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Banks, financial markets, and social welfare

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Abstract

This paper constructs a general equilibrium model of banking and financial markets. The model allows to compare financial systems in which banks have access to financial markets with financial systems in which banks do not have access to financial markets. Allen and Gale [A welfare comparison of intermediaries and financial markets in Germany and the US. European Economic Review 39 (1995) 179–209] find that the Anglo-Saxon model of financial intermediation in which financial markets play a dominant role does not necessarily improve social welfare in comparison with the German model in which banks dominate. Our model provides a theoretical foundation for this view.

JEL classification: G10
Keywords: Comparative financial systems; Banks; Financial markets; Welfare analysis

1. Introduction

Financial systems perform several functions. One of the primary purposes of financial systems is to channel funds from agents with positive saving to agents with negative saving. They process information to allocate resources efficiently. They allow intertemporal smoothing of consumption by households. Also, one of the most

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important functions of financial systems is to allow agents to share risks. Allen and Gale (1995, 2000) distinguish between cross-sectional risk sharing and intertemporal risk sharing. Cross-sectional risk sharing pertains to situations in which agents exchange risks at a given point in time. Intertemporal risk sharing pertains to situations where risks are averaged over time. In this paper we focus on cross-sectional risk sharing. Basically, we extend Marini (2003) by introducing financial markets. We compare five financial systems:

1. A mutual bank which makes a nil profit.
2. A mutual bank with a complete set of financial markets for hedging the aggregate risk.
3. A capitalized bank which makes a nil expected profit.
4. A capitalized bank which makes a positive expected profit.
5. A mutual bank which makes a positive expected profit, with a complete set of financial markets for hedging the aggregate risk.

In financial systems 1, 2 and 3, there is free entry in banking, while in financial systems 4 and 5, entry in banking is regulated. This paper studies how these five financial systems share risks.

Also, the paper analyzes the effect of financial liberalization on the banks vulnerability to insolvency. Financial liberalization can mean many things such as decreasing reserve requirements, increasing competition in the banking sector, abolishing interest rate ceilings on bank deposits, liberalizing capital markets, etc. In this paper, we focus on changes in the degree of competition in the banking sector. We study how deregulation can affect social welfare and the banks vulnerability to insolvency.

The paper assumes that the economy is populated by risk-averse agents who are subject to idiosyncratic liquidity shocks, and one representative risk-neutral agent who is not subject to liquidity shocks. Since the risk-neutral agent has an endowment of capital, we call him the capitalist. There is also an aggregate risk which takes the form of shocks to the returns on a long asset. The information on liquidity shocks is private, while the information on aggregate shocks is public. As a result, the liquidity risk cannot be shared with Arrow–Debreu securities. But a bank can optimally share this risk. Also, Arrow–Debreu securities can share the aggregate risk.

The literature on comparative financial systems addresses important questions. Among them: are some systems more vulnerable to crises than others? Should countries move towards a more market-based system? These questions have important policy implications. Our model allows to address these questions. It provides the following results:

1. Comparing financial systems 2 and 3 on the one hand, and 4 and 5 on the other hand, shows that a complete set of financial markets for hedging the aggregate risk does not improve social welfare in comparison with a capitalized bank.
2. Financial markets do not reduce the bank vulnerability to insolvency.

3. When the capitalist's stock of capital is greater than a threshold value, financial liberalization does not lead to bank insolvency. However, when the stock of capital is less than this threshold value, financial liberalization makes the bank vulnerable to insolvency.

The model contributes to the debate about the optimal organization of financial systems. Financial theorists often suggest that markets are the best way to achieve an efficient allocation of risks. As a result, countries should move towards a more market-based financial system. Melitz (1990) shows that financial liberalization in France between 1984 and 1986 was inspired by this theory. In contrast with this view, our model shows that financial markets do not improve risk sharing in comparison with a capitalized bank.

Allen and Gale (1995) offer a welfare comparison of financial systems in Germany and the United States. They find that the Anglo-Saxon model of financial intermediation in which financial markets play a dominant role does not necessarily dominate the German model in which banks dominate. Our model provides a theoretical foundation for this view.

A related approach is found in Gale (2003), Allen and Gale (2003), and Gale (forthcoming). In comparison with our model, they offer a model of the risk sharing function of capital which provides a more advanced analysis of capital adequacy requirements. However, a difference with our model is that they do not analyze the effects of financial liberalization.

The rest of the paper is organized as follows. Section 2 describes the basic economy. Section 3 defines the five financial systems considered in the model. Section 4 derives the equilibria in financial systems 1, 2 and 3. Section 5 derives the equilibria in financial systems 4 and 5. Section 6 compares these five financial systems. Section 7 provides a numerical example which illustrates the model. Section 8 concludes.

2. The basic economy

There are three periods $T = 0, 1, 2$. The good is used for consumption and investment. There are $N + 1$ agents. One agent is risk-neutral and N agents are risk-averse.

Risk-averse agents are subject to idiosyncratic preference shocks. Their preferences are given by:

$$u(c_T) = \begin{cases} u(c_1) & \text{with probability } t, \\ u(c_2) & \text{with probability } 1 - t, \end{cases} \tag{1}$$

where $u(\cdot)$ is a von Neumann–Morgenstern utility function and c_T denotes consumption at period T. The utility function $u(\cdot)$ is twice continuously differentiable, increasing, strictly concave, and satisfies Inada conditions $u'(0) = \infty$ and $u'(\infty) = 0$. We assume that $u(c_T) = c_T^{1-\alpha}/(1 - \alpha)$ with $\alpha > 1$, where α is the relative risk-aversion coefficient.

A risk-averse agent who wants to consume at $T = 1$ is subject to a liquidity shock and is designated a type 1 agent, while a risk-averse agent who wants to consume at $T = 2$ is not subjected to a liquidity shock and is designated a type 2 agent. At $T = 0$, risk-averse agents do not know their type. Each agent learns his type at $T = 1$, and this information is private. We also assume that there is no uncertainty on the proportion of type 1 agents in the population: at $T = 0$, it is common knowledge that tN risk-averse agents will be early consumers, and $(1 - t)N$ risk-averse agents will be late consumers.

The risk-neutral agent is not subject to liquidity shocks: at $T = 0$, he knows that he will want to consume only at $T = 2$. So he maximizes his expected consumption at $T = 2$.

