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Financial crisis and bank run: an analysis through game theory

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INTRODUCTION

The idea of modern financial systems rests on a fundamental tension: the transformation of short-term liquid liabilities into long-term illiquid investments. This transformation allows savings to be utilized for productive purposes and creates the conditions for economic growth. But it also creates structural fragility. The mechanism that provides banks with both liquidity and risk sharing may give rise to destabilizing dynamics driven not by fundamentals, but by expectations in certain situations.

At the heart of this tension is a microeconomic issue. There is uncertainty surrounding when consumers need to consume. Though long-term investments normally produce higher earnings, unexpected liquidity shocks can compel agents to sell their assets sooner than expected. Financial intermediation emerges precisely to address this intertemporal trade-off: it pools resources and provides insurance against individual liquidity exposure.

But once intermediation is brought into view, various kinds of strategic interactions emerge. Stability depends not only on fundamentals, but also on beliefs.

This dissertation develops this microeconomic analysis of financial crisis and bank runs through intertemporal choice and game theory as tools. Its aim is to demonstrate how endogenous fragility comes up in a robust and efficient ecosystem of financial intermediation.

The first chapter lays the theoretical bases. From a mere intertemporal model of liquidity risk, we examine three institutional models: autarky, a competitive securities market, and the role of a central planner. This analysis shows how financial intermediation, through deposit contracts, can reconstitute such allocation and achieve a Pareto-efficient distribution of consumption, while covering exposure to liquidity shocks. Under standard assumptions, therefore, banks are seen as institutions that can maximise expected utility through maturity transformation and risk pooling.

The second chapter brings in the landmark work of Diamond and Dybvig (1983), emphasizing the fundamentally fragile nature of this system. When early liquidation technology and sequential service are taken into account, the banking model accommodates a number of equilibria. In addition to the efficient equilibrium appears a bank run equilibrium in which rational depositors, acting on the assumption of what they expect others to do, cooperate and stimulate the insolvency they dread. The crisis isn't necessarily the result of faulty fundamentals, but of coordination failure. By strategically presenting depositors' choices, the bank run becomes a self-fulfilling equilibrium. In this section we will also reflect on policy responses including the suspension of convertibility and deposit insurance and discuss not only the stabilizing behaviour of such actions, but the moral hazard problems they could create.

The third chapter takes the analysis further into the wider financial system and into sovereign debt crises focused explicitly on Europe. The link between banking fragility, sovereign risk, and central bank intervention generates what is commonly referred to as twin crises. The role of the European Central Bank, and in particular the Outright Monetary Transactions (OMT) program, is examined as a mechanism aimed at stabilizing expectations and avoiding self-fulfilling crises in sovereign bond markets. Credibility, conditionality, and reputational costs are highlighted, emphasizing how economic authorities and national governments strategically interact.

The thesis advances three main claims. First, financial crises cannot be simply attributed to irrational behaviour or external shocks. They can, however, arise from rational judgments made under uncertainty in structurally weak systems. Second, when liquidity transformation confronts imperfect and strategic information and interdependence, expectations take centre stage. Third, in such environments stability is not ensured by fundamentals alone: it requires coordination, institutional design, and credible policy intervention.

Using intertemporal microeconomic modeling together with game-theoretic analysis, this work endeavours to offer a framework explaining how efficient financial structures may generate their own instability, and how policy might address, though not completely erase, this fragility.

Chapter I

LIQUIDITY RISK AND INTERTEMPORAL INVESTMENT CHOICES

1.1 Introduction to Liquidity Needs

Over the course of their lifetime, individuals inevitably face unexpected situations that require the consumption of wealth, sometimes substantial, alternating with periods in which the management of liquidity is more predictable and routine. Because of this uncertainty regarding the timing of consumption[1], individuals develop heterogeneous liquidity needs that must be reconciled with their investment decisions.

In light of this uncertainty, it is useful to introduce a model that allows us to analyze the consumer's behaviour and the investment choices he undertakes after carefully weighing their respective advantages and disadvantages, while taking into account possible future liquidity shocks.

The framework considered in this chapter is structured around three different scenarios, each characterized by distinct institutional features. By comparing these settings, we aim to determine which one enables the investor to achieve a consumption plan that is Pareto-efficient[2].

The first scenario analyzes investment under autarky[3], where no trade is possible. The second introduces the possibility of operating in a securities market. The third incorporates the presence of a central planner who allocates resources so as to maximize expected utility.

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[1] For the theory of intertemporal choice under uncertainty, see Arrow (1971); Mas-Colell et al. (1995).

[2] Ross M. Starr, General Equilibrium Theory, Cambridge University Press, pp. 205 – 224 ; for a formal definition of Pareto efficiency, see Debreu (1959).

[3] Autarkic allocations correspond to economies without trade in state-contingent claims. See Arrow and Debreu (1954) ; the maximization problem under budget constraints follows standard consumer theory. See Varian (1992).

1.2 The Structure of the Model

The model[4] is structured over three consecutive time periods[5] (or dates), indexed by $t = 0, 1, 2$.

1.2.1 Types of Investment

With regard to investment opportunities, the consumer can choose between two alternatives: a short-term liquid investment and a long-term illiquid investment.

The short-term investment allows one unit of the good invested at period $t$to yield a real return equal to 1 at date $t + 1$, for $t = 0, 1$. This type of investment can be interpreted as a deposit that does not increase the initial endowment (since its return is equal to 1) but enables the consumer to access liquidity after only one period.

By comparison, the long-term investment is more productive. One unit of the good invested at date 0 is transformed into $R > 1$ units of the good at date 2. In this case, the initial endowment yields a certain real return equal to $R > 1$, at the cost of forgoing access to liquidity for two periods.

As a result, the consumer must choose between a liquid asset that matures after one period but offers a lower return and an illiquid asset that matures after two periods and offers a greater return.

1.2.2 Liquidity Preferences

The consumer is endowed with an initial allocation of goods equal to one unit at date $t = 0$, and zero endowment at the remaining two dates. Consumption may take place either at date 1 or at date 2; however, the individual is uncertain about the exact timing of consumption, as this depends on future liquidity needs.

Consequently, the model assumes the existence of two types of consumers. An impatient consumer faces the need to consume at date $t = 1$, while a patient consumer prefers to consume at date $t = 2$. The impatient type derives no utility from consumption at date 2, whereas the patient type derives no utility from consumption at date 1. At the initial date $t = 0$, the consumer does not know which type he will be; this information is revealed only at the beginning of period 1.

Although the consumer always seeks to maximize returns by choosing the most profitable investment, the possibility of facing an unexpected liquidity need induces him to consider investments in more liquid assets.

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[4] For a standard treatment of intertemporal choice under uncertainty and expected utility theory, see Mas-Colell, Whinston and Green (1995), Chapter 6; Varian (1992), Chapter 9.

[5] Three-period intertemporal models are standard in banking theory. See Freixas and Rochet (2008).

In the model, the consumer knows the probability of becoming impatient, denoted by γ[6]; consequently, the probability of being patient is equal to $1-\gamma$. This probability can also be interpreted as a measure of the consumer's degree of liquidity preference. When $\gamma = 1$, the consumer exhibits a very high preference for liquidity, since he is certain to need consumption at date 1 and therefore cannot wait until date 2. Conversely, when $\gamma = 0$, the consumer has no preference for liquidity, as he can carry the investment through to date 2 without any inconvenience and thus obtain a higher return.

Only when $\gamma \in (0,1)$ is the consumer uncertain about his future liquidity needs and unable to predict whether he will turn out to be impatient or patient. In the former case, he would prefer not to invest in long-term assets, while in the latter he would prefer not to invest in short-term assets.

1.3 Investment under Autarky

The consumer is assumed to be described by a utility function $U(C_t^\tau)$, where t denotes the date of consumption and τ identifies the type of consumer, either patient (p) or impatient (i). The utility function is assumed to be increasing, strictly concave, and at least twice continuously differentiable.

In order to determine consumption at each date, it is necessary to analyze the portfolio choices made by the consumer at date $t = 0$. Let b denote the fraction of the initial endowment invested in the short-term liquid asset, and let $a$denote the fraction invested in the long-term illiquid asset. Since the initial endowment is equal to one unit of the good, the amount invested in the long-term asset can be expressed as $1-b$.

Once the investment portfolio (a,b), equivalently $(b,1-b)$, has been determined, consumption in periods 1 and 2 can be analyzed, taking into account the consumer's type through the consumption function

$$C_t^\tau(b,1-b).$$

It is immediate that a patient consumer does not consume in period 1, while an impatient consumer has no consumption in period 2. Accordingly,

$$C_1^p(b,1-b) = 0$$

$$C_2^i(b,1-b) = 0.$$

[6] The probabilistic structure of liquidity needs follows the standard specification in Diamond and Dybvig (1983).

Effective consumption takes place in period 1 for the impatient consumer and is given solely by

$$C_1^i(b, 1-b) = b$$

since the returns from the long-term investment cannot be consumed at that date. Consumption in period 2 for the patient consumer is instead given by

$$C_2^p(b, 1-b) = b + (1-b)R,$$

where, in addition to the return generated by the illiquid investment, the wealth invested in the short-term asset, reinvested from period 1 to period 2, can also be consumed.
It is worth noting that $C_2^p > C_1^i$except in the special case $b = 1$. In this case, the consumer fully avoids risk by investing only in the liquid asset, but does so at the cost of accepting a lower average level of consumption.
The consumer's expected utility is therefore given by

$$\gamma U\big(C_1^i(b, 1-b)\big) + (1-\gamma)U\big(C_2^p(b, 1-b)\big)$$

which can be written as

$$\gamma U(b) + (1-\gamma)U(b + (1-b)R)$$

The consumer's decision problem consists in choosing b as to maximize expected utility, taking into account optimal consumption choices in periods 1 and 2.[7]
At date $t = 0$, the problem can therefore be written as

$$max_b \qquad \gamma U(b) + (1-\gamma)U(b + (1-b)R)$$

$$\textit{such that} \qquad 0 \leq b \leq 1.$$

Since the utility function U is continuous and differentiable over the interval $(0, 1)$, the optimal value of b satisfies the first-order condition[8]

$$\gamma U'(b) + (1-\gamma)U'(b + (1-b)R)\,(1-R) = 0$$

To better understand the consumer's choice under autarky, it is useful to derive the budget constraint governing feasible consumption in periods 1 and 2. Inefficient consumption

[7] The maximization problem under a budget constraint follows standard consumer theory. See Varian (1992); Mas-Colell, Whinston and Green (1995).

[8] For first-order conditions in constrained optimization problems, see Varian (1992); Mas-Colell, Whinston and Green (1995).

allocations C_1^p and C_2^i, both equal to zero, are henceforth disregarded, and attention is restricted to the cases $C_1^i = b$ and $C_2^p = b + (1-b)R$.
Since $b \in [0,1]$, two extreme consumption plans can be identified:

$$\left(\bar{C}_1^i, \bar{C}_2^p\right) = (0, R) \qquad \text{and} \qquad \left(\hat{C}_1^i, \hat{C}_2^p\right) = (1, 1)$$

Given the linearity of the feasibility constraint, it can be represented by the equation of the straight line passing through these two extreme points[9]. The equation is easily obtained by applying the standard formula for a straight line

$$C_2^p - \bar{C}_2^p = \frac{\left(\hat{C}_2^p - \bar{C}_2^p\right)}{\left(\hat{C}_1^i - \bar{C}_1^i\right)} \left(C_1^i - \bar{C}_1^i\right)$$

from which it follows that

$$C_2^p - R = (1-R)\, C_1^i$$

so

$$(R-1)\, C_1^i + C_2^p = R\ .$$

This budget line, however, is subject to additional restrictions. Since b must lie within the interval $[0, 1]$, and given that $C_1^i = b$, it follows that C_1^i is also restricted to the interval $[0, 1]$. Consequently, the budget constraint faced by the consumer in making his investment decision is given by

$$\begin{cases} (R-1)\, C_1^i + C_2^p = R \\ \qquad 0 \leq C_1^i \leq 1 \end{cases}$$

In a Cartesian diagram, where C_2^p is measured on the vertical axis and C_1^i on the horizontal axis, this constraint can be represented by a downward-sloping straight line over the interval $[0, 1]$.

