Active Intermediation in Overlapping Generations Economies with Production and Unsecured Debt

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Abstract
It is well known that the first welfare theorem fails for the pure exchange overlapping generations economy studied by Samuelson (1958) and for the private production overlapping generations economy studied by Diamond (1965). Tirole (1985) combines and extends the Samuelson and Diamond frameworks by permitting both unsecured debt and private production and shows that the first welfare theorem still fails to hold. This paper shows that the reason for this failure is that intermediation is modelled as a purely passive coordination activity implemented by a Walrasian Auctioneer.

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Active Intermediation in Overlapping Generations Economies with Production and Unsecured Debt

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Active Intermediation in Overlapping Generations Economies with Production and Unsecured Debt*

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ABSTRACT

It is well known that the first welfare theorem fails for the pure exchange overlapping generations economy studied by Samuelson (1958) and for the private production overlapping generations economy studied by Diamond (1965). Tirole (1985) combines and extends the Samuelson and Diamond frameworks by permitting both unsecured debt and private production and shows that the first welfare theorem still fails to hold. This paper shows that the reason for this failure is that intermediation is modelled as a purely passive coordination activity implemented by a Walrasian Auctioneer. When intermediation is instead modelled as a contestable activity carried out by a corporate intermediary owned by consumer-shareholders and operated in their interest, every equilibrium must by Pareto efficient. In broader terms, these findings caution that the inefficiency observed in standard modelling of overlapping generations economies may not be the reflection of an intrinsic market failure, as is often claimed. Rather, the observed inefficiency could instead be due to a fundamental incompleteness in the model specification—the presumed inability of private agents to exploit the earnings opportunities associated with incurring and forever rolling over debt.

KEYWORDS Intermediation, overlapping generations, Pareto efficiency, production, unsecured debt, bubbles.

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1. Introduction

Tirole (1985) studies an overlapping generations economy in which agents can issue consumption loans, as in Samuelson (1958), and can also engage in private goods production as in Diamond (1965, pp. 1130-1135). In particular, the savings of each generation can be used in part to finance the capital investment of firms and in part to finance the consumption of agents whose consumption demands are in excess of their endowments. Tirole shows that the resulting economy fails to satisfy the first welfare theorem. Specifically, as reviewed in Section 2, below, two stationary competitive equilibria exist for this economy: a Pareto inefficient equilibrium with no consumption loans; and a Pareto efficient "golden rule" equilibrium in which consumption loans are made.

This paper suggests that the failure of the Tirole economy to satisfy the first welfare theorem can be attributed to the passive role assigned to intermediation. The only intermediary in the Tirole economy is an implicitly present Walrasian Auctioneer concerned with coordination but not with optimization. As detailed in Section 3, below, private agents in the Tirole economy do not exploit viable and profitable debt issue opportunities.

To explore this point further, the Tirole economy is generalized in Section 4 to include the explicit presence of a corporate intermediary owned by consumer-shareholders. The efficiency properties exhibited by the resulting "Brokered Economy" then depend on the exact modelling of the intermediary's objective. One possibility is that the Brokered Economy intermediary behaves as a Walrasian Auctioneer, i.e., as a price-setting agent concerned only with trade and credit coordination. In Section 5.A it is shown that the Brokered Economy reduces to the Tirole economy in this case.

Another possibility, however, is that the intermediary moves beyond mere coordination and acts in the interests of its shareholders. In Section 5.B we retain the assumption that the intermediary is a price setter, but we also assume the intermediation market is contestable.

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1In Pingle and Tesfatsion (1991a) it is shown that passive intermediation is the root cause of Pareto inefficiency problems for Samuelson's (1958) pure exchange economy, a special case of the Tirole economy.

2Bernanke and Gertler (1986) also introduce intermediaries ("banks" or "insider investment coalitions") into an overlapping generations model. However, they focus on the potential role of these intermediaries in reducing deadweight losses due to principal-agent problems in the loan market for investment projects. They do not permit intermediaries to issue consumption loans. The closest forerunner to the present paper appears to be E. Thompson (1967). Thompson argues that genuinely perfect competition requires the introduction of a market for private debt instruments (e.g., a corporate pension fund), a market omitted from models such as Samuelson (1958).
That is, we assume that entry occurs when an entrant can feasibly assume the liabilities of the existing corporate intermediary and can strictly increase the dividends paid to its current shareholders. We assume that the existing corporate intermediary sets its stock share prices so as to prevent the entry of any competitors, and we extend the standard definition of an equilibrium to include this corporate intermediary objective. Under these assumptions, we show that every Brokered Economy equilibrium is Pareto efficient.

The crucial fact used to establish this Brokered Economy first welfare theorem is that entry into the intermediation market is feasible only if a certain price condition fails to hold. This price condition is analogous to the well-known Cass-Balasko-Shell transversality condition shown by Balasko and Shell (1980) to be necessary for Pareto efficiency in the context of a pure exchange overlapping generations economy. Our findings thus suggest an economic interpretation for this transversality condition as a constraint on the price-setting behavior of an optimizing corporate intermediary in a contestable intermediation market.

Overall, our findings suggest that the Pareto inefficiency exhibited by commonly used models of dynamic open-ended economies with finite-lived agents can, to a large extent, be accounted for by the fact that intermediation is modeled as a purely passive coordination activity. As demonstrated here for the Tirole economy, this inefficiency may be ameliorated or even eliminated if intermediation is more realistically modeled as an activity oriented toward the exploitation of available profit opportunities.

2. The Tirole Economy

A. Basic Model Structure

As depicted in Figure 1, the model of an economy developed by Tirole (1985)—hereafter referred to as the “Tirole Economy”—is an overlapping generations economy in which each consumer lives for just two periods, “youth” and “old age.” The generation of consumers born at the beginning of period t consists of $L_t$ consumers and is referred to as “generation t.” Population grows at the rate $n \geq 0$, so that $L_{t+1} = [1 + n]L_t$. The economy begins in period 1 with $L_0 > 0$ old consumers of generation 0 and $L_1 = [1 + n]L_0$ young consumers of generation 1.
The Tirole Economy has a single physical resource which may either be consumed or used in production as capital. Adopting the conventional time dating of goods, the resource during period \( t \) will be referred to as “good t.” Each young consumer in each generation \( t \geq 1 \) inelastically supplies one unit of labor in return for a real (resource) wage \( w_t \). Wage income is used by young consumers to provide young-age consumption \( c_t^1 \) and savings \( s_t \). Old-age consumption \( c_{t+1}^2 \) is provided entirely from savings and accumulated interest; old consumers do not work.

Consumer saving is held in two possible forms: units of capital; and units of a bubble asset that pays no dividends.\(^3\) The bubble asset can be thought of as vouchers representing real purchasing power—for example, as real money balances, or as a credit or debit held on account with an intermediary. If capital and the bubble asset are both to be held in competitive equilibrium, the bubble asset must bear the same yield as capital. Thus, it is assumed that saving in either form has a common rate of return \( r_{t+1} \) over each period \( t \geq 1 \).

Consumers have identical preferences. The objective of each generation \( t \) young consumer is to maximize his lifetime utility \( U(c_t^1, c_{t+1}^2) \), where \( U(\cdot) \) has the usual curvature properties.\(^4\) Given any \( \psi_t^1 > 0 \) and \( \psi_{t+1}^2 > -1 \), the problem faced by this young consumer takes the form

\[
\begin{align*}
\max \quad & U(c_t^1, c_{t+1}^2) \\
\text{subject to} \quad & c_t^1 = w_t - s_t \\
& c_{t+1}^2 = [1 + r_{t+1}]s_t \\
& c_t^1 \geq 0, c_{t+1}^2 \geq 0.
\end{align*}
\]

Let the solution to this problem be denoted by

\[
x(w_t, r_{t+1}) = (s(w_t, r_{t+1}), c_t^1(w_t, r_{t+1}), c_{t+1}^2(w_t, r_{t+1})).
\]

\(^3\) An asset is said to exhibit a “bubble” at time \( t \) if its price at time \( t \) differs from its fundamental value, determined as the present value of its current and future dividends. A “bubble asset” is any asset on which a bubble may form. When an asset pays no dividends, it necessarily exhibits a bubble whenever its price is positive. Tirole (1985) does not incorporate a market for stock shares into his model, hence bubbles on capital holdings are not considered.

\(^4\) Specifically, it is assumed that \( U(\cdot) \) is twice continuously differentiable, strictly increasing, and strictly quasi-concave, with \( U(0, c_{t+1}^2) = U(c_t^1, 0) = U(0, 0) \).
Each old consumer in the initial period 1 receives a payment \([1 + r_1]s_0\) of principal plus interest, where the savings level \(s_0\) satisfies \(s_0 = s(w_0, r_1)\) and the savings function \(s(\cdot)\) coincides with the savings function determined for each generation \(t \geq 1\) agent in (2). The consumption of each old consumer in period 1 is therefore \(c_1^t = [1 + r_1]s(w_0, r_1)\).

Output in the Tirole Economy is produced at the beginning of each period by a firm that uses capital and labor inputs in accordance with the production relation \(Y = F(K, L)\). The production function \(F(\cdot)\) is assumed to exhibit constant returns to scale, and to satisfy the usual continuity and curvature restrictions. More precisely, the following restrictions are imposed on \(F(\cdot)\): twice continuous differentiability and strict concavity over the positive orthant \(R^+_2\), with \(F(0,0) = 0\), \(F_K > 0\), \(F_L > 0\), and \(F_{KK} < 0\); continuity over the nonnegative orthant \(R^+_2\); and, for each \(L > 0\), \(F_K(K, L) \to 0\) as \(K \to +\infty\) and \(F_K(K, L) \to +\infty\) as \(K \to 0\).

Output in the Tirole Economy is produced at the beginning of each period by a firm that uses capital and labor inputs in accordance with the production relation \(Y = F(K, L)\). The production function \(F(\cdot)\) is assumed to exhibit constant returns to scale, and to satisfy the usual continuity and curvature restrictions. Letting \(k \equiv K/L\) and \(y \equiv Y/L\) denote the capital-labor ratio and the output-labor ratio, respectively, the production relation can be expressed in per-capita (i.e., per-worker) form as \(y = F(k, 1) = f(k)\).

In each period \(t \geq 1\) the firm must pay the wage rate \(w_t\) to each unit of employed labor as well as a rental rate for each unit of employed capital. The rental rate on capital in period \(t\) is assumed to be the same as the interest rate \(r_t\) on savings. The price-taking firm selects levels of capital and labor inputs to maximize profits. Formally, the firm's problem may be stated as

\[
\max_{K \geq 0, L \geq 0} [F(K, L) - r_t K - w_t L]
\]

In order for a positive vector \((K_t, L_t)\) of capital and labor inputs to solve problem (3), it is both necessary and sufficient that the capital-labor ratio \(k_t \equiv K_t/L_t\) satisfy

\[
(4) \quad r_t = f'(k_t)
\]

\[
(5) \quad w_t = f'(k_t)k_t
\]

Conditions (4) and (5) generate the well-known "factor-price frontier" relationship between the wage rate \(w_t\) and the interest rate \(r_t\). For any given interest rate \(r_t > 0\), let \(k(r_t)\) denote the capital-labor ratio \(k_t\) that uniquely satisfies condition (4). Substituting \(k(r_t)\) into condition (5), the wage rate \(w_t\) that satisfies condition (5) is then uniquely determined as a strictly decreasing function \(w(r_t)\) of the interest rate \(r_t\).