Each agent has an endowment of the good at $T = 0$ and none at $T = 1$ and $T = 2$. Each risk-averse agent is endowed with one unit of the good, and the risk-neutral agent is endowed with NK units of the good. In other words, he is endowed with K units of the good per risk-averse agent.

The risk-neutral agent is called the capitalist.The capitalist can be thought of as a representative agent: it is equivalent to assume that there are N capitalists, each endowed with K units of capital, or one capitalist endowed with NK units of capital.

Since agents have an endowment at $T = 0$ and want to consume at $T = 1$ or at $T = 2$, they have to transfer the good from $T = 0$ to $T = 1$ and $T = 2$. They can do this by investing in assets.

There are two assets: a short asset and a long asset. The short asset is a storage technology: one unit invested at T yields one unit at $T + 1$. The long asset yields a return after two periods. One unit invested at $T = 0$ yields a nil return at $T = 1$, and a random return $R(s)$ at $T = 2$, where $s \in S$ is a state of nature which is realized at $T = 2$. So the investment in the long asset is completely irreversible because it cannot be liquidated at $T = 1$.

We assume that there are only two possible states of nature at $T = 2$ denoted H and L, with $R(H) > R(L)$. At $T = 0$, all agents have a common prior probability density $P(s)$ over the states of nature H and L. The uncertainty about the realization of s is resolved at the beginning of period $T = 2$. We also assume that $E(\widetilde{R}) = P(H)R(H) + P(L)R(L) > 1$, i.e., the expected long term return is greater than the short term return.

The economy is subject to two kinds of uncertainty. First, risk-averse agents are subject to idiosyncratic liquidity shocks at $T = 1$. Second, the entire economy is subject to aggregate shocks on the return on the long asset at $T = 2$.

In autarky, each risk-averse agent solves

$$\text{Max} \quad tu(c_1^1) + (1 - t)P(H)u(c_2^2(H)) + (1 - t)P(L)u(c_2^2(L)) \tag{2}$$

$$\text{s.t.} \quad c_1^1 = y, \tag{3}$$

$$c_2^2(H) = R(H)(1 - y) + y, \tag{4}$$

$$c_2^2(L) = R(L)(1 - y) + y, \tag{5}$$

where c_1^1 is the consumption of a type 1 agent at $T=1$, $c_2^2(H)$ is the consumption of a type 2 agent at $T=2$ when $\widetilde{R}=R(H)$, $c_2^2(L)$ is the consumption of a type 2 agent at $T=2$ when $\widetilde{R}=R(L)$, and y is the proportion of the endowment invested in the short asset.

Eq. (2) is the expected utility function, Eq. (3) is the budget constraint at $T=1$, and Eqs. (4) and (5) are the budget constraints at $T=2$ when $\widetilde{R}=R(H)$ and $\widetilde{R}=R(L)$ respectively.

In autarky, consumptions are given by:

$$tu'(c_1^1)=(1-t)P(H)(R(H)-1)u'(c_2^2(H))+(1-t)P(L)(R(L)-1)u'(c_2^2(L)). \qquad (6)$$

Also, the capitalist is someone with capital to invest who does not have to worry about short-term liquidity. Therefore, in autarky, he invests all his endowments in the long asset and expects the utility $E(\widetilde{R})NK$.

3. Financial systems

3.1. Financial markets

In our model, since the economy is populated by N risk-averse agents and one capitalist who is risk-neutral, a financial system increases social welfare in comparison with autarky by allowing risk sharing. Optimal risk sharing requires that the capitalist bears all the aggregate risk at $T=2$. Since the realization of the return on the long asset at $T=2$ is public information, a complete set of Arrow–Debreu securities contingent on the states of nature H and L can optimally share the aggregate risk at $T=0$. A complete set of Arrow–Debreu securities markets for hedging the aggregate risk is defined as follows. For the state of nature H, there is a security traded at $T=0$ that promises one unit of the good at $T=2$ if state H is observed, and nothing if state L is observed. Let $p_2(H)$ be the price of one unit of the Arrow–Debreu security contingent on state H. This price is the number of units of the good which is needed at $T=0$ to buy the promise that one unit of the good will be delivered at $T=2$ if, and only if, the state of nature is H. Also, there is a security traded at $T=0$ that promises one unit of the good at $T=2$ if state L is observed. The price of this security is denoted $p_2(L)$.

The paper assumes that while the capitalist can trade directly on securities markets, risk-averse agents do not have access to financial markets. They can only invest in banks, and banks have access to financial markets. So risk-averse agents have an indirect access to financial markets through banks. This is the assumption of limited market participation made by Diamond (1997) and Allen and Gale (2004).

Diamond (1997) argues that there are several motivations for this limited participation. For some investors, the cost of time in the financial market may be too high, so that they will not participate in the market. Limited participation could also be motivated by information asymmetry: some investors can easily evaluate some financial assets, while other investors cannot. However, following Diamond (1997) and Allen and Gale (2004), no formal analysis of differential opportunity costs of time, or information acquisition costs, is presented. Limited market participation is simply assumed.

3.2. Banks

Risk-averse agents would value an opportunity to insure themselves at $T=0$ against the risk of turning out to be type 1. However, since the information on agents' type is asymmetric, Arrow–Debreu securities contingent on agents' types cannot exist at $T=0$. However, a bank can optimally share the risk of turning out to be type 1.

A bank is a financial institution which invests in the short and long assets on behalf of depositors and provides them with consumption at $T=1$ and $T=2$. Each investor gives his endowment to the bank at $T=0$. In exchange, he gets a demand deposit contract which gives him the right to withdraw from the bank r_1 units of the good at $T=1$, or r_2 units at $T=2$. In other words, a demand deposit is a contract that requires a bank to make a non-contingent payment to depositors on demand, or else declare bankruptcy. A bank is restricted in its contracting technology. It is restricted to issue demand deposit contracts which are incomplete contracts because they promise fixed returns at $T=1$ and at $T=2$, i.e., returns that are not contingent on the state of nature.

A bank can provide insurance against liquidity shocks by pooling large numbers of investors who have uncertain liquidity needs. This is because it can take advantage of the law of large numbers to share the higher expected return from long term investments with investors who have to liquidate their claims early.