[9] The intertemporal production structure follows the standard two-asset framework used in banking models. See Diamond and Dybvig (1983); Freixas and Rochet (2008).

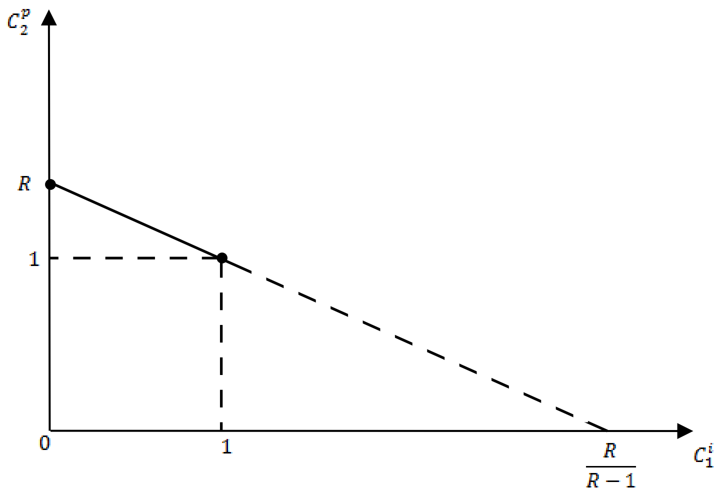

Figure Consumer's budget constraint in the autarky model.

The derived budget constraint provides a clearer view of the problem faced by the consumer at date $t = 0$. The consumer seeks to maximize utility while taking into account the constraints discussed above. Accordingly, the problem can be formulated as follows:

$$max_{C_1^i, C_2^p} \qquad \gamma U\left(C_1^i\right) + (1-\gamma)U\left(C_2^p\right)$$

$$such\ that \qquad \begin{cases} (R-1)\ C_1^i + C_2^p = R \\ \quad 0 \le C_1^i \le 1 \end{cases}$$

Given this formulation, the consumer may choose any investment portfolio that generates consumption at dates 1 and 2 consistent with the budget constraint, in order to maximize utility.

1.3.1 Possible Optimal Allocations under Autarky

To fully understand the model presented above, it is useful to consider two possible optimal allocations, namely two consumption plans that maximize the consumer's utility. The first solution is derived under a generic utility function, while the second focuses on a specific functional form, namely logarithmic utility.
The first solution analyzed for the consumer's problem considers an optimal consumption bundle $\left(C_1^{i*}, C_2^{p*}\right)$ such that $0 < C_1^{i*} < 1$, that is, corner solutions are ruled out. This implies that the consumer's maximum utility is attained at an interior point of the budget constraint. Consequently, this solution must satisfy the condition that the marginal rate of substitution[10] equals the slope of the feasibility constraint. The latter is given by the slope of the budget line, which is equal to $1 - R$, since the budget constraint can equivalently be written as:

$$C_2^p = (1-R)\ C_1^i + R.$$

[10] The tangency condition between the marginal rate of substitution and the budget constraint follows standard consumer theory. See Varian (1992); Mas-Colell et al. (1995).

This slope must be equated to the marginal rate of substitution, which can be expressed as the negative ratio of the partial derivatives of the utility function. Therefore:

$$SMS = -\frac{\gamma U'\left(C_1^{i*}\right)}{(1-\gamma)U'\left(C_2^{p*}\right)}$$

The resulting equality is therefore given by

$$-\frac{\gamma U'\left(C_1^{i*}\right)}{(1-\gamma)U'\left(C_2^{p*}\right)} = (1-R)$$

or, equivalently, removing the negative sign

$$\frac{\gamma U'\left(C_1^{i*}\right)}{(1-\gamma)U'\left(C_2^{p*}\right)} = (R-1)$$

From a graphical point of view, the figure below illustrates that the hypothetical utility function is tangent to the budget constraint at an interior optimal allocation.

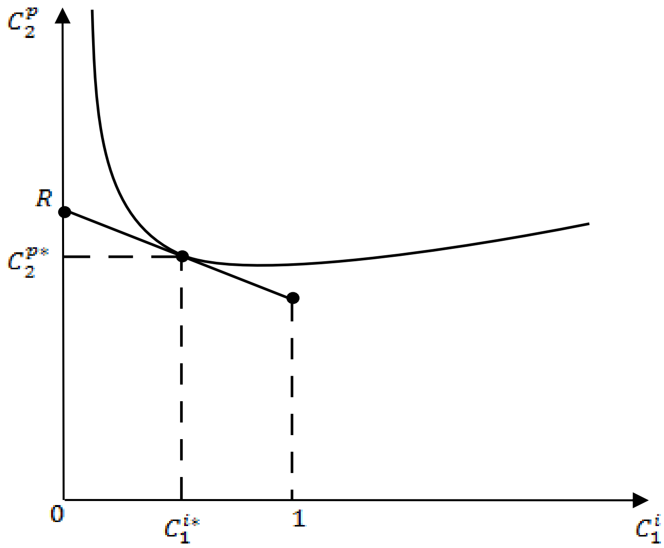

Figure Optimal allocation in the first solution of the consumer's problem under autarky.

In the second solution considered for the consumer, the utility function of consumption is assumed to take the form of a natural logarithm, namely $U(C) = \ln C$. The problem can therefore be formulated as follows:

$$max_{C_1^i, C_2^p} \qquad \gamma \ln\left(C_1^i\right) + (1-\gamma)\ln\left(C_2^p\right)$$

$$such\ that \qquad \begin{cases} (R-1)\, C_1^i + C_2^p = R \\ 0 \le C_1^i \le 1 \end{cases}$$

The slope of the budget line is the same as that derived in the previous case, namely $1 - R$. The difference lies in the computation of the marginal rate of substitution, which is given by:

$$SMS = -\frac{\frac{\gamma}{C_1^i}}{\frac{1-\gamma}{C_2^p}}$$

The equality characterizing optimal consumption therefore becomes:

$$-\frac{\frac{\gamma}{C_1^{i*}}}{\frac{1-\gamma}{C_2^{p*}}} = (R-1)$$

or, equivalently, removing the negative sign:

$$\frac{\frac{\gamma}{C_1^{i*}}}{\frac{1-\gamma}{C_2^{p*}}} = (1-R)$$

By combining this condition with the budget constraint, it is possible to compute the optimal consumption levels. For values of γsuch that $0 < \gamma < \frac{R-1}{R}$, optimal consumption is given by:

$$C_1^{i*} = \frac{R\gamma}{R-1}$$

$$C_2^{p*} = (1-\gamma)R.$$

An optimal solution also exists for other values of γ, namely for $\frac{R-1}{R} \leq \gamma \leq 1$. In this range, however, the optimum is no longer characterized by equality between the marginal rate of substitution of the utility function and the slope of the budget constraint, since the interior feasibility condition $0 < C_1^i < 1$ is violated. Consequently, the optimal allocation is attained at the boundary of the budget constraint, and the corresponding optimal consumption levels are $C_1^{i*} = 1$ and $C_2^{p*} = 1$.

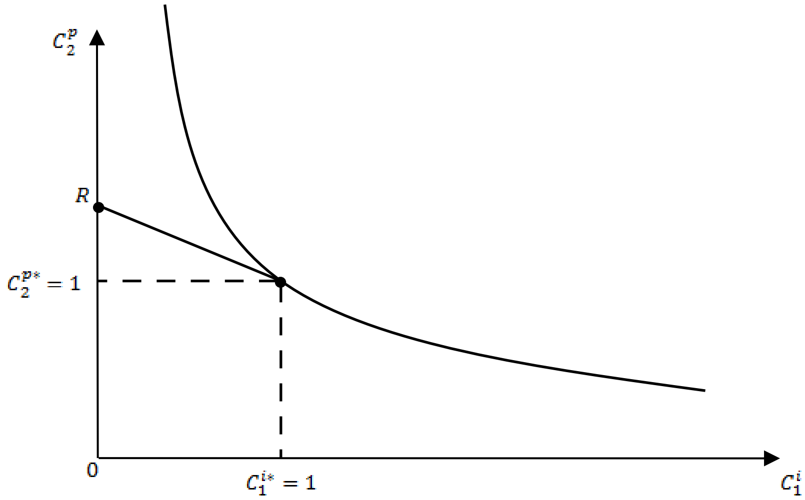

Figure Optimal allocation under the second solution of the consumer's problem in the autarky model for $\frac{R-1}{R} \leq \gamma \leq 1$.

1.3.2 Remarks on the Autarky Scenario

In this model, agents are assumed to operate under a state of autarky[11], that is, in an environment in which trading is not possible and consumption must rely exclusively on the returns generated by the investment portfolio chosen at date $t = 0$. However, the assumption of autarky is far removed from real-world economic conditions. In practice, individuals typically have the opportunity to sell their assets in order to obtain their corresponding value in liquid form.

One of the primary functions of financial markets is precisely to meet the liquidity needs of investors holding illiquid assets. For this reason, the second model to be analyzed introduces the possibility of operating in a securities market.

[11] For the theory of complete and incomplete markets, see Arrow and Debreu (1954); Debreu (1959).

1.4 Investment Model with Market Participation

In this model, it is assumed that there exists a market in which assets can be bought and sold at time $t = 1$, after the investor has discovered his liquidity needs. Therefore, if the investor turns out to be an impatient consumer at $t = 1$, he can sell his long-term illiquid assets at the prevailing market price and consume the proceeds. Conversely, if the investor discovers that he is patient, he can sell his liquid assets and use the proceeds to purchase illiquid assets, again at market prices.

This possibility provides the consumer with a form of insurance against liquidity shocks arising from unpredictable future needs.

The market underlying this model is assumed to operate under perfect competition[12]. In this sense, all agents take the market price as given and consider it to be constant across all three periods ($t = 0,1,2$).

The initial setup of the model is similar to that previously analyzed under autarky. Time is divided into three periods, $t = 0, 1, 2$, and the investor is endowed with one unit of the good at time 0. This endowment can be invested either in a long-term illiquid asset yielding a return R, or in a short-term liquid asset. It is assumed that, also in this framework, the investment portfolio is given by (a, b), meaning that the investor allocates $a$units to the illiquid asset and $b$units to the liquid asset. Clearly, the portfolio is subject at time $t = 0$ to the constraint $a + b = 1$.

At time $t = 1$, the investor discovers whether he is a patient or an impatient consumer.

If he turns out to be impatient, he can liquidate all his long-term illiquid assets on the market and consume the proceeds together with the liquid assets held in his portfolio. Assuming that illiquid assets trade at a market price p, the revenue obtained from their sale is equal to $a * p$. Therefore, consumption at time $t = 1$ for an impatient consumer is given by

$$C_1^i = b + pa.$$

If, instead, the consumer turns out to be patient, he is able to transform the short-term liquid assets in his portfolio into long-term illiquid assets. The investor is willing to undertake such a transaction only if the wealth generated by the long-term asset purchased at time $t = 1$ exceeds the wealth he would obtain by reinvesting his $b$units in the short-term asset. This occurs only if the condition $p \leq R$ holds.