In each period \(t \geq 1\) the supply of capital consists of aggregate savings \(S_{t-1} = L_{t-1}s_{t-1}\) less that part of savings held in the form of the bubble asset. Let \(B_{t-1} = L_{t-1}b_{t-1}\) denote
aggregate bubble asset holdings and \( K_t \) denote the firm's aggregate demand for capital. Then, in per capita terms, supply equals demand\(^6\) in the capital market when

\[
[s_{t-1} - b_{t-1}]/[1 + n] = k_t .
\]

As in Tirole (1985, p. 1503), the following restriction is imposed on the growth of the aggregate bubble asset holdings \( B_t \):

\[
B_t = [1 + r_t] B_{t-1} ,
\]

or, in per-capita terms,

\[
b_t = [(1 + r_t)/(1 + n)] b_{t-1} .
\]

The implications of restriction (7) are examined in Section 3, below.

Young consumers in each period \( t \geq 1 \) supply labor inelastically, in total amount \( L_t \). Supply equals demand in the labor market when the firm chooses to employ this labor supply. As in Tirole (1985), it is assumed that supply equals demand in the labor market in each period \( t \), so that \( L_t \) denotes the period \( t \) work force as well as the period \( t \) population of young consumers.

Since capital in the Tirole Economy does not depreciate, the total supply of product available in each period \( t \) is \( Y_t + K_t \). The total demand for product includes capital demand for the following period, \( K_{t+1} \), and aggregate consumption for the current period, \( L_t c_t + L_{t-1} c_{t} \). In per capita terms, supply equals demand in the product market for period \( t \) when

\[
y_t + k_t = [1 + n] k_{t+1} + c_t^1 + c_t^2 / [1 + n] .
\]

Finally, following Tirole (1985), the economy is initialized by assuming that the capital-labor ratio \( k_0 > 0 \) and the per capita bubble asset holdings \( b_0 \geq 0 \) are exogenously given. The capital-labor ratio \( k_0 \) in turn determines the initial interest rate \( r_0 \) and the initial wage

\(^6\)In the standard Arrow-Debreu general equilibrium model with nonsatiated consumers, market clearing conditions typically only require that supply be at least as great as demand in quantity terms. Walras' law then implies that any good in excess supply must have a zero price. However, as detailed in Pingle and Tesfatsion (1994), Walras' law need not hold in overlapping generations models without unsecured debt. Consequently, market clearing conditions have traditionally been stated in a stronger form requiring directly that supply equal demand in each market in real value terms. See, for example, Diamond (1965), Gale (1973), Balasko and Shell (1980), Tirole (1985), and Azariadis (1993, Chapter 13).
rate $w_0$ in accordance with the marginal productivity conditions:

\begin{align}
(10) & \quad r_0 = f'(k_0); \\
(11) & \quad w_0 = f(k_0) - f'(k_0)k_0.
\end{align}

The Tirole Economy can then be reduced to a pair of difference equations in the "state variables" $k_t$ and $b_t$ over times $t \geq 1$,

\begin{align}
(12) & \quad (1 + n)k_t = s(f(k_{t-1}) - f'(k_{t-1})k_{t-1} - f'(k_t)) - b_{t-1}; \\
(13) & \quad b_t = ([1 + f'(k_t)]/[1 + n])b_{t-1};
\end{align}

starting from the exogenously determined initial values $k_0$ and $b_0$.

B. Competitive Equilibrium and Efficiency

As in Tirole (1985), a competitive equilibrium will now be defined for the Tirole Economy in terms of optimality conditions for the consumers and the firm, the capital market clearing condition, and the growth restriction on bubble asset holdings, all in per capita form.\footnote{Given consumer and firm optimization and the capital market clearing condition (6), the bubble asset growth restriction (8) is equivalent to the product market clearing condition (9). To see this, consider the following sequence of implications in both the forward and reverse directions:}

DEFINITION 1 [Tirole Equilibrium]: Given initial values $k_0 > 0$ and $b_0 \geq 0$ for capital and bubble asset holdings, a sequence $(s_t, c_t^1, c_t^2, k_t, b_t, r_t, w_t; t \geq 1)$ of savings levels $s_t$, consumption levels $c_t^1$ and $c_t^2$, positive capital-labor ratios $k_t$, per capita bubble asset levels $b_t$, interest rates $r_t > 0$, and wage rates $w_t > 0$ is a competitive equilibrium $e(k_0, b_0)$ for the per capita Tirole Economy if and only if it satisfies the following four conditions:

\begin{align}
(1 + n)k_{t+1} + c_t^1 + c_t^2/[1 + n] & = y_t + k_t; \\
(1 + n)k_{t+1} + [w_t - s_t] + [1 + r_t]s_{t-1}/[1 + n] & = y_t + k_t; \\
(1 + n)k_{t+1} + [w_t - s_t] + [1 + r_t]s_{t-1}/[1 + n] & = w_t + [1 + r_t]k_t; \\
(1 + n)k_{t+1} - s_t + [1 + r_t]s_{t-1}/[1 + n] & = [1 + r_t]k_t; \\
(1 + n)k_{t+1} - [b_t + [1 + n]k_{t+1}] + [1 + r_t][b_{t-1} + [1 + n]k_t]/[1 + n] & = [1 + r_t]k_t; \\
-b_t + [1 + r_t]b_{t-1}/[1 + n] & = 0.
\end{align}
- [Firm Optimization] Conditions (4) and (5) hold for each \( t \geq 0 \).

- [Consumer Optimization] In each period \( t \geq 1 \), the young consumer's choice vector \( x_t = (s_t, c_t^1, c_{t+1}^1) \) solves the lifetime utility maximization problem (1) conditional on \( w_t \) and \( r_{t+1} \), i.e., \( x_t = x(w_t, r_{t+1}) \); and each old consumer in period 1 consumes \( c_t^1 = [1 + r_1]s_0 \) with \( s_0 = s(f(k_0) - f'(k_0)k_0, r_1) \).

- [Capital Market Clearing] In each period \( t \geq 1 \), condition (6) holds.

- [Bubble Asset Growth Restriction] In each period \( t \geq 1 \), per capita bubble asset holdings grow in accordance with condition (8).

A competitive equilibrium \( (k_0, b_0) \) for the Tirole Economy will be called stationary if \( k_t = k_0 \) and \( b_t = b_0 \) for each period \( t \geq 1 \).

Tirole (1985) assumes that there exists a unique \( \bar{r} \) satisfying \( s(w(\bar{r}), \bar{r}) = [1 + n]k(\bar{r}) \), with \( 0 < \bar{r} < n \). Also, as detailed in Section A of the Appendix, several additional technical regularity conditions are imposed on the savings function \( s(\cdot) \) and the production function \( f(\cdot) \). Given these regularity conditions, the Tirole Economy has two distinct stationary competitive equilibria: a Pareto inefficient equilibrium characterized by the interest rate \( r = \bar{r} \) and zero bubble asset holdings; and a Pareto efficient golden rule equilibrium characterized by the interest rate \( r = n \) and positive bubble asset holdings.

Given the stationary interest rate \( r = \bar{r} \), the optimal consumer and firm choice variables and the wage rate are stationary and are given by \( \bar{x} = x(w(\bar{r}), \bar{r}), \bar{k} = k(\bar{r}) \); and \( \bar{w} = w(\bar{r}) \). It is easily established that the sequence \( \bar{e}(\bar{k}, 0) = (\bar{x}, \bar{k}, 0, \bar{r}, \bar{w} : t \geq 1) \) satisfies the conditions in Definition 1 characterizing a stationary competitive equilibrium. Hereafter this bubbleless stationary competitive equilibrium will be abbreviated by \( \bar{e} \).

The allocation achieved under the bubbleless stationary equilibrium \( \bar{e} \) is not Pareto efficient. Since \( \bar{r} < n \), a suitably small reduction in the equilibrium capital-labor ratio \( \bar{k} \) in any given period \( t' \), offset by a corresponding increase in bubble asset holdings, permits an increased stationary level of net output \( y - nk \) in all periods \( t \geq t' \). This in turn implies that young and old age per-capita consumptions can also be increased in all periods \( t \geq t' \); see condition (9).
Given the stationary interest rate \( r = n \), the optimal consumer and firm choice variables and the wage rate take on the stationary values \( x^n = x(w(n), n), k^n = k(n), \) and \( w^n = w(n) \). Bubble asset holdings are then given by \( b^n = s(w(n), n) - [1 + n]k(n) \). Although the sign of \( b^n \) is not explicitly determined by Tirole (1985), it can be shown that \( b^n \) is positive. It is then easily verified that the sequence \( e^n(k^n, b^n) = (x^n, k^n, b^n, n, w^n : t \geq 1) \) satisfies all of the conditions in Definition 1 characterizing a stationary competitive equilibrium. The allocation generated under \( e(k^n, b^n) \) is the Pareto efficient allocation yielding maximum net output \( y - nk \) in each period \( t \geq 1 \). Hereafter the equilibrium \( e^n(k^n, b^n) \) will be abbreviated by \( e^n \).

Tirole (1985, Prop. 1, p. 1504, and Prop. 2, p. 1507) provides a complete characterization of the stability and efficiency properties of the Tirole Economy under the assumption that \( r < n \). Specifically, given any initial capital-labor ratio \( k_0 > 0 \), he shows that there exists a maximum feasible value \( b(k_0) \) for the initial bubble asset holdings \( b_0 \) such that the following two results are true. First, given the initial conditions \((k_0, b(k_0))\), there exists a unique competitive equilibrium \( e(k_0, b(k_0)) \); this equilibrium is Pareto efficient, and it converges to the Pareto efficient golden rule stationary equilibrium \( e^n \). Second, given the initial conditions \((k_0, b_0)\) for any \( b_0 \) satisfying \( 0 \leq b_0 < b(k_0) \), there exists a unique competitive equilibrium \( e(k_0, b_0) \); this equilibrium is Pareto inefficient, and it converges to the Pareto inefficient bubbleless stationary equilibrium \( \bar{e} \). These properties are schematically depicted in Figure 2, a reproduction of Figure 1 in Tirole (1985, p. 1505).

In general, of course, Pareto inefficiency of a stationary equilibrium does not necessarily imply that any equilibrium converging to this stationary equilibrium must itself be Pareto inefficient. Consider, for example, the Ramsey-Cass-Koopmans one-sector neoclassical optimal growth model with a positive social discount rate and an infinite time horizon (see, e.g., Blanchard and Fischer (1989, Fig. 2.2, p. 46)). To each positive initial capital-labor ratio there corresponds a unique optimal (hence Pareto efficient) growth path; but this optimal growth path converges to a stationary equilibrium that is strictly Pareto-dominated by the golden-rule stationary equilibrium. For the Tirole Economy, however, each equilibrium...