Following Marini (2003), the paper distinguishes between two types of banks: a mutual bank and a capitalized bank. A mutual bank issues a demand deposit contract only. This mutual bank is a coalition of the N risk-averse agents. By pooling the risk-averse agents' investments, this bank can provide insurance against the liquidity shock which cannot be provided by financial markets. Each risk-averse agent deposits his endowment in the bank, and the bank invests it in a portfolio $(x_B; y_B)$ consisting of x_B units of the long asset and y_B units of the short asset, with $x_B + y_B = 1$. In a mutual bank, there is no capital buffer to absorb any losses.

A capitalized bank issues demand deposit contracts and equity. This bank is a coalition of the N risk-averse agents with the capitalist. Marini (2003) shows that a capitalized bank is a mutually beneficial arrangement between the N risk-averse agents (the depositors) and the capitalist (the banker). The banker promises a fixed return $\bar{r}_2$ at $T=2$ to depositors. If the banking system is not perfectly competitive, i.e., if there is no free entry in banking, the banker has a pricing power on the interest rate on deposits. He can set $\bar{r}_2$ such that it is smaller than the expected return of the deposit contract issued by a mutual bank, and yet increases the expected utility of type 2 depositors. This is because depositors are risk-averse. Since $\bar{r}_2$ is smaller than the expected return of the deposit contract issued by a mutual bank, the deposit contract issued by a capitalized bank allows the banker to increase his expected consumption in comparison with autarky. In other words, it allows him to make a positive expected profit. The banker can provide complete insurance against the aggregate risk if his capital is high enough. So when the state of nature is L at $T = 2$, the banker must cover with his capital the difference between his promises to depositors and the bank's assets. Complete insurance against the technological shock means that the bank cannot be insolvent at $T = 2$ if there is no panic at $T = 1$.

This paper compares five financial systems. A financial system which consists of a mutual bank only which makes a nil profit because the banking system is perfectly competitive. This financial system is called financial system 1 and denoted FS 1. A financial system which is made up of a mutual bank which makes a nil profit, and a complete set of financial markets for hedging the aggregate risk. This financial system is denoted FS 2. A financial system made up of a capitalized bank only which makes a nil profit because there is free entry in banking. This financial system is denoted FS 3. A financial system made up of a capitalized bank only which makes a positive expected profit because there is no free entry in banking. This financial system is denoted FS 4. And a financial system denoted FS 5, which is made up of a mutual bank which makes a positive expected profit and complete financial markets.

In FS 1, FS 2 and FS 3, the banking sector is perfectly competitive, i.e., the bank makes a nil profit because there is free entry in banking. In FS 4 and FS 5, the bank makes a positive expected profit because the banking sector is not perfectly competitive, i.e., there is no free entry in banking.

4. A perfectly competitive banking system

4.1. A mutual bank without financial markets (FS 1)

In this section, the bank is treated as a coalition of individual agents bent on maximizing their joint welfare. As a result, the bank earns no profits and maximizes the expected utility of the representative depositor. An interpretation is that there is free entry into the banking sector. Therefore, competition among the banks forces them to maximize the ex ante expected utility of the typical depositor.

Formally, the bank maximizes the expected utility of its typical depositor subject to its two budget constraints (one for each state of nature at $T = 2$) and an incentive-compatibility constraint that guarantees that at $T = 1$, a type 2 agent has no interest in lying, i.e., claiming to be a type 1 agent:

$$\text{Max} \quad t\frac{(c_1^1)^{1-\alpha}}{1-\alpha} + (1-t)P(H)\frac{(c_2^2(H))^{1-\alpha}}{1-\alpha} + (1-t)P(L)\frac{(c_2^2(L))^{1-\alpha}}{1-\alpha} \tag{7}$$

$$\text{s.t.} \quad tc_1^1 + \frac{(1-t)c_2^2(L)}{R(L)} = 1, \tag{8}$$

$$tc_1^1 + \frac{(1-t)c_2^2(H)}{R(H)} = 1, \tag{9}$$

$$P(L)\frac{(c_2^2(L))^{1-\alpha}}{1-\alpha} + P(H)\frac{(c_2^2(H))^{1-\alpha}}{1-\alpha} \geqslant \frac{(c_1^1)^{1-\alpha}}{1-\alpha}. \tag{10}$$

The optimal demand deposit contract is the solution of the constrained maximization problem defined by Eqs. (7)–(10), and is given by ($r_1 = c_1^1$; $r_{2L} = c_2^2(L)$; $r_{2H} = c_2^2(H)$). Eq. (7) is the expected utility of depositors. Eqs. (8) and (9) are the budget constraints which are similar to the budget constraint in the Diamond and Dybvig (1983) model. The only difference is that there are two budget constraints because there are two states of nature at $T = 2$. Eq. (10) is the incentive-compatibility constraint in which the left-hand side is the expected utility of a type 2 agent and the right-hand side is the utility of a type 1 agent. The incentive-compatibility constraint guarantees that a type 2 agent will not withdraw at $T = 1$.

The optimal demand deposit contract is derived from the Kuhn–Tucker conditions. When the incentive-compatibility constraint is not binding, the returns of the deposit contract are given by:

$$r_1 = c_1^1 = \frac{\delta}{t\delta + \frac{1-t}{R(L)}}, \tag{11}$$

$$r_{2L} = c_2^2(L) = \frac{1}{t\delta + \frac{1-t}{R(L)}}, \tag{12}$$

$$r_{2H} = c_2^2(H) = \frac{R(H)}{R(L)} r_{2L}, \tag{13}$$

where

$$\delta \equiv \left[R(H)P(H)\left(\frac{R(H)}{R(L)}\right)^{-\alpha} + R(L)P(L) \right]^{\frac{-1}{\alpha}}.$$

When the incentive-compatibility constraint is binding, the deposit contract is given by:

$$r_1 = \frac{\xi}{t\xi + \frac{1-t}{R(H)}}, \tag{14}$$

$$r_{2H} = \frac{1}{t\xi + \frac{1-t}{R(H)}}, \tag{15}$$

$$r_{2L} = \frac{R(L)}{R(H)} r_{2H}, \tag{16}$$

where

$$\xi \equiv \left[P(H) + P(L)\left(\frac{R(L)}{R(H)}\right)^{1-\alpha} \right]^{\frac{1}{1-\alpha}}.$$

Following Jacklin and Bhattacharya (1988), the deposit contract defined by Eqs. (11)–(15) is interpreted as follows. The uncertain second period return reflects the fact that the bank may not be able to make its promised second-period payment in full because it has invested in a risky technology. The bank promises an amount r_{2H} that it will be able to pay only if $\widetilde{R} = R(H)$. If $\widetilde{R} = R(L)$, the bank is insolvent and depositors get a fraction $R(L)/R(H)$ of their promised payment.