In this case, at time $t = 1$, the consumer can use his $b$units of the short-term asset to purchase $\frac{b}{p}$ units of the long-term asset, which will generate wealth at time $t = 2$ equal to

$$b\frac{R}{p} \geq b$$

[12] For competitive equilibrium under complete markets, see Arrow and Debreu (1954); Mas-Colell et al. (1995).

Since reinvesting $b$units in the short-term liquid asset would yield exactly $b$units of wealth, it is optimal for the consumer to hold only long-term investments at time $t = 1$.

The assumption $p \leq R$ represents an equilibrium condition[13]. If instead the price satisfied $p > R$, consumption at time $t = 1$ would necessarily exceed consumption at time $t = 2$, and no investor would be willing to hold long-term assets, as it would be more convenient to reinvest short-term consumption from time $t = 1$ until time $t = 2$. Such behavior would generate a sharp decline in the price of long-term assets, eventually restoring the market to an equilibrium situation in which $p \leq R$.

These considerations imply that, at time $t = 1$, a consumer who turns out to be patient has a strict incentive to hold only long-term investments. Consequently, consumption for a patient individual at time $t = 2$ is given by

$$C_2^p = \left(a + \frac{b}{p}\right) R$$

The investor's decision problem at time $t = 0$ can therefore be defined. Given that γ denotes the probability of turning out to be impatient, and $1 - \gamma$ the probability of being patient, the investor seeks to maximize expected utility subject to the constraints derived above. Accordingly, the problem can be stated as follows:

$$max_{a,b} \qquad \gamma U(b + pa) + (1 - \gamma) U\left[\left(a + \frac{b}{p}\right) R\right]$$

$$such\ that \qquad \begin{cases} a + b = 1 \\ p \leq R \end{cases}$$

It can be observed that the investor's decision is strongly influenced by the price $p$of the long-term asset. As previously stated, the market under consideration is assumed to be perfectly competitive, meaning that agents take the price as given and constant. However, depending on the value that the price may take at time $t = 0$, situations of disequilibrium between the demand for and the supply of assets may arise, potentially leading to the breakdown of the model.

If $p > 1$, individuals at time $t = 0$ would find it strictly more convenient to invest their entire endowment in long-term illiquid assets. This advantage would materialize regardless of whether, at time $t = 1$, they turn out to be patient or impatient.

In the former case, consumers would obtain the highest possible level of wealth at time $t = 2$ by having invested exclusively in long-term assets. This is because, had they invested part of their endowment in short-term assets, it would be disadvantageous to exchange them on the market for long-term assets. Given the high price of the latter, they would end up holding a

[13] The pricing condition follows from the absence of arbitrage in competitive asset markets. See Ross (1976); Duffie (2001).

smaller quantity of illiquid assets at time $t = 2$ than they would have obtained by investing solely in long-term assets at time $t = 0$.

In the latter case, once consumers discover that they are impatient, they could still operate in the market and sell their long-term assets at a favourable price (since $p > 1$), thereby obtaining a higher level of wealth than they would have achieved had they invested only in short-term assets.

At time $t = 0$, this therefore appears as a highly advantageous scenario for investors. Attracted by the higher returns, all consumers would choose to invest exclusively in long-term illiquid assets. However, this behavior gives rise to a fundamental problem. If, at time $t = 1$, a consumer were to turn out to be impatient, he would attempt to sell his illiquid assets but would be unable to find a counterparty willing to exchange them for liquid assets, since no agent invested in short-term assets at time $t = 0$.

As a result, all impatient consumers would hold only illiquid assets in their portfolios, which they would be unable to liquidate on the market. Such a situation would lead to a collapse in the price of long-term assets, driving it down to $p = 0$. This outcome would therefore contradict the assumptions of the model.

A similar argument applies if the price satisfies $p < 1$. In this case, investors at time $t = 0$ would be induced to allocate their entire endowment to short-term liquid assets.
Impatient consumers would then be able to consume their short-term assets at time $t = 1$, obtaining a payoff equal to 1, which exceeds p, the wealth they would obtain had they invested in long-term assets and subsequently been forced to sell them on the securities market. Patient consumers, instead, would attempt to enter the market in order to purchase illiquid assets, aiming to obtain a return equal to a $R/p > R$, where R denotes the return generated by holding long-term assets until maturity.
However, under these circumstances, no agent would be willing to supply long-term assets in the market at time $t = 1$, since no investor chose to hold such assets at time $t = 0$. As a result, patient consumers would end up holding only liquid assets in their portfolios, which they would be unable to exchange for more profitable illiquid investments.
Given the absence of supply, the price $p$would continue to rise until it reaches $p = R$, since the feasibility constraint requires $p \leq R$. This outcome would represent yet another contradiction with the assumptions of the model.
A situation consistent with the model's assumptions can therefore arise only if the consumer's investment choice entails a balance between the two types of assets[14]. Such a situation occurs exclusively when the price satisfies $p = 1$. At this price, no asymmetry in incentives emerges that would systematically push investors toward one asset over the other.
Having established this property of the price of the long-term asset, consumption levels can be rewritten as follows:

$$C_1^i = b + pa = a + b = 1$$

[14] For competitive equilibrium under asset trade, see Arrow and Debreu (1954); Mas-Colell, Whinston and Green (1995).

and

$$C_2^p = \left(a + \frac{b}{p}\right) R = (a + b)R = R$$

As a consequence, the utility function must also be rewritten and becomes

$$\gamma\, U(1) + (1 - \gamma)\, U(R).$$

The results derived above lead to the conclusion that the consumer's optimal allocation is given by $(C_1^{i*}, C_2^{p*}) = (1, R)$.
Regardless of the initial composition of the investment portfolio, by accessing the securities market the consumer is always able to attain this unique optimal allocation.

1.4.1 Efficiency and Comparison with the Autarky Scenario

In order to compare the model just described with the autarky framework analyzed earlier, it is possible to show that the consumer is better off when he has access to a securities market. To do so, it is sufficient to compare the allocation attained by the investor in the competitive market equilibrium, namely $(C_1^{i*}, C_2^{p*}) = (1, R)$, with the set of all efficient allocations that can be achieved under autarky.
In the autarky model, consumption depends on the portfolio choice. In particular, consumption is given by

$$C_1^i = b$$

and

$$C_2^p = b + (1 - b)R$$

with

$$0 \leq b \leq 1.$$

Therefore, the maximum attainable value for an impatient consumer is obtained at $(C_1^{i*}, C_2^{p*}) = (1,1)$, whereas the maximum attainable value for a patient consumer corresponds to the allocation $(C_1^{i*}, C_2^{p*}) = (0, R)$.
As previously discussed, the line segment connecting these two points represents the set of all feasible efficient allocations under autarky.

By plotting the set of possible optimal allocations under autarky together with the market equilibrium allocation in a single diagram (Figure), it becomes evident that the autarky model is less efficient than the market-based model.

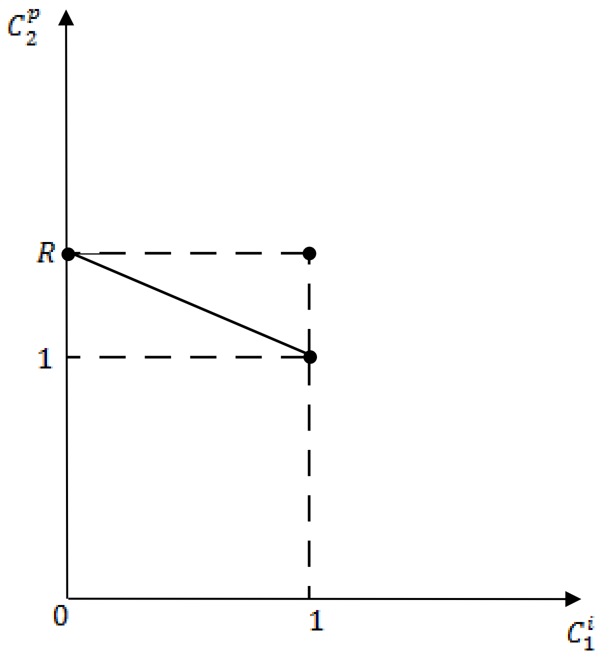

Figure Comparison between the feasible allocations under autarky and the market allocation.

In the figure, the market allocation $(1, R)$ lies well above any optimal allocation attainable under autarky. Therefore, the market-based model is more efficient than the autarky framework[15].

1.5 Investment Model with the Presence of a Planner

After analyzing the simple autarky scenario and the framework in which agents are allowed to operate in a market, an additional assumption is now introduced, which forms the basis of the third investment model. Consider the presence of a central planner[16] who has both the ability and the objective to determine how the initial endowment of individuals should be allocated in order to maximize their expected utility. It is further assumed that the planner has complete knowledge of the economy, including the ability to identify the type of each consumer.

The central planner chooses the per-capita quantity a invested in long-term assets and the per-capita quantity $b$invested in short-term assets for the entire population. Moreover, the planner selects the level of consumption C_1 for impatient consumers at time $t = 1$ and the level of consumption C_2 for patient consumers at time $t = 2$.

Naturally, the planner's decisions are constrained by feasibility requirements. As a result, he must satisfy three distinct feasibility constraints.

[15] This result reflects the First Welfare Theorem under competitive markets. See Debreu (1959); Mas-Colell et al. (1995).

[16] The planner's problem corresponds to a standard social welfare maximization framework. See Arrow (1951); Debreu (1959).

The first constraint applies at time $t = 0$, when the planner determines how to allocate the initial endowment. It is immediate that total per-capita investment must equal the per-capita initial endowment. Therefore,

$$a + b = 1.$$

The second constraint applies at time $t = 1$. At this date, the feasibility condition concerns total per capita consumption, which must be less than or equal to the returns generated by short-term investment. Since γ denotes the fraction of impatient consumers and C_1 represents the consumption of a representative impatient consumer, total per capita consumption at time $t = 1$ is equal to γC_1. Therefore, the feasibility constraint is given by $\gamma C_1 \leq b$. From this inequality, it follows that part of the available resources may remain unconsumed at time $t = 1$ and can be reinvested in short-term assets to be consumed at time $t = 2$.

As a consequence, total per capita wealth available at time $t = 2$ is given by $Ra + (b - \gamma C_1)$. This amount must be at least as large as total per capita consumption of patient consumers at time $t = 2$, which equals $(1 - \gamma)C_2$, since the fraction of patient consumers is $1 - \gamma$ and C_2 denotes the consumption of a representative patient consumer. Therefore, the final feasibility constraint is:

$$(1 - \gamma)C_2 \leq Ra + (b - \gamma C_1),$$

which can equivalently be written as

$$(1 - \gamma)C_2 \leq R + (1 - R)b - \gamma C_1.$$

The planner's objective is to choose an investment portfolio (a, b) and a consumption allocation (C_1, C_2) in order to maximize the investor's expected utility.

At this stage, the central planner's problem can be stated as follows:

$$max_{C_1,C_2} \qquad \gamma U(C_1) + (1 - \gamma)U(C_2)$$

$$such\ that \quad \begin{cases} a + b = 1 \\ \gamma C_1 \leq b \\ (1 - \gamma)C_2 \leq R + (1 - R)b - \gamma C_1 \end{cases}$$

After deriving the constraints, it is useful to make an observation that allows us to simplify the planner's problem. The planner aims to achieve an optimal allocation. However, reinvesting wealth that remains unconsumed at time $t = 1$ in short-term assets in order to consume it at time $t = 2$ does not appear to be an efficient choice.

