for general equilibrium models with finitely many agents and finitely many goods. Moreover, the set of equilibria then depends upon the actions taken by the intermediary. In particular, the incorporation of an active earnings-driven intermediary can reduce, or even eliminate, the possibility of inefficient equilibria. These findings suggest that the OG model is incomplete without an explicit description of the intermediation process.

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Introduction

Trade and credit arrangements in modern market economies are primarily accomplished through active earnings-driven intermediaries such as retail stores, banks, and brokerage firms. Understanding the effects which the actions of intermediaries can have upon the allocation of resources is therefore of considerable importance. Nevertheless, the primary paradigm currently used in economics to study the general system-wide allocation of resources—the Walrasian general equilibrium model—typically incorporates at most three types of agents in explicit form: consumers; producers; and government policymakers. The intermediation process is rarely articulated.

Consider, for example, the traditional Walrasian general equilibrium model consisting of finitely many consumers, finitely many producers, and finitely many goods. To date, this model has largely been used to focus on the role of price systems as resource allocation mechanisms. Any intermediaries which might exist to facilitate exchange are not recognized as earnings-driven agents whose actions could have an impact upon equilibrium outcomes. The only intermediary in the model is an implicit “Walrasian Auctioneer” who passively calls out prices until coordination is achieved.

As it turns out, *within this traditional Walrasian general equilibrium framework*, abstracting from the intermediation process is a perfectly sensible modelling strategy. In particular, transforming the passive Walrasian Auctioneer into an active earnings-driven intermediary would add nothing essential to the story. In any competitive equilibrium, Walras’ Law ensures that the value of any good in excess supply is zero. The value of the goods delivered by the Walrasian Auctioneer must therefore equal the value of the goods he receives, implying that his net earnings are necessarily zero. Consequently, even if the Walrasian Auctioneer were to have an earnings objective, the set of competitive equilibria would not be affected.

The difficulty arises when this modelling strategy is extended to other general equilibrium

contexts. For example, the overlapping generations (OG) model is a general equilibrium model of a dynamic open-ended economy incorporating birth and death. Consequently, unlike the traditional Walrasian general equilibrium model, an OG model necessarily includes infinitely many consumers and infinitely many goods. As noted by Wilson (1981), the value of the aggregate social endowment in an OG model can be infinite in equilibrium, implying that the usual implications of Walras' Law need not hold. In particular, goods in excess supply need not have a zero value in equilibrium.

The possibility that positively valued excess supplies can exist in equilibrium is demonstrated, below, for a simple OG model under standard technology and preference assumptions. No consumer or producer has any claim upon these excess supplies. Rather, they represent the net earnings accruing to intermediation activity. Consequently, another way to state this finding is that intermediaries in OG models can potentially satisfy the trade and credit plans of consumers and producers and still achieve positive net earnings in equilibrium.

Why hasn't this observation been made previously? Interestingly, the reason appears to lie in a seemingly innocuous change which researchers have made in the traditional Walrasian general equilibrium assumptions when adapting these assumptions to the OG model. While the traditional Walrasian general equilibrium approach has been to state market clearing conditions as *inequalities* which allow for an excess supply of goods in equilibrium, the traditional OG approach has been to state market clearing conditions as *equalities* which require that supply exactly equal demand in each market. Consequently, in OG models as opposed to traditional Walrasian general equilibrium models, positive net earnings for intermediaries are ruled out *a priori*.

The use of a strict supply-equal-demand definition of market clearing in the OG model is overly restrictive. No consumer or producer cares whether supply exactly equals demand. Consumers and producers are happy as long as their trade and credit plans are realized. However, once this strict definition of market clearing is weakened to the traditional Walrasian

definition allowing for excess supply in equilibrium, the OG intermediary can potentially achieve positive net earnings. Consequently, the OG model is fundamentally incomplete without a further clarification of the intermediary's stance towards net earnings.

This paper explores the implications for intermediation in OG models when market clearing conditions are relaxed to inequalities, thus allowing for excess supply. Section I sets out the basic structure of a simple illustrative OG model, a pure exchange desert island economy referred to as the "Basic Coconut Economy." Two alternative definitions of equilibrium are considered for the Basic Coconut Economy in sections II and III. A traditional OG modelling of equilibrium with strict supply-equal-demand market clearing conditions is given in section II. The resulting economy is referred to as the "Traditional Coconut Economy." Section III sets out an alternative extension of the Basic Coconut Economy, referred to as the "Nontraditional Coconut Economy," in which market clearing conditions take the form of inequalities allowing for excess supply.

