# Financial Regulation and Financial Development: tradeoff or synergy?

## A Transaction Costs Approach

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**Stavros B. Thomadakis**[1]

[1]University of Athens, Department of Economics, Postal address: 14 Evripidou Street, Athens, 10559, Greece, email: thomadakis@econ.uoa.gr

**Konstantinos I. Loizos**[2]

[2]University of Athens, Department of Economics, Postal address: 12 Ioannou Zervou Street, N. Heraklio Attikis, 14121, Greece, Phone numbers: 30-210-2710-516 (home), 30-6944-586264 (mobile), email: komilos@hol.gr

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## *Abstract*

Financial regulation can be designed as policy that would accommodate rather than antagonize financial development, since regulation can be linked to building institutional protections for savers/investors. In a governance framework, regulation can lower transaction costs related to contract rights, information and enforcement costs. By doing so it can supplement pecuniary with non-pecuniary returns to savers and provide safeguards that gradually increase confidence, which corresponds to a cumulative process of 'institution-building'. This can be achieved in a manner that endogenizes fiscal sustainability, as benefits bestowed by government to the investing public can be financed by a tax on financial returns.



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## 1. INTRODUCTION

The tension between financial stability and financial liberalization is obvious, even to the layman, after the great financial crisis of 2008. Financial regulation has historically sought to achieve stability. Liberalization has long been proposed as policy that fosters financial development. Since the 1970s, the use of administered interest rates has been branded as 'financial repression' of market agents. In this paper we reconsider the nexus of government regulation and financial market development through the lens of a governance structure which could, under conditions, preserve stability and also foster development. Early critics of 'financial repression' have bequeathed a narrative of negative tradeoffs between regulation and development. This narrative misses an important ingredient: *institutional development* as an ongoing process. We argue that *when this missing element is factored into the analysis, the antagonism between regulation and development may in fact become a synergy*.

In a world where uncertainty gives rise to incomplete contracting and endogenous 'crises of confidence' in financial markets, it is necessary to think of institutional arrangements not as an exogenous infrastructure but as a process that co-evolves and interacts with the path of financial development and financial crisis. Reconsidering the nexus of public intervention and financial development as a governance structure, we utilize the insights of Williamson's (1985) (1996) contractual analysis to *expand the notion of financial return* from simple pecuniary benefit offered by private agents to non-pecuniary safeguards offered by government. We understand non-pecuniary safeguards, as they stabilize and cumulate, to reflect institutional development, the indispensable companion of financial development. On the opposite side, a financial crisis implies, in addition to pecuniary losses, negative non-pecuniary returns because it overwhelms previous safeguards, increases transaction costs and engenders institutional crisis.

The understanding of safeguards is based on Williamson's concept of 'asset specificity'. Following Williamson (1979) we understand the degree of 'ease of verification' of financial returns as having the same meaning as asset specificity.

Overcoming financial asset specificity devolves on institutional arrangements that protect asset-holders from contractual hazards by promoting verifiability of returns and confidence. Bodies of rules for disclosure, investor and creditor protection, deposit guarantees and interventions of 'last resort' are examples of 'confidence building' safeguards embedded in institutional arrangements. They all have an evolutionary element as they require the buildup of confidence based on experience and progressive acquisition of competencies in effective enforcement. They are also path-dependent, as a crisis will imply a discrete change in asset specificity and a large decline in confidence and the value of previously accumulated experience.

Our chosen approach is to show an example of how 'repression' in the form of interest rate restrictions can be consistent with development funding by maintaining the aggregate level of savings at the theoretically 'unrepressed' level; this is achieved through the offer of non-pecuniary benefits-safeguards to financial savers. We use a simple multi-period model with representative agents including banks, saver-households, and the government in a loanable-funds framework with finite horizon. We show that intervention consistent with development can be feasibly modeled, in a transaction-costs economizing framework, and depends on the risk profile of agents in the economy, including the government. A major feature of this model is that it can embody fiscally sustainable interventions over a finite but long horizon. This is a clear advantage of the selected framework, given the ultimate importance of fiscal sustainability in the overall stability of the financial system.

We show that the buildup of an optimum stock of safeguards depends on the government's rate of "political" time preference that interacts with private agents' risk-adjusted time preference. The embodiment of safeguards in the attitudes of agents is the outcome of institutional development, though with a strong behavioral component. An adverse twist in confidence, as in the 2008 crisis, can render the existing institutional edifice inadequate and require new safeguards against rising asset specificity. Consistency of interventionist policy is paramount for the attainment of its objectives.

The remainder of the paper is organized in four sections. In section 2 we undertake a review of literature on the significance of institutional development. In section 3 we develop motivation for a model which embodies the nexus of government intervention and private optimization as a governance structure providing safeguards and institutional enhancement. In section 4 we develop and analyze such a simple model. In section 5 we discuss implications and conclusions.

## 2. BRIEF LITERATURE REVIEW

Policies of interest rate regulation were heavily criticized in the McKinnon-Shaw theoretical tradition. They were deemed to be responsible for reduced supply of capital to finance investment (McKinnon, 1973; Shaw, 1973) and lower efficiency of funded investment projects (Fry, 1995). On the contrary, financial liberalization was viewed as optimal policy that would restore prices at their market levels and enable "financial deepening" (Shaw, 1973). These were cast as prerequisites for financial development that would boost both the volume and efficiency of investment.

Financial development includes increased intermediation and innovation. Levine (1997) identifies the functionality of the financial system with its ability to decrease aggregate risk by enhancing liquidity and diversifying idiosyncratic risk, to allocate capital efficiently by lowering the costs of acquiring information and coping with principal-agent problems among firms' stakeholders; to pool and channel savings from surplus to deficit units by devising contracts that lower transaction costs. The underlying unifying principle of financial development is, according to Fry(1995) the minimization of transaction and information costs. Hence, financial development appears closely related to institutional development, even in the thought of repression critics. Issues such as accounting systems for information disclosure, contract enforcement and definition and enforcement of property rights are institutional developments which are seen to directly reduce the risks that lenders assume (World Bank, 1989).

In this context, a different strand of literature stresses the importance of the legal infrastructure of LDCs concerning contract enforcement, bankruptcy procedures and banking regulation and supervision (Arestis (1999). Arestis and Glickman (2002) assert that financial liberalization in countries with weak regulatory frameworks precipitated and made financial crises more severe. The inefficiency of financial liberalization policies arises in economies institutionally unprotected from abrupt international short-term capital flows. Arestis and Stein (2005) propose a theoretical framework for institutional transformation that would take into account the existing institutional matrix of each country concerning norms, rules, incentives and existing capacities of financial organizations to assume the burden of transformation towards a more liberalized regime. Institutional development is viewed as a *process that embodies experience and expands over time*.

Noting the importance of the legal environment, the so-called 'law and finance' literature (La Porta et.al., 1998, 1999; Beck and Levine, 2004) argues that common law jurisdictions enable protections that open the horizon to arms-length markets for finance and financial development, as compared to civil law jurisdictions. In this approach the institutional makeup of societies, as expressed in legal systems, is seen as an 'endowment' which liberates markets from a multitude of encumbrances from the government and entrenched interests.