4.2. A mutual bank with financial markets (FS 2)

4.2.1. The mutual bank

The assumption that there is a complete set of Arrow–Debreu securities markets for hedging the aggregate risk implies that in equilibrium a mutual bank solves

$$\text{Max} \quad t\frac{(r_1)^{1-\alpha}}{1-\alpha} + (1-t)P(H)\frac{(r_{2H})^{1-\alpha}}{1-\alpha} + (1-t)P(L)\frac{(r_{2L})^{1-\alpha}}{1-\alpha} \tag{17}$$

$$\text{s.t} \quad tr_1 + (1-t)p_2(H)r_{2H} + (1-t)p_2(L)r_{2L} = 1, \tag{18}$$

$$P(H)\frac{(r_{2H})^{1-\alpha}}{1-\alpha} + P(L)\frac{(r_{2L})^{1-\alpha}}{1-\alpha} \geqslant \frac{(r_1)^{1-\alpha}}{1-\alpha}. \tag{19}$$

Eq. (18) is the budget constraint in equilibrium. The left-hand side are the discounted consumptions per capita, and the right-hand side is the endowment at $T = 0$ per capita. There is only one intertemporal budget constraint because there is an Arrow–Debreu security for each state of nature at $T = 2$.

This intertemporal constraint can be derived as follows. Let y_B be the proportion of deposits invested in the short asset, z_B be the proportion of deposits invested in the long asset, and $n_B(s)$ be the quantity of Arrow–Debreu securities bought by the bank, with $s = H,L$. Since total deposits are equal to 1, at $T = 0$ the budget constraint of the bank is

$$y_B + z_B + p_2(H)n_B(H) + p_2(L)n_B(L) = 1.$$

At $T = 1$, the budget constraint is $tr_1 = y_B$, i.e., the bank meets withdrawals tr_1 with the short asset. At $T = 2$, when the state of nature is H, the budget constraint is $(1-t)r_{2H} = R(H)z_B + n_B(H)$. The bank meets withdrawals $(1-t)r_{2H}$ with the returns on the long asset $R(H)z_B$ and the $n_B(H)$ units of good provided by the $n_B(H)$ units of Arrow–Debreu securities bought at $T = 0$. Similarly, when the state of nature is L, the budget constraint is $(1-t)r_{2L} = R(L)z_B + n_B(L)$. Summing these three budget constraints yields the unique intertemporal constraint

$$\begin{aligned} &tr_1 + (1-t)p_2(H)r_{2H} + (1-t)P_2(L)r_{2L} \\ &\quad = y_B + [p_2(H)R(H) + p_2(L)R(L)]z_B + p_2(H)n_B(H) + p_2(L)n_B(L). \end{aligned}$$

In equilibrium, it is impossible to use the Arrow–Debreu securities and the long asset to make a profit: $p_2(H)R(H) + p_2(L)R(L) = 1$. As a result, $tr_1 + (1-t)p_2(H)r_{2H} + (1-t)p_2(L)r_{2L} = 1$.

When the incentive-compatibility constraint is not binding, the returns on the deposit contract are given by:

$$r_1 = \frac{1}{t + (1-t)\left[p(H)^{1/\alpha}p_2(H)^{(\alpha-1)/\alpha} + P(L)^{1/\alpha}p_2(L)^{(\alpha-1)/\alpha}\right]}, \tag{20}$$

$$r_{2H} = \left[\frac{P(H)}{p_2(H)}\right]^{1/\alpha} r_1, \tag{21}$$

$$r_{2L} = \left[\frac{P(L)}{p_2(L)}\right]^{1/\alpha} r_1. \tag{22}$$

When the incentive-compatibility constraint is binding, the deposit contract is given by:

$$r_1 = \left[P(H)\Psi^{(1-\alpha)/\alpha} + P(L)\right]^{1/(1-\alpha)} r_{2L}, \tag{23}$$

$$r_{2H} = r_{2L}\Psi^{1/\alpha}, \tag{24}$$

$$r_{2L} = \frac{1}{t\left[P(H)\Psi^{(1-\alpha)/\alpha} + P(L)\right]^{1/(1-\alpha)} + (1-t)p_2(H)\Psi^{1/\alpha} + (1-t)p_2(L)}, \tag{25}$$

where $\Psi = \dfrac{p_2(L)P(H)}{p_2(H)P(L)}$.

4.2.2. The capitalist

Since the capitalist is risk-neutral and derives satisfaction only from a consumption at $T = 2$, he solves

$$\text{Max} \quad P(H)c_2^N(H) + P(L)c_2^N(L), \tag{26}$$

$$\text{s.t} \quad p_2(H)c_2^N(H) + P_2(L)c_2^N(L) = NK, \tag{27}$$

$$P(H)c_2^N(H) + P(L)c_2^N(L) \geqslant E(\tilde{R})NK, \tag{28}$$

where $c_2^N(H)$ is the consumption at $T = 2$ in the state of nature H, and $c_2^N(L)$ is the consumption at $T = 2$ in the state of nature L. Eq. (26) is the expected consumption. Eq. (27) is the budget constraint which can be derived as follows.

Let z_C be the proportion of wealth that the capitalist invests in the long asset, and $n_C(s)$ be the quantity of Arrow–Debreu securities that he buys, with $s = H,L$. At $T = 0$, the budget constraint of the capitalist is $NK = z_C + p_2(H)n_C(H) + p_2(L)n_C(L)$. At $T = 2$, his consumptions are given by $c_2^N(H) = n_C(H) + R(H)z_C$ and $c_2^N(L) = n_C(L) + R(L)z_C$. Substituting these two budget constraints at $T = 2$ into the budget constraint at $T = 0$ yields the intertemporal budget constraint

$$NK = z_C + p_2(H)\left[c_2^N(H) - R(H)z_C\right] + p_2(L)\left[c_2^N(L) - R(L)z_C\right]$$

which can be rewritten

$$NK = p_2(H)c_2^N(H) + p_2(L)c_2^N(L) + z_c - [p_2(H)R(H) + p_2(L)R(L)]z_C.$$

Since $p_2(H)R(H) + p_2(L)R(L) = 1$ in equilibrium, the budget constraint of the capitalist is given by (27).