The Traditional Coconut Economy is shown to have precisely two stationary equilibria. Because the strict market clearing conditions rule out the possibility of excess supplies in equilibrium, the intermediary necessarily achieves zero net earnings in both of these equilibria. In contrast, the Nontraditional Coconut Economy is shown to have infinitely many nontraditional stationary equilibria with *positively priced* goods in *excess supply*, in addition to the two stationary equilibria possessed by the Traditional Coconut Economy. In each of the nontraditional stationary equilibria, the intermediary achieves positive net earnings.

Interpretations for the Traditional and Nontraditional Coconut Economies are provided in section IV. It is shown that the Traditional Coconut Economy can be viewed as an OG economy in which trade and credit arrangements are mediated either by a *fixed* supply of fiat money, or by a passive central clearing house whose only objective is to ensure that supply equals demand in each market. On the other hand, the Nontraditional Coconut Economy can be viewed as an OG economy in which trade and credit arrangements are mediated

either by a *nondecreasing* supply of fiat money, or by a passive central clearing house whose only objective is to ensure that the trade and credit plans of all consumers and producers can be carried out.

Although intermediation is passively focused on some type of coordination objective in both the Traditional and Nontraditional Coconut Economies, the intermediary in the Nontraditional Coconut Economy can potentially achieve positive net earnings. Since intermediaries in reality are primarily interested in net earnings, not trade coordination per se, it is suggested in section V that a new approach to OG modelling might fruitfully be adopted. First, market clearing conditions should be weakened to inequalities allowing for excess supply, as is done for the Nontraditional Coconut Economy. And second, at least one active earnings-driven intermediary should be incorporated as an agent whose earnings objective must be satisfied in order for an equilibrium to exist.

The question then arises whether the incorporation of an active earnings-driven intermediary into the Nontraditional Coconut Economy has any economically significant effect on the set of equilibria. In section VI, the answer is shown to be affirmative. Once such an intermediary is introduced, the *only* possible stationary equilibrium for the Nontraditional Coconut Economy is a single Pareto efficient equilibrium. At each other potential stationary equilibrium, the intermediary would perceive the possibility of increasing its net earnings in each period at the given set of prices by an appropriate rearrangement of its receipts and deliveries.

What about the efficiency properties of the equilibria which can be price-supported with active earnings-driven intermediation in more general OG contexts? Although this question is still under study, section VI reviews some preliminary findings along these lines from Pingle and Tesfatsion (1991a,b) which suggest the potential welfare-enhancing power of active intermediation. For example, for the well-known OG model developed by Tirole (1985), a generalization of the Traditional Coconut Economy, it is shown in Pingle and

Tesfatsion (1991b) that the introduction of a corporate intermediary with an appropriate dividend (net earnings) objective can guarantee that all equilibria, both stationary and nonstationary, are Pareto efficient.

I. The Basic Coconut Economy

The Basic Coconut Economy is a pure exchange overlapping generations (OG) economy which begins in period 1 and extends into the infinite future. The rate of population growth is constant and equal to zero. For simplicity, it is assumed that only one consumer is born in each period. The “generation t consumer” is born at the beginning of period t , lives for two periods, and then dies. Consumers in generations $t \geq 1$ are identical aside from time of birth. In the initial period 1, the population of the economy consists of one generation 1 young consumer and one old consumer, referred to as the “generation 0 consumer.” The generation 0 consumer dies at the end of period 1.

The economy has only one consumable resource, coconuts, assumed to be completely perishable and divisible. Adopting the standard convention that goods are distinguished by date of availability, the coconuts available during period t represent “good t .” The economy thus has an infinite number of goods. Each consumer gathers a positive amount w^y of coconuts when young, referred to as his “coconut endowment.” Old consumers are not nimble enough to gather any coconuts.

The young age and old age coconut consumptions of the generation t consumer are denoted by the consumption profile (c_t^y, c_{t+1}^o) . The lifetime consumption preferences of the generation t young consumer are represented by a utility function $U(c_t^y, c_{t+1}^o)$ which is twice continuously differentiable, strictly increasing, and strictly quasiconcave. For reasons to be clarified below, it is assumed as a regularity condition that the consumer’s marginal rate of substitution at the endowment profile $(w^y, 0)$ is less than one, i.e.,

$$(1) \quad MRS(w^y, 0) \equiv U_1(w^y, 0)/U_2(w^y, 0) < 1 .$$

The utility of the generation 0 consumer is assumed to be a strictly increasing function of his coconut consumption in period 1.