To demonstrate this, suppose by contradiction that $\gamma C_1 < b$. It follows that a positive amount of wealth, say $\theta > 0$, is not consumed at time 1 and is therefore reinvested in the short-term asset until time 2. Since the short-term asset yields a return equal to 1, this reinvestment generates wealth equal to θ at time 2.

However, had this same amount θ been invested in the long-term asset at time $t = 0$, it would have generated wealth equal to θR, with $\theta R > \theta$. This implies that it cannot be efficient to find oneself at time 1 in a situation where $\gamma C_1 < b$. Therefore, in order to reach an optimal allocation, it must hold that $\gamma C_1 = b$, and consequently $(1-\gamma)C_2 = Ra$.
It follows that, once a and b have been determined, the optimal consumption allocation satisfies the relations $C_1 = \frac{b}{\gamma}$ and $C_2 = \frac{Ra}{1-\gamma}$.
The expression for C_2can also be rewritten by using the variable $b$instead of a, as follows:

$$C_2 = \frac{R(1-b)}{1-\gamma}.$$

Once the consumption equations have been identified, they can be used to characterize the set of feasible allocations in the planner's problem. Since any choice of $b$must lie in the interval [0, 1], it is possible to derive the corresponding boundary allocations.

Consumption for a patient individual is maximized when $b = 0$. Under this condition, the resulting allocation is $(C_1, C_2) = (1/\gamma, 0)$. Conversely, consumption for an impatient individual is maximized when $b = 1$. In this case, the allocation becomes $(C_1, C_2) = (0, R/(1-\gamma))$.

Since the consumption equations are linear in b, every point on the line segment connecting $(1/\gamma, 0)$ with $(0, R/(1-\gamma))$ belongs to the feasibility frontier of the planner's problem. Using the equation of the straight line passing through two points, as already done in the autarky model, the feasibility constraint can be written as follows:

$$C_2 = -\frac{R\gamma}{1-\gamma}C_1 + \frac{R}{1-\gamma}$$

this can be rewritten as

$$(1-\gamma)C_2 + \gamma R C_1 = R$$

Based on these considerations, the planner's problem can be formulated as follows:

$$max_{C_1,C_2} \qquad \gamma U(C_1) + (1-\gamma)U(C_2)$$

$$\textit{such that} \qquad (1-\gamma)C_2+\gamma R C_1 = R.$$

If we exclude the possibility of corner solutions, that is, cases in which $b = 1$ or $b = 0$, the optimal consumption allocation can be determined by equating the marginal rate of substitution implied by the utility function to the slope of the feasibility constraint. Therefore,

$$-\frac{\gamma U'(C_1^*)}{(1-\gamma)U'(C_2^*)} = -\frac{R\gamma}{1-\gamma}$$

Simplifying the above expression, we obtain

$$\frac{U'(C_1^*)}{U'(C_2^*)} = R$$

which can be rewritten as

$$U'(C_1^*) = U'(C_2^*)R.$$

From this condition, several observations can be derived that help clarify the planner's problem. Since $R > 1$, it immediately follows that $U'(C_1^*) > U'(C_2^*)$. The derivative of a function at a given point represents the slope of the tangent line to the function at that point. Therefore, given that the utility function is increasing and concave, it follows that

$$C_1^* < C_2^*.$$

The above result can be easily visualized by referring to the graph of a utility function.

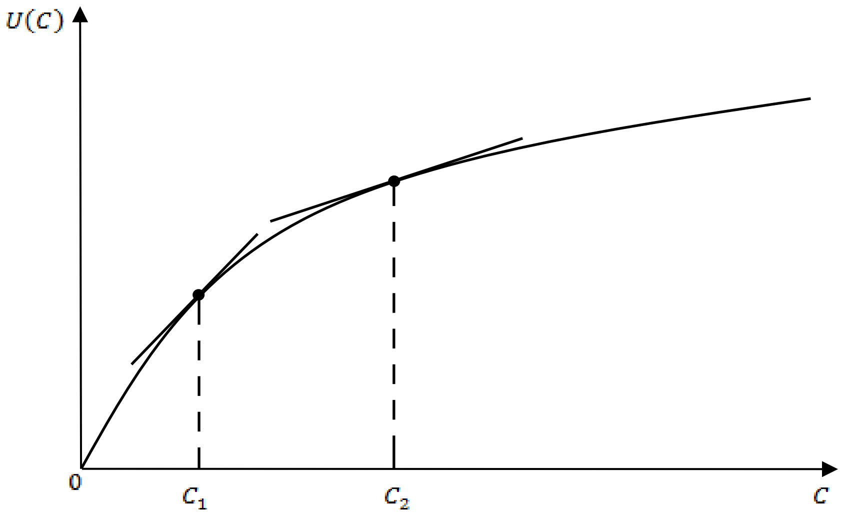

Figure Possible utility function $U(C)$with the values $C_1$and C_2highlighted.

From the graph, it can be observed that the derivative at $C_1$is larger (and therefore the tangent is steeper) than at C_2.

This inequality provides an additional insight into the set of optimal consumption allocations. Not all points on the line segment connecting $(1/\gamma, 0)$ with $(0, R/(1-\gamma))$ represent optimal allocations; rather, only the subset of points satisfying the condition $C_1 < C_2$ can be optimal.

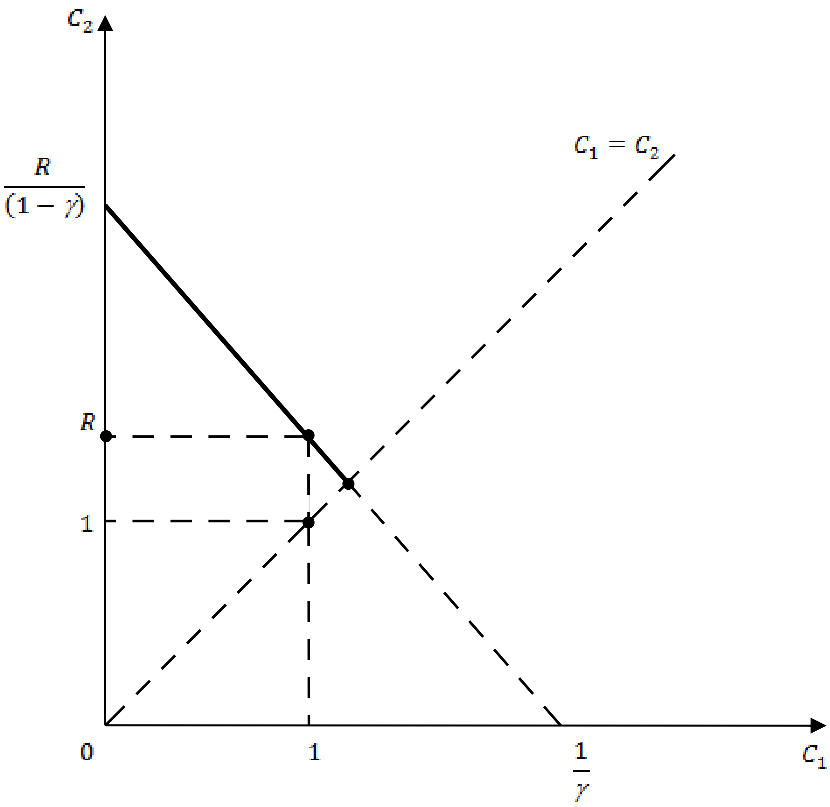

Figure Feasible and optimal consumption allocations in the planner's problem.

The optimal allocation is determined at the tangency between the feasibility frontier and the highest attainable indifference curve, and its position along the frontier depends on the consumer's preferences.

1.5.1 Possible Optimal Allocations in the Planner's Problem

To represent the consumer's preferences, one may adopt a utility function with constant relative risk aversion (CRRA)[17]. This class of utility functions is defined as

$$U(C) = \frac{C^{1-\sigma}}{1-\sigma} \quad if \quad \sigma > 0 \quad and \quad \sigma \neq 1$$

and

$$U(C) = \ln c \quad if \quad \sigma = 1.$$

[17] The CRRA utility specification was introduced by Arrow (1965) and Pratt (1964).

In this specification, the parameter σ represents the coefficient of relative risk aversion[18]. Consequently, different values of σ correspond to different degrees of risk aversion.

As previously established, the optimal allocations in the planner's problem must satisfy the condition

$$\frac{U'(C_1^*)}{U'(C_2^*)} = R$$

Using this equality, the optimal allocations can be computed under the CRRA utility specification, parametrizing the solution with respect to σ.

In the case where $\sigma > 0$ and $\sigma \neq 1$, the first derivative of the CRRA utility function is given by

$$U'(C) = C^{-\sigma}$$

Therefore, the ratio of the first derivatives evaluated at C_1 and C_2, respectively, is equal to

$$\frac{U'(C_1)}{U'(C_2)} = \frac{C_1^{-\sigma}}{C_2^{-\sigma}} = \left(\frac{C_2}{C_1}\right)^{\sigma}$$

Since, at an optimal allocation, this ratio must be equal to R, it follows that

$$\left(\frac{C_2^*}{C_1^*}\right)^{\sigma} = R$$

which can be rewritten as

$$\frac{C_2^*}{C_1^*} = R^{\frac{1}{\sigma}}$$

Therefore, when $\sigma > 0$ and $\sigma \neq 1$, the efficient allocation satisfies the following conditions:

$$C_2^* = C_1^* \, R^{\frac{1}{\sigma}}$$

and

$$(1-\gamma)C_2^* + \gamma R C_1^* = R$$

The optimal allocations clearly depend on the value of the parameter σ.
By analyzing the behaviour of $R^{1/\sigma}$, it can be observed that, since $R > 1$, when $\sigma < 1$ we have $R^{1/\sigma} > R$, whereas when $\sigma > 1$ it follows that $R^{1/\sigma} < R$.
rom this, it follows that as σincreases, that is, as the degree of relative risk aversion increases, the ratio C_2^*/C_1^* progressively decreases. In other words, the consumer increases consumption at time 1 and reduces consumption at time 2.

[18] On the interpretation of relative risk aversion, see Arrow (1965).

In the special case where $\sigma = 1$, the CRRA utility function reduces to the natural logarithm. Its first derivative is therefore given by

$$U'(C) = \frac{1}{C}.$$

Therefore, the equality between the ratio of the first derivatives evaluated at $C_1$and $C_2$and R becomes

$$\frac{\frac{1}{C_1^*}}{\frac{1}{C_2^*}} = R$$

which can be rewritten as

$$C_2^* = C_1^* R$$

Hence, when $\sigma = 1$, the efficient allocation satisfies the following conditions:

$$C_2^* = C_1^* R$$

and

$$(1-\gamma)C_2^* + \gamma R C_1^* = R$$

Since the parameter σ does not appear in these two equations, being fixed at 1, they can be solved simultaneously to determine the optimal consumption levels in the two periods. The solution is $(C_1^*, C_2^*) = (1, R)$.
Now that all feasible optimal allocations have been characterized, it is also possible to examine graphically how the allocation varies with the degree of relative risk aversion σ (Figure).