In Eq. (28), the left-hand side is his expected consumption when he participates in financial markets, and the right-hand side is his expected consumption in autarky. This constraint says that the capitalist participates in financial markets if this participation does not decrease his expected consumption.

When the budget constraint is binding and the participation constraint is not binding, the demand function of the capitalist is given by

$$c_2^N(H) = 0 \quad \text{and} \quad c_N^2(L) = \frac{NK}{p_2(L)} \qquad \text{if } p_2(H) > \frac{P(H)}{P(L)}p_2(L),$$

$$c_2^N(H) = \frac{NK}{p_2(H)} \quad \text{and} \quad c_2^N(L) = 0 \qquad \text{if } p_2(H) < \frac{P(H)}{P(L)}p_2(L),$$

$$p_2(H)c_2^N(H) + \frac{P(L)}{P(H)}p_2(H)c_2^N(L) = NK \quad \text{if } p_2(H) = \frac{P(H)}{P(L)}p_2(L).$$

Not surprisingly, when $p_2(H)$ is low enough and $P(H)$ is high enough, the capitalist consumes nothing in the state of nature L, and devotes all his wealth to buy consumption in state H.

The budget constraint and the participation constraint are binding when $p_2(H) = \frac{P(H)}{E(\widetilde{R})}$ and $p_2(L) = \frac{P(L)}{E(\widetilde{R})}$. When $p_2(H) = P(H)\frac{p_2(L)}{P(L)}$, we have $c_2^N(H) > 0$ and $c_2^N(L) > 0$. In this case, any $(c_2^N(H); c_2^N(L))$ satisfying (27) is a solution to the optimization problem of the capitalist. When $p_2(L) \geqslant \frac{P(L)}{P(H)}p_2(H)$, we have $c_2^N(L) = 0$ and $c_2^N(H) = \frac{E(\widetilde{R})NK}{P(H)} = \frac{NK}{p_2(H)}$.

For simplicity, we do not consider the other cases because we do not use them later. Also, in equilibrium $c_2^N(H)$ cannot be nil because efficient risk sharing requires that the capitalist insures the bank against the aggregate risk.

4.2.3. Equilibrium

We distinguish between two cases. First, we consider an equilibrium in which bank insolvency cannot occur. Second, we consider an equilibrium in which the mutual bank can be insolvent.

Although the capitalist is risk-neutral, his consumption cannot be negative. As a result, the losses he can absorb are limited by his capital. If his capital is not high enough, he cannot provide complete insurance to risk-averse depositors. Hence, the bank is insolvent because it cannot honor its non-contingent promise to depositors in the bad state of nature.

Equilibrium without bank insolvency: Financial markets open at $T = 0$. On these markets, the bank and the capitalist can buy or sell the two Arrow–Debreu securities defined in Section 3.1. Financial markets are in equilibrium when two conditions are satisfied.

First, it must be true that

$$Ntr_1 = Ny_B + NKy_N, \tag{29}$$

$$(1-t)Nr_{2H} + c_2^N(H) = NR(H)(1-y_B) + NKR(H)(1-y_N), \tag{30}$$

$$(1-t)Nr_{2L} + c_2^N(L) = NR(L)(1-y_B) + NKR(L)(1-y_N), \tag{31}$$

$$c_2^N(H) \geqslant 0, \tag{32}$$

$$c_2^N(L) \geqslant 0, \tag{33}$$

where y_N is the proportion of wealth that the capitalist invests in the short asset.

In Eq. (29), the left-hand side is the consumption of type 1 agents at $T = 1$. The right-hand side represents the resources available at $T = 1$. They are given by investments in the short asset at $T = 0$ which yield a return of 1 at $T = 1$. At $T = 0$, the N risk-averse agents have deposited N units of the good into the bank, and the bank has invested Ny_B in this asset. Also, the capitalist has invested NKy_N in the short asset. Eq. (29) says that the consumptions at $T = 1$ are financed by the investments in the short asset. This is because the return on the long asset is nil at $T = 1$.

In Eq. (30), the left-hand side represents the consumptions at $T = 2$ when the realized state of nature is H. Since the bank pays r_{2H} to type 2 agents and $(1 - t)N$ agents are type 2, the consumption of type 2 agents is $(1 - t)Nr_{2H}$. The consumption of the capitalist is $c_2^N(H)$. The right-hand side represents the resources available at $T = 2$ in the state of nature H. They are provided by the investments in the long asset which mature at $T = 2$. The bank has invested $N(1 - y_B)$ in the long asset, while the capitalist has invested $NK(1 - y_N)$ in this asset. Since the long asset yields $R(H)$ in the state of nature H, the resources available at $T = 2$ in this state are $NR(H)(1 - y_B) + NKR(H)(1 - y_N)$.

By the same logic, equilibrium in the state of nature L is given by Eq. (31). Also, Eqs. (32) and (33) say that in equilibrium, the consumption of the capitalist cannot be negative.

The second condition is that arbitrage opportunities cannot exist in equilibrium. Therefore,

$$p_2(H)R(H) + p_2(L)R(L) = 1. \tag{34}$$

By investing 1 at $T = 0$ in the long asset, an individual obtains $R(H)$ in state of nature H or $R(L)$ in state of nature L. Obtaining this returns profile by investing in financial markets costs $p_2(H)R(H) + p_2(L)R(L)$. These two costs must be equal. If this is not the case, there is an arbitrage opportunity, and thus financial markets are not in equilibrium.

The bank cannot be insolvent, i.e., $r_{2H} = r_{2L}$. Therefore, $\left[\frac{P(L)p_2(H)}{P(H)p_2(L)}\right]^{1/\alpha} = 1$. From this condition and (34), it is easy to derive the equilibrium prices:

$$p_2(H) = \frac{P(H)}{P(H)R(H) + P(L)R(L)} = \frac{P(H)}{E(\widetilde{R})}, \tag{35}$$

$$p_2(L) = \frac{P(L)}{P(H)R(H) + P(L)R(L)} = \frac{P(L)}{E(\widetilde{R})}. \tag{36}$$

With these prices, the participation constraint of the capitalist is binding. As a result, the demand of the capitalist is given by

$$p_2(H)c_2^N(H) + \frac{P(L)}{P(H)} p_2(H)c_2^N(L) = NK.$$

With $r_{2H} = r_{2L}$, Eqs. (29)–(33) can be reduced to

$$\frac{c_2^N(H)}{N} = \frac{K + \frac{P(H)}{P(L)} p_2(H)[R(H) - R(L)](1 - tr_1 + K)}{p_2(H)\left[1 + \frac{P(L)}{P(H)}\right]}. \tag{37}$$

The demand of the capitalist and (37) imply that $c_2^N(L) \geqslant 0$ if

$$K \geqslant \frac{r_{2H}(1-t) - R(L)(1 - tr_1)}{R(L)} \equiv \overline{K}. \tag{38}$$

Condition (38) is necessary for the existence of an equilibrium. In this equilibrium, bank insolvency cannot occur.