Direct coconut-for-coconut trades between a young consumer and an old consumer in any given period are not possible, since old consumers have no coconuts; but, in any case, such trades of a single type of resource would not be welfare enhancing. In contrast, intertemporal coconut trades can enhance the welfare of consumers. That is, consumers might benefit from giving up some of their coconut endowment when young in return for receiving coconuts when old.

Since coconuts are perishable, they cannot be stored. The completion of an intertemporal trade therefore requires the future involvement of as-yet unborn consumers. When a young consumer transfers coconuts to an old consumer in some period t in hopes of receiving coconuts when old, he must depend on the young consumer born in period $t + 1$ to furnish these additional coconuts. But the generation $t + 1$ young consumer will have no incentive to give up these coconuts unless he in turn is guaranteed to receive coconuts from the next generation, and so forth.

Consequently, intertemporal trades in the Basic Coconut Economy are necessarily intergenerational trades; and they will not take place unless facilitated by a medium of exchange which also acts as a store of value. Since the Basic Coconut Economy lacks any durable consumable good, such a medium of exchange must represent an accounting convention or an intrinsically useless durable object which somehow has gained social acceptance as a unit of account.

As is standard in general equilibrium models, the precise nature of the intermediation process will be abstracted from here by assuming that intertemporal trades in the Basic Coconut Economy are facilitated by a price system $\mathbf{p} = (p_1, p_2, \dots)$, where p_t denotes the price of coconuts in period t . Prices might be measured in terms of a numeraire good such as period 1 coconuts, or in terms of some monetary unit of account. Given \mathbf{p} , the value of any

coconuts sold in period t can be stored to enable subsequent coconut purchases in period $t + 1$.

Given a nonnegative price sequence \mathbf{p} , the lifetime utility maximization problem faced by the young consumer in any generation $t \geq 1$ takes the form:

$$(2) \quad \max U(c_t^y, c_{t+1}^o)$$

with respect to the coconut consumption profile (c_t^y, c_{t+1}^o) subject to the lifetime budget and nonnegativity constraints

$$p_t c_t^y + p_{t+1} c_{t+1}^o = p_t w^y ;$$

$$c_t^y \geq 0, \quad c_{t+1}^o \geq 0 .$$

Solutions to (2) entailing positive amounts of coconut consumption in each period of life are characterized by the first-order condition

$$(3) \quad MRS(c_t^y, c_{t+1}^o) = p_t / p_{t+1} ,$$

together with the lifetime budget constraint. For simplicity, it will hereafter be assumed that solutions to (2) satisfy the first-order condition (3) for all price sequences \mathbf{p} satisfying $p_t / p_{t+1} \geq MRS(w^y, 0)$.

II. Traditional OG Modelling of Equilibrium for the Basic Coconut Economy

Market clearing conditions are equilibrium conditions which guarantee that all trading plans can be actualized. In an attempt to define these equilibrium conditions in the weakest manner possible, theorists working in the context of traditional Walrasian general equilibrium models involving finitely many consumers and finitely many goods often state these market clearing conditions as inequalities which allow for excess supply in equilibrium. In contrast, beginning with the seminal paper by Samuelson (1958; p. 470), and continuing to the present, it has become standard for theorists studying OG economies to state market

clearing conditions in a stronger form: namely, as requirements that supply exactly equal demand in each market.¹

The implications of this strengthening of the market clearing definition will be taken up in the next section. In this section, we will follow the OG tradition and state market clearing conditions as equalities. In particular, all markets will be said to clear when the supply of coconuts equals the demand for coconuts in each period, i.e., when

$$(4) \quad w^y = c_t^y + c_t^o, \quad t \geq 1.$$

Given a price sequence p for the Basic Coconut Economy, a (*traditional*) equilibrium will be said to exist if two conditions are satisfied. First, each young consumer solves the lifetime utility maximization problem (2), conditional on p . And second, all markets clear in the sense that condition (4) holds. A Basic Coconut Economy for which this traditional OG definition of equilibrium is used will hereafter be referred to as a *Traditional Coconut Economy*.