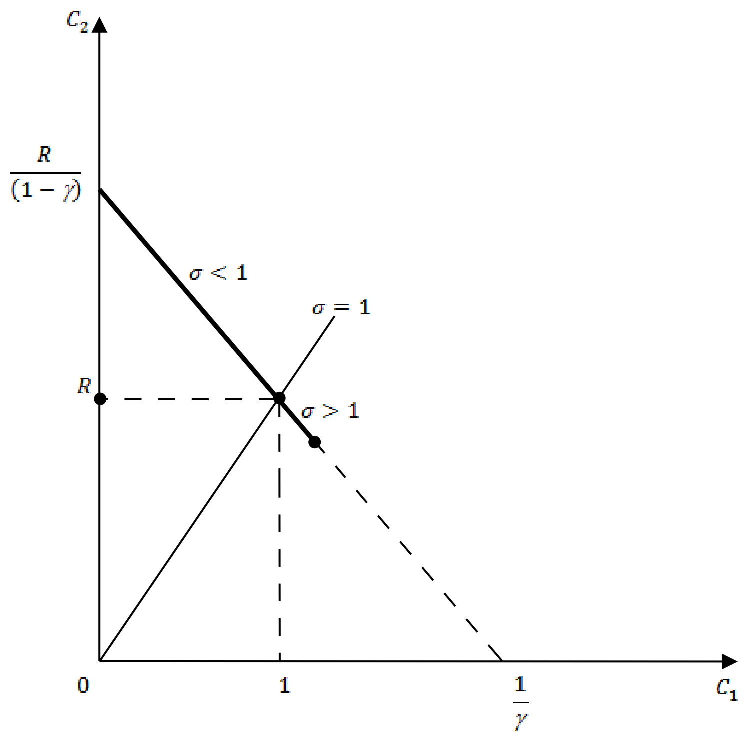

Figure Efficient consumption allocations as a function of σ.

From the graph, it can be observed that, as discussed previously, for higher values of σ the consumer is more risk-averse. As a consequence, the consumer prefers to smooth consumption more heavily toward the earlier period, increasing C_1 relative to C_2. A higher level of consumption at time 1 effectively represents a form of insurance against potential liquidity shocks.

Conversely, for lower values of σ, the consumer is less risk-averse and is therefore more willing to postpone consumption in order to obtain the higher return associated with long-term investment. In this case, the consumer allocates relatively more consumption to time 2 and is less concerned about possible unexpected liquidity needs.

In this framework, the planner effectively determines the optimal allocation by taking into account the aggregate degree of relative risk aversion in the population, as captured by the parameter σ.

1.5.2 Efficiency and Comparison with the Market Scenario

It has already been shown that the model with market participation is more efficient than the autarky framework[19]. We now turn to the analysis of the efficiency of the planner's model, comparing it with the market outcome.

If one considers the set of feasible optimal consumption allocations in the planner's model, it can be observed that the market allocation, namely $(C_1, C_2) = (1, R)$, belongs to this set. The point $(1, R)$ lies in the interior of the feasibility frontier $(1-\gamma)C_2 + \gamma R C_1 = R$ and it also satisfies the condition $C_1 < C_2$. Therefore, it may represent an optimal allocation in the planner's problem.

Having established that this allocation belongs to the set of optimal points, it is necessary to determine whether it is efficient relative to the other possible allocations. As previously discussed, the efficient allocation depends on the consumer's preferences. The CRRA utility specification can again be employed to identify the conditions under which the allocation $(1, R)$ is efficient.

The allocation $(1, R)$ is efficient under CRRA preferences only in the case where the utility function takes the logarithmic form $U(C) = \ln C$,[20] as shown in the previous derivations. Hence, when $\sigma = 1$, that is, when the coefficient of relative risk aversion equals one, the market allocation coincides with the efficient allocation chosen by the planner. For any other value of $\sigma > 0$, the highest level of efficiency can be achieved only through the intervention of a central planner.

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[19] This result reflects the First Welfare Theorem under competitive markets. See Debreu (1959); Mas-Colell, Whinston and Green (1995).

[20] Logarithmic utility corresponds to the special case σ = 1 within the CRRA class. See Arrow (1965).

1.5.3 The Banking Intermediary and the Deposit Contract

Consider now a hypothetical banking intermediary and one of its primary functions, namely the provision of deposit contracts. Suppose that the bank offers consumers the possibility of withdrawing a predetermined amount of wealth, denoted by $\hat{C}_1$, in the event that they turn out to be impatient, or a predetermined amount $\hat{C}_2$ if they are revealed to be patient. Consumers receive this promise in exchange for transferring their initial endowment to the bank, which can then invest it efficiently in short-term and long-term assets.

Assume further that the banking sector is characterized by free entry and the absence of barriers. This has two important implications. First, the expected profits of banking intermediaries must be equal to zero. Second, due to competition, each bank has an incentive to maximize the utility of its depositors.

In this framework, the problem faced by the bank is equivalent to that previously analyzed for the central planner. The bank can therefore enable its clients to achieve an efficient consumption allocation by offering a deposit contract such that $\hat{C}_1 = C_1^*$ and $\hat{C}_2 = C_2^*$. By signing this contract, consumers obtain an efficient consumption plan consistent with their degree of risk aversion, while also benefiting from insurance against unexpected liquidity needs.

An additional important aspect is that the bank is able to implement the efficient consumption allocation even though it cannot observe in advance whether a consumer will turn out to be patient or impatient. This result follows from the fact that $C_2^* > C_1^*$. Since patient consumers receive a higher payoff at time 2, they have no incentive to misrepresent themselves as impatient in order to withdraw $\hat{C}_1$ at time 1 and reinvest it privately until time 2. For this reason, the efficient allocation implemented by the bank, like that chosen by the planner, is said to be incentive compatible[21].

This framework highlights three fundamental aspects of banking activity.

The first concerns the maturity structure of bank assets, namely the possibility of offering investment opportunities with different degrees of liquidity and corresponding returns[22]. In this model, there exists a short-term liquid asset yielding a return equal to 1 and a long-term illiquid asset yielding a return $R > 1$. Greater liquidity is therefore associated with a lower return.

The second aspect relates to the theory of liquidity preference[23], that is, the uncertainty faced by consumers regarding their future liquidity needs at the time investment decisions are made.

The third concerns the insurance that the bank provides to its clients through the deposit contract against possible liquidity shocks. This insurance is made possible by pooling the resources of depositors[24]. Through risk sharing, each consumer is able to achieve a consumption plan that is

[21] On incentive compatibility in banking contracts, see Diamond and Dybvig (1983); Freixas and Rochet (2008).

[22] On maturity transformation as a core function of banking, see Diamond and Dybvig (1983); Allen and Gale (2007).

[23] The concept of liquidity preference was originally introduced by Keynes (1936).

[24] On risk pooling and delegated monitoring in banking, see Diamond (1984).

superior to the one attainable under autarky and superior (or equal, in the case $\sigma = 1$) to the allocation achieved in a securities market.

CHAPTER II

BANK FRAGILITY AND MULTIPLE EQUILIBRIA: THE DIAMOND-DYBVIG MODEL

2.1 Banking Efficiency and Fragility

In light of the results obtained in the previous chapter, the bank appears as a remarkable institution capable of implementing a Pareto-efficient allocation and maximizing investors' expected utility, regardless of their liquidity preferences[25].

However, while theoretically sound, this conclusion is not universally valid. Economic history provides numerous examples of banking and financial crises that have destroyed wealth for both financial intermediaries and depositors, often leading economies into recessions and, in some cases, severe depressions[26].

A banking crisis can be defined as a situation in which multiple banks simultaneously face liquidity pressures that may ultimately threaten their solvency. Historical examples include the U.S. banking crises prior to World War I, the Great Depression of 1929, the Asian financial crisis of 1997, and the global financial crisis of 2008.

The contribution of Diamond and Dybvig (1983) goes beyond demonstrating the efficiency of deposit contracts[27]. Their model highlights the inherent fragility of financial intermediation by developing a theoretical framework of bank runs.

Within this framework, a bank run represents an alternative equilibrium to the efficient one.[28] Although this equilibrium arises from rational behaviour, it is inefficient and may lead to the bank's default even in the absence of fundamental shocks.

By introducing the possibility of a bank run, Diamond and Dybvig identify a fourth fundamental feature of banking activity, in addition to maturity transformation, liquidity preference, and risk sharing, namely the fragility arising from multiple equilibria.[29]

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[25] For the welfare properties of competitive allocations and deposit contracts, see Debreu (1959); Diamond and Dybvig (1983).

[26] On the macroeconomic consequences of banking crises, see Bernanke (1983); Reinhart and Rogoff (2009).

[27] Douglas W. Diamond – Philip H. Dybvig, *Bank Runs, Deposit Insurance, and Liquidity*, in «Journal of Political Economy», Vol. 91, n. 3, 1983, pp. 401–419.

[28] On coordination games and multiple equilibria, see Drew Fudenberg and Jean Tirole, *Game Theory*, MIT Press, 1991.

[29] On financial fragility as an equilibrium outcome of maturity transformation, see Diamond and Rajan (2001).

2.2 Bank Run Model

Assume that the allocation (C_1, C_2) represents the optimal consumption levels promised by a bank deposit contract at dates $t = 1,2$, and that (a, b) is the bank's optimal portfolio, with a invested in long-term illiquid assets and $b$invested in short-term liquid assets. Under the assumption that there is no aggregate uncertainty[30], because liquidity risk is diversified at the aggregate level across depositors, the optimal portfolio (a, b) provides an efficient level of liquidity at each date, as long as only impatient consumers withdraw at date 1 and all patient consumers withdraw at date 2. In this case, the economy is in an efficient equilibrium, since the bank maximizes depositors' utility by delivering optimal consumption both when the depositor turns out to be patient and when the depositor turns out to be impatient.

After outlining the deposit contract framework discussed in the previous section, a new assumption is introduced. The long-term asset has so far been treated as completely illiquid, meaning that it could not be converted into consumption at date 1. Suppose now that a liquidation technology[31] exists, allowing the premature conversion of long-term illiquid assets into consumption at date 1. Early liquidation requires a loss in value and therefore yields a lower payoff. In particular, if one unit of the long-term asset is liquidated prematurely at date 1, it delivers $r \leq 1$ units of the consumption good. Premature liquidation therefore generates a loss equal to $R - r$ per unit. This means that the bank can meet withdrawals at date 1 not only by using liquid assets, but also by liquidating long-term investments.

These assumptions can lead the model to an alternative equilibrium. The basic idea behind a bank run is that depositors may come to believe that the bank will not be able to honour its commitments due to insolvency, and that they may therefore be unable to withdraw anything in the future. In this scenario, all depositors would rush to the bank, hence the term run, in order to withdraw as much as possible before the bank becomes insolvent. Faced with such a situation, the bank would be forced to liquidate its long-term assets, incurring the loss $R - r$, which would place the bank under severe stress and, as withdrawals continue, may ultimately lead it to default.

In a run equilibrium, not only impatient consumers withdraw at date 1, but patient consumers withdraw as well, driven by the fear of receiving nothing at date 2. This behaviour undermines the efficient equilibrium described above.

To see this result more clearly, suppose that all depositors, both patient and impatient, decide to withdraw at date 1. The bank would then be unable to meet withdrawals using liquid assets alone and would therefore be forced to liquidate long-term assets. As a consequence, the total value that the bank can generate at date 1 equals

$$ra + b \leq a + b = 1$$

[30] Diamond and Dybvig assume liquidity risk is idiosyncratic and diversified at the aggregate level; see Diamond and Dybvig, 1983.

[31] Diamond and Dybvig, *Bank Runs*, cit., pp. 408–410.

In this case, the bank cannot pay more than one unit of consumption at date 1.

If $C_1 > ra + b$, the bank becomes insolvent and is unable to satisfy the full consumption promised to depositors who withdraw at date 1. It will only be able to repay a fraction of the promised amount.

It is important to note that if the bank exhausts all its resources to meet early withdrawals, any depositor who decides to wait until date 2 will receive nothing.