Financial markets are in equilibrium if the wealth of the capitalist is sufficiently high. This is because in an equilibrium without bank insolvency, risk sharing must be efficient. Therefore, the capitalist must bear all the aggregate risk at $T = 2$. But this is possible only if the capitalist is sufficiently wealthy. His capital allows him to sell to the mutual bank a quantity of Arrow–Debreu securities sufficient to enable the mutual bank to promise a fixed return on the deposit contract at $T = 2(r_{2H} = r_{2L})$. Type 2 depositors are completely insured against the aggregate risk. Therefore, risk sharing is efficient, and the mutual bank cannot be insolvent.

Equilibrium with bank insolvency: When $K < \overline{K}$, the bank is potentially insolvent. Therefore, $r_{2H} > r_{2L}$. When the deposit contract is given by (20)–(21), the equilibrium price $p_2(H)$ is given by the implicit function

$$\frac{R(L)(1+K)\left\{\frac{(1-t)}{t}\left[\frac{P(H)}{p_2(H)}\right]^{1/\alpha} + R(H)\right\}}{\frac{(1-t)}{t}\left[\frac{P(L)R(L)}{1 - p_2(H)R(H)}\right]^{1/\alpha} + R(L)} - R(H)(1+K) + \frac{K}{p_2(H)} = 0. \tag{39}$$

When the deposit contract is given by (23)–(25), the equilibrium price is given by the implicit function

$$\frac{R(L)(1+K)\left\{\left[\frac{(1-t)}{t}\eta^{1/\alpha}\right]\left[P(H)\eta^{(1-\alpha)/\alpha} + R(L)\right]^{1/(\alpha-1)}\right\}}{\frac{(1-t)}{t}\left\{P(H)\eta^{(1-\alpha)/\alpha} + R(L)\right\}^{1/(\alpha-1)} + R(L)}$$
$$- R(H)(1+K) + \frac{K}{p_2(H)} = 0, \tag{40}$$

where $\eta \equiv \dfrac{P(H)(1 - p_2(H)R(H))}{p_2(H)P(L)R(L)}$.

Since the implicit functions (39) and (40) cannot be transformed into explicit functions, we will use a numerical example to illustrate certain properties of an allocation of resources in FS 2 when bank insolvency is possible. This is done in Section 7.

4.3. A perfectly competitive capitalized bank (FS 3)

This section considers FS 3, i.e., a financial system which consists of a perfectly competitive capitalized bank. Since free entry in banking means that a bank cannot earn a positive profit, a capitalized bank in FS 3 promises the r_{2H} promised in FS 2 and makes a nil expected profit. As a result, social welfare in FS 3 is the same as in FS 2.

At $T = 2$, if the realized state of nature is L, the bank is not insolvent if its assets are equal to its liabilities. At $T = 0$, the bank has invested Ntr_1 in the short asset in order to finance withdrawals by type 1 agents at $T = 1$. Therefore, it has invested $N(1 - tr_1)$ in the long asset. This investment yields $R(L)N(1 - tr_1)$ at $T = 2$ when the state of nature is L. Also, the capitalist has invested his wealth NK in the long asset, which yields $R(L)NK$. Since he pledges his wealth to insure depositors against the aggregate risk, the bank's assets are $R(L)N(1 - tr_1) + R(L)NK$. At $T = 0$, the bank promises r_{2H} to agents who withdraw at $T = 2$. Since $N(1 - t)$ agents are type 2, at $T = 2$ the bank's liabilities are $r_{2H}N(1 - t)$. The bank cannot be insolvent if $R(L)N(1 - tr_1) + R(L)NK \geqslant r_{2H} \ {}_{\mathrm{N}}(1 - t)$, which is equivalent to $K \geqslant \frac{r_{2H}(1-t)-R(L)(1-tr_1)}{R(L)} \equiv \overline{K}$. Therefore, FS 2 and FS 3 need the same amount of capital to prevent bank insolvency. These two financial systems are equivalent in terms of social welfare and vulnerability to insolvency crises. Agents can optimally share the aggregate risk through financial markets or through a capitalized bank.

5. An imperfectly competitive banking system (FS 4 and FS 5)

In this section, we assume that there is no free entry in banking. As a result, the capitalist who sets up a capitalized bank can earn a positive expected profit. Basically, we follow Marini (2003).

Since depositors are risk-averse, the capitalist can increase his expected utility by promising them a fixed return $\bar{r}_2$ at $T = 2$, with $\bar{r}_2 \leqslant P(H)r_{2H} + P(L)r_{2L}$ and $u(\bar{r}_2) \geqslant P(H)u(r_{2H}) + P(L)u(r_{2L})$. He provides them insurance against the aggregate risk at $T = 2$ by pledging his capital. This insurance is credible if his capital is at least equal to the possible loss at $T = 2$, i.e., if $K \geqslant \frac{\bar{r}_2(1-t)-R(L)(1-tr_1)}{R(L)} \equiv K^*$, where r_1 is the return at $T = 1$ of the deposit contract issued by the mutual bank in FS 1. If this condition is satisfied, bank insolvency cannot occur.

Let r_2^* be defined by $u(r_2^*) = P(H)u(r_{2H}) + P(L)u(r_{2L})$. In other words, r_2^* is the certainty equivalent of the deposit contract issued by a perfectly competitive mutual bank. By setting $\bar{r}_2 = r_2^* + \varepsilon$, with $\varepsilon > 0$ sufficiently small, the capitalist earns a positive expected profit.

This arrangement is mutually beneficial because it increases the expected utility of depositors and the expected consumption of the banker. Therefore, social welfare in FS 4 is greater than social welfare in FS 1. Also, the amount of capital necessary to prevent bank insolvency is smaller in FS 4 than in FS 1, FS 2 and FS 3. This is because $\bar{r}_2 < r_{2H}$. Barriers to entry in banking allow the banker to reduce the interest rate on deposits. Therefore, he needs less capital to insure depositors against the aggregate risk.