--- Insert Figure 2 About Here ---

--- Since the proof is not entirely straightforward, it is given in Section A of the Appendix. ---
\( e(k_0, b_0) \) with \( 0 \leq b_0 < b(k_0) \) is Pareto inefficient because it is characterized by capital over-accumulation in every period—cf. Tirole (1985, Fig. 1, p. 1505). A suitably small increase in the bubble asset holdings \( b_{t-1} \) offset by a decrease in the capital labor ratio \( k_t \) in any period \( t \) permits an increase in the period \( t \) net output \( y_t - nk_{t+1} \) and hence also in the per capita consumptions for the young and old consumers in all periods \( t' \geq t \).

3. Passive Mediation in the Tirole Economy

The Tirole Economy does not include an explicit intermediating institution. Nevertheless, it is still possible to consider production and intermediation as distinct functions. Production is the transformation of capital and labor inputs into output. Intermediation matches agents who have demands with suppliers who can meet those demands. Here, attention will be focused on the intermediation of demands and supplies for savings, and the term “intermediary” will be used as a short-hand for the implicit agency that mediates savings activities in the Tirole Economy.

The Tirole Economy differs from the economy modelled by Diamond (1965) in one crucial respect: The market clearing condition for capital is relaxed to allow for consumption loans, i.e., intergenerational transfers of goods that permit some agents to consume more than their current endowments. Specifically, as depicted in Figure 1, the Diamond market clearing condition \( S_t = K_{t+1} \) is replaced by the condition \( S_t = B_t + K_{t+1} \). From the viewpoint of period \( t \) young consumers, \( B_t \) represents the portion of their savings held in the form of a bubble asset. From the viewpoint of the intermediary, \( B_t \) represents the portion of his deposits not invested in capital. The intermediary is thus potentially able to use \( B_t \) to enhance the consumption of generation \( t-1 \) old consumers.

More precisely, the incoming receipts of the Tirole intermediary in period \( t \) consist of the savings deposits \( S_t \) received from young consumers and the repayment \( [1 + r_t]K_t \) of principal plus interest received from the firm for capital borrowed in period \( t-1 \). On the other hand, the intermediary is obliged to pay \( [1 + r_t]S_{t-1} \) of principal plus interest to generation \( t-1 \) old consumers and to provide the firm’s demand for capital, \( K_{t+1} \). The net receipts received by the intermediary in period \( t \) are therefore given by

\[
\begin{align*}
\Pi_t &= S_t + [1 + r_t]K_t - [1 + r_t]S_{t-1} - K_{t+1} \\
&= [S_t - K_{t+1}] - [1 + r_t][S_{t-1} - K_t]
\end{align*}
\]
Comparing (14) with the restriction (7) imposed by Tirole on the growth of the bubble asset holdings \( B_t \), the latter restriction appears in a new light. Specifically, restriction (7) forces the intermediary’s net receipts (14) to be zero in every period \( t \geq 1 \). In imposing condition (7), Tirole (1985, p. 1503) correctly notes that physical capital and the bubble asset must earn the same yield in order for both assets to be held in equilibrium. The equality of these yields, however, does not imply that restriction (7) must hold. Rather, restriction (7) holds if and only if an additional special-case restriction is invoked: namely, the bubble asset remains in fixed supply.

To see this, let \( \Theta_{t-1} \) denote the quantity of the bubble asset supplied by the intermediary in period \( t-1 \), and let \( p^\theta_{t-1} \) denote the price of the bubble asset during period \( t-1 \) measured in units of good \( t-1 \). Because the bubble asset is used exclusively to finance consumption loans, it follows that \( B_{t-1} = p^\theta_{t-1} \Theta_{t-1} \). For the bubble asset to be held at the same time capital loans are being made, the bubble asset must earn the same rate of return as capital, meaning that \( p^\theta_t / p^\theta_{t-1} = [1 + r_t] \). Consequently, the following sequence of equalities must hold in the forward and reverse directions:

\[
\Pi_t = B_t - [1 + r_t] B_{t-1} = p^\theta_t \Theta_t - [1 + r_t] p^\theta_{t-1} \Theta_{t-1} = p^\theta_t [\Theta_t - \Theta_{t-1}] .
\]

As condition (15) makes clear, whether or not Tirole’s restriction (7) holds, and hence whether or not the intermediary has nonzero net receipts, depends upon whether or not the supply of the bubble asset is fixed.

As shown in Section 2 (Footnote 7), Tirole’s restriction (7) is equivalent to the restriction that supply exactly equals demand in the product market. Thus, if restriction (7) need not hold, product market clearing in this strong form need not hold either (cf. Footnote 6). In fact, the intermediary’s ability to achieve positive net receipts depends upon his ability to generate an excess supply in the product market. When there is an excess demand in the product market, \( B_t \) is strictly less than \( [1 + r_t] B_{t-1} \) and the intermediary’s net receipts \( \Pi_t \) are negative. This situation cannot arise in competitive equilibrium because the intermediary
is unable to fulfill all contractual obligations. In contrast, when there is an excess supply in the product market, i.e., when $B_t$ is strictly greater than $[1 + r_t]B_{t-1}$, the intermediary’s net receipts are positive. In this case, the intermediary can meet all contractual obligations and then keep the remaining excess supply.

In short, once the assumption of a fixed bubble asset supply is relaxed, it is possible for the intermediary to obtain ownership over a positive quantity of the economy’s resources by increasing the supply of the bubble asset. With this opportunity present, is it reasonable to suppose that the coordination of trade and credit transactions remains the intermediary’s sole objective? If not, the intermediary’s stance toward accumulating net receipts must be clarified in order for the model of the economy to be complete.

The next section sets out a generalization of the Tirole Economy that explicitly includes a corporate intermediary with an objective that goes beyond passive coordination. In particular, the intermediary is not required to keep the bubble asset in fixed supply. The efficiency implications of assuming this more active form of intermediation are explored in Section 5.

4. The Brokered Economy

Consider an extension of the Tirole Economy, hereafter referred to as the “Brokered Economy,” in which all savings activities are explicitly mediated by a single intermediary. Consumers have the opportunity to purchase two assets from the intermediary: namely, bonds; and shares of stock in the intermediary. There are no risk differences between bonds and stock shares, so that consumers base their asset choices only upon expected rate of return.

Each young consumer in generation $t \geq 1$ demands $\lambda_t^d$ bonds and $\theta_t^d$ shares of stock, to be sold in the subsequent period. The period $t$ prices of bonds and stock shares in terms of good $t$ are $p_t^b$ and $p_t^g$, $t \geq 1$, and are taken as given by consumers. The intermediary distributes dividends to its consumer-shareholders in accordance with the following dividend policy: Each share of stock purchased during period $t$ entitles the owner to a per share dividend in period $t + 1$.

Let $d_{t+1}$ denote the per share dividend expected by each young consumer in generation $t \geq 1$. The utility maximization problem of this price-taking young consumer then takes the
form
\[ (16) \quad \max U(c^1_t, c^{2+1}_t) \]
with respect to \((c^1_t, c^{2+1}_t, \lambda^d_t, \theta^d_t)\) subject to the budget and nonnegativity constraints
\[
\begin{align*}
    c^1_t &= w_t - p^1_t \lambda^d_t - p^d_t \theta^d_t ; \\
    c^{2+1}_t &= p^1_{t+1} \lambda^d_t + p^d_{t+1} \theta^d_t + d^{t+1}_t \theta^d_t ; \\
    c^i_t &\geq 0, \quad c^{2+1}_t \geq 0 .
\end{align*}
\]

The utility function appearing in (16) is assumed to be the same as described in Section 2 for the Tirole Economy.

No sign restrictions are placed on \(\lambda^d_t\) or \(\theta^d_t\), implying that short sales are allowed for both bonds and stock shares. Consequently, assuming all prices are positive, no finite solution exists for problem (16) unless bonds and stock shares yield a common positive gross rate of return, i.e., unless
\[ (17) \quad \frac{p^1_{t+1}}{p^1_t} = \frac{[p^d_{t+1} + d^{t+1}_t]/p^d_t}{[1 + r^{t+1}]} \]
for some \(r^{t+1} > -1\).

Given positive prices, together with the viability condition (17), it is straightforward to show that the utility maximization problem (16) faced by each generation \(t\) young consumer in the Brokered Economy can equivalently be expressed in form (1), i.e., in the same form as the utility maximization problem faced by each generation \(t\) young consumer in the Tirole Economy. Consequently, as for the Tirole Economy, an optimal solution exists for the consumer's planned savings level \(s_t = [c^1_t - w_t]\) and consumption levels \((c^1_t, c^{2+1}_t)\) as a function of the wage \(w_t\) and the common rate of return \(r^{t+1}\). Hereafter this optimal solution will be denoted by
\[ (18) \quad (s(w_t, r^{t+1}), c^1(w_t, r^{t+1}), c^{2+1}(w_t, r^{t+1})) . \]

Recalling the definitions for the factor-price frontier functions \(u(r)\) and \(k(r)\) given in Section 2.A, it will be assumed here as for the Tirole Economy that there exists a unique \(\bar{r}\) satisfying \(s(u(\bar{r}), \bar{r}) = [1 + \bar{r}]k(\bar{r})\), with \(\bar{r} < n\). Also, as noted in Section 2.B, Tirole (1985) imposes several additional technical regularity conditions on the savings function \(s(\cdot)\) and the production function \(f(\cdot)\). These regularity conditions are also assumed to hold for the Brokered Economy. A detailed statement of these regularity conditions can be found in Part A of the Appendix.
On the other hand, the individual bond and stock share demands of each Brokered Economy consumer are indeterminate since the consumer is indifferent among all bond and stock share combinations \( (\lambda_t^d, \theta_t^d) \) that yield his optimal planned savings level.

The problem facing the firm in the Brokered Economy is identical to that facing the firm in the Tirole Economy. In each period \( t \geq 1 \), the profit-maximizing firm has the opportunity to rent capital from the intermediary to be used as an input to production along with the labor \( L_t \) supplied inelastically by young consumers. The rental capital \( K_t^d \) which the firm plans to employ during period \( t \) is demanded from the intermediary during period \( t - 1 \). As for the Tirole Economy, it is assumed that the interest rate charged to the firm for the rental of this capital is the same as the interest rate \( r_t \) on savings. Consequently, the firm plans to make a payment \( [1 + r_t]K_t^d \) of principal plus interest to the intermediary in period \( t \).

The intermediary’s net receipts \( \Pi_t \) in period \( t \geq 1 \) are equal to the quantity of good \( t \) remaining in the intermediary’s possession after all of his contractual obligations are fulfilled apart from dividend payments. These net receipts are determined by a consideration of the intermediary’s bond, stock share, and capital transactions.