If the generation 0 consumer is unable to obtain any coconuts prior to the initial round of trade in period 1, then the only equilibrium possible for the Traditional Coconut Economy is the harsh no-trade equilibrium in which each young consumer consumes his coconut endowment and old consumers consume nothing. On the other hand, the generation 0 consumer might have a source of real purchasing power—e.g., some form of credit—despite his inability to engage in coconut-gathering activities. Thus, a fundamental question first raised by Gale (1973, p. 23), and explored below in section IV, is how this initial source of purchasing power might come about.

Call an equilibrium “stationary” if the terms of trade between any two successive periods

¹For example, see the definitions of market clearing used by Diamond (1965; p. 1132), Cass and Yaari (1966; p. 354), Shell (1971; p. 1004), Gale (1973; p. 18), Cass-Okuno-Zilcha (1979; p. 46), Balasko and Shell (1980; p. 285), Wilson (1981; p. 101), Scheinkman (1983; p. 7), Woodford (1984; Section I), Yamamoto (1984; p. 14), Dechert and Yamamoto (1985; p. 10), and Tirole (1985; p. 1502).

are constant over time, i.e., if

$$(5) \quad p^t/p^{t+1} = R, \quad t \geq 1,$$

where R is an interest factor equal to one plus a stationary rate of interest. As shown by Gale (1973), any economy having the basic structure of the Traditional Coconut Economy has exactly two stationary equilibria. Retracing Gale's logic, this fact can be deduced from the consumer budget constraints and the market clearing conditions.

Condition (5) implies that each optimizing young consumer in a stationary equilibrium will choose the same coconut consumption profile, say (c^y, c^o) . To see this, simply multiply the lifetime budget constraint for the generation t young consumer by $1/p_t$, $t \geq 1$. Thus, in a stationary equilibrium, the budget constraint for each generation t young consumer can be written without loss of generality as

$$(6) \quad c^o = R[w^y - c^y].$$

Given the stationary consumption profile (c^o, c^y) for generations $t \geq 1$, the market clearing condition (4) for periods $t \geq 2$ becomes

$$(7) \quad w^y = c^y + c^o.$$

The market clearing condition (4) for period $t = 1$, with $c_1^y = c^y$, then forces the coconut consumption c_1^o of the generation 0 consumer to equal c^o .

The stationary consumption profile (c^y, c^o) must satisfy conditions (6) and (7) simultaneously. Combining these conditions yields the condition

$$(8) \quad 0 = [R - 1][w^y - c^y].$$

Exactly two stationary equilibria satisfy condition (8). One stationary equilibrium is characterized by the stationary consumption profile $c^w \equiv (w^y, 0)$, where each young consumer consumes his coconut endowment and each old consumer makes due with nothing.

The interest factor R^w associated with this no-trade stationary equilibrium satisfies $R^w = MRS(w^y, 0) < 1$, implying that the interest rate $R^w - 1$ is negative. The second stationary equilibrium is characterized by the stationary consumption profile $\bar{c} \equiv (\bar{c}^y, \bar{c}^o)$ associated with the interest factor $\bar{R} = 1$, implying that the interest rate $\bar{R} - 1$ is equal to zero. At \bar{c} , each young consumer abstains from consuming a portion of his coconut endowment w^y . The stationary equilibrium consumption profiles c^w and \bar{c} are depicted in Figure 1; these profiles satisfy the strong market clearing (7), which appears as Line L in Figure 1.

INSERT FIGURE 1 ABOUT HERE

Note that the interest rate $\bar{R} - 1 = 0$ associated with the second stationary equilibrium coincides with the population growth rate for the Basic Coconut Economy. The population growth rate is traditionally referred to as the “golden-rule interest rate” because of its desirable efficiency properties. Indeed, as Gale (1973) observes, the no-trade consumption profile c^w associated with R^w is Pareto inefficient, while the golden-rule consumption profile \bar{c} associated with \bar{R} is Pareto efficient.

III. Nontraditional Modelling of Equilibrium for the Basic Coconut Economy

Suppose, instead, that market clearing conditions are introduced into the Basic Coconut Economy in the form of inequalities. That is, suppose that all markets are defined to clear when

$$(9) \quad w^y \geq c_t^y + c_t^o, \quad t \geq 1.$$

As noted in section II, the market clearing conditions (9) are weaker than those traditionally used in OG analyses.