From a viewpoint of stability and normal functioning of markets, Modigliani and Perotti (1997) argue that financial liberalization, not accompanied by institutions providing legal protections of investors *and their enforcement*, might lead to instability and crisis. The absence of such protections results in a shift of institutionally underdeveloped economies to systems characterized by long-term relationship finance instead of arms-length transparent markets.

In another important strand of literature (Rajan and Zingales, 2003a, 2003b, 1998), financial repression is characterized as a governance structure constructed on a relationship-based system among incumbent large firms, banking oligopolies and the government. An important ingredient is the restriction of capital flows that insulates the financial system from external competition and market discipline. Investor protection takes on non-price forms such as specific monopoly power of the bank over the firms it finances, using connections with managers and politicians, as a means of contract enforcement. In a sense, hierarchical control is substituted for market control and makes the efficiency of the legal system and contract enforcement less important. Furthermore, dissemination of information is discouraged rather than encouraged, since disclosure endangers the system of relationship finance. All these mean that financial repression serves incumbent interests and impedes financial development.

This short review indicates a common major issue: Although it is desirable to lower the cost of capital and boost investment and financial stability through regulatory policies, the price to be paid is high as these policies might impede financial development. On the other hand, financial liberalization policies without adequate institutional apparatus might prove self-defeating. Is there then a way to think of regulation as a policy that would accommodate rather than prevent financial development? Our paper answers by studying policies from the perspective of governance structures, admitting also that institutions are not given a priori but co-evolve with the operation of the financial system.

## 3. GOVERNANCE STRUCTURES: LIBERALIZATION, REGULATION AND FINANCIAL CONTRACTS

When critics of 'financial repression' proposed liberalization as optimal policy, they implicitly accepted the existence of a *counterfactual*: a market that would freely achieve equilibrium with full-information prices. In a classic statement Fry (1995) writes: "Financial restriction encourages financial institutions and financial instruments from which government can expropriate significant seigniorage, and discourages others. … Private bond and equity markets are suppressed through transaction taxes, … and an unconducive legal framework, because seigniorage cannot be extracted as easily from private bonds and equities"[1].

Fry's assertions embody three assumptions. First, that seigniorage taxes are used for unrelated purposes or wasted; second that, if such tax burdens were absent, markets would attain a perfect, full-information equilibrium. Third, that the

[1] See Fry (1995), p. 14.

‘unconducive legal framework’ can be replaced by one conducive to development instantaneously and costlessly. These assumptions can be questioned by considering that market failures do not arise simply from government policy but from deeper issues of information, opportunism[2] and lack of confidence. The predominance of banks in less developed countries could be simply a way for market agents to bypass problems of informational imperfections and agency conflicts, *even in the absence of public interventions*.

In his seminal contributions to the governance of contracts, Williamson (1985), (1996) considers the case in which arms-length markets offer optimal allocations. Full – information prices do not succumb (in principle) to opportunistic perturbations and markets clear with no (or minimal) transaction costs. To this idealized condition, Williamson juxtaposes situations in which opportunistic behavior is possible and creates contractual hazards; as, for example, in inter-temporal bilateral contracts where one party can take advantage of her position to reduce the value due to another. Williamson argues that prices will then diverge from their full-information level, and that governance mechanisms will emerge, offering non-price safeguards which mitigate the effects of opportunistic behavior. He develops these mechanisms as his famous ‘hierarchies’.

A central analytical category is ‘asset specificity’. A financial contract becomes transaction-specific if the transaction costs incurred for its completion are specific to the pertaining asset and hence, not retrievable in the market. The more difficult it is to verify the future income streams from an asset, the higher these costs will be. In other words, the degree of ‘ease of verification’ of financial returns obtains the same meaning as ‘the degree of transaction-specific investment’ (Williamson (1979)). The transaction costs associated with acquisition of an asset are undertaken in order to provide confidence about the value of the asset in the face of opportunism by the issuer *after the transaction is completed*. The safeguards required may be provided by the issuer himself through pledges, covenants and

[2] The notion of opportunism is defined by Williamson (1985: 47) as “…self-interest seeking with guile” and it “…refers to the incomplete or distorted disclosure of information…”.

rights provided to the buyer. These come under the general rubric of contract design. (Tirole, 2006; Gale and Hellwig, 1985).

However, in the context of an institutionally undeveloped market, privately supplied safeguards may not suffice as they are themselves tainted by future opportunistic behaviors. It then falls to the state and its powers of contract enforcement to supply credible safeguards. Hence, in undeveloped financial markets, asset specificity poses not a technical but an institutional problem: the credible provision of public safeguards which allow a general reduction of transaction cost for financial assets, mitigating asset specificity.

History and theory suggest a long list of safeguards embedded in institutional arrangements and rules: mandatory public disclosure, accounting and auditing standards, legal bankruptcy, anti-fraud regulations, minority protections in joint-stock companies, insider trading prohibitions. All these require the organization of public enforcement mechanisms. This implies commitment of resources for the organization of agencies of enforcement, their operation and their reputation. Mechanisms for monitoring and resolution of disputes, authorities with powers of 'last resort' interventions, judicial authorities and regulatory agencies are practical public instruments making up the armory of confidence in financial transactions. The variety of such public instruments has responded to historical conditions both in developed and in emerging economies. This same variety cannot be simply explained by the need of government to extract seigniorage.

The public provision of safeguards is not a frictionless process. It incurs tangible costs that must be financed. It also requires, as we said, the buildup of a regulatory reputation by the public mechanisms of enforcement. In short, it requires money, time and policy consistency. Practices characterized as 'repression' may then be alternatively interpreted as means for obtaining resources to be used for provision of institutional structures that underpin general confidence in the financial system.

To look at issues of time-paths, consistency, and the values of critical parameters in the context of an economy that uses intermediation, we need a tractable multi-period model. To achieve tractability we focus on banks as agents of intermediation. A simplified banking market with deposits and loans is found in most models of 'repression', capturing the essence of the financing relationship.

Looking at each side of a bank's functions, depositors provide funds and obtain promises, motivated by the level of interest but also by confidence that the bank will honor nominal commitments. Confidence is not a vague subjective feeling, but devolves on concrete, describable safeguards, such as deposit guarantees and mechanisms that shield the bank from opportunism by its borrower-clients. Bank loans are bearers of asset specificity and incur transaction costs. Banks themselves are agents with some capabilities in selecting ex ante good projects to lend to, in monitoring ex-post borrower performance and in enforcing final repayment, as compared to individual savers and investors. Thus, they may themselves be an institutional response to asset specificity. Yet, the *public provision* and *enforcement* of *general rules* of transparency, audit and bankruptcy may offer superior results as it will achieve at least two goals. On one hand, it will increase confidence in banking firms competing for clients by improving the general quality of loan portfolios; on the other hand it will free up resources that banks would otherwise devote to selection and monitoring of their clients in an institution-less environment; under competition this will produce pecuniary benefit by suppressing banks' intermediation margins. Thus, even with the simplest portrayal of a capital market as a market for deposits and loans, publicly provided safeguards can produce both non-pecuniary and pecuniary benefits.