Let \( \Lambda_t^s \equiv L_t \lambda_t^s \) and \( \Theta_t^s \equiv \Theta_t^s \) denote the total amounts of bonds and stock shares which the intermediary plans to supply to consumers in period \( t \), and let \( K_t^d \) denote the amount of rental capital which the intermediary plans to supply to the firm for use in period \( t \). As a result of bond sales and purchases, the intermediary in period \( t \) plans to receive \( p_t^i \Lambda_t^s \) units of good from generation \( t \) young consumers and to deliver \( p_t^i \Lambda_{t-1}^s \) units of good \( t \) to generation \( t - 1 \) old consumers. Moreover, as a result of stock share sales and purchases, the intermediary in period \( t \) plans to receive \( p_t^e \Theta_t^s \) units of good from generation \( t \) young consumers and to deliver \( p_t^e \Theta_{t-1}^s \) units of good \( t \) to generation \( t - 1 \) old consumers. Finally, as a result of capital rental transactions, the intermediary in period \( t \) plans to receive a principal-plus-interest payment \( [1 + r_t]K_t^d \) from the firm and deliver capital \( K_{t+1}^d \) to the firm to be employed in the subsequent period \( t + 1 \). Consequently, the intermediary’s planned period \( t \) net receipts take the form

\[
\Pi_t = p_t^i [\Lambda_t^s - \Lambda_{t-1}^s] + p_t^e [\Theta_t^s - \Theta_{t-1}^s] - [K_{t+1}^d - (1 + r_t)K_t^d], \quad t \geq 1.
\]

In the Tirole Economy, only one asset—the “bubble asset”—is used to finance consumption loans. In the Brokered Economy there are two assets that the intermediary could use
to finance consumption loans: namely, bonds and stock shares. To achieve a more direct comparison with the Tirole Economy, it is useful to place the following financing restriction on the intermediary which ensures that stock shares in the Brokered Economy correspond to units of bubble asset in the Tirole Economy:

\[ p_{t-1}^\lambda \Lambda_{t-1}^\ast = K_t^\ast \quad \text{and} \quad p_{t-1}^\phi \Theta_{t-1}^\ast = B_{t-1}, \quad t \geq 1. \]

Specifically, restriction (20) guarantees that the intermediary finances his capital loans \( K_t^\ast \) solely by means of bond transactions and his consumption loans \( B_{t-1} \) solely by means of stock share transactions. Letting \( b_t \equiv B_t/L_t \) denote per capita consumption loans, this financing restriction in per capita terms reduces to

\[ p_{t-1}^\lambda \Lambda_{t-1}^\ast = (1 + n)K_t^\ast \quad \text{and} \quad p_{t-1}^\phi \Theta_{t-1}^\ast = b_{t-1}, \quad t \geq 1. \]

Given the viability condition (17) and the financing restriction (20), the intermediary's period \( t \) net receipts (19) can be expressed as

\[ \Pi_t = \frac{\Theta_t^\ast - \Theta_{t-1}^\ast}{\Omega_t^\ast - \Theta_{t-1}^\ast} = B_t - \left[ \frac{p_t^\phi}{p_{t-1}^\phi} \right] B_{t-1} = \frac{d_t \Theta_{t-1}^\ast + B_t - [1 + r_t]B_{t-1}}{\Omega_t^\ast - \Theta_{t-1}^\ast}. \]

By assumption, the intermediary uses these net receipts to fulfill his dividend obligations, \( d_t \Theta_{t-1}^\ast \), where \( d_t \) is the period \( t \) per share dividend expected by generation \( t-1 \) old shareholders.

If the intermediary's dividend obligations exhaust his net receipts, i.e., if \( \Pi_t = d_t \Theta_{t-1}^\ast \), then it follows from (22) that Tirole's bubble asset growth restriction (7) holds for the Brokered Economy. In particular, (7) holds with net receipts and dividend payments both equal to zero if the intermediary issues no new stock shares in period \( t \). Note, however, that (7) is not an ex ante restriction on intermediary behavior. For example, as will be explored in Section 5.B, below, it may be that a competing intermediary is able to successfully enter against an existing intermediary in some period \( t \) by offering a windfall dividend to shareholders in excess of \( d_t \) which the competing intermediary finances by new stock share issue. In this case, \( \Pi_t > d_t \Theta_{t-1}^\ast \) and Tirole's restriction (7) fails to hold.

To close the model, we now impose initial conditions. As for the Tirole Economy, it is assumed that initial values \( k_0 > 0 \) and \( b_0 \geq 0 \) for per capita capital and per capita
consumption loans are exogenously given, and that the initial interest rate \( r_0 \) and wage rate \( w_0 \) are determined by conditions (10) and (11).

Extending Tirole’s initial conditions to recognize financial assets, it is also assumed that each old consumer in the initial period 1 owns a positive number \( \lambda_0 \) of bonds and a nonnegative number \( \theta_0 \) of stock shares, where \( \lambda_0 \) and \( \theta_0 \) are exogenously given. Thus, the aggregate quantities of bonds and stock shares in existence in period 1 are \( \Lambda_0 \equiv L_0 \lambda_0 \) and \( \Theta_0 \equiv L_0 \theta_0 \).

It is assumed throughout the remainder of the paper that \( \Lambda_0 \equiv \Lambda_0 \) and \( \Theta_0 \equiv \Theta_0 \). Moreover, it is assumed that \( \theta_0 = 0 \) if and only if \( b_0 = 0 \), so that a positive initial real bubble \( b_0 \) exists if and only if the price \( p_0^0 \) of the bubbly financial asset (stock shares) is positive.

The expected income of each old consumer in the initial period 1 is determined by the sale value of his bond and stock share holdings as well as by his dividend payment \( d_1 \theta_0 \). Thus, each old consumer in period 1 plans to consume

\[
C^*_1 = p_1^\lambda \lambda_0 + p_1^\theta \theta_0 + d_1 \theta_0.
\]

This planned consumption is assumed to derive from an unmodelled time 0 choice problem, of the form (16).

More precisely, it is assumed that the viability condition (17) holds for \( t = 0 \) for some \( r_1 > 0 \), where the initial prices \( p_0^\lambda \) and \( p_0^\theta \) are taken to be any positive values satisfying the financing restriction (21). In particular, then, \( p_0^\lambda \lambda_0 = [1 + n] k(r_1) \) and \( p_0^\theta \theta_0 = b_0 \). Consequently, the planned consumption of old agents in period 1 can equivalently be expressed in the form

\[
C^*_1 = [1 + r_1] s(w_0, r_1),
\]

where the savings function \( s(\cdot) \) coincides with the savings function determined for each generation \( t \geq 1 \) agent in (18). Moreover, it follows from condition (11) and from the previous discussion that this savings function satisfies

\[
s(f(k_0) - f'(k_0) k_0, r_1) = [1 + n] k(r_1) + b_0.
\]

Given the regularity conditions imposed by Tirole (1985, p. 1502) on the curvature of the savings function \( s(\cdot) \) and the production function \( f(\cdot) \) and assumed also in the present paper (see Section 2 and Appendix A), relation (25) uniquely determines \( r_1 > 0 \) as a function of \( k_0 \) and \( b_0 \).
The Brokered Economy is not yet complete. An objective for the intermediary needs to be specified, along with market clearing conditions. In standard overlapping generations models, these two specifications have traditionally been equated; the intermediary is assumed to be a passive Walrasian Auctioneer concerned only with trade and credit coordination. As will now be clarified, changing the specification of the intermediary from a passive coordinator to an active agent motivated by net receipts has immediate and dramatic implications for the efficient operation of the economy.

5. Modelling the Intermediary: Efficiency Implications

A. The Intermediary as a Passive Coordinator

Suppose the Brokered Economy intermediary passively mediates savings activities in concert with the Walrasian Auctioneer who passively mediates trades in goods and services. That is, the intermediary and the Walrasian Auctioneer together set prices and per share dividends and then stand ready to mediate trades for bonds, stock shares, goods, and services and to channel savings into capital investment and consumption loans. In particular, the intermediary does not engage in new stock share issue. Rather, the sole objective of the intermediary is to coordinate market transactions.

The labor, capital, and product markets for the Brokered Economy, then operate in the same manner as in the Tirole Economy. In particular, labor is supplied inelastically to the firm by young consumers and the firm is assumed to employ this labor. Also, in accordance with the financing restriction (20), the intermediary engages in bond transactions with consumers in order to supply the capital demanded by the firm. Finally, the intermediary distributes all net receipts back to consumer-shareholders as dividends in each period $t$.

Given the viability condition (17), it follows from (22) that the intermediary's per capita net receipts $\pi_t \equiv \Pi_t/L_t$ in each period $t \geq 1$ are given by

\begin{equation}
\pi_t = p_t^e [\theta_t^e - \theta_{t-1}^e/(1+n)]
= b_t - [p_t^e/(1+n)p_{t-1}^e]b_{t-1}
= d_t [\theta_t^e/(1+n)] + b_t - [(1+r_t)/(1+n)]b_{t-1}.
\end{equation}

The stock shares $\Theta_t^e$ supplied by the intermediary in period $t$ are given by the stock shares $\Theta_{t-1}^e$ that generation $t-1$ old agents sell back to the intermediary in period $t$. That is, in
per capita terms,
\[(27) \quad \theta_t^e = \theta_{t-1}^e/(1 + n).\]

Given relation (27), it follows from (26) that the net receipts of the intermediary are zero in each period \( t \geq 1 \).

Given zero net receipts in each period \( t \geq 1 \), the intermediary can feasibly make the per share dividend payments \( d_t \) expected by shareholders if and only if these expected dividend payments are zero. It then follows from (26) with \( d_t = 0 \) that Tirole's state equation (13) must hold. As previously shown in Section 2 (footnote 7), this state equation is equivalent to product market clearing in a strong supply-equal-demand sense.

Finally, given the viability condition (17), the optimization problems faced by consumers and the firm in the Brokered Economy coincide with the optimization problems faced by consumers and the firm in the Tirole Economy once the identification \( s_t \equiv [c_t^l - w_t] \) is made for the Brokered Economy. The specific mix of bonds and stock shares purchased by each consumer in the Brokered Economy is determined by the specific mix of bonds and stock shares supplied to young consumers by the intermediary in accordance with his capital supply objective, subject to the restriction that the portfolio purchased by each consumer must be equal in value to the consumer's optimally chosen savings level. In particular, for each \( t \geq 1 \), the intermediary's stock share supply \( b_{t-1}^s = p_{t-1}^s \theta_{t-1}^d \) must satisfy Tirole's state equation (12). The only difference from the Tirole Economy is that the instruments for achieving the consumers' optimal savings levels are now explicitly identified as bonds and stock shares.

For later reference, the Brokered Economy market clearing conditions for bonds, stock shares, capital, and product are listed below in per capita form:10

\[(28) \quad p_t^s \lambda_t^s = p_t^d \lambda_t^d, \quad t \geq 1;\]

\[(29) \quad p_t^s \theta_t^s = p_t^d \theta_t^d, \quad t \geq 1;\]

10As noted in Section 3, excess supply in the product market could feasibly occur in the Tirole Economy because the intermediary could accumulate positive net receipts (positive amounts of good) which he does not distribute back to consumers. Consequently, the supply-equal-demand equilibrium condition for the Tirole product market is overly restrictive. In the Brokered Economy with passive intermediation, however, it is assumed that all of the intermediary's net receipts are distributed back to consumers in the period in which they are accumulated. Thus, all goods produced in any period \( t \) are acquired by consumers through wages, dividends, and net receipts from stock and bond transactions. The supply-equal-demand condition (31) is therefore an appropriate product market clearing condition for the Brokered Economy with passive intermediation.
In summary, when the market coordination conditions (27) through (31) are imposed on the Brokered Economy, the resulting "Walrasian" Brokered Economy is essentially equivalent to the Tirole Economy. In particular, every Walrasian Brokered Economy satisfies the two Tirole state equations (12) and (13), implying that the same paths are generated for per capita capital \( k_t \) and per capita consumption loans \( b_t \) for the Brokered Economy and the Tirole Economy if the same initial values \( k_0 > 0 \) and \( b_0 > 0 \) are given.