Financial system FS 5 is equivalent to FS 4 in terms of social welfare and the stock of capital necessary to prevent bank insolvency. The argument follows the same logic as in Section 4.2 and is left to the reader.

6. Comparing these five financial systems

If $K \geqslant \overline{K}$, only FS 1 is vulnerable to an insolvency crisis. Comparing FS 2, FS 3, FS 4, and FS 5, shows that financial liberalization increases the welfare of depositors, decreases the welfare of the banker, and does not increase the vulnerability to bank insolvency. This is because bank deposits are more remunerated when the degree of competition in the banking sector increases. As a result, bank liabilities increase. But when $K > \overline{K}$, they are always smaller than bank assets.

If $\overline{K} > K \geqslant K^*$, financial liberalization, i.e., the transition from FS 4 or FS 5 to FS 3 or FS 2, makes the banking system vulnerable to an insolvency crisis. This is because financial liberalization leads to an increase in the interest rates on bank deposits. Therefore, the amount of capital necessary to prevent bank insolvency increases. As a result, if $\overline{K} > K \geqslant K^*$, regulations that limit competition in the banking sector prevent insolvency crises because the range of circumstances in which bank insolvency can take place shrinks.

In the polar case of monopoly banking, the capitalist is granted the exclusive right to run a bank. In that case, the monopoly banker maximizes his expected profit subject to the requirement that the expected utility of depositors be no lower than $P(H)u(r_{2H} + P(L)u(r_{2L})$. Therefore, he will set $\bar{r}_2 = r_2^*$. The expected utility of depositors is the same as the one achieved by a perfectly competitive mutual bank. Not surprisingly, monopoly benefits only to the banker.

The main result of the paper is that FS 2 and FS 3 on the one hand, and FS 4 and FS 5 on the other hand, are equivalent in terms of social welfare. A financial system in which a mutual bank has access to a complete set of financial markets for hedging the aggregate risk implements the same allocation of risks as a capitalized bank with no access to financial markets. Also, these two financial systems need the same amount of capital to prevent bank insolvency. This result illustrates the view developed in Allen and Gale (1995): the Anglo-Saxon model of financial intermediation in which financial markets play a dominant role does not necessarily dominate the German model in which banks dominate.

7. A numerical example

Let $t = 0.5$, $\alpha = 2$, $P(H) = P(L) = 0.5$, $R(H) = 1.8$, and $R(L) = 0.8$. In FS 2, the deposit contract is given by $r_1 = 1.065$ and $r_{2H} = 1.214$. Bank insolvency cannot occur if there is an equilibrium in which $r_{2H} = r_{2L}$. With $P(H) = P(L) = 0.5$,

$p_2(H) = P_2(L) = \frac{1}{R(H)+R(L)} = \frac{1}{2.6}$ are the equilibrium prices. In FS 2, the mutual bank cannot be insolvent if the capital of the capitalist satisfies $K \geqslant 0.292$.

With $K \geqslant 0.292$, financial markets are in equilibrium if $y_N = 0$, $y_B = 0.532$, $c_2^N(L) = 0$, and $\frac{c_2^N(H)}{N} = 0.759$.

The capitalist invests all his wealth in the long asset, while the mutual bank invests a proportion 0.532 of its portfolio in the short asset. At $T = 2$, when the state of nature is H, the capital of the capitalist yields $1.8 \times 0{,}292 = 0.525$. The mutual bank pays 0.233 to the capitalist. The expected consumption of the capitalist is 0.379, which is equal to his expected consumption in autarky. The mutual bank can pay 1.214 to its depositors.

In state of nature L, the capitalist consumes nothing. He pays $0.8 \times 0.29 = 0.233$ to the mutual bank. At $T = 0$, the mutual bank buys 0.233 Arrow–Debreu securities contingent on L. The cost is $p_2(L) \times 0.233 = 0.0899$. These promises are sold by the capitalist. The capitalist buys 0.233 Arrow–Debreu securities contingent on H. These securities cost $p_2(H) \times 0.233 = 0.0899$. These promises are sold by the mutual bank. In this financial system, the expected utility of depositors is equal to -0.88. The expected consumption of the capitalist is equal to 0.379, i.e., his expected consumption in autarky.

In deriving the equilibrium with $K \geqslant 0.292$, we guessed that $r_{2H} = r_{2L}$, i.e., the bank cannot be insolvent in equilibrium. We show in Appendix A that our guess is verified.

A capitalized bank in FS 3 cannot be insolvent if $K \geqslant 0.292$. Therefore, FS 2 and FS 3 need the same amount of capital to prevent bank insolvency.

In FS 1, the demand deposit contract issued by the mutual bank is given by $r_1 = 1.025$, $r_{2L} = 0.779$, $r_{2H} = 1.754$. With this contract, the expected utility of depositors is -0.95. If the capitalist promises $\bar{r}_2 = 1.08$ at $T = 2$, he increases the expected utility of depositors in comparison with FS 1 and makes a positive expected profit. The expected utility of depositors is -0.9505 while the expected profit of the banker is 0.093. Therefore, in FS 4, the bank cannot be insolvent if $K \geqslant 0.187$.

Now I consider FS 5 in which the mutual bank issues the deposit contract ($r_1 = 1.025$; $\bar{r}_2 = 1.08$) and the wealth of the capitalist is equal to 0.1877.

Financial markets are in equilibrium if $y_N = 0$, $y_B = 0.512$, $\frac{c_2^N(H)}{N} = 0.675$, $\frac{c_2^N(L)}{N} = 0$, $p_2(H) = 0.278$. and $p_2(L) = 0.624$.

In state of nature H, the mutual bank must pay $\bar{r}_2(1 - t) = 0.54$ to depositors, and its assets are equal to 0.877. In the state of nature L, the assets of the bank are equal to 0.389. At $T = 0$, the bank buys $0.54 - 0.389 = 0.15$ Arrow–Debreu securities contingent on L. These securities cost $p_2(L) \times 0.15 = 0.0937$ to the bank. In the state of nature L, the capitalist delivers 0.15 to the bank. His wealth is equal to $0.8 \times 0.187 = 0.15$. Therefore, his consumption $c_2^N(L)$ is nil. In the state of nature H, the return on the capital of the capitalist is 0.338, and the bank delivers 0.337 to him. This is because the bank's assets are equal to 0.878, while its liabilities are equal to 0.54, and $0.878 - 0.54 = 0.337$. Therefore, the capitalist consumes $c_2^N(H) = 0.338 + 0.337 = 0.675$. At $T = 0$, the capitalist buys 0.337 Arrow–Debreu securities contingent on H which cost $0.337 \times p_2(H) = 0.0937$. In autarky, the expected consumption of the capitalist is equal to $1.3 \times 0.187 = 0.244$, while in FS 5 it is $P(H)\frac{c_2^N(H)}{N} + P(L)\frac{c_2^N(L)}{N} = 0.3375$. Obviously, $0.244 + 0.093 = 0.337$. Also, it is easy to verify that the expected rent of the banker is $E(\tilde{r}) = 0.093$ for every $K \geqslant 0.187$.