Suppose now that the bank must use a large share of its assets to satisfy an unexpectedly high level of early withdrawals. In order to deliver the promised consumption level C_1, the bank is forced to liquidate a substantial amount of long-term assets. However, because $r \leq 1$, liquidation destroys value. As a result, the bank can no longer guarantee the full promised level of consumption C_2 to those who wait until date 2. Since long-term assets are liquidated at a discount, the reduction in available resources is more than proportional to the increase in early withdrawals. Some patient depositors may therefore receive nothing.

Faced with such a situation, a patient depositor who believes that all other depositors will withdraw at date 1 finds it optimal to withdraw as well, in order to secure at least part of the promised payment before resources are depleted. Waiting until date 2 would imply receiving nothing.

It follows that a bank run constitutes an equilibrium of the banking model.

The decision to withdraw early or remain patient depends on expectations[32] about others' behaviour. For this reason, the situation can be analyzed as a strategic game. Let the rows represent the possible actions of a representative patient depositor, and the columns represent the actions of all other patient depositors taken collectively. The game is non-cooperative but not of the standard two-by-two type, since the column player represents the aggregate behaviour of all other patient depositors rather than a single individual. The equilibrium therefore depends on the best response of the representative depositor given the collective action of the others.

The payoff pairs in the matrix represent the outcome for the representative patient depositor (first element) and for the remaining patient depositors (second element). The game can therefore be represented as follows[33]:

	Run	$Wait$
Run	$(ra + b; ra + b)$	$(C_1; C_2)$
$Wait$	$(0; ra + b)$	$(C_2; C_2)$

[32] On self-fulfilling crises, see Jean Tirole, *The Theory of Corporate Finance*, Princeton University Press, 2006.

[33] For a formal treatment of bank runs as coordination games, see Franklin Allen and Douglas Gale, *Financial Contagion*, Journal of Political Economy, 2000.

Keeping in mind that

$$0 < ra + b < C_1 < C_2,$$

it follows that the two possible equilibria of the game are $(Run\,;\ Run)$ and $(Wait\,;\ Wait)$. From the payoff matrix, it is straightforward to see how both equilibria may arise. The first is the Pareto-efficient equilibrium in which all patient depositors wait and the bank continues to operate normally. The second is the bank run equilibrium, in which all depositors withdraw early.

The efficient equilibrium is clearly preferable for both depositors and the bank. However, whether a run occurs does not depend on poor management or excessively risky portfolio choices. Rather, the selection of the equilibrium depends entirely on expectations. What matters is what each depositor believes the others will do.

If depositors expect others to wait, waiting is optimal. If they expect others to withdraw, withdrawing becomes the best response. The bank run is therefore a self-fulfilling equilibrium[34] driven by beliefs rather than fundamentals.

2.2.1 A Self-Fulfilling Prophecy

A self-fulfilling prophecy[35] can be defined as a belief or expectation concerning a particular situation that is initially false, but which, merely by being expressed or believed, triggers behaviours that ultimately make that situation become true.

This sociological concept was introduced by Robert K. Merton (1968), who drew inspiration from another American sociologist, William Thomas, author of what is known as the Thomas theorem: “If men define situations as real, they are real in their consequences” (1928).[36]

Reflecting on Thomas’s work, Merton stressed that individuals act not only on objective facts, but on how they interpret the situation around them, based on the information and beliefs they hold. Human action depends not only on objective circumstances, but also on the way individuals perceive and interpret those circumstances through their beliefs and cultural background.

The phenomenon of a bank run can be interpreted as a self-fulfilling prophecy. If depositors come to believe that a bank is insolvent, they will act as if this were true by rushing to withdraw their deposits in order to safeguard their savings. This behaviour, regardless of whether the bank is fundamentally sound or actually insolvent, may push the bank into distress and ultimately into default, thereby validating the initial belief.

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[34] On coordination failures and multiple equilibria, see Michael Cooper and Andrew John, *Coordinating Coordination Failures*, Quarterly Journal of Economics, 1988.

[35] Robert K. Merton, *The Self-Fulfilling Prophecy*, The Antioch Review, 8(2), 1948.

[36] William I. Thomas and Dorothy S. Thomas, *The Child in America*, Knopf, 1928.

Merton himself illustrated the idea of a self-fulfilling prophecy through a parable describing a bank run, which he used to demonstrate how expectations alone can generate real economic consequences.

"It is the year 1932. The Last National Bank is a flourishing institution. A large part of its resources is liquid without being watered. Cartwright Millingville has ample reason to be proud of the banking institution over which he presides. Until Black Wednesday. As he enters his bank, he notices that business is unusually brisk. A little odd, that, since the men at the A.M.O.K. steel plant and the K.O.M.A. mattress factory are not usually paid until Saturday. Yet here are two dozen men, obviously from the factories, queued up in front of the tellers' cages. As he turns into his private office, the president muses rather compassionately: 'Hope they haven't been laid off in midweek. They should be in the shop at this hour.'

But speculations of this sort have never made for a thriving bank, and Millingville turns to the pile of documents upon his desk. His precise signature is affixed to fewer than a score of papers when he is disturbed by the absence of something familiar and the intrusion of something alien. The low discreet hum of bank business has given way to a strange and annoying stridency of many voices. A situation has been defined as real.

And that is the beginning of what ends as Black Wednesday—the last Wednesday, it might be noted, of the Last National Bank. Cartwright Millingville had never heard of the Thomas theorem. But he had no difficulty in recognizing its workings. He knew that, despite the comparative liquidity of the bank's assets, a rumor of insolvency, once believed by enough depositors, would result in the insolvency of the bank. And by the close of Black Wednesday—and Blacker Thursday—when the long lines of anxious depositors, each frantically seeking to salvage his own, grew to longer lines of even more anxious depositors, it turned out that he was right.

The stable financial structure of the bank had depended upon one set of definitions of the situation: belief in the validity of the interlocking system of economic promises men live by. Once depositors had defined the situation otherwise, once they questioned the possibility of having these promises fulfilled, the consequences of this unreal definition were real enough […]. The rumored insolvency of Millingville's bank did affect the actual outcome. The prophecy of collapse led to its own fulfillment."
(Merton, R. K. (1948). "The Self-Fulfilling Prophecy." *The Antioch Review*, 8(2), 193–210.)

2.2.2 Suspension of Convertibility

Several criticisms[37] were raised against the Diamond-Dybvig model, arguing that bank runs could be prevented through the suspension of convertibility, that is, by allowing the bank to refuse withdrawal requests once a certain threshold has been reached.

This criticism is based on a fundamental feature of the model: depositors who wish to withdraw must line up and are served sequentially. During a run, the bank pays each depositor the promised amount in full until its resources are exhausted, leaving those who arrive later with nothing. It is precisely this sequential service structure that generates the incentive to withdraw early and has therefore been the focus of the criticism.

If banks commit to suspending convertibility[38] once the proportion of withdrawals equals the proportion of impatient consumers, patient depositors would have no incentive to withdraw prematurely. They would know that the bank will not be forced to liquidate long-term investments to meet an excessive level of early withdrawals, and that sufficient resources will remain available to honour the promised payments at date 2. Moreover, if a patient depositor were to withdraw at date 1, he would receive less than the promised future payment and would therefore be strictly worse off than if he had waited until date 2. Under such a rule, the bank run equilibrium would not arise.

Motivated by these criticisms, Diamond and Dybvig incorporated into their model a sequential service constraint within the deposit contract. Under this assumption, depositors are served one after another and receive the promised amount C_1 until the bank can no longer meet additional withdrawal demands.

The combination of the sequential service constraint and suspension of convertibility can eliminate the possibility of a bank run, but only if the bank knows the exact fraction of impatient consumers. Only with such information can the bank determine the precise moment at which convertibility should be suspended. If instead the proportion of impatient consumers is random and unknown, as is the case in reality, the optimal allocation cannot generally be implemented through suspension alone. The bank would not know when to impose suspension and would only discover the appropriate threshold once a run is already underway. In such circumstances, suspension of convertibility cannot reliably prevent a bank run.

2.2.3 Sunspot

The analysis proposed by Diamond and Dybvig highlights the intrinsic fragility of a banking system based on maturity mismatch, that is, the transformation of short-term liquid liabilities into long-term illiquid assets. This structural feature gives rise to two possible equilibria.

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[37] For critiques of the suspension mechanism, see Gary Gorton, *Banking Panics and Business Cycles*, Oxford Economic Papers, 1988.

[38] On suspension clauses in banking history, see Calomiris and Gorton, *The Origins of Banking Panics*, 1991.

Both equilibria emerge from decisions taken at date 0, when the bank chooses a portfolio (a, b) and promises a consumption allocation $(C_1; C_2)$ with the expectation of implementing the efficient allocation. In other words, the potential bank run at date 1 is not anticipated at date 0 by the planner or by the bank. The run equilibrium is not incorporated into the initial optimization problem.

In this framework, decisions at date 0 are made under the assumption that no run will occur. If a bank run were perfectly foreseeable, the bank would adopt a different portfolio strategy. For example, if a run were certain at date 0, the bank would invest exclusively in liquid assets. However, in such a case, the role of the bank would become redundant, since the same allocation could be achieved under autarky without financial intermediation.

The uncertainty[39] surrounding bank runs stems from the fact that they may arise from a wide range of economic circumstances, most of which are not directly related to the fundamentals of the monetary or banking system.

This conclusion was further developed by David Cass and Karl Shell (1983), who demonstrated that rational behaviour alone is not sufficient to ensure a unique economic equilibrium. In particular, they showed that equilibria may depend on extrinsic uncertainty[40], that is, on events that have no direct effect on fundamentals but can influence expectations.

In this perspective, a bank run arises from the common belief among depositors that others will withdraw their savings. The diffusion of panic is therefore driven by expectations rather than by observable fundamentals, and such expectations are inherently unpredictable.

2.2.4 Deposit Insurance and Moral Hazard

Suspension of convertibility can eliminate the possibility of a bank run only if the bank knows the exact fraction of impatient consumers. This assumption is unrealistic in an actual banking system, where the volume of withdrawals is stochastic and cannot be known with certainty in advance.

Diamond and Dybvig therefore propose an alternative mechanism to eliminate the incentives for a run, namely a system of deposit insurance. Under deposit insurance, the consumption promised by the bank is guaranteed to all depositors. This guarantee may be provided by the government, which commits to supporting the bank in the event of an unexpected surge in withdrawals. By absorbing the pressure generated by a run, the government ensures that long-term investors have no reason to fear that they will be unable to withdraw their promised funds in the future. As a consequence, patient depositors will optimally choose to wait until the maturity of their investments.

By removing the possibility of a bank run, deposit insurance eliminates the inefficient equilibrium and leaves only the efficient allocation[41] identified in the planner's solution.

[39] On extrinsic uncertainty and sunspot equilibria, see Cass and Shell, 1983.

[40] David Cass and Karl Shell, *Do Sunspots Matter?*, Journal of Political Economy, 91(2), 1983.

[41] Diamond and Dybvig, 1983, pp. 414–417.

Historically, deposit insurance has been implemented to prevent banking panics. In the United States, for example, the Glass-Steagall Act of 1933 introduced federal deposit insurance through the creation of the Federal Deposit Insurance Corporation (FDIC). Following its introduction, the U.S. banking system experienced several decades without major bank runs. Although the Glass-Steagall Act will be examined in greater detail later, its early introduction here illustrates the effectiveness of deposit insurance in stabilizing expectations and preventing runs.

However, deposit insurance introduces a significant problem: moral hazard. Up to this point, the analysis has focused exclusively on depositors' behaviour, both in terms of beliefs and actions. In the theoretical model, a bank run may occur independently of the bank's portfolio choices. In reality, however, banks actively choose their investment portfolios, facing the standard trade-off between risk and return.