Given any particular price sequence \mathbf{p} for the Basic Coconut Economy, a (*nontraditional*) *equilibrium* will be said to exist if two conditions are met. First, each young consumer solves the lifetime utility maximization problem (2), conditional on \mathbf{p} . And second, all markets

clear in the sense that condition (9) holds. A Basic Coconut Economy for which this weaker concept of equilibrium is used will hereafter be referred to as a *Nontraditional Coconut Economy*.

Call an equilibrium for the Nontraditional Coconut Economy “stationary” if condition (5) holds, i.e., if all consumers face the same stationary interest factor R . In any stationary equilibrium, each young consumer in each generation $t \geq 1$ chooses the same stationary coconut consumption profile, say (c^y, c^o) . Consequently, the market clearing conditions (9) reduce to the condition

$$(10) \quad w^y \geq c^y + c^o .$$

By definition, then, a consumption profile (c^y, c^o) can be price-supported as a stationary equilibrium consumption profile for the Nontraditional Coconut Economy if and only if it lies on the darkened portion of the offer curve depicted in Figure 1.² This darkened portion includes the consumption profiles c^w and \bar{c} , shown in Section II to be supportable as stationary equilibrium consumption profiles for the Traditional Coconut Economy. These profiles lie on line L in Figure 1, where condition (7) is satisfied and the supply of coconuts equals the demand for coconuts in each period t . However, all of the remaining consumption profiles on the darkened portion of the offer curve satisfy

$$(11) \quad w^y > c^y + c^o ,$$

meaning there is an excess supply of coconuts in each period t . Consequently, these profiles violate the strict supply-equal-demand definition of market clearing, and hence are not supportable as stationary equilibrium consumption profiles for the Traditional Coconut Economy. The weakening of the traditional OG market clearing definition has therefore resulted in a significant increase in the number of potential stationary equilibria.

²The offer curve drawn in Figure 1 exhibits gross substitutability, meaning that the generation t young consumer desires to save more coconuts as the interest rate is increased. This particular preference assumption does not significantly affect the main issues addressed in this paper.

Moreover, in each nontraditional stationary equilibrium characterized by excess coconut supply, the price of coconuts is nevertheless positive. To see this, note that the interest factor R associated with any such equilibrium satisfies $0 \leq R^w < R < \bar{R} = 1$, where R^w and \bar{R} are the interest factors associated with the two traditional stationary equilibria c^w and \bar{c} . Consequently, it follows from condition (5) that the equilibrium price for coconuts is positive in each period t despite the fact that coconuts are in excess supply in each period t .

Why does the set of stationary equilibria change when the market clearing conditions for the Traditional Coconut Economy are relaxed to inequalities? In general equilibrium models which have a finite number of consumers and a finite number of goods, Walras' Law holds. In such models, Walras' Law implies that if there does exist an excess supply of a good in equilibrium, then that good will have a price equal to zero. Walras' Law also implies that the supply of a good must equal the demand for the good if the price of the good is strictly positive. Thus, when Walras' Law holds and only positive price sequences are being considered, stating market clearing conditions as equalities is not any more restrictive than stating them as inequalities. The same set of equilibria results in either case.

However, relaxing the market clearing conditions for the Traditional Coconut Economy—an OG economy with infinitely many consumers and infinitely many goods—expands the set of equilibria. As has previously been recognized (see, e.g., Wilson (1981)), a basic problem in OG economies is that the value of the aggregate endowment, here $\sum_{t=1}^{t=\infty} [p_t w^y]$, can be infinite in equilibrium. In this case, the standard implications of Walras' Law do not necessarily hold. We have, in fact, shown that the Nontraditional Coconut Economy can generate equilibria where coconuts in excess supply have a positive price.

IV. Interpreting the Traditional and Nontraditional OG Approaches

Given the Basic Coconut Economy described in section I, is there any reason why equilibria involving excess supply should be ruled out *a priori* by the introduction of market

clearing conditions in the form of equalities? The answer must surely be no.

The only agents in the Basic Coconut Economy are consumers. No consumer cares whether or not supply exactly equals demand. Consumers are happy as long as they can satisfy their coconut demands at the given set of prices. Given a stationary interest factor R satisfying $R^w < R < \bar{R}$, the coconut demands of all consumers can be satisfied *and* there is a positive amount of coconuts left over in each period t . Although such a situation is clearly wasteful, there is no agent in the Coconut Economy to ensure that such waste does not occur.