One implication of this equivalence is that the Walrasian Brokered Economy supports the Pareto inefficient outcome \( \mathbf{e} \) as a competitive equilibrium. Another implication is that the intermediary implicitly present in the Tirole Economy is a peculiarly passive agent who does not seek out opportunities to increase the welfare of his consumer-shareholders. In particular, as indicated by (26), the intermediary ignores the possibility that his net receipts—paid out as dividends to his consumer-shareholders—could potentially be increased by issuing additional shares of stock. In contrast, real-world intermediaries generally take advantage of the opportunity to issue additional stock shares up to the point where stock dilution is perceived as having adverse consequences.

It will now be shown that the passive intermediary in period 0 is susceptible to entry in period 1 unless \( b_0 \) happens by chance to be equal to \( b(k_0) \); cf. Figure 2. Specifically, if \( b_0 < b(k_0) \), a competitor can feasibly assume the liabilities of the existing passive intermediary while at the same time offering current shareholders a windfall dividend secured by means of new stock issue.

B. Potential Entry by Active Intermediaries

Suppose the existing intermediary in period 1 is currently subject to government regulations that protect its monopoly position against potential entrants. Some measure of protection against unrestricted entry is certainly necessary, for an entering intermediary with no liabilities can always attract potential shareholders away from an existing intermediary.

\[ k_t^d = k_t^d, \ t \geq 1; \]
\[ y_t + k_t^s = [1 + n]k_{t+1}^d + c_t^1 + c_t^2/[1 + n], \ t \geq 1. \]

Specifically, any equilibrium \((s^1, c^1, c^2, k_t, b_t, r_t, w_t: t \geq 1)\) for a Tirole Economy with initial conditions of the form \( k_0 > 0 \) and \( b_0 > 0 \) is an equilibrium sequence of real outcomes for a Walrasian Brokered Economy with initial conditions of the form \((k_0, \lambda_0) > 0 \) and \((b_0, \beta_0) \geq 0 \), and vice versa, where \( s_t \equiv [c_t^1 - w_t] \) for the Brokered Economy.
who has liabilities resulting from the previous issue of unsecured debt. In addition, suppose
the existing intermediary is subject to a no-profit regulation and hence is currently playing
a purely passive coordination role as described in Section 5.A.

Suddenly government in period 1 decides to open up the intermediation market to permit
entry in any period \( t \geq 1 \) by active profit-seeking intermediaries in accordance with the
following chartering restriction: Entrance is permitted by any competitor who can assume
the liabilities of the existing intermediary and offer a feasible intermediation plan under which
shareholder dividends in the entry period are increased.\(^\text{12}\) In particular, both the existing
intermediary and potential entrants are now permitted to be active intermediaries who can
issue bonds and stock shares (bubble asset) in the pursuit of higher dividends for shareholders
as long as all contractual obligations are met. If he wishes to retain his monopoly position,
the existing intermediary must then seek a feasible intermediation plan that will prevent
entry, and the question arises whether this preventive behavior is socially beneficial. As
will be shown, below, social welfare is unambiguously increased by this preventive behavior
unless the initially given level \( b_0 \) for per capita consumption loans happens by chance to be
just at the "right" level.

The first task is to describe more concretely our modelling of an active intermediary.
Two basic possibilities can be considered: the active intermediary is a price-taker who sets
quantities; or the active intermediary is a price-setter who takes quantities as given.

The first possibility is attractive in that the consumers and the firm are already assumed
to be price-takers. Nevertheless, the original motivation for explicitly introducing the inter-
mediary was to put a corporate business suit on the passive Walrasian Auctioneer in the
Tirole Economy, and this auctioneer is most certainly a price-setter rather than a price-taker.
We thus choose to model the active intermediary as a price-setting agent who posts prices
for bonds and stock shares. Moreover, to restrict attention to the most interesting case in
which bonds and stock shares are both held in equilibrium, we further assume that these

\(^{12}\)Empirical findings suggest that chartering and other government-imposed restrictions currently in force
do restrict entry into U.S. financial markets [Amel and Liang (1992)]. Indeed, as noted by Kaufman (1992,
p. 296), among the requirements typically included for obtaining a commercial bank charter in the U.S. is
a demonstration that the services proposed by the applicant are needed and will not endanger the solvency
of other similar financial institutions. Our assumption that any entering intermediary must assume the
liabilities of the existing intermediary can be interpreted as a buy-out condition that prevents the insolvency
of the existing intermediary.
posted prices are positive.

Specifically, following the decision by government in period 1 to open up the intermediation market, the existing now-active intermediary publicly posts a positive bond price sequence \( p^\lambda = (p^\lambda_1, p^\lambda_2, \ldots) \), a positive stock share price sequence \( p^\theta = (p^\theta_1, p^\theta_2, \ldots) \), and a nonnegative per share dividend sequence \( d = (d_1, d_2, \ldots) \). The collection of sequences \( I = (p^\lambda, p^\theta, d) \) will be referred to as the intermediary's prospectus.

Assuming entry does not occur, consumers and the firm then solve their individual optimization problems conditional on the intermediary's posted prospectus. Although the price and dividend expectations of the consumers and the firm can differ in principle from the planned prices and dividends posted by the intermediary in his prospectus, the definition of an equilibrium for the Brokered Economy presented below will include the requirement that the intermediary fulfills all of his contractual obligations. Without loss of generality, then, we simplify the exposition by assuming from the start that the price and dividend expectations of the consumers and the firm coincide with the planned prices and dividends appearing in the intermediary's prospectus.

Roughly stated, a prospectus \( I \) is "feasible" if it enables the intermediary to fulfill all contractual obligations. An analytical characterization of feasibility for a prospectus \( I \) will now be developed.

First, we assume the intermediary understands that it is not feasible in the Brokered Economy for the per capita consumer share holdings, \( b_t = p^\theta_t \theta_t^i \), to become arbitrarily large over time. This fact, established in Section B of the appendix, follows from the assumption of diminishing marginal returns to capital and is independent of the intermediary's behavior.

Second, the intermediary would presumably recognize or discover that bonds and stock shares must earn a common positive gross rate of return if consumer optimization is to result in finite demands for bonds and stock shares. Moreover, given the financing restriction (21), it follows from the regularity conditions imposed on the production function in Section 2 that the interest rate on bond holding must be positive in each period \( t \). We therefore assume that the intermediary requires his prospectus to satisfy the viability condition (17). In particular, then, the intermediary's prospectus implies that bonds and stock shares earn a common interest rate \( r_{t+1} > 0 \) in each period \( t \geq 1 \).

Third, once the intermediary has posted his prospectus \( I \), he must fulfill certain con-
tractual obligations to young consumers and the firm in each period $t \geq 1$. Specifically, the intermediary must be able to sell bonds and stock shares to period $t$ young consumers at the posted bond and stock share prices $p_t^b$ and $p_t^s$ in order to realize their savings level objectives, and he must be able to supply the capital demanded by the period $t$ firm at the implied interest rate $r_t$. Since bonds and stock shares earn the same interest rate, however, only the overall level of savings matters to consumers. The specific mix of bonds and stock shares demanded by consumers is thus determined by the specific mix of bonds and stock shares supplied by the intermediary. In particular, given the financing restriction (21), the per capita level of consumption loans (stock share holding) is determined by the extent to which the optimal consumer savings level exceeds the firm’s optimal capital demand. Consequently, for each $t \geq 0$, the intermediary’s period $t$ per capita consumption loans $b_t = p_t^s \theta_t^s$ must satisfy\(^{13}\)

\[
(32) \quad b_t = b(r_t, r_{t+1}) \equiv s(w(r_t), r_{t+1}) - [1 + n]k(r_{t+1}) .
\]

Fourth, the intermediary must fulfill his contractual obligations to old consumers in each period $t \geq 1$. Specifically, he must redeem their bond and stock share holdings and make per share dividend payments to them in accordance with the prices and per share dividends posted in his prospectus. The intermediary can ensure redemption of bond and shock share holdings at his posted prospectus prices by ensuring (32) holds for each $t \geq 0$. As will now be shown, however, the intermediary also needs to abide by a further restriction in order to ensure he can fulfill his dividend obligations.

Given the viability condition (17), the financing restriction (21), and relation (32) for consumption loans, it follows from (22) that the per capita net receipts of the intermediary take the form

\[
(33) \quad \pi_t = \frac{d_t \theta_{t-1}^s}{1 + n} + b(r_t, r_{t+1}) - \frac{1 + r_t}{1 + n}k(r_{t+1}, r_t) , \quad t \geq 1 ,
\]

where $d_t$ denotes the per share dividend promised to period $t$ consumer-shareholders in the intermediary’s prospectus. Consequently, in order for the intermediary to be able to make

\(^{13}\)In reality, the intermediary would have to discover the form of the function $b(r_t, r_{t+1})$ in the process of implementing his prospectus. For this initial study, however, we make the simplifying assumption that the intermediary knows this function.
these dividend payments, it must hold that

\begin{equation}
\pi_t \geq \frac{d_t \theta_{t-1}^s}{1+n}, \quad t \geq 1,
\end{equation}

or equivalently, that

\begin{equation}
b(r_t, r_{t+1}) - \frac{1 + r_{t+1}}{1 + n} b(r_{t-1}, r_t) \geq 0, \quad t \geq 1.
\end{equation}

Finally, in total value terms, note that the intermediary can meet all of his obligations to agents in each period \( t \geq 1 \) if and only if the intermediary's per capita net receipts \( \pi_t \) are nonnegative in each period \( t \geq 1 \). Relation (34), together with the assumption that the intermediary posts positive stock share prices and nonnegative dividend payments, show that this nonnegativity holds if \( b_{t-1} = p_{t-1}^q \theta_{t-1}^s \) is nonnegative for each \( t \geq 1 \). The latter condition is ensured by conditions (32) and (35), however, given the assumed nonnegativity of \( b_0 = b(r_0, r_1) \) and the positivity of \( r_x \).

In summary, a collection of sequences \( \mathbf{I} = (p^A, p^S, d) \) will be said to constitute a feasible prospectus for the intermediary if it satisfies the following three conditions: (i) The bond and stock share prices posted in \( \mathbf{I} \) are positive and the dividend payments posted in \( \mathbf{I} \) are nonnegative; (ii) \( \mathbf{I} \) satisfies the viability condition (17) with \( r_{t+1} > 0 \) for each \( t \geq 1 \); and (iii) the per capita consumption loans supplied to consumers by the intermediary, given by (32), are uniformly bounded above and satisfy condition (35).