By removing the risk faced by depositors, deposit insurance alters banks' incentives. If losses are ultimately borne by the insurance system and therefore by taxpayers, banks may be encouraged to undertake riskier investments in pursuit of higher returns. The additional profits generated by these higher-risk strategies may be transferred to shareholders and depositors, while the downside risk is absorbed by the public guarantee.

Moreover, insured banks do not face the same market discipline[42], since depositors no longer have an incentive to withdraw funds in response to increased risk-taking. Banks may even attract more customers by offering higher returns than more prudent competitors.

The shifting of additional risk onto the government, and ultimately onto taxpayers, encourages excessive risk-taking and increases the likelihood of financial instability. This may lead to more frequent government interventions during crises, creating a vicious circle in which public guarantees generate risk-taking, which in turn generates crises that require further public support.

The only way to directly address this problem is through prudential regulation[43] that limits excessive risk-taking by insured banks. However, restricting banks' portfolio choices may reduce the availability of high-risk, high-return deposit products that some less risk-averse investors would willingly choose. These investors may respond by seeking alternative, less regulated financial instruments that offer higher returns.

This imbalance between regulated supply and investor demand has contributed to the development of new financial intermediaries that perform functions similar to traditional banks but operate outside the same regulatory framework. These alternative institutions often offer higher returns precisely because they are subject to fewer regulatory constraints.[44]

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[42] On market discipline in banking, see Calomiris and Kahn, *The Role of Demandable Debt*, Journal of Political Economy, 1991.

[43] For regulation and moral hazard in banking, see Freixas and Rochet, *Microeconomics of Banking*, MIT Press, 2008.

[44] On the rise of shadow banking, see Tobias Adrian and Hyun Song Shin, *The Shadow Banking System*, Federal Reserve Bank of New York Staff Report, 2009.

2.3 Shadow Banking System

To properly understand the development of these new forms of financial intermediation, it is first necessary to distinguish them from the concept of traditional banking, similar to the banking model analyzed in the previous sections. In Italy, banking activity is legally defined by Article 10 of Legislative Decree No. 385/1993 (the Consolidated Banking Act), which states that “the collection of savings from the public and the granting of credit constitute banking activity […] and the exercise of banking activity is reserved to banks.” This definition emphasizes the core functions of traditional banking: deposit-taking from the public and credit provision.

In the United States, the first formal separation between commercial banks and other financial institutions was introduced in 1933, following the financial crisis that began in 1929 and culminated in the Great Depression. During that period, repeated bank runs severely weakened the financial system, creating the need to limit speculative activities and restore confidence in the banking sector. The Glass-Steagall Act[45] of 1933 introduced two major reforms. First, it established a strict separation between commercial banking and investment banking, prohibiting a single institution from engaging simultaneously in both activities. This measure aimed to prevent instability in investment banking from spreading to deposit-taking institutions. Second, the Act imposed significant restrictions on the risks that commercial banks could undertake, while introducing deposit insurance through the creation of the Federal Deposit Insurance Corporation (FDIC). This public guarantee, backed by taxpayers, was intended to prevent bank runs and reduce the likelihood of systemic banking panics. Investment banks, by contrast, were subject to lighter regulation, largely because they did not accept insured deposits and were therefore not directly exposed to traditional bank runs. This regulatory framework contributed to financial stability in the United States for several decades, despite episodes of turbulence such as those experienced during the 1980s.

The hypothesis that alternative forms of intermediation would develop alongside or in place of traditional bank deposits is not merely theoretical. Lucas and Stokey (2011)[46] document that in 1965 traditional bank deposits accounted for approximately 18 percent of U.S. GDP, whereas by 2005 this share had declined to about 5 percent. As investors gradually shifted away from regulated deposit instruments, investment banks and money market funds increasingly assumed the role of alternative providers of financial services similar to those offered by commercial banks. Like traditional banks, these institutions accepted funds in exchange for the promise of repayment with interest, while granting investors flexibility in deciding when to withdraw their funds. The underlying objective remained unchanged: to reconcile the depositor’s desire to earn return, often generated through relatively illiquid investments, with the need for readily

[45] Banking Act of 1933 (Glass-Steagall Act), Pub. L. 73–66.

[46] Robert E. Lucas and Nancy L. Stokey, *Liquidity Crises*, NBER Working Paper No. 17317, 2011.

available liquidity. In this sense, these institutions replicated the liquidity transformation function characteristic of traditional banking.

The crucial difference, however, lies in regulation. These non-bank credit intermediaries operate under significantly lighter regulatory constraints, which allow them to assume greater risk and potentially achieve higher returns. The collection of these institutions and activities constitutes what is commonly referred to as the shadow banking system. Pozsar et al. (2010)[47] define shadow banking as the system of credit intermediation that takes place outside the traditional banking sector and operates without official public guarantees on the solvency and liquidity of liabilities. The shadow banking system encompasses a wide range of intermediaries and financial instruments performing functions similar to those of banks.

Estimates by the Financial Stability Board (FSB, 2012)[48] highlight both the size and the rapid expansion of the shadow banking sector. In 2010, the global shadow banking system amounted to approximately €46 trillion, more than double its estimated size of €21 trillion in 2002. This represented roughly 25 to 30 percent of the global financial system and nearly 50 percent of total banking assets. In the United States, shadow banking accounted for between 35 and 40 percent of the overall financial system. During the period 2005–2010, the share of non-bank financial intermediaries within the global shadow banking system increased significantly in Europe, while declining in the United States.

The expansion of shadow banking in the United States gained momentum during the 1980s, particularly as the regulatory framework established by Glass-Steagall gradually weakened. The oil shocks of the 1970s marked the end of the long period of postwar economic stability, and the divergence between the relatively low interest rates paid on regulated and insured bank deposits and the higher returns available in less regulated money markets encouraged depositors to reallocate their funds. Money market funds, operating outside the constraints imposed on commercial banks, offered higher yields and attracted substantial inflows. Shadow banking institutions relied heavily on short-term wholesale funding instruments, such as commercial paper and repurchase agreements, to finance longer-term investments, including asset-backed securities.

This model of intermediation, characterized by the absence of deposit insurance and by a heavy reliance on short-term market-based liabilities, is inherently more fragile. Although investors are attracted by higher interest rates, the structural maturity mismatch between short-term liabilities and longer-term, less liquid assets exposes these institutions to the risk of runs. While such runs may differ in form from traditional retail bank runs, the underlying mechanism remains similar: if short-term creditors refuse to roll over funding, institutions may be forced into fire sales of assets, potentially leading to insolvency. A system that combines short-term liabilities with investments that cannot be easily liquidated is therefore vulnerable to destabilizing withdrawal dynamics that may ultimately compromise its solvency.

[47] Zoltan Pozsar et al., *Shadow Banking*, Federal Reserve Bank of New York Staff Report No. 458, 2010.

[48] Financial Stability Board, *Global Shadow Banking Monitoring Report*, 2012.

2.3.1 The Repurchase Agreement Market

To fully understand the shadow banking system and the mechanisms through which it may become unstable, it is useful to analyze one of its most representative instruments, the repurchase agreement, commonly referred to as a repo contract.

In a repurchase agreement, a lender provides cash to a borrower in exchange for securities, which may include government bonds or other money market instruments. These securities serve as collateral, since the borrower commits to repurchasing them at a predetermined future date and at a predetermined price, typically higher than the initial sale price. From an economic perspective, a repo contract is equivalent to a short-term collateralized loan. The initial transfer of securities corresponds to the extension of credit, while the repurchase at a higher price reflects the repayment of principal plus interest. Repo contracts are generally short-term in nature, ranging from overnight maturity to several months, with an average duration between one and three months.

The main providers of funds in the repo market include money market mutual funds, hedge funds, and investment banks. For these institutional investors, the repo market performs a function similar to that of a commercial bank for its depositors. By entering into repo contracts, lenders avoid leaving their cash idle and instead put it to work in a relatively safe and flexible way. Rather than holding liquidity that earns nothing, they can generate a return while still retaining the ability to access their funds on short notice. Because repo agreements are typically very short-term, lenders remain in control: if uncertainty rises or market conditions shift, they can simply decline to renew the contract and recover their money. Under normal circumstances, this balance between profitability and flexibility makes the repo market especially appealing. It offers a way to keep cash productive without giving up the reassurance of being able to withdraw it quickly if needed.

Viewed in this way, a repurchase agreement closely resembles a bank deposit contract. It is therefore necessary to examine whether the repo market may also be subject to dynamics analogous to a bank run.

Consider a shock that increases uncertainty regarding the financial soundness of borrowing institutions. In such a scenario, lenders may decide not to renew repo contracts and instead withdraw their funds in order to meet potential liquidity demands from their own clients. Borrowers would then face difficulty in securing short-term financing. The resulting contraction in funding supply could force them to sell assets to generate liquidity, thereby exerting downward pressure on asset prices. A decline in collateral values may further weaken borrowers' balance sheets, potentially leading to a liquidity spiral[49] and financial distress.

The role of collateral in repo contracts resembles, to some extent, the role of deposit insurance in traditional banking. When lenders decide whether to renew short-term funding, the presence

[49] On liquidity spirals, see Markus Brunnermeier and Lasse Pedersen, *Market Liquidity and Funding Liquidity*, Review of Financial Studies, 2009.

of relatively safe collateral increases their willingness to continue providing funds and reduces the probability of a run. However, unlike deposit insurance, collateral does not eliminate the risk entirely, since its value is subject to market fluctuations. If the market value of collateral declines, lenders may demand higher haircuts or refuse to roll over contracts altogether.

Like other forms of short-term financing, repo contracts are therefore vulnerable to run-like dynamics[50]. Suppose that a significant number of lenders simultaneously decide not to renew their loans. Such behaviour may spread if market participants begin to doubt the quality of the collateral or the solvency of borrowing institutions. Even if the initial withdrawals do not immediately generate widespread insolvency, they may trigger a substantial decline in collateral values and redirect funding toward contracts backed by assets perceived as safer. The resulting liquidity pressure can destabilize the system, particularly when institutions rely heavily on short-term wholesale funding to finance longer-term and less liquid investments.

In this respect, the repo market illustrates how shadow banking replicates the fundamental mechanism of maturity transformation characteristic of traditional banks, while remaining exposed to similar forms of instability. A system characterized by short-term liabilities and assets that cannot be liquidated without significant losses is inherently vulnerable to withdrawal dynamics that may ultimately threaten solvency.

[50] Gary Gorton and Andrew Metrick, *Regulating the Shadow Banking System*, Brookings Papers on Economic Activity, 2010.

CHAPTER III

THE EUROZONE CRISIS AND CENTRAL BANK INTERVENTION

3.1 Coordination in Sovereign Markets

From a microeconomic perspective, the Eurozone sovereign debt crisis can be interpreted as a coordination problem similar to the bank run mechanism discussed in the previous chapter[51]. In the Diamond–Dybvig model, instability does not necessarily arise because fundamentals are weak, but because individual decisions depend on expectations about others' behaviour. If depositors expect others to withdraw, withdrawing becomes the rational strategy.

A similar logic applied to sovereign bond markets during the crisis. Investors were not reacting only to fiscal indicators, but also to their beliefs about how other investors would behave. If market participants expected widespread selling of sovereign bonds, prices would fall and yields would increase. Higher yields would then worsen refinancing conditions and raise doubts about debt sustainability. In this way, expectations could become self-fulfilling[52].