With $K = 0.187$ in FS 2, it is easy to verify that $p_2(H) = 0.338$, $p_2(L) = 0.489$, $r_1 = 1.049$, $r_{2H} = 1.276$, $r_{2L} = 1.061$. With these values, the expected utility of depositors is -0.908, and the expected rent of the capitalist is $E(\tilde{r}) = 0.0827$. By the same logic as before, when $r_1 = 1.025$ and $r_{2H} = r_{2L} = 1.15$, $K^* = 0.23125$ in FS 4 and FS 5. In these two financial systems, the expected utility of depositors is -0.9225, and the expected rent of the capitalist is 0.0587.

We can recapitulate the main findings of this example in the following table, where K_N denotes the amount of capital necessary to prevent bank insolvency (i.e., $K_N \equiv \overline{K}$ in FS 1, FS 2 and FS 3, and $K_N \equiv K^*$ in FS 4 and FS 5), $E(\tilde{r})$ denotes the expected rent of the capitalist, u_D denotes the expected utility of depositors:

	K_N	K	u_D	$E(\tilde{r})$	r_{2H}	r_{2L}	r_1
FS 1	–	–	-0.9507	0	1.75	0.78	1.025
FS 2	0.29	$\geqslant 0.29$	-0.8808	0	1.214	1.214	1.065
FS 2	0.29	0.1877	-0.908	0.0827	1.276	1.061	1.049
FS 3	0.29	$\geqslant 0.29$	-0.8808	0	1.214	1.214	1.065
FS 4	0.1877	$\geqslant 0.1877$	-0.9505	0.0938	1.08	1.08	1.025
FS 4	0.23125	$\geqslant 0.23125$	-0.9225	0.0587	1.15	1.15	1.025
FS 5	0.1877	$\geqslant 0.1877$	-0.9505	0.0938	1.08	1.08	1.025

Comparing these five financial systems illustrates three properties of the model.

1. Complete financial markets for hedging the aggregate risk do not reduce the vulnerability to bank insolvency. We draw this result from the fact that for a given deposit contract, on the one hand FS 2 and FS 3 have the same K_N, and on the other hand FS 4 and FS 5 also have the same K_N.
2. Financial liberalization, i.e., the passage from FS 4 or FS 5 to FS 2 or FS 3, leads to an increase of the interest rate on deposits. This is due to the increased competition into the banking sector. Therefore, the amount of capital necessary to prevent bank insolvency is higher. Financial liberalization does not lead to bank insolvency when $K \geqslant 0.29$. However, financial liberalization makes the bank vulnerable to insolvency when $0.1877 < K < 0.29$.
3. For a given amount of capital, the allocation implemented in FS 2 (FS 5) can also be implemented in FS 3 (FS 4). This result can be interpreted as follows. The Anglo-Saxon model of financial intermediation in which financial markets dominate is not superior to a more bank-based system like the German model. This is in accordance with Allen and Gale (1995). This is the main result of the paper.

8. Conclusion

This paper has constructed a general equilibrium model in which a financial system which consists of a mutual bank having access to a complete set of financial markets does not improve social welfare in comparison with a capitalized bank. This paper casts some doubt on the presumption that the Anglo-Saxon model of financial intermediation in which financial markets dominate is superior to a more bank-based system like the German model. This is in accordance with Allen and Gale (1995). Also, the model has shown that financial liberalization does not necessarily makes the bank more vulnerable to insolvency.

These results have limitations because the paper has focused on only one function performed by financial systems, i.e., cross-sectional risk sharing. However, financial systems perform other important functions. As a result, future research should consider financial liberalization in more complex financial systems.

Also, the paper has considered only one aspect of financial liberalization, i.e., increased competition in the banking sector. Other aspects like decreasing reserve requirements and liberalizing capital markets should also be considered in future research.

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Appendix A

In deriving the equilibrium with $K = 0.292$, we guessed that $r_{2H} = r_{2L}$ i.e., the bank cannot be insolvent in equilibrium. We show that the guess is verified, i.e., we do not impose the restriction $r_{2H} = r_{2L}$, and we show that equilibrium in financial markets implies that $r_{2H} = r_{2L}$.

With $\alpha = 2$, $r_{2H} = \sqrt{\frac{1}{2p_2(H)}}r_1$ and $r_{2L} = \sqrt{\frac{1}{2p_2(L)}}r_1$. Therefore, financial markets are in equilibrium when

$$0.5\sqrt{\frac{1}{2p_2(H)}}r_1 + \frac{c_2^N(H)}{N} = 1.8(1+K) - 0.9r_1,$$

$$0.5\sqrt{\frac{1}{2p_2(L)}}r_1 + \frac{c_2^N(L)}{N} = 0.8(1+K) - 0.4r_1,$$

$$p_2(H)\left[\frac{c_2^N(H)}{N} + \frac{c_2^N(L)}{N}\right] = K,$$

$$1.8p_2(H) + 0.8p_2(L) = 1,$$

$$c_2^N(H) \geqslant 0 \quad \text{and} \quad c_2^N(L) \geqslant 0.$$

From these conditions, it is easy derive that the equilibrium price $p_2(H)$ is given by the implicit function:

$$p_2(H)\left\{2.6(1+K) - \frac{2.6 + \sqrt{\frac{1}{2p_2(H)}} + \sqrt{\frac{0.8}{2-3.6p_2(H)}}}{1 + \sqrt{\frac{p_2(H)}{2}} + \sqrt{\frac{1-1.8p_2(H)}{1.6}}}\right\} - K = 0$$

With $K = 0.292$, the solution is $p_2(H) = p_2(L) = \frac{1}{2.6}$. Therefore, the guess $r_{2H} = r_{2L}$ is verified.

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