Given a feasible prospectus \( \mathbf{I} \), it follows from the general structure of the Brokered Economy set out in Section 4 that the only aspect of the prospectus that affects real outcomes in the economy is the associated interest rate sequence \( (r_1, r_2, \ldots) \). Hereafter this interest rate sequence will be referred to as the *intermediation plan* associated with \( \mathbf{I} \), denoted by \( r(\mathbf{I}) \). Conversely, any interest rate sequence \( r = (r_1, r_2, \ldots) \) with \( r_t > 0 \) for all \( t \geq 1 \) that satisfies condition (iii) in the definition of a feasible prospectus will be said to be a feasible intermediation plan for the intermediary; for any such interest rate sequence constitutes an intermediation plan \( r(\mathbf{I}) \) for at least one feasible prospectus \( \mathbf{I} \).\(^{14}\)

\(^{14}\)To see this, first note that no intermediary in period 1 has any leeway in the setting of \( r_1 \) or in the setting of the associated initial prices \( p_0^A \) and \( p_0^S \) if existing contractual obligations are to be fulfilled. Specifically, it follows from condition (iii) in the definition of a feasible prospectus that \( r_1 > 0 \) is uniquely determined as a function of the exogenously given values \( k_0 \) and \( b_0 \) by relation (32) for \( t = 0 \), which then determines \( p_0^A \) and \( p_0^S \) as well (see Section 4). To construct a feasible prospectus that supports the interest rate sequence
Conditions have now been set out that define what it means for the existing intermediary to view an interest rate sequence as a feasible intermediation plan. Still to be specified, however, is the objective of the intermediary that determines how he will choose a particular intermediation plan from this feasible set in order to protect himself against potential entrants able to attract away his prospective shareholders.

It will first be shown that, relative to an existing intermediary with a feasible intermediation plan \( r \), a potential entrant in period \( t \) that assumes the liabilities of the existing intermediary can feasibly increase the dividends paid out in period \( t \) if and only if he can feasibly offer a higher interest rate \( r_{t+1} \).

To see this, suppose that a potential entrant offers an intermediation plan \( r' \) in some period \( t \geq 1 \) as a feasible alternative to an existing intermediation plan \( r \). As explained above, feasibility of an intermediation plan requires the period 1 interest rate \( r_1 \) to satisfy relation (32) for \( t = 0 \). As discussed in Section 4, this requirement determines a unique positive value for \( r_1 \), so potential entrants have no feasible way to change \( r_1 \).

Suppose, then, that \( r'_s = r_s \) for all \( s \leq t \) and \( r'_{t+1} > r_{t+1} \). Given that the potential entrant assumes the liabilities of the existing intermediary, his net receipts in period \( t \) are determined by (33) with \( r'_{t+1} \) in place of \( r_{t+1} \). It follows that the increase in \( r_{t+1} \) will increase period \( t \) net receipts relative to the net receipts of the existing intermediary—and thus provide for the possibility of a windfall per share dividend payment to period \( t \) shareholders in excess of their currently expected per share dividend payment \( d_t \)—if and only if the consumption loan level \( b(r_1, r_{t+1}) \) of each period \( t \) young consumer increases with increases in \( r_{t+1} \); that is, if and only if

\[
\frac{\partial s(w(r_t), r_{t+1})}{\partial r_{t+1}} > [1 + n]k'(r_{t+1}) .
\]

Condition (36) is equivalent to a condition imposed by Tirole (1985, p. 1502) on the slope of the savings supply curve relative to the capital demand curve. As noted in Section 2 and detailed in Section A of the Appendix, condition (36) is one of the regularity conditions assumed to hold throughout the present paper. Consequently, the increase in \( r_{t+1} \) will increase feasible dividend payments in the entry period.

It then suffices to let the dividend payment \( d_t \) be zero for each \( t \geq 1 \) and to set the bond and stock share prices \( p^b_t \) and \( p^s_t \) for \( t \geq 1 \) to positive values that satisfy the viability condition (17) in each period \( t \geq 1 \) for the given interest rate sequence.
Conversely, suppose \( r_s' = r_s \) for all \( s \leq t \) and \( r_{t+1}' < r_{t+1} \). Given (36), it is immediately seen that dividend payments in the entry period must then decrease.

It follows as a corollary to these arguments that a potential entrant in period \( t \) who assumes the liabilities of the existing intermediary can always offer an alternative intermediation plan \( r' \) that is feasible through period \( t \) and that increases period \( t \) dividends: simply let \( r' \) coincide with the existing intermediation plan \( r \) through period \( t \) and satisfy \( r_{t+1}' > r_{t+1} \). The possibility of successful entry against the existing intermediary in period \( t \) thus hinges upon whether or not there exists an intermediation plan of this form that is also feasible for all periods \( s > t \). If so, the existing intermediation plan \( r \) will be said to be susceptible to entry in period \( t \).

An intermediation plan \( r \) will be said to be optimal if: (a) it is feasible; and (b) it is not susceptible to entry in any period \( t \). In principle, the set of optimal intermediation plans can be determined through the use of conditions (32) and (35) once values are given for the exogenous parameters \( k_0 \) and \( b_0 \). Letting \( R(k_0, b_0) \) denote this set of optimal intermediation plans, it is assumed that the existing intermediary in period 1 selects a new intermediation plan from the set of optimal plans in \( R(k_0, b_0) \) after the government in period 1 opens the intermediation market to potential entrants.

A definition of an equilibrium will now be given for the Brokered Economy in per capita form that includes the no-entry objective of the intermediary as well as the objectives of the consumers and the firm.

**DEFINITION 2 [Brokered Economy Equilibrium]:** Let initial values \((k_0, \lambda_0) > 0\) and \((b_0, \theta_0) \geq 0\) for per capita capital, bonds, consumption loans, and stock shares be given, where \( b_0 = 0 \) if and only if \( \theta_0 = 0 \). Then a sequence \((v_t, k_t^d, m_t, w_t : t \geq 1)\) consisting of consumer choice vectors \( v_t = (c_t^1, c_t^2, s_t, \lambda_t, \theta_t) \), firm per capita capital demands \( k_t^d > 0 \), intermediary choice vectors \( m_t = (r_t, p_t^1, p_t^0, d_t, k_t^s, \lambda_t^s, b_t, \theta_t^s) \), and wage rates \( w_t > 0 \) is a Brokered Economy equilibrium \( e(k_0, \lambda_0, b_0, \theta_0) \) if the following five conditions are met:

- **[Firm Optimization]** In each period \( t \geq 0 \), \( r_t = f'(k_t^d) \) and \( w_t = f(k_t^d) - f'(k_t^d)k_t^d \), where \( k_0^d \equiv k_0 \).

- **[Consumer Optimization]** In each period \( t \geq 1 \), the young consumer's choice vector \( x_t = (s_t, c_t^1, c_{t+1}^2) \) solves the lifetime utility maximization problem (1), conditional on
w_t and r_{t+1}, i.e., x_t = x(w_t, r_{t+1}) = (s(w_t, r_{t+1}), c^1(w_t, r_{t+1}), c^2(w_t, r_{t+1})); and each old consumer in period 1 consumes c_1^2 = [1 + r_1] s(w_0, r_1).

- **Financing Restriction** [In each period \( t \geq 1 \), capital loans \( (1 + n)k_t^\star \) are financed solely by means of bond transactions \( p_{t-1}^\lambda \lambda_t^\star \) and consumption loans \( b_{t-1} \) are financed solely by means of stock share transactions \( p_{t-1}^\theta \theta_t^\star \), where \( \lambda_0^\star = \lambda_0, \theta_0^\star = \theta_0 \), and \( p_0^\lambda \) and \( p_0^\theta \) are any positive values satisfying \( (1 + n)k_1^\star = p_0^\lambda \lambda_0 \) and \( b_0 = p_0^\theta \theta_0 \).]

- **Intermediary Optimization** [For each \( t \geq 0 \), the consumption loan level \( b_t = p_t^\lambda \lambda_t^\star \) equals \( s(w_t, r_{t+1}) - (1 + n)k_t^\star \) and the total portfolio value \( p_t^\lambda \lambda_t^\star + p_t^\theta \theta_t^\star \) supplied to each young consumer equals \( s(w_t, r_{t+1}) \), where \( w(r) \) and \( k(r) \) are the factor-price frontier functions derived from \( r = f'(k) \) and \( w = f(k) - f'(k)k \). Moreover, the interest rate sequence \( \mathbf{r} = (r_1, r_2, \ldots) \) is an element of the set \( R(k_0, b_0) \) of optimal intermediation plans, and the collection of sequences \( \mathbf{I} = (p^\lambda, p^\theta, d) \) constitutes a feasible prospectus that supports this optimal intermediation plan.

- **Market Clearing Conditions** [In each period \( t \geq 1 \), the bond, stock share, and capital market clearing conditions (28) through (30) hold; and the product market clears in the sense that excess supply is nonnegative.\(^{15}\)]

A Brokered Economy equilibrium \( e(k_0, \lambda_0, b_0, \theta_0) \) will be called stationary if \( k_t = k_0 \), \( \lambda_t = \lambda_0 \), \( b_t = b_0 \), and \( \theta_t = \theta_0 \) for all \( t \geq 1 \).

An immediate and important implication of this equilibrium definition with active intermediation is that the Pareto inefficient stationary equilibrium \( \bar{e} \) for the Tirole Economy cannot be supported as an equilibrium real outcome for the Brokered Economy because it is susceptible to entry. More generally, as will be shown in Theorem 1, below, the optimizing behavior of the active intermediary rules out any path for the Brokered Economy that converges to \( \bar{e} \) in real terms because all such equilibria are susceptible to entry.

\(^{15}\)These market clearing conditions are actually implied by the previous conditions of the definition and are stated only for clarity. As the intermediary acts to mediate savings into investment, he also acts to ensure the market clearing conditions for bonds, stock shares, and capital. Moreover, nonnegative excess supply in the product market is ensured by condition (35); cf. Section 2 (footnote 7). Positive excess product supply can only occur if the intermediary is able to generate net receipts in excess of his dividend obligations without permitting successful entry by a competitor.
One key observation used in the proof of Theorem 1 is that the active intermediary in the Brokered Economy, able to issue new stock shares, functions as a selection mechanism for picking out which Tirole equilibrium path the Brokered Economy will follow in real terms.

To see this, note that the two basic state equations (12) and (13) characterizing a Tirole Economy equilibrium are also satisfied by any Brokered Economy equilibrium once the intermediary stops issuing new stock shares, in which case all actual dividend payments are zero. More generally, these two state equations hold whenever the per share dividends promised in the intermediary’s prospectus absorb all of his net receipts, whether or not these net receipts are zero and whether or not new stock shares are issued. These claims follow from a consideration of the form (33) for the intermediary’s per capita net receipts.

Another key observation used in the proof of Theorem 1 is that the possibility of successful entry by a competing intermediary through additional stock share issue permits the Brokered Economy to traverse from one Tirole equilibrium path to another if the existing Brokered Economy intermediary is not currently pursuing an optimal intermediation plan.

**Theorem 1:** Given any value \( k > 0 \) for per capita capital, let \( b(k) \geq 0 \) denote the maximum feasible value for per capita consumption loans as determined for the Tirole Economy by Tirole (1985, Prop. 1, p. 1504). Then the following holds. Given \((k_0, b_0)\) such that \(0 < b_0 < b(k_0)\), there exists a unique optimal intermediation plan for the Brokered Economy. Moreover, the interest rates \( r_t \) that constitute this optimal intermediation plan satisfy \( r_t \rightarrow n \) as \( t \rightarrow \infty \).

**Proof.** The proof of Theorem 1 follows directly from simple modifications in the proof of Proposition 1 by Tirole (1985, p. 1504).