A central feature of any model of institutional development is the government. It is both a bearer of public power and a promoter of public interest. The political economy of government action represents a complex field of modern analysis (Stiglitz, 1989; Tanzi, 2011). From our perspective, it is not an acceptable premise to posit the government either as an avid myopic extractor of rents or as an infinitely generous supplier of free benefits. In any simple model of tradeoffs offered by public action two elements are needed. First, the supply of public benefits must be fiscally sustainable so that its net costs are zero. Second, the public powers must view safeguards as improvements that build up over time, providing benefits to be reaped in future. This means that the government is not myopic, i.e. does not have infinitely high time-preference, as a regime might if we assumed extreme populism. These modest precepts are portrayed in the simple model which we present.

# 4. A FORMAL MODEL OF TAXES AND SAFEGUARDS TO DEPOSIT RETURNS

## 4.1. Defining a Williamsonian set-up

We assume a Z-period economy comprising households, banks and the government, each expressed by a representative agent. All variables are presented in real terms. Households are both savers and owners of firms but do not know how to manage them. They employ managers who choose investment projects to maximize firms' profits. However, households do not have the capability to monitor managers and cannot prevent an opportunistic manager from selecting bad projects. In effect, opportunism emerges because households' bounded rationality and limited calculability prevents them from singling out a bad project: this task is performed by banks which have to devote resources to this function. But the quality of banks' monitoring is also imperfect and depends in turn on the provision of institutional arrangements such as disclosure policies, accounting standards, law enforcement.

The government oversees the whole system and intervenes to alter incentives. The model focuses on the interaction of household – supplier of funds – and the government, with banks playing a passive intermediating role, pricing their funds at marginal cost. A government policy which lowers average deposit rates $\bar{d}_t$ administratively, in order to lower the average loan rates $\bar{l}_t$ to boost investment, may drive a wedge between investment demand and supply of loan capital, as decreased savings reduce deposit flow to banks.

Williamson's (1985) contracting schema indicates that lowering market price in the face of high asset specificity is possible if a new governance structure is able to provide safeguards. To the degree that both economy-wide and individual projects' risk reflect institutional gaps, the government could intervene by providing (for example) more efficient law plus better enforcement, impose common accounting standards, impose disclosure of information to firms and so forth. Its actions could extend to improving human capital, advancing values of business ethics and installing permanent monitoring mechanisms. Government could also safeguard from short-term stability risks through its lender of last resort and deposit insurance functions[3]. All these actions offer examples of additional safeguards for protection against borrower or managerial opportunism.

Define a variable $\theta_t > 1$ indicating government investment in "safeguards" or government intervention to provide safeguards as opposed to a value of $\theta_t = 1$ representing no-intervention.How can this affect the behavior of savers and total savings?

Saving, in typical models of household behavior, results from preference between current and future consumption given their relative prices. If the price of current consumption is the financial variable $(1 + \tilde{d}_t)$ ($\tilde{d}_t$ being the stochastic deposit rate) then the price of future consumption is $(1 + \rho_t)$ and it is determined by the subjective risk-adjusted preference factor $\rho_t$ (assumed common to all households). A low $\rho_t$ increases the value of future consumption (increases the discount factor $\frac{1}{1+\rho_t}$) and therefore increases current savings, ceteris paribus.

Safeguards can alter the risk-adjusted preference for future consumption by providing institutional guarantees for the protection of households' savings. The price that the state must pay to provide these guarantees depends on the factor of subjective risk-adjusted preference $\rho_t$ [4]. Then $\theta_t$ applied to the discount factor $\frac{1}{1+\rho_t}$ raises the present value of the utility obtained from future consumption and hence, increases savings. Furthermore, if agents adjust their expectations according to

[3] Deposit insurance and lender of last resort functions have themselves been accused of becoming a source of opportunism, this time of banks' stakeholders at the expense of taxpayers. Yet, they are an indispensible ingredient of modern safeguards against the impairment of the public good of liquidity provided by the banking system, given that the latter is well capitalized (Benston & Kaufman (1996), Dow (1996)).

[4] Since the subjective rate of time preference of the agent $\rho$ represents the price paid for delayed consumption or the loss incurred by him/her in this case, then it is plausible to assume that the government should compensate him/her with safeguards priced at this rate.

recent experience, government expenditure on safeguards in period $t$ should also affect the *paths* of the deposit rate and of the risk-adjusted preference factor, i.e. the paths of opportunity costs for current and future consumption respectively. Finally, since the ultimate aim of policy is to secure financing for development, *investment* in safeguards $\theta_t$ cumulates to a *stock* of institutions $\Theta_T$ at the policy horizon $T$. This affects both the behavior of households and the intermediation margin of banks, yielding lower loan rates for given deposit rates. This fulfills the ultimate goal for development with the embedded feature of institutional development.

Define a variable $\alpha_t < 1$ on the deposit rate that defines the administered deposit rate $\alpha_t \tilde{d}_t < \tilde{d}_t$. Note that if $\alpha_t = 1$ then $\alpha_t \tilde{d}_t = \tilde{d}_t$ and there is no difference between the administered and the market interest rate. i.e. no government intervention. If $\alpha_t < 1$, the difference $\tilde{d}_t - \alpha_t \tilde{d}_t = (1 - \alpha_t)\tilde{d}_t$ is an explicit tax levied on deposit interest income with the tax rate being $(1 - \alpha_t)$. This tax finances the regulatory policy, i.e. provision of safeguard $\theta_t > 1$. Is it sensible to opt for this kind of tax? A tax on personal income would not do since it would tax both current consumption and savings in the present, irrespective of time preference. A tax on firms' profits would decrease the incentive for investment that the policy is meant to boost. Finally, a direct tax on banks' loan rate would entail an indirect tax on the deposit rate – to the degree that the marginal cost of banks is left unaltered – and would lead to a net transfer of resources from lenders to borrowers (firms) as a direct subsidy to them without any resources left to finance safeguards to depositors. A tax on deposit interest income enables a direct trade-off between pecuniary loss and non-pecuniary gain by safeguards offered to depositors and financed by them without affecting aggregate expenditure, investment demand or the viability of the banking sector.

Having in mind the above set-up we now turn to examine the problems solved by the three major agents of our economy: the bank, the household/saver and the government.

### 4.2 The Representative Bank

In a world without money but with default risk for firms, a typical competitive (risk-neutral) bank maximizes its expected profit given the difference between the proceeds from extended loans$\sum_{j=1}^{k} \bar{l}_{tj}\mathcal{L}_{tj}$ and costs of deposits $\sum_{h=1}^{m} \bar{d}_{th}D_{th}$ plus the cost of operation $C_t(\mathcal{L}_{jt}, \Theta_T)$. The latter depends positively on the volume of loans extended $\mathcal{L}_{jt}$ and negatively on the institutional conditions in the financial markets $\Theta_T$ which determine the cost of monitoring and enforcing loan contracts. Operating cost on loans increases as loans increase because of the effort needed to identify the default risk of an additional project proposed for finance.