Providing an interpretation of the traditional OG approach, where market clearing conditions are stated as equalities, and the nontraditional OG approach where market clearing conditions are stated as inequalities, requires a more detailed analysis of the mediation process. When considering the mediation of intertemporal trade for an OG model with a structure similar to the Basic Coconut Economy, Gale (1973) examined two ideas: (i) intertemporal trade is mediated by fiat money, i.e., unbacked currency with no intrinsic value; and (ii) intertemporal trade is mediated by a central clearing house. Consider each of these, in turn, for the Basic Coconut Economy.

Suppose, first, that intertemporal trade in the Basic Coconut Economy is mediated by otherwise useless palm fronds, assumed to be durable. Thus, intertemporal coconut trades can now take place if the generation t young consumer is willing to give coconuts to the generation $t - 1$ old consumer in exchange for palm fronds in each period $t \geq 1$. For trade to occur in the initial period 1, the generation 0 old consumer must be endowed with an initial quantity of palm fronds in period 1.

The price p_t for period t coconuts is now assumed to be a spot price measured in palm fronds; that is, p_t denotes the quantity of palm fronds received in period t in exchange for one coconut. Letting m_t denote the palm frond demand of the generation t young consumer,

the lifetime utility maximization problem facing this young consumer takes the form:

$$(12) \quad \max U(c_t^y, c_{t+1}^o)$$

with respect c_t^y , c_{t+1}^o , and m_t subject to the budget and nonnegativity constraints

$$p_t c_t^y + m_t \leq p_t w^y ;$$

$$p_{t+1} c_{t+1}^o \leq p_{t+1} w^o + m_t ;$$

$$c_t^y \geq 0, \quad c_{t+1}^o \geq 0, \quad m_t \geq 0 .$$

Since the utility function $U(\cdot)$ is assumed to be strictly increasing, implying that consumers are never satiated, the young age and old age budget constraints in (12) will be satisfied as equalities in any equilibrium, and all prices will be strictly positive. The young age budget constraint of the generation t consumer and the old age budget constraint of the generation $t - 1$ consumer, taken as equalities, together imply that the condition

$$(13) \quad p_t [w^y - c_t^y - c_t^o] + [m_{t-1} - m_t] = 0$$

must hold in each period $t \geq 1$. From condition (13) and the positivity of p_t , it follows that if there is an excess supply of coconuts during period t , then there will also be an excess demand for palm fronds. That is, if $w^y > c_t^y - c_t^o$, then $m_{t-1} < m_t$. Consequently, if the supply of palm fronds is held constant over time, an excess supply of coconuts is not possible in equilibrium.

This discussion suggests the following interpretations for the traditional and nontraditional OG approaches. Intertemporal trade in the traditional OG approach is essentially mediated by a *fixed* supply of fiat money. In contrast, intertemporal trade in the nontraditional OG approach is essentially mediated by a possibly *increasing* supply of fiat money. More precisely, in the latter approach, a positive excess coconut supply $[w^y - c_t^y - c_t^o]$ in any period t can potentially be sustained by a positive injection $[m_t - m_{t-1}]$ of fiat money.

Now consider, instead, a version of the Basic Coconut Economy in which intertemporal coconut trades are mediated by a central clearing house. The generation 0 consumer is assumed to have some amount of credit on account with the clearing house which can be used to obtain coconuts from the clearing house in period 1. To simplify the exposition, we again focus exclusively on stationary equilibria.

Given any stationary interest factor R , where $R^w \leq R \leq \bar{R}$, all young consumers in generations $t \geq 1$ desire to consume the same amount of coconuts, say c^y . Consequently, all young consumers also desire to save the same amount of coconuts: namely, $s \equiv w^y - c^y$. During period t , the generation t young consumer delivers s coconuts to the clearing house in exchange for credit to buy Rs coconuts in period $t + 1$. Also during period t , the generation $t - 1$ old consumer receives Rs coconuts from the clearing house in exchange for s coconuts supplied to the clearing house in period $t - 1$. It follows that, during each period t , the clearing house receives s coconuts and must in turn deliver Rs coconuts. That is, the clearing house receives a net of $[1 - R]s$ coconuts.