Suppose, first, that \( b_0 \) satisfies \( 0 \leq b_0 < b(k_0) \). This initially places the Brokered Economy at a point \((k_0, b_0)\) in the \((k, b)\)-plane that is strictly below the locus of points \((k, b)\) with \( b = b(k) \), hereafter referred to as the Tirole saddle path. One such point is illustrated in Figure 2.

Given \( k_0 \) and \( b_0 \), feasibility requires the existing intermediary, as well as any potential entrant in period 1, to set the period 1 interest rate in accordance with relation (32) for \( t = 0 \). As discussed in Section 4, the latter relation determines a unique positive value \( \hat{r}_1 \)

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16 See Section 2, above.
for \( r_1 \) as a function of \( k_0 \) and \( b_0 \), which in turn determines a unique positive value \( \hat{k}_1 \) for the period 1 level \( k_1 \) of per capita capital through the firm profit maximization condition \( \hat{r}_1 = f' (\hat{k}_1) \).

However, as detailed earlier in this section, a potential entrant in period 1 could deliver a greater dividend to shareholders in period 1 than the existing intermediary by increasing the period 2 interest rate \( r_2 \). Condition (36) ensures that this increase in \( r_2 \) moves the economy vertically upwards from the point \((\hat{k}_1, b_1)\) where the economy would otherwise have been in period 1 if the economy had simply pursued the Tirole equilibrium resulting under passive intermediation, starting from the initial conditions \((k_0, b_0)\).

If the increase in \( r_2 \) results in an increase in the consumption loan level \( b_1 \) that is less than \( b(\hat{k}_1) \)—implying that the economy is below the Tirole saddle path—this places the economy on another feasible Tirole equilibrium path; but further entry in period 1 is still feasible. If the increase in \( r_2 \) results in an increase in \( b_1 \) to the value \( b(\hat{k}_1) \), this places the economy on a feasible Tirole equilibrium path—the Tirole saddle path—for which further entry is not feasible. The reason for this is that, once on the saddle path, any attempt to offer a higher interest rate in some period \( t \) than is currently being offered would move the economy above the Tirole saddle path and hence onto an infeasible path where the consumption loan levels eventually explode. Finally, if the increase in \( r_2 \) results in an increase in \( b_1 \) to a value that lies above \( b(\hat{k}_1) \), implying the economy is above the Tirole saddle path, the economy immediately moves onto an infeasible path where the consumption loan levels eventually explode, implying the entrant’s proposed intermediation plan is not feasible. These arguments directly follow from Proposition 1 in Tirole (1985, p. 1504) and can be intuitively understood by referring to Figure 2.

It follows from these arguments that, to protect against entry in period 1, the optimizing intermediary should set the period 2 interest rate so that the period 1 consumption loan level equals \( b(\hat{k}_1) \). Note by condition (36) that \( b(\hat{r}_1, r_2) \) is a strictly increasing function of \( r_2 \), hence the particular interest rate \( \hat{r}_2 \) that achieves \( b(\hat{k}_1) \) is a uniquely determined value. Moreover, \( \hat{r}_2 \) must be positive; for, by construction, all interest rates that support Tirole equilibria must be positive.

Similar arguments apply for protection against entry in all subsequent periods \( t \geq 2 \). Consequently, to protect against entry in all periods \( t \geq 1 \), the optimizing intermediary
must set the period 1 interest rate to the unique value $\hat{r}_1 > 0$ that satisfies relation (32) for $t = 0$ for the given initial values $k_0$ and $b_0$ and then set the uniquely determined interest rates $\hat{r}_t > 0$ for subsequent periods $t \geq 2$ that ensure the Brokered Economy moves along the Tirole saddle path, i.e., that ensure a consumption loan level equal to $b(k_t)$ for all $t \geq 1$. By construction, the consumption loan levels $b(k_t)$ for $t \geq 1$ lie along a Tirole equilibrium path—namely, the Tirole saddle path—and hence satisfy Tirole's bubble asset growth restriction (8) for all $t \geq 2$. Consequently, relation (35) holds for all $t \geq 2$ as well. Moreover, $b_1$ and $b_0$ lie along a (different) Tirole equilibrium path and hence satisfy (8) for $t = 1$ with $r_1 = \hat{r}_1$. Since $b(k_1) \geq b_1$ by construction, it follows that condition (35) holds for $t = 1$. The uniquely determined positive interest rate sequence $(\hat{r}_1, \hat{r}_2, \hat{r}_3, \ldots)$ thus constitutes a unique optimal intermediation plan in the sense defined earlier in this section.

Finally, as established by Tirole (1985, Prop. 1, p. 1505) and indicated in Figure 2, along the Tirole saddle path the level $\hat{k}_t$ for per capita capital either monotonically increases or monotonically decreases to the golden rule level $k^* = k(n)$, implying that the interest rates $\hat{r}_t$ satisfy $\hat{r}_t \rightarrow n$ as $t \rightarrow \infty$.

If $b_0 = b(k_0)$, it is clear from the above arguments that the optimizing intermediary would again set $r_t = \hat{r}_t$ in all periods $t \geq 2$ to ensure the Brokered Economy moves along the Tirole Saddle path in periods $t \geq 1$. The only change from the previous case is that the value for the period 1 interest rate $r_1$ now supports the per capita consumption loan level $b(k_0)$ on the Tirole saddle path, implying that the Brokered Economy equilibrium path coincides with the Tirole saddle path for all $t \geq 0$. □

The corollary, below, demonstrates that the no-entry objective of the active Brokered Economy intermediary is consistent with the goal of market value maximization. The proof of this corollary follows immediately from the proof of Theorem 1.

**COROLLARY 1:** Given any Brokered Economy equilibrium, the market value $B_t = p_t^2 \Theta_t$ of the active intermediary in each period $t \geq 1$ is positive and takes on its maximum feasible
value $L_t b(k_t)$.

For use in the next theorem, define

\begin{equation}
q_t = \frac{1 + r_t}{1 + n}, \quad t \geq 1,
\end{equation}

and

\begin{equation}
Q_t = [q_t q_{t-1} \cdots q_1] b_0, \quad t \geq 1.
\end{equation}

Also, for each $t$ and $k$ satisfying $t \geq k \geq 1$, define

\begin{equation}
s_{t,k} = [q_t q_{t-1} \cdots q_{k+1} q_k]
\end{equation}

and

\begin{equation}
S_t = \sum_{k=1}^{t} s_{t,k}
\end{equation}

\textbf{THEOREM 2:} If $r$ is a feasible intermediation plan for the Brokered Economy that is not susceptible to entry, then

\begin{equation}
\lim_{t \to +\infty} S_t = +\infty,
\end{equation}

and the sequence $(Q_t)$ is uniformly bounded above. Conversely, if $r$ is a feasible intermediation plan that is susceptible to entry under which stock shares are in fixed supply, then the sequence $(S_t)$ must converge and the sequence $(Q_t)$ must converge to 0.

\textbf{Proof.} As established in the proof for Theorem 1, the unique intermediation plan for the Brokered Economy that is not susceptible to entry is the plan $r$ that follows the Tirole saddle path for $t \geq 1$ with $r_t$ converging monotonically to $n$. Given $r_t \to n$ as $t \to \infty$, however, the tail sum $S_t - S_{t'}$ can be made arbitrarily large by making $t$ sufficiently larger than $t'$ for some sufficiently large $t'$; for in this way the terms $s_{t,k}$ appearing in this tail sum can be made arbitrarily close to 1. Since $S_{t'}$ is positive for all $t'$, it follows that (41) must hold.

Also, if $r$ is an optimal (hence feasible) intermediation plan for the Brokered Economy, it follows by the definition of feasibility that the associated sequence $(b_t)$ of per capita consumption loan levels must be uniformly bounded above and must satisfy $b_t \geq Q_t$ for each $t \geq 1$. The sequence $(Q_t)$ must therefore be uniformly bounded above.
Conversely, suppose that \( r \) is an intermediation plan susceptible to entry under which stock shares are in fixed supply. Any feasible intermediation path for the Brokered Economy that involves a fixed stock share supply must satisfy the two state equations (12) and (13) characterizing Tirole equilibria and hence must move the Brokered Economy in real terms along a Tirole equilibrium path. If \( r \) is susceptible to entry, however, it follows from the proof of Theorem 1 that this Tirole equilibrium path cannot be the Tirole saddle path. As established by Tirole (1985, Prop. 1, p. 1504), all Tirole equilibrium paths apart from the Tirole saddle path are characterized by interest rates that converge to \( \bar{r} \) as \( t \to \infty \), where \( \bar{r} < n \); cf. Figure 2. Consequently, any such Brokered Economy equilibrium must be characterized by interest rates \( r_t \) that ultimately converge to \( \bar{r} \), which implies that \( q_t \) defined as in (37) converges to \( \bar{q} = [1 + \bar{r}] / [1 + n] < 1 \). By construction, the terms \( S_t \) defined in (40) are positive terms that satisfy \( S_t = q_{t-1}[1 + S_{t-1}] \). Given \( q_t \to \bar{q} < 1 \), it follows by backward recursion that \( (S_t) \) is uniformly bounded, hence \( S_t \) must converge to \( \bar{q} / [1 - \bar{q}] \).

Finally, if \( r_t \to \bar{r} \) as \( t \to \infty \), then \( Q_t \to 0 \) as \( t \to \infty \). □

The price condition (41) appearing in Theorem 2 is the Brokered Economy analog of the well-known Cass-Balasko-Shell transversality condition shown by Balasko and Shell (1980, Proposition 5.6; pp. 296-297) to be necessary for Pareto efficiency in a pure exchange overlapping generations context. Balasko and Shell do not provide an economic motivation for their transversality condition. Theorem 2 demonstrates that, for the Brokered Economy, condition (41) constitutes a necessary condition for the intermediary's selected intermediation plan to be optimal. Moreover, in the absence of new stock share issue, it is also sufficient for optimality.

Interestingly, given a Brokered Economy with \( b_0 < b(k_0) \), it is feasible (but not optimal) for an active intermediary to continually traverse across Tirole Economy equilibria with successive new stock share issues so that \( b_t < b(k_t) \) for each \( t \geq 0 \) but \( r_t \to n \) as \( t \to \infty \). Consequently, condition (41) holds despite the fact that the intermediation plan is susceptible to entry in each period \( t \geq 1 \). This is why the qualifier concerning stock share issue is needed.

\[ ^{17} \text{In further analogy to Theorem 2, Balasko and Shell also show the sufficiency of this transversality condition for Pareto efficiency if certain additional restrictions hold.} \]
in the sufficiency direction for Theorem 2.

**THEOREM 3:** There exists at least one stationary equilibrium for the Brokered Economy. Every stationary equilibrium generates the same real outcome \((s, c^1, c^2, k, b, r, w)\), where \(s \equiv [c^1 - w]; \) namely, the Pareto efficient real outcome \(e^n = e(k^n, b^n)\) constituting the golden rule equilibrium for the Tirole Economy. In particular, the unique stationary equilibrium interest rate \(r\) for the Brokered Economy is given by \(r = n\).

**Proof.** Theorem 1 implies that the unique optimal stationary intermediation plan \(r\) for the Brokered Economy is given by \(r_t = n\) for all \(t \geq 1\). Consequently, the corresponding stationary equilibrium values for per capita capital and per capita consumption loans are given by the Tirole golden rule solution values \((k^n, b^n)\), where \(f'(k^n) = n\) and \(b^n = b(k^n)\); see Section 2. The remaining assertions of Theorem 3 are then easily verified. 