Following Klein (1971) and Santomero (1984)[5], the maximization problem of a competitive bank $b$ becomes

$$max_{\mathcal{L}}\Pi_{\mathrm{t}} = \bar{l}_t\mathcal{L}_t - \bar{d}_tD_t - C_t(\mathcal{L}_t, \Theta_T) \tag{1}$$

s.t.

$$\mathcal{L}_t = \sum_{j=1}^{k}\mathcal{L}_{tj} = \sum_{h=1}^{m} D_{th} = D_t$$

Define $\bar{l}_t = \sum_{j=1}^{k} x_j\bar{l}_{tj}$ as the weighted average loan rate charged on a portfolio of loans with $x_j$ the weight of asset type $j$ in this portfolio. Similarly define $\bar{d}_t$ as the all-purpose deposit rate. Then we can also define the financial intermediation margin for a competitive bank which equals marginal operating cost:

$$\bar{l}_t - \bar{d}_t = {C_t}'(\mathcal{L}_t, \Theta_T) \tag{2}$$

The existence of asymmetric information and manager opportunism requires each bank to devote resources to discern the creditworthiness of the borrower given past history, management competence and the perceived prospects of the proposed

[5] In fact, this is a simplified version of the Monti-Klein model of the banking firm in competitive conditions.

projects in a noisy environment. This expenditure of resources is expressed in their operating cost and hence, households pay a price to them for this function. This is the spread of financial intermediation. Falling marginal cost, due to an improved institutional environment (a rising $\Theta_T$) , is then followed by a falling spread, that is, a lower loan rate for a given deposit rate. The marginal operating cost of banks, which is affected by institutional conditions, is the determinant of their pricing policy.

### 4.3 The Representative Household/Saver

Assume that households are interested in smoothing their consumption over time. To do this they include in their maximand the expected profits of firms at each period $W_t^i$, which households receive as income, and the expected deposit rate offered by banks $\bar{d}_t$. In a multiperiod model the household cannot know from period 1 the projects that the manager of the firm will pursue in period t, so as to estimate the related profits that will flow to it as income. Consequently, its expectation of the future and the competence of the manager for the immediately following period, condition its expectation for ensuing periods. Also, the household cannot know the deposit rate that will be effective in future periods since this will be determined as the difference of the loan rate and the marginal cost of the bank, hence we treat the deposit rate in the multiperiod framework as an expected quantity. The households' problem is solved by discounting intertemporal utility using households' subjective risk-adjusted preference factor$\rho_t$.

Following these assumptions and Sargent (1987), the maximization of the household becomes:

$$\max_{C_t} E_0 \left[ \sum_{t=0}^{Z-1} \left( \frac{{\vartheta_{t-1}}^{1/t}}{1+\rho_{t-1}} \right)^t u_i(C_t^i) \right]$$

s.t.

$$S_{t+1}^i = (S_t^i + W_t^i - C_t^i)(1 + \alpha_t \bar{d}_t)$$

$$S_0^i = given$$

(3)

$$E_0\left(\frac{{\vartheta_{Z-1}}^{1/Z}}{1+\rho_{Z-1}}\right)^Z (S_Z^i) = 0$$

The last condition excludes the case of perpetual borrowing so that there is neither outstanding debt at time $t = Z$ nor savings left over. This yields the Euler equation:

$$u'(C_t) = \frac{\theta_t}{1+\rho_t} E_t\left[u'(C_{t+1})\left(1+\alpha_t \tilde{d}_t\right)\right] \tag{4}$$

We assume that $\alpha_t$ and $\theta_t$ are known to the agent in period $t$, i.e that government policy is known at decision time. We will now prove that the path of consumption, and hence saving, as this is described by the Euler equation, will be affected by government intervention.

*Lemma 1*:

*Government intervention described by the inequalities* $\alpha_t < 1,\ \theta_t > 1$ *implies the following conditions should hold: either* $\theta_t\left(1+\alpha_t \bar{d}_t\right)$=$\left(1+\bar{d}_t\right)$ *and* $\theta_t < \frac{1}{\alpha_t}$

*or* $\theta_t\left(1+\alpha_t \bar{d}_t\right) > \left(1+\bar{d}_t\right)$ *and* $\theta_t = \frac{1}{\alpha_t}$

*Proof*:

For $\alpha_t < 1$, $\theta_t > 1$ and $\theta_t\left(1+\alpha_t \bar{d}_t\right) = \left(1+\bar{d}_t\right)$ we obtain

$$\alpha_t < 1 \Rightarrow \alpha_t + \alpha_t \bar{d}_t < 1 + \alpha_t \bar{d}_t \Rightarrow \alpha_t\left(1+\bar{d}_t\right) < 1 + \alpha_t \bar{d}_t \Rightarrow \frac{1+\bar{d}_t}{1+\alpha_t \bar{d}_t} < \frac{1}{\alpha_t} \Rightarrow$$
$$\Rightarrow \theta_t < \frac{1}{\alpha_t} \tag{5a}$$

For $\alpha_t < 1$, $\theta_t > 1$ and $\theta_t = \frac{1}{\alpha_t}$ we obtain

$$\alpha_t < 1 \Rightarrow \alpha_t \bar{d}_t + \alpha_t < 1 + \alpha_t \bar{d}_t \Rightarrow \alpha_t\left(1 + \bar{d}_t\right) < 1 + \alpha_t \bar{d}_t \Rightarrow \theta_t \alpha_t\left(1 + \bar{d}_t\right) < \theta_t\left(1 + \alpha_t \bar{d}_t\right) \Rightarrow \left(1 + \bar{d}_t\right) < \theta_t\left(1 + \alpha_t \bar{d}_t\right)$$

(5b)

■

*Theorem 1*:

*For given risk-adjusted preference of households $\rho_t$ government intervention described by $\alpha_t < 1$, $\theta_t > 1$ implies a higher level of savings than the one attained before intervention*

*Proof*:

A given risk-adjusted preference of households $\rho_t$ implies the equality of the ratios derived by the two Euler equations before and after government intervention, namely

$$\frac{E_t\left[u'(C_{t+1})\left(1 + \tilde{d}_t\right)\right]}{u'(C_t)} = \frac{E_t\left[u'(C_{t+1})\theta_t\left(1 + \alpha_t \tilde{d}_t\right)\right]}{u'(C_t)} = 1 + \rho_t$$

(6)

Decomposing these ratios we obtain:

$$E\left[\frac{u_i'(C_{t+1})\left(1 + \tilde{d}_t\right)}{u_i'(C_t)}\right] = E\left[\frac{u_i'(C_{t+1})}{u_i'(C_t)}\right] E\left[\left(1 + \tilde{d}_t\right)\right] + cov\left[\frac{u_i'(C_{t+1})}{u_i'(C_t)}, \tilde{d}_t\right]$$

(7a)

$$E\left[\frac{u_i'(C_{t+1})\theta_t\left(1 + \alpha_t \tilde{d}_t\right)}{u_i'(C_t)}\right] = $$

$$= E\left[\frac{u_i'(C_{t+1})}{u_i'(C_t)}\right] E\left[\theta_t\left(1 + \alpha_t \tilde{d}_t\right)\right] + \theta_t \alpha_t cov\left[\frac{u_i'(C_{t+1})}{u_i'(C_t)}, \tilde{d}_t\right]$$

(7b)

Then, given government intervention described by $\alpha_t < 1$, $\theta_t > 1$ and *Lemma 1* , $E_t\left[\frac{u\prime(C_{t+1})}{u\prime(C_t)}\right]$ should have to decrease for (6) to hold. Yet, for $u''(C) < 0$ this implies a steeper path for consumption and hence, current savings above the levels attained before government intervention. ■

There is at least one plausible economic explanation to the rise of savings above the levels in the unregulated regime. As Llewellyn (1999) puts it, this could be a case of "Akerlof's lemons" and "confidence". Asymmetric information entails both a higher risk premium, but also implies that marginal (risk averse) investors exit the financial market, lowering the level of savings available for investment. Financial regulation can have the opposite effect: attracting marginal surplus units back to the market and raising savings above the unregulated levels. In our representative agent model, this is translated into a rise in the confidence of the household on the efficiency of the financial system, producing a rise in its savings.