If either $R = R^w$ (implying $s = 0$) or $R = \bar{R}$ (i.e., $R = 1$), this net coconut amount is zero. That is, in each period t the quantity of coconuts delivered by the clearing house to the generation $t - 1$ old consumer is equal to the quantity of coconuts received from the generation t young consumer. Note that R^w and \bar{R} are the interest factors associated with the two stationary equilibria c^w and \bar{c} for the Traditional Coconut Economy.

This suggests another interpretation of the traditional OG approach. Intertemporal trade is brokered by an intermediary—e.g., a central clearing house—whose only objective is to ensure that the quantity of each good received is equal to the quantity of each good delivered. Given the stringency of its trade coordination objective, the traditional intermediary is forced to have zero net earnings.

On the other hand, if $R^w < R < \bar{R}$, then during each period t the net coconut receipts of the clearing house are positive, meaning the clearing house can satisfy all coconut con-

sumption demands and still have some amount of coconuts left over. No consumer has any claim on these net coconut receipts. Therefore, they might rightly be considered to be the net earnings of the clearing house received in payment for its intermediation activities. This describes the situation that occurs in an excess supply equilibrium for the Nontraditional Coconut Economy.

This suggests another interpretation of the nontraditional OG approach. Intertemporal trade is brokered by an intermediary—e.g., a central clearing house—whose only objective is to ensure that the consumption demands of all consumers are satisfied. The nontraditional intermediary does not care if its inflow of goods is equal to its outflow in each period t . It merely requires that its inflow be at least great enough to meet its outflow requirements. Consequently, the nontraditional intermediary can have positive net earnings in equilibrium whereas the traditional intermediary cannot.

V. A New Approach to OG Modelling

The discussion presented in the previous section raises a fundamental issue. How should intermediation be modelled for dynamic open-ended economies incorporating birth and death, that is, for OG economies?

Thus far we have demonstrated three findings for the Basic Coconut Economy. First, intertemporal trade can be brokered by an intermediary. Second, it is possible for the intermediary to have positive net earnings in each period t while responsibly meeting all of its obligations to consumers. And third, the stringent trade coordination objective implicitly assigned to the intermediary under the traditional OG definition of equilibrium rules out the possibility of positive net earnings for the intermediary *a priori*.

Institutions which function as intermediaries in reality are not concerned with trade coordination per se. To the contrary, as for producers, the basic objective of intermediaries in the real world concerns net earnings. The satisfying of customer demands is not the

overriding objective. Rather, customer demands are met in order to improve the bottom line. Consequently, we suggest that a fruitful approach to the modelling of intermediation in OG economies would be one which recognizes and permits the possibility of positive net earnings for intermediaries. Zero net earnings then becomes a possible characteristic of equilibrium outcomes rather than an *a priori* imposed restriction.

Specifically, we propose two fundamental modifications of the traditional OG modelling approach. First, weaken market clearing conditions to inequalities which allow for excess supply, as is done in the Nontraditional Coconut Economy. Second, include at least one active earnings-driven intermediary as an agent whose earnings objective must be satisfied in order for an equilibrium to exist.

VI. Active Earnings-Driven Intermediation in OG Models: An Example

To date, we have explored the economic implications of active intermediation in two concrete OG settings. In Pingle and Tesfatsion (1991a), we consider the implications of active intermediation for a pure exchange OG economy first described by Samuelson (1958). In Pingle and Tesfatsion (1991b), a similar analysis is undertaken for the private production OG economy investigated by Diamond (1965) and later generalized by Tirole (1985) to include the possibility of bubble asset investment. In each setting, we find that active intermediation has strong efficiency implications. This section briefly reviews our findings for the Diamond-Tirole economy.

The only intermediary in the Diamond-Tirole economy is an implicitly present Walrasian Auctioneer concerned with the coordination of trade and credit arrangements, but not with the *optimization* of these arrangements. As Tirole shows, the First Welfare Theorem fails for the Diamond-Tirole economy. Unless initial bubble asset holdings are set just right, the economy will follow a Pareto inefficient competitive equilibrium path.

In Pingle and Tesfatsion (1991b), the Diamond-Tirole economy is generalized to include a

corporate intermediary, owned by consumer-shareholders, which distributes all net earnings as dividends to shareholders. The efficiency properties of the resulting "Brokered Economy" then depend on the exact modelling of the intermediary's earnings objective.