The market could therefore move between different equilibria. In one equilibrium, yields reflect macroeconomic fundamentals and long-term fiscal capacity. In another, spreads incorporate panic and coordination failure. Once borrowing costs reach certain levels, rollover risk intensifies and the perception of insolvency can spread rapidly. What makes this dynamic particularly fragile is that it does not necessarily require a dramatic deterioration in fundamentals. Rational investors, acting under uncertainty and observing rising spreads, may simply decide that selling is the safest option. When enough agents do so, the crisis materializes.

In this sense, the sovereign crisis resembled a large-scale version of a bank run.[53] The key element is not irrationality, but strategic interdependence. Investors' choices are interconnected, and this interdependence opens the possibility of multiple equilibria.

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[51] Douglas W. Diamond and Philip H. Dybvig, *Bank Runs, Deposit Insurance, and Liquidity*, Journal of Political Economy, 91(3), 1983, pp. 401–419.

[52] Paul De Grauwe and Yuemei Ji, *Self-Fulfilling Crises in the Eurozone*, Journal of International Money and Finance, 2013.

[53] On sovereign debt as a coordination problem, see Guillermo Calvo, *Servicing the Public Debt: The Role of Expectations*, American Economic Review, 1988.

3.2 Monetary Union Without Fiscal Backing

To really understand what happened during the Eurozone crisis, it is not enough to look only at market behaviour or investor expectations. There is also a deeper institutional issue that needs to be considered. The Eurozone is a monetary union, but it is not a fiscal union[54]. This sounds like a standard statement, but its implications are actually quite significant.

Member states issue debt in a currency they do not individually control. They do not have a national central bank that can directly create liquidity if markets suddenly stop buying their bonds. In that sense, Eurozone governments are in a very different position compared to countries like the United States or the United Kingdom. Those countries issue debt in their own currency and have a central bank that can always act as a lender of last resort. Of course this does not eliminate all risks, but it changes the nature of the problem.

In the Eurozone, instead, individual governments are closer to entities that borrow in a currency that is not fully under their control. When markets become nervous, refinancing can suddenly become very expensive. If investors start to doubt a country's ability to roll over its debt, yields can rise quickly, even if long-term fundamentals have not changed dramatically. At that point, the distinction between liquidity and solvency becomes blurred[55]. A country might be solvent in the long run, but still face severe short-term financing stress simply because confidence has weakened.

This is where the analogy with bank runs becomes particularly strong. Just as a bank relies on confidence to fund long-term assets with short-term liabilities, governments in the Eurozone rely on continuous access to bond markets. If confidence disappears, the system becomes fragile very quickly. The problem is not necessarily excessive debt in the immediate sense, but the absence of a guaranteed backstop at the national level.

The crisis therefore exposed a structural weakness in the design of the monetary union. Monetary policy was centralized, but fiscal policy remained national. There was no automatic fiscal stabilization mechanism at the European level, and no clear lender of last resort[56] for sovereigns at the beginning of the crisis. Markets were aware of this institutional gap, and once doubts emerged, they could easily amplify them.

From today's perspective, it seems clear that part of the instability was rooted in this incomplete architecture. The system was integrated enough to transmit shocks quickly, but not integrated enough to absorb them smoothly. In this context, the role of the ECB became crucial. The announcement of OMT can be seen as an attempt to compensate, at least partially, for this structural weakness. It did not create a fiscal union, and it did not solve all long-term issues.

[54] On the institutional asymmetry of the Eurozone, see Paul De Grauwe, *The Governance of a Fragile Eurozone*, CEPS Working Document, 2011.

[55] On the liquidity versus solvency distinction in sovereign crises, see Guillermo Calvo, *Capital Flows and Capital-Market Crises*, Journal of Applied Economics, 1998.

[56] European Central Bank, *The ECB's Role in Financial Stability*, Monthly Bulletin, 2012.

But it reduced the likelihood that temporary liquidity stress would escalate into a full sovereign crisis driven mainly by expectations.

Looking back, the Eurozone crisis was not only about fiscal numbers. It was also about institutional credibility and about the limits of a monetary union without full political and fiscal integration. This tension is still present today, even if markets are more stable. The experience showed that in a system like the Eurozone, credibility and institutional backing are not optional. They are necessary conditions for stability.

3.3 OMT And Credible Commitment

The Outright Monetary Transactions program[57], announced by the European Central Bank in September 2012, can be understood as an attempt to eliminate the panic equilibrium by reshaping expectations. The program allowed for potentially unlimited purchases of short-term sovereign bonds in secondary markets. However, what ultimately mattered was not the volume of purchases, but the credibility of the commitment.

From a game-theoretic perspective, OMT changed the payoff structure faced by investors. Without intervention, investors could coordinate on a pessimistic equilibrium. With a credible central bank backstop, betting against sovereign debt became significantly riskier. If the ECB was willing to intervene without predefined limits, the strategy of coordinating on a speculative attack lost much of its appeal.

The logic is similar to deposit insurance in the Diamond–Dybvig model. Deposit insurance removes the bank run equilibrium by guaranteeing payments. OMT removed the sovereign panic equilibrium by guaranteeing liquidity support under specific conditions. In both cases, credibility is central. If agents believe that the authority will intervene decisively, the incentive to run disappears. The mere announcement can be sufficient to stabilize expectations.

Another important feature of OMT was the commitment to full sterilization[58]. The ECB made clear that any bond purchases would not translate into a permanent expansion of the monetary base. This distinction was crucial in order to maintain price stability expectations. By separating liquidity support from monetary accommodation, the ECB avoided creating a second source of instability linked to inflation fears. The design of the instrument shows how credibility depends not only on strength, but also on consistency with the institution's mandate.

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[57] European Central Bank, *Technical Features of Outright Monetary Transactions*, Press Release, 6 September 2012.

[58] European Central Bank, *Liquidity-Absorbing Operations Related to OMT*, 2012.

3.4 Incentives And Perspective

Conditionality was another essential part of the OMT framework. Access to the program required a formal adjustment plan under the European Stability Mechanism[59]. This condition was not just procedural. It addressed a fundamental incentive problem.

If governments expected unconditional central bank support, fiscal discipline might weaken over time. The situation resembles the moral hazard issue discussed in Chapter II. Providing stability can reduce the incentive to behave prudently. The challenge is therefore to stabilize markets without encouraging irresponsible policies. Conditionality was designed to achieve that balance. It reassured investors that intervention would not replace structural reforms and, at the same time, protected the ECB from the accusation of financing governments without limits.

This structure also introduced a strategic interaction between governments and the central bank. A government facing rising spreads had to decide whether to request assistance, knowing that such a request could carry political costs. Waiting might reduce immediate domestic pressure, but it could also allow market tensions to worsen. The ECB, on its side, could only intervene after a formal request. This created a delicate sequencing problem in which economic rationality and political considerations did not always align.

Looking back from the perspective of 2026, OMT is widely regarded as a turning point in the Eurozone crisis. What is striking is that it was never actually activated. Sovereign spreads declined significantly after the announcement, suggesting that markets reacted primarily to the credibility of the commitment rather than to concrete purchases. This outcome supports the idea that a large part of the crisis was driven by expectations and coordination failures rather than by immediate insolvency.

In the years that followed, the logic introduced by OMT influenced other ECB instruments, including the Public Sector Purchase Programme[60], the Pandemic Emergency Purchase Programme[61], and the Transmission Protection Instrument[62]. Although these tools differ in scope and context, they share a common intuition: in financially integrated systems, instability can emerge from strategic interaction, and credible institutions are necessary to anchor expectations.

The broader lesson is consistent with the core argument of this dissertation. Financial crises often arise from rational decisions taken in environments characterized by uncertainty and interdependence. When agents' choices depend on what others are expected to do, multiple equilibria become possible. In such settings, the role of policy is not limited to correcting market failures. It is about shaping beliefs and ensuring that the efficient equilibrium becomes the most

[59] Treaty Establishing the European Stability Mechanism (ESM), 2 February 2012.

[60] European Central Bank, *Decision (EU) 2015/774 on a secondary markets public sector asset purchase programme*.

[61] European Central Bank, *ECB announces €750 billion Pandemic Emergency Purchase Programme (PEPP)*, Press Release, 18 March 2020.

[62] European Central Bank, *Transmission Protection Instrument*, Press Release, 21 July 2022.

plausible outcome. From today's perspective, OMT remains one of the clearest examples of how credibility alone can stabilize a fragile system.

CONCLUSIONS

This dissertation started from a very simple intuition, inspired by the film *A Beautiful Mind* and by John Nash's idea that outcomes do not depend only on individual rationality, but on strategic interaction. The story of Nash shows that even when individuals act rationally, the result may not be socially optimal. The equilibrium that emerges depends on how agents anticipate each other's choices.

From that initial idea, the analysis moved into the financial system. The Diamond–Dybvig model provided a formal framework to understand how banks, even when fundamentally sound, can become fragile because depositors' decisions are interdependent. A bank run is not necessarily the consequence of irrational panic. It can emerge from rational behaviour in a context where each agent tries to anticipate what others will do. In such a setting, multiple equilibria become possible. Stability is not automatic.

The same logic reappears in modern financial markets. The 2008 crisis and the subsequent sovereign debt crisis in the Eurozone showed that fragility is not limited to traditional banks. Maturity transformation, liquidity risk and strategic complementarities exist also in shadow banking and in sovereign bond markets. Investors, like depositors, observe each other. Expectations can shift quickly. When confidence weakens, rational behaviour can amplify instability instead of containing it.

The Eurozone crisis made this mechanism particularly visible. Member states issue debt in a currency they do not individually control. Without a clear lender of last resort, sovereign bond markets became vulnerable to coordination failures. Rising spreads were not only a reflection of fiscal fundamentals, but also of expectations about market behaviour. In that environment, the European Central Bank's intervention through the OMT program functioned as an equilibrium-selection device. By credibly committing to act if necessary, the ECB changed the structure of the game. The inefficient equilibrium became less plausible, even though the program was never activated.

What emerges from this analysis is that financial instability is often endogenous. It does not always require dramatic shocks or irrational bubbles. It can arise from the normal functioning of markets in which agents are interdependent. When choices depend on beliefs about others' choices, coordination becomes fragile. In such systems, institutions play a central role. Not because they eliminate risk entirely, but because they shape expectations. Credibility, commitment and institutional design become economic variables, not only political ones.

Looking back at the initial inspiration from Nash, the connection becomes clearer. Financial crises are not simply failures of rationality. They are failures of coordination under rational behaviour. The challenge for policymakers is not only to regulate balance sheets or adjust interest rates, but to influence expectations in a credible way. The experience of the Eurozone suggests that well-designed institutional commitments can prevent inefficient equilibria without necessarily requiring massive interventions.

At the same time, this study also shows the limits of purely technical solutions. A monetary union without full fiscal integration remains structurally fragile. OMT addressed an immediate coordination failure, but it did not remove the deeper institutional tensions within the Eurozone. Stability requires both credible monetary backing and political commitment.

In the end, what this dissertation suggests is that finance is not only about numbers or models. It is about interaction. It is about how individuals, institutions and markets respond to what they think others will do. Nash's insight, developed in a completely different context, turns out to be deeply relevant for understanding modern financial systems. The beauty of the theory lies in its simplicity, but also in its realism. Markets are made of people. And people, even when rational, can generate fragile outcomes when coordination breaks down.

If there is one broader lesson, it is that stability cannot be taken for granted. It must be built through credible institutions capable of anchoring expectations. In a world characterized by interdependence and uncertainty, the equilibrium we reach is not inevitable. It depends on the structure of the game and on the trust that agents place in the rules of that game.

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