**4.4 The Cost-minimization Problem of the Government**

Under what conditions should the government lower the deposit rate? So far, the model embodies all three factors of Williamson's (1985) schema, appropriately translated to the situation of financial markets. Additional safeguards offered – by the state in our case – when asset specificity is high, permit a lower price – the interest rate in our case – for the deposit claim. In this context, a financial framework of administratively set deposit rates $\alpha_t\bar{d}_t$, supplemented by the necessary safeguards is a representation of a financial governance structure coping with problems of non-verifiability of project returns, in an institution-less environment.

However, the shift to this governance structure (Williamson, 1991a, 1991b) also entails costs. Taking as given the bureaucratic costs of hierarchies as part of general government outlays, we will focus on the costs of downgrading incentives along with the net pecuniary cost of safeguard provision. The first is the cost created by setting interest rates lower by fiat. This cost is represented by the difference between the return on savings at the market rate and the return after the imposition of the administered rate, namely

$$(1+\bar{d}_t)-(1+\alpha_t\bar{d}_t)=(1-\alpha_t)\bar{d}_t \tag{8}$$

This is what savers lose from the return on their savings.

The second cost relates to what the government has to pay in order to provide safeguards to savers to mitigate the effect of distorted interest rates. Since the variable of safeguards that acts upon the risk-adjusted preference parameter of households takes on values above 1, we can represent this cost as the difference[6]

$$(\theta_t-1)\rho_t \tag{9}$$

Obviously, for the lowest value of $\theta_t=1$, which indicates that no safeguards are provided, this cost is zero. This cost may represent expenditures of the "monetary authority" for monitoring and enforcement functions. It may also include costs of establishing new institutions etc.

The net cost of government intervention is, therefore, the difference between the cost of safeguards and the receipts from the tax on deposit interest income, namely:

$$NC=(\theta_t-1)\rho_t-(1-\alpha_t)\bar{d}_t \tag{10}$$

[6] One can envisage a linear relationship between the non-pecuniary $\theta_t$ that enters the households' maximization problem and the pecuniary say $\theta_t'=\zeta+\eta\theta_t$ that enters the minimization problem of the government. Since such a modification would not change essentially neither the theoretical implications of the model nor their mathematical representations we drop it for simplicity.

What is a cost to the government is a benefit to savers. The cost of safeguards is an indirect subsidy to savers while the receipts from tax on deposit interest is a tax to them. Hence, another way to see this relation is the difference, from the perspective of savers, of the subsidy provided to them as safeguards by the government *minus* the subsidy paid by them to firms, to satisfy their increased investment demand.

In governance terms, if $(1-\alpha_t)\bar{d}_t$ is a fee paid by agents to the government for policies that lower transaction costs the objective of the government is to minimize the net cost of implementing this task. However, the constraint in regulatory policy is that savings is maintained at levels equal or greater than those prevailing before intervention. This, by Lemma 1, is reflected in the condition $\theta_t \leq \frac{1}{\alpha_t}$.

Given the above, the time path of the deposit rate (its equation of motion) is given by:

$$\bar{d}_{t+1} = \bar{d}_t - (1-\theta_t\alpha_t)\bar{d}_t \tag{11}$$

$$\bar{d}_{t+1} \leq \bar{d}_t \quad if \quad \theta_t \leq \frac{1}{\alpha_t}$$

By (11) the level of the deposit rate for the next period depends on the level of the deposit rate in the current period minus the compound effect of the government's intervention variables on current deposit rate. If $\theta_t = \frac{1}{\alpha_t}$ then $\bar{d}_{t+1} = \bar{d}_t$ whilst if $\theta_t < \frac{1}{\alpha_t}$ then $\bar{d}_{t+1} < \bar{d}_t$.

Assuming that agents learn from recent experience, government investment on safeguards $\theta_t$ at time $t$ will also affect the value for the risk-adjusted preference factor of households for the next period. Its equation of motion is given by:

$$\rho_{t+1} = \frac{\rho_t}{\theta_t}$$

$$\rho_{t+1} \leq \rho_t \quad if \quad \theta_t \geq 1 \tag{12}$$

Equation (12) describes a process of embodiment of safeguards in households' attitudes and behavior. The latter involves a gradual decline of $\rho_t$.

Given these relationships, the minimization problem for the government is:

$$\min_{\alpha_t,\theta_t} V = \sum_{t=0}^{T-1} \beta^t \left[ (\theta_t - 1)\rho_t - (1 - \alpha_t)\bar{d}_t \right]$$

s.t.

$$\begin{gathered}
\bar{d}_{t+1} = \bar{d}_t + (\alpha_t \theta_t - 1)\bar{d}_t \\
\bar{d}_0 = given \\
\bar{d}_T = free \\
\rho_{t+1} = \rho_t + \rho_t \left( \frac{1}{\theta_t} - 1 \right) \\
\rho_0 = given \\
\rho_T = free \\
T = given
\end{gathered} \tag{13}$$

There are two control variables, $\theta_t$ and $\alpha_t$, and two state variables, $\bar{d}_t$ and $\rho_t$. The government seeks to minimize the value function $V$ which is the discounted sum of the net cost of intervention with $\beta = \frac{1}{1+\gamma} < 1$ as discount factor. To achieve this, the government must choose a path for the control variables subject to the equations of motion for the state variables. The initial values of the interest rate and the risk-adjusted discount factor of savers are assumed to be given and so is the government's time horizon T, assumed different than that of the household, $Z$.

Solving we obtain[7]:

$$\bar{d}_t^* = \bar{d}_0 \quad \forall t \tag{14}$$

$$\rho_t^* = \left(\frac{1}{(1+\gamma)}\right)^t \rho_0 = \rho_{min} \tag{15}$$

$$\alpha_t^* = \frac{1}{(1+\gamma)} \quad \forall t \tag{16}$$

$$\theta_t^* = 1+\gamma \quad \forall t \tag{17}$$

$$\Theta_T^* = (\theta_t^*)^T = (1+\gamma)^T \tag{18}$$

The paths for the control variables, $\alpha_t = \frac{1}{(1+\gamma)}$ and $\theta_t = 1+\gamma$ depend on the time preference factor $\gamma$ and imply that $\theta_t \alpha_t = 1 \Rightarrow \theta_t = \frac{1}{\alpha_t}$, which by (11) points to the case where $\bar{d}_{t+1} = \bar{d}_t = \bar{d}_0$. On the other hand, the path of the preference factor of households $\rho_t^* = \left(\frac{1}{(1+\gamma)}\right)^t \rho_0$ is decreasing, depending on $\gamma$ and the initial $\rho_0$. Finally, the stock of institutional safeguards $\Theta_T^*$ is derived as the cumulative safeguards to $T$ and depends positively on both the time preference of the government $\gamma$ and the horizon of its policy $T$. In this sense, another way to view equation (15) is by expressing $\rho_T$ as the initial $\rho_0$ decreased by the stock of institutional safeguards, $\Theta_T$:

[7] See the Mathematical Appendix.

$$\rho_T = \frac{1}{(1+\gamma)^T}\rho_0 = \frac{1}{\Theta_T}\rho_0 = \rho_{min} \tag{19}$$

The results on the conditions that determine the government's choice for intervention are summarized in Table 1.