Theorem 3 demonstrates that the Pareto efficient golden rule equilibrium for the Tirole Economy is the unique real outcome possible for the Brokered Economy in any stationary equilibrium. In particular, the Pareto inefficient stationary equilibrium \(e\) for the Tirole Economy is not supported as a stationary equilibrium real outcome for the Brokered Economy. As noted in Section 2.B, all Pareto inefficient equilibria for the Tirole Economy converge to \(e\); hence one might surmise that the elimination of this Pareto inefficient outcome would lead to the restoration of a first welfare theorem. The next theorem establishes that this is indeed the case.

**THEOREM 4:** All Brokered Economy equilibria are Pareto efficient.

**Proof.** As established by Tirole (1985, Prop. 1, p. 1504), the set of equilibria for the Tirole Economy can be partitioned into two subsets: the Pareto efficient equilibria characterized by interest rates that converge to \(n\); and the Pareto inefficient equilibria characterized by interest rates that converge to \(\tilde{r} < n\). As shown in the proof of Theorem 1, above, the unique optimal intermediation plan for the Brokered Economy is characterized by interest rates converging to \(n\), and the equilibrium paths for \(k_t\) and \(b_t\) that are supported by this intermediation plan coincide for all \(t \geq 1\) with the Pareto efficient Tirole Economy equilibrium given by the Tirole saddle path. Moreover, given \(k_0\) and \(b_0\), there is no way to achieve a
Pareto improvement of these $k_t$ and $b_t$-paths without violating the feasibility condition (32) at $t = 0$. □

To summarize, the key result of this section is that the inefficiency observed in the Tirole Economy is completely eliminated when intermediation is modelled as a contestable activity carried out by a corporate intermediary owned by consumer-shareholders and operated in their interest. Assuming $b_0 < b(k_0)$, this elimination requires the active intermediary to issue new stock shares in period 1, which results in an increase in his net receipts in excess of his current contractual obligations. These excess net receipts constitute a windfall dividend payment for the intermediary's current shareholders, the initial generation 0 old consumers. Interestingly, this windfall can be generated without permitting successful entry by competitors.

These findings caution that the inefficiency observed in standard modelings of overlapping generations economies with production and unsecured debt may not be the reflection of an intrinsic market failure. Rather, the observed inefficiency could instead be due to a fundamental incompleteness in the model specification—the presumed inability of private agents to exploit the earnings opportunities associated with incurring and forever rolling over debt.
REFERENCES


APPENDIX

A. Proof that $b^n > 0$

Tirole (1985, equ.(8), p. 1502) assumes that the equation $0 = z(r)$ has a unique solution $\bar{r}$, where

$$z(r) \equiv \left[ L_{t-1} s(w(r), r) - L_t k(r) \right] / L_t = s(w(r), r) / [1 + n] - k(r)$$

denotes the excess supply of savings per young consumer when each optimizing consumer and producer is faced with the interest rate $r$. In addition, much of Tirole's analysis focuses on the case in which inefficiency is possible, which requires $\bar{r} < n$. As noted in Section 2.B, these regularity conditions are also assumed to hold in the present paper.

It will first be shown that, under these assumptions, the excess supply of savings $z(r)$ is an increasing function of $r$ at $r = \bar{r}$; i.e., $0 < z'(\bar{r})$. Using this result, it will then be shown that

$$0 < z(r) \text{ for all } r \text{ satisfying } \bar{r} < r.$$

Hence, in particular, $0 < z(n) = b^n / [1 + n]$.

Given the stationary interest rate $\bar{r}$, producer optimization in the Tirole Economy implies that the capital-labor ratio $k$ and the wage rate $w$ satisfy $\bar{r} = f'(k)$ and $w = f(k) - f'(k)k$. Consequently, it follows from Section 2.A that $k = k(\bar{r})$ and $w = w(\bar{r})$ with

$$k'(\bar{r}) = 1 / f''(k(\bar{r})) ;$$
$$w'(\bar{r}) = -k(\bar{r}) \cdot f''(k(\bar{r})) ; k' = -k(\bar{r}).$$

Using conditions (44) and (45), one obtains

$$z'(\bar{r}) = \left[ s_w(w(\bar{r}), \bar{r}) w'(\bar{r}) + s_r(w(\bar{r}), \bar{r}) \right] / [1 + n] - k'(\bar{r})$$
$$= \left[ s_r(w(\bar{r}), \bar{r}) - s_w(w(\bar{r}), \bar{r}) k(\bar{r}) f''(k(\bar{r})) k'(\bar{r}) \right] / [1 + n] - k'(\bar{r})$$
$$= \left[ s_r(w(\bar{r}), \bar{r}) - s_w(w(\bar{r}), \bar{r}) k(\bar{r}) \right] / [1 + n] - k'(\bar{r}).$$

Diamond (1965, eq.(11), p. 1133) places a condition on the relative slopes of the capital market supply and demand curves along any competitive equilibrium path. In particular, for the unique stationary competitive equilibrium $\vec{e} = e(k(\bar{r}), 0)$ associated with $\bar{r}$, this condition reduces to

$$f''(k(\bar{r})) s_w(w(\bar{r}), \bar{r}) / [1 + n] - f''(k(\bar{r})) s_r(w(\bar{r}), \bar{r}) > 0.$$

Moreover, to guarantee that consumption is a normal good in each period of life for each agent, Diamond (1965, fn. 6, pp. 1131-2) assumes that $0 < s_w < 1$. The numerator in condition (47) is therefore negative. Thus, in order for condition (47) to hold, the denominator must be positive; i.e.,

$$1 + n - f''(k(\bar{r})) s_r(w(\bar{r}), \bar{r}) > 0.$$
Diamond (1965, equ.(12), p. 1134) also assumes that \( \bar{e} \) is locally stable, and he gives a condition that is necessary for this to be the case; namely,

\[
(49) \quad \left| \frac{-k(\bar{r})f''(k(\bar{r}))s_w(w(\bar{r}), \bar{r})}{[1 + n - f''(k(\bar{r}))s_r(w(\bar{r}), \bar{r})]} \right| \leq 1.
\]

These same conditions are imposed by Tirole (1985, p. 1502) and are assumed to hold in the present paper as well.

A sufficient condition for the local stability of \( \bar{e} \) is that condition (49) holds with strict inequality. This slightly stronger condition is assumed by Tirole (1985, p. 1502) and is also assumed to hold in the present paper. Using conditions (44), (46), (48), and (49) with strict inequality, one then obtains the following series of implications:

\[
-k(\bar{r})f''(k(\bar{r}))s_w(w(\bar{r}), \bar{r}) < [1 + n - f''(k(\bar{r}))s_r(w(\bar{r}), \bar{r})];
\]

\[
0 < k(\bar{r})f''(k(\bar{r}))s_w(w(\bar{r}), \bar{r}) + 1 + n - f''(k(\bar{r}))s_r(w(\bar{r}), \bar{r})];
\]

\[
0 < [-k'(\bar{r})f''(k(\bar{r}))s_w(w(\bar{r}), \bar{r}) - k'(\bar{r})[1 + n] + k'(\bar{r})f''(k(\bar{r}))s_r(w(\bar{r}), \bar{r})];
\]

\[
0 < [s_r(w(\bar{r}), \bar{r}) - s_w(w(\bar{r}), \bar{r})k(\bar{r})]/[1 + n] - k'(\bar{r});
\]

As previously noted, \( \bar{r} \) satisfies \( 0 = z(\bar{r}) \). It follows from (50) that, for some positive \( \epsilon \), \( 0 < z(\bar{r}) \) for all \( r \) in the interval \( (\bar{r}, \bar{r} + \epsilon) \). Suppose that \( z(r^*) \leq 0 \) for some \( r^* \) satisfying \( \bar{r} + \epsilon < r^* \). By continuity of \( z(\cdot) \), this would imply the existence of some \( r^0 \) lying between \( \bar{r} + \epsilon \) and \( r^* \) which satisfies \( 0 = z(r^0) \), a contradiction of the assumption that there exists a unique solution to the equation \( 0 = z(r) \).

It follows that condition (43) must hold for the Tirole Economy.

B. Proof that \( b_t \) Cannot Diverge in Any Brokered Economy Equilibrium

Along any equilibrium path for the Brokered Economy, the per capita consumption loan levels \( b_t \) supplied by the intermediary are given by relation (32), implying that \( b_t = [s_t - (1 + n)k_{t+1}] \) for each \( t \geq 0 \). In addition, they must satisfy condition (35) in order to guarantee that dividend obligations can be met. Suppose the sequence \( (b_t) \) diverges to infinity. Since the historically given value \( b_0 \) is nonnegative by assumption, and all equilibrium interest rates are positive, it follows from (35) that the sequence \( (b_t) \) is nonnegative. Consequently, \( b_t \) must become infinitely large as \( t \) approaches infinity.

The equilibrium savings \( s_t \) of each generation \( t \) young consumer must be nonnegative and less than his endowment \( w_t \) in order for the consumer to consume a nonnegative amount of good when young and when old. Since all equilibrium interest rates are positive, the producer optimization condition (4) implies that the equilibrium capital-labor ratios \( k_t \) must also be positive. Consequently, it follows from (32) that \( b_t \) can only become infinitely large if \( s_t \) and thus \( w_t \) both become infinitely large.
Using these observations, together with the producer optimization condition (5), it must hold for each \( t \geq 1 \) that

\[
0 \leq \frac{b_t}{k_t} \leq \frac{s_t}{k_t} \leq \frac{w_t}{k_t} = f(k_t)/k_t - f'(k_t) < f(k_t)/k_t .
\]

By conditions (4) and (5), and the production function restrictions given in Section 2 (footnote 5), for \( w_t \) to become infinitely large as \( t \) approaches infinity, the interest rate \( r_t \) must approach zero and the capital-labor ratio \( k_t \) must become infinitely large as \( t \) approaches infinity. Consequently, by strict concavity of the production function \( f(\cdot) \), and the assumption that \( f'(k) \) approaches zero as \( k \) approaches infinity, the average product of capital \( f(k_t)/k_t \) must approach zero as \( t \) approaches infinity, implying from relation (51) that the ratio \( s_t/k_t \) also approaches zero as \( t \) approaches infinity.

Finally, it follows from (32) and previous observations that

\[
s_{t-1}/k_{t-1} - [1 + n]k_t/k_{t-1} = b_{t-1}/k_{t-1} \geq 0
\]

for each \( t \geq 1 \). Since \( s_{t-1}/k_{t-1} \) approaches zero as \( t \) approaches infinity, the (positive) term \( [1 + n]k_t/k_{t-1} \) must also approach zero as \( t \) approaches infinity in order to have the right term remain nonnegative for all \( t \). Consequently, \( k_t < k_{t-1} \) for all sufficiently large \( t \). But this contradicts the fact, established above, that \( k_t \) becomes infinitely large as \( t \) approaches infinity.

It follows that no equilibrium consumption loan sequence \( (b_t) \) for the Brokered Economy can diverge to infinity. \( \Box \)
Figure 1: The Tirole Economy
Figure 2: Phase Diagram for the Tirole Economy