One possibility is that the corporate intermediary behaves as a Walrasian Auctioneer, i.e., a price-setting agent concerned only with trade and credit coordination. It is shown that the Brokered Economy reduces to the Diamond-Tirole economy in this case. In particular, competitive equilibria need not be Pareto efficient. The Traditional Coconut Economy, a special case of the Diamond-Tirole economy, illustrates this result. As shown in section II, the Pareto-inefficient no-trade consumption profile $c^w \equiv (w^y, 0)$ can be supported as a stationary equilibrium consumption profile for the Traditional Coconut Economy.

Another possibility, however, is that the corporate intermediary is a price-taking agent with an earnings objective. In this case, it is shown that Pareto inefficient outcomes cannot be supported as competitive equilibria for the Brokered Economy under *any* reasonable specification of the intermediary's earnings objective. In particular, given any Pareto inefficient outcome, the corporate intermediary would perceive the possibility of increasing its net earnings in each and every period.

The Nontraditional Coconut Economy set out in section III, a special case of the Brokered Economy, can be used to illustrate this result. Given a price-taking earnings-driven intermediary for this economy, the only consumption profile which can reasonably be supported as a stationary equilibrium consumption profile is the Pareto efficient golden-rule profile \bar{c} . As explained in section IV, given any other possible stationary equilibrium consumption profile, i.e., any other consumption profile lying on the darkened portion of the offer curve depicted in Figure 1, the corresponding interest factor R satisfies $R < 1$. The net earnings received by the price-taking intermediary in each period t per each unit of savings it brokers are then given by $[1 - R] > 0$. Consequently, the intermediary would perceive the possibility of obtaining arbitrarily large net earnings in each period t by an appropriate rearrangement of

its receipt and delivery plans at the current interest rate $R - 1$.

In short, the Pareto inefficient outcomes which arise as equilibria for the Diamond-Tirole economy are ruled out as equilibria for the Brokered Economy under any reasonable specification of an earnings objective for the corporate intermediary. But what about the Pareto efficiency of equilibria for the Brokered Economy?

The answer to this question depends upon the precise specification of the corporate intermediary's earnings objective. What form this objective should take is still under investigation. However, some preliminary results along these lines are reported in Pingle and Tesfatsion (1991b) which suggest the potential welfare-enhancing power of active intermediation.

Specifically, after explaining why the usual specification of a present value profit maximization objective is ill-defined for the corporate intermediary, an illustrative example of a dividend (net earnings) objective is considered for the intermediary which takes into account the varied interests of all shareholders: namely, maximize the minimum per capita dividend distributed to shareholders over time. Given this dividend objective, it is shown that the market value of the corporate intermediary attains its maximum feasible value in each period t , and *all* competitive equilibria for the Brokered Economy are Pareto efficient.

The key fact used to establish these findings is that a solution exists for the corporate intermediary's dividend distribution problem if and only if certain price conditions hold which are analagous to the Cass-Balasko-Shell transversality conditions shown by Balasko and Shell (1980) to be necessary and sufficient for Pareto efficiency in the context of a pure exchange OG model. The interesting point here is that an economic interpretation is provided for these price conditions; they are the "transversality conditions" for the optimizing corporate intermediary.

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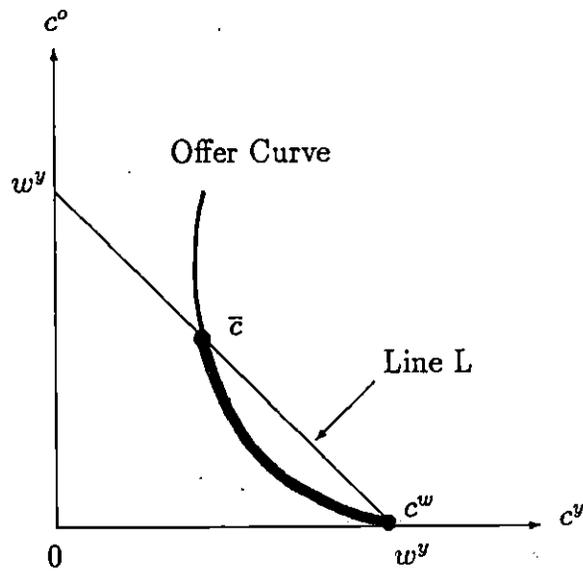


Figure 1: Stationary Equilibria