**Table 1: The choice for government intervention**

| | No government intervention | Government intervention |
|---|---|---|
| $\alpha_t$ | $\alpha_t = 1$ | $\alpha_t = \frac{1}{(1+\gamma)} < 1$ |
| $\theta_t$ | $\theta_t = 1$ | $\theta_t = 1+\gamma > 1$ |
| $\Theta_T$ | $\Theta_T = 0$ | $\Theta_T = (1+\gamma)^T$ |
| $\gamma$ | $\gamma = 0$ | $\gamma = \left(\frac{\rho_0}{\bar{d}_0}\right)^{\frac{1}{t-1}} - 1$ |
| $d_t$ | $d_t = d_0$ | $d_t = d_0$ |
| $\rho_t$ | $\rho_t = \rho_0$ | $\rho_t = \left(\frac{1}{(1+\gamma)}\right)^t \rho_0 = \rho_{min}$ |
| $NC^*$ | $NC^* = 0$ | $NC^* = \gamma\left(\left(\frac{1}{(1+\gamma)}\right)^t \rho_0 - \frac{\bar{d}_0}{1+\gamma}\right)$ |

## 5. FISCAL SUSTAINABILITY AND TIME CONSISTENT REGULATION

The simplistic representation of public behavior, pervasive in models of financial repression, becomes enriched here with the provision of public benefits, as counterpart to the extraction of taxes. Yet, a negative optimum net cost (a positive net revenue) would justify the "financial repression" critique which portrays the government as a maximizer of rent. On the other hand, positive optimum net cost might end up encumbering the government's budget and forcing the accumulation of public debt. The question arises: under which conditions, a policy for provision of safeguards, as described in the previous section, can co-exist with the achievement of fiscal balance in the long-run? This is an important issue since self-financed safeguards make unnecessary any analytical recourse to accumulating government debt which may create various other effects upon financial development, such as financial crowding out, for example.

*Theorem 2*:

*Government intervention is self-financed if the administered deposit rate equals the households-savers' optimum risk adjusted preference factor.*

*Proof*:

Inserting the optimum values for the parameters into the objective function we obtain the optimum net cost:

$$NC^* = (\theta_t^* - 1)\rho_t^* - (1 - \alpha_t^*)\bar{d}_t^* =$$

$$= \gamma\rho_t^* - \left(1 - \frac{1}{1+\gamma}\right)\bar{d}_0 =$$

$$= \gamma\rho_t^* - \frac{\gamma}{1+\gamma}\bar{d}_0 =$$

$$= \gamma\left(\rho_t^* - \alpha_t^*\bar{d}_0\right) \tag{20}$$

A government would prefer this net cost to be zero, otherwise it may have to supplement its tax receipts by borrowing in order to finance its supply of safeguards. This expression is zero if the term in parentheses is zero, which entails:

$$NC^{*} = 0 \Rightarrow \rho_t^{*} = \alpha_t^{*}\bar{d}_0 \tag{21}$$

■

According to Theorem 2, a fiscally sustainable regulatory policy entails the appropriate selection of the tax rate $(1 - \alpha_t^{*})$ given the optimum risk adjusted preference factor of households/savers $\rho_t^{*}$. In other words, the lower is the 'target' $\rho_t^{*}$ (set by the government), the lower the administered deposit rate $\alpha_t^{*}\bar{d}_0$ and the higher the tax rate $(1 - \alpha_t^{*})$ should be. Yet, both $\rho_t^{*}$ and $\alpha_t^{*}$ depend on the time preference factor of the government γ.

Two points are worth mentioning. First, the model explicitly produces paths ('equations of motion') for critical variables which are smooth, thereby underlining the importance of consistency and continuity in government decision behavior. It is implied that a process of haphazard provision of safeguards will undermine the cumulative effect portrayed here as stable institutional development.

Second, there is a critical difference between the time preference factors of households and government respectively (ρ, γ). Whereas the factor for households is taken as a risk-adjusted reflection of the perception of the environment at each point in time, the government time preference is inevitably a more 'managed' factor in the sense that government may have a more strategic view of long term goals.

Time consistency of government policy and fiscal sustainability depend, as expected, on the value a government assigns to its time preference factor.

*Theorem 3*:

*A time consistent and self-financed government intervention entails a constant time preference factor $\gamma$ for the government which is lower the higher the deposit rate $\bar{d}_0$ given the initial value of households-savers' risk-adjusted preference factor $\rho_0$.*

*Proof*:

$$\rho_t^* = \alpha_t^* \bar{d}_0 \Rightarrow \frac{\rho_0}{(1+\gamma)^t} = \frac{\bar{d}_0}{1+\gamma} \Rightarrow (1+\gamma)^{t-1} = \frac{\rho_0}{\bar{d}_0} \Rightarrow \gamma = \left(\frac{\rho_0}{\bar{d}_0}\right)^{\frac{1}{t-1}} - 1$$

(22)

For given $\rho_0$, the higher $d_0$ is, the lower the 'public' $\gamma$ should be set by government for the net cost of intervention to be zero. ■

*Theorem 4*:

*The longer the time horizon $T$ set by the government the more patient it will be in the implementation of its interventional policy and hence, the lower its time preference factor $\gamma$*

*Proof*

Differentiating (22) by $t$ we obtain:

$$\frac{d\gamma}{dt} = -(t-1)^{-2} \left(\frac{\rho_0}{\bar{d}_0}\right)^{\frac{1}{t-1}} \ln\left(\frac{\rho_0}{\bar{d}_0}\right) < 0$$

(23)

■

Theorems 3 and 4 indicate a government acting as an agent less driven by risk-aversion compared to private agents. Such a government would implement a time consistent and fiscally sustainable policy devoted to institutional and economic development by selecting constant tax rate and institutional investment policy variables which ultimately imply a constant and low government time preference factor. This is consistent with the view that in environments of low institutional development, the government may have a view that is less noisy and more 'visionary' than that of price-taking households.

*Corollary 1*:

The optimum selection of $\alpha_t$ and $\theta_t$ ,which depend on a constant time-indifferent $\gamma$ ,will sustain a self-financed and time consistent policy.

## 6. THE PROCESS OF INSTITUTIONAL DEVELOPMENT AND THE CURRENT CRISIS

The model we have analyzed embodies basic micro-foundations to macroeconomic paths in the spirit of Williamson's conception of safeguards. In our model, the consistent provision of safeguards exercises a cumulative influence which can be conceived as 'institutional development'. This feature of our model corresponds to a long line of contributions in the literature about the contribution of institutions to financial markets.

A major analytical choice in the model is that safeguards exercise *cumulative influence* upon the risk-adjusted rate of time preference of households. In fact, we identify a two-step process. The first step is the implementation of the government's safeguards as these are expressed by a $\theta_t$ above unity, operating on the saving decision of households. The second step is the embodiment of these safeguards in the attitudes and behavior of agents. We have seen in the model that this might be a gradual process for savers as they learn from their period-by-period experience. Then financial development entails a change in agents' preferences for future consumption – or for higher saving – namely $\rho_T < \rho_0$ , along with a lower loan rate $\bar{l}_T < \bar{l}_0$ , indicating lower marginal costs for banks $\bar{l}_T - \bar{d}_0 = C_T'(\mathcal{L}_T, \Theta_T)$ ,in an institutionally more developed market[8].

Households' perception of insecurity may be caused by a very noisy environment where low disclosure, lack of transparency, heavy asymmetries of

[8] Note that this kind of government intervention is not a short-lived income transfer from lenders/savers to borrowers. On the contrary, it is long-term policy as lower lending rates are granted to firms because bank verification cost decreases, aided by the institutional infrastructure safeguards.

information and lack of mechanisms controlling opportunistic behaviors are reflected in saving decisions through high risk aversion and time preference. In fact all these conditions can be mitigated by public safeguards which, however, do not work instantaneously but through gradual learning in the actual environment. Uncertainty may be mollified – to a degree - by the existence of standby institutional arrangements such as safeguard provisions of last resort, e.g. deposit insurance, lender of last resort facilities, bankruptcy resolution regimes and reserve funds for strategic bailouts. In our conception of financial development, therefore, the linkage of institutional development with the structure of risk perceptions of saver-households is a valuable tool for understanding the functioning and the evolution of a financial market. The simple model we have analyzed underlines this linkage.

What the model predicts in a situation of an abrupt plummeting in confidence in the financial markets? The 2008 crisis episode and the subsequent adverse twist in confidence is a case in point. Even if the system has reached a level of mature institutions that render continuous government intervention redundant (after time $T$) , there is still the issue of the need to preserve stability. As Dow (1996) indicates, financial development goes hand in hand with the need for regulation, although the latter might take more sophisticated or more contingent forms. To put it in the context of the previous model, a low value of $\rho_t$ depends not only on the establishment of confidence in the system through past values of $\theta_t$, but also on the established expectation that the state would provide the adequate safeguards were these to be needed in adverse future conditions. This could be exogenous shocks, or contagious panic over lost confidence in the solvency of the banks. The immediate effect could be a decrease of deposits held at banks. In this environment asset specificity rises again, the deposit rate will also rise along with the loan rate, as banks attempt to maintain the flow of savings at previous levels. In the model described in this paper, a change in the preference for postponing consumption – that is a preference for a decrease in savings – can be represented by an upward shock to the risk-adjusted preference factor $\rho_t$. In such a situation, investors demand for safeguards shifts once again. Then, a government policy that intervenes in the market by providing a rising $\theta_t$, though at the expense of a falling $\alpha_t$, is again required for the restoration of confidence.

In this context, prudential regulation requires a safeguard provider "of last resort". By this apparent neologism we mean the need of the continuous background presence of the government over the financial system as ultimate gatekeeper of its liquidity and stability. Deposit insurance and Lender of Last Resort facilities do not exhaust the list of safeguard provisions even in developed markets. Such provisions require commitment of regulatory authorities to stand by and design safeguards on an emergency or non-emergency basis.

This makes the role of past and future expected $\theta_t$ crucial for financial stability: $\rho_t$ will *remain* low only if $\theta_t$ is above unity by a small amount $\varepsilon$, so that $\theta_t - 1 = \varepsilon > 0$, providing a signal to market participants that regulators will act with a safeguarding plan if needed. By the same token, $\alpha_t$ would never be exactly equal to unity but close to it, the difference being a small $\varepsilon'$ which represents the price agents have to pay for having a regulatory authority acting as a gatekeeper of the system. This is, as Llewellyn (1999) puts it, the "insurance premium" that agents pay. To put it differently, we may consider $\theta_t - 1 = \varepsilon$, financed by $\alpha_t = 1 - \varepsilon'$, as expenditure necessary to keep up the stock of institutional safeguards $\Theta_T$. Then, if $d_t$ is the hypothetical benchmark rate of an ideal unregulated market, $\alpha_t d_t = (1 - \varepsilon')d_t$ is the prevailing interest rate in a world with developed and prudentially regulated financial markets surrounded by information asymmetries.

A final word of warning. In the construction of the model we have opted for a self-imposed limitation in portraying banks as passive agents in the process of finance. The drawback of this assumption is that it ignores bank strategies to use their incumbent powers and maintain margins *despite* institutional development, i.e. not allow the passing of its benefits through lower rates to borrowers. This admitted limitation ignores another area of possible regulatory intervention, i.e. the regulation of non-competitive behavior by banks, which is a separate matter. However, this simplification allows a portrayal of government as an active decision-maker, without making the model intractable.

## MATHEMATICAL APPENDIX

The problem of the government becomes:

$$\max_{\alpha_t,\theta_t} -V = \sum_{t=0}^{T-1} \beta^t\big[-(\theta_t - 1)\rho_t + (1-\alpha_t)\bar{d}_t\big]$$

(A1)

s.t.

$$\bar{d}_{t+1} = \bar{d}_t + (\alpha_t\theta_t - 1)\bar{d}_t$$
$$\bar{d}_0 = given$$
$$\bar{d}_T = free$$
$$\rho_{t+1} = \rho_t + \rho_t\left(\frac{1}{\theta_t} - 1\right)$$
$$\rho_0 = given$$
$$\rho_T = free$$
$$T = given$$

The current value Hamiltonian is:

$$H_c = -(\theta_t - 1)\rho_t + (1-\alpha_t)\bar{d}_t + \beta\lambda_{1t+1}(\alpha_t\theta_t - 1)\bar{d}_t + \beta\lambda_{2t+1}\left(\frac{1}{\theta_t} - 1\right)\rho_t$$

(A2)

The Lagrangian is:

$$L = \sum_{t=0}^{T-1} \beta^t\left\{H_c + \beta\lambda_{1t+1}\left(\bar{d}_t - \bar{d}_{t+1}\right) + \beta\lambda_{2t+1}(\rho_t - \rho_{t+1})\right\}$$

(A3)

Then by the maximum principle conditions we obtain:

$$\frac{\partial L}{\partial \theta_t} = \frac{\partial H_c}{\partial \theta_t} = -\rho_t + \beta\lambda_{1t+1}\alpha_t\bar{d}_t - \beta\lambda_{2t+1}\frac{\rho_t}{(\theta_t)^2} = 0$$

(A4)

$$\frac{\partial L}{\partial \alpha_t} = \frac{\partial H_c}{\partial \alpha_t} = -\bar{d}_t + \beta\lambda_{t+1}\theta_t\bar{d}_t = 0 \Rightarrow$$

$$\Rightarrow \theta_t = \frac{1}{\beta\lambda_{1t+1}}$$

(A5)

$$\frac{\partial L}{\partial \beta \lambda_{1t+1}} = 0 \Rightarrow \bar{d}_{t+1} - \bar{d}_t - (\alpha_t \theta_t - 1)\bar{d}_t = 0$$

(A6)

$$\frac{\partial L}{\partial \beta \lambda_{2t+1}} = 0 \Rightarrow \rho_{t+1} - \rho_t - \rho_t \left(\frac{1}{\theta_t} - 1\right) = 0$$

(A7)

$$\frac{\partial L}{\partial \bar{d}_t} = 0 \Rightarrow \beta \lambda_{1t+1} - \lambda_{1t} = -\frac{\partial H_c}{\partial \bar{d}_t} \Rightarrow$$

$$\Rightarrow \beta \lambda_{1t+1} - \lambda_{1t} + (1 - \alpha_t) + \beta \lambda_{1t+1}(\alpha_t \theta_t - 1) = 0$$

(A8)

$$\frac{\partial L}{\partial \rho_t} = 0 \Rightarrow \beta \lambda_{2t+1} - \lambda_{2t} = -\frac{\partial H_c}{\partial \rho_t} \Rightarrow$$

$$\Rightarrow \beta \lambda_{2t+1} - \lambda_{2t} - (\theta_t - 1) + \beta \lambda_{2t+1} \left(\frac{1}{\theta_t} - 1\right) = 0$$

(A9)

From (A5) and (A8) we obtain:

$$(A5), (A8) \Rightarrow \beta \lambda_{1t+1} - \lambda_{1t} + (1 - \alpha_t) + \beta \lambda_{1t+1} \left(\frac{1}{\beta \lambda_{1t+1}} \alpha_t - 1\right) = 0 \Rightarrow \lambda_{1t} = 1 \; \forall t$$

(A10)

Then by (A5):

$$(A5) \Rightarrow \theta_t = \frac{1}{\beta} = 1 + \gamma$$

(A11)

Using this expression and substituting into (A7) we have:

$$(A7),(A11) \Rightarrow \rho_{t+1} - \rho_t - \rho_t(\beta - 1) = 0 \Rightarrow$$

$$\Rightarrow \rho_{t+1} = \beta\rho_t \Rightarrow \rho_{t+1} = \frac{1}{(1+\gamma)}\rho_t$$

(A12)

Using the definition of $\beta = \frac{1}{1+\gamma}$ and solving this difference equation we obtain the path for the subjective rate of households:

$$\rho_t = \left(\frac{1}{(1+\gamma)}\right)^t \rho_0$$

(A13)

Then we can also define the stock of thetas until time $T$as the compound effect on the initial $\rho_0$ :

$$\Theta_T = (1+\gamma)^T$$

(A14)

By (A9), (A11), and (A13) we have:

$$(A9),(A11),(A13) \Rightarrow \beta\lambda_{2t+1} - \lambda_{2t} - \left(\frac{1}{\beta} - 1\right) + \beta\lambda_{2t+1}(\beta - 1) = 0 \Rightarrow$$

$$\Rightarrow \beta^2\lambda_{2t+1} - \lambda_{2t} - \left(\frac{1}{\beta} - 1\right) = 0 \Rightarrow$$

$$\Rightarrow \lambda_{2t+1} = \frac{1}{\beta^2}\lambda_{2t} + \frac{1-\beta}{\beta^3}$$

(A15)

Solving this difference equation we obtain the path of the costate variable $\lambda_{2t}$ :

$$\lambda_{2t} = \left(\lambda_{2_0} - C\right)(1+\gamma)^{2t} + C$$

(A16)

Where

$$C = \frac{\frac{1-\beta}{\beta^3}}{1 - \frac{1}{\beta^2}}$$

Furthermore, by (A4), (A10), (A15) and (A16) and substituting we get:

$$(A4), (A10), (A15), (A16) \Rightarrow \alpha_t \bar{d}_t - \lambda_{2t+1}\beta^2 \rho_t - \frac{\rho_t}{\beta} = 0 \Rightarrow$$

$$\Rightarrow \alpha_t \bar{d}_t = \left[\left(\lambda_{2_0} - C\right)(1+\gamma)^{2t} + C + 2\gamma + 1\right]\left(\frac{1}{(1+\gamma)}\right)^t \rho_0 \Rightarrow$$

$$\Rightarrow \alpha_t = \frac{A(t)}{\bar{d}_t}\rho_0$$

(A17)

Define the expression A $(t) = \left[\left(\lambda_{2_0} - C\right)(1+\gamma)^{2t} + C + 2\gamma + 1\right]\left(\frac{1}{(1+\gamma)}\right)^t$. Then by (A6), (A11) and (A17) we obtain:

$$(A6), (A11), (A17) \Rightarrow \bar{d}_{t+1} = \alpha_t \theta_t \bar{d}_t \Rightarrow$$

$$\Rightarrow \bar{d}_{t+1} = (1+\gamma)A(t)\rho_0$$

(A18)

However, the transversality conditions for this truncated vertical terminal line problem are:

$$\lambda_2(T) \geq 0, \rho_T \geq \rho_{min} \; and \; (\rho_T - \rho_{min})\lambda_2(T) = 0$$

(A19)

$$\lambda_1(T) \geq 0, \bar{d}_T \geq \bar{d}_{min} \; and \; \left(\bar{d}_T - \bar{d}_{min}\right)\lambda_1(T) = 0$$

(A20)

Then (A19) holds for $\lambda_2(T) > 0$, $\rho_T = \rho_{min}$ and a falling $\rho_t$ from a $\rho_0$ to a minimum $\rho_{min}$ as (A13) indicates.

On the other hand, (A20) holds for $\lambda_1(T) > 0$, $\bar{d}_T = \bar{d}_{min}$ in either of two cases:

1) If $\bar{d}_T = \bar{d}_{min} = \bar{d}_0 = \bar{d}_t$ namely, the deposit rate remains at its initial level in every period $t$ ($\bar{d}_{t+1} = \bar{d}_t$) then by (A18) $\alpha_t = \frac{1}{1+\gamma} \forall t$.
2) If $\bar{d}_T = \bar{d}_{min}$ and $\bar{d}_{t+1} < \bar{d}_t$ then by (A18) $\alpha_t < \frac{1}{1+\gamma}$ and $\bar{d}_t$ falls from an initial level $\bar{d}_0$ to $\bar{d}_T = \bar{d}_{min}$.

However, the last case, though mathematically possible, lacks economic justification. We should expect that depositors would demand a deposit rate at least equal to its original level and certainly not falling below this, given their additional tax burden. If there is an upper bound for the deposit rate set out by the maximization problem of banks then it is reasonable to expect a constant path $\bar{d}_0 = \bar{d}_t$.

Besides, forming the maximized Hamiltonian $H_c^o$, that is the Hamiltonian evaluated along the $\alpha_t^*, \theta_t^*$ paths, we can prove that it is concave in the state variables $\bar{d}_t$ , $\rho_t$ $\forall t$ for given $\lambda_{1t}$, $\lambda_{2t}$ , which satisfies the Arrow sufficiency theorem (Chiang, 1992) for the conditions of the maximum principle to be sufficient for the global maximization of the objective functional. Indeed, forming $H_c^o$ we obtain:

$$H_c^o = -\left(\frac{1}{\beta} - 1\right)\rho_t + (1-\beta)\bar{d}_t + \left(\frac{1}{\beta}\lambda_{2t} + \frac{1-\beta}{\beta^2}\right)(\beta - 1)\rho_t \tag{A21}$$

Since $H_c^o$ is linear in $\bar{d}_t$ and $\rho_t$ for every $t$ then it is also concave in $\bar{d}_t$ and $\rho_t$ and hence, the Arrow sufficiency theorem is satisfied.

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