Capital Flows, Debt and Liquidity: Assessing Capital Market Interventions to Mitigate Balance Sheet Channel Effects*

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Abstract

The paper is motivated by the debate on the causes and propagation of crisis in Latin America, such as the recent 1995 Tequila crisis, and possible measures to resolve them. The two most suggested recommendations are to have more flexible exchange rate agreements and to strengthen prudential regulations. We focus on prudential aspects, specifically on the role capital market interventions may have in mitigating balance sheet effects.

According to the balance sheet channel of the monetary transmission mechanism, high debt collateralized on falling asset prices is central in explaining the deep problems in credit markets, the consequent credit crunch, and hence the deep decline in economic activity experienced in affected countries. The motivation behind this paper is that even though there is extensive literature on emerging market crisis in general and the balance sheet channel in particular, there is a surprising lack of models which attempt to assess which capital market intervention might be optimal in order to mitigate the balance sheet channel.

We develop an small open economy version of the Kiyotaki and Moore (1997) model in which the propagation of a small shock to fundamentals causes a sharp decrease in real output. We consider a pure capital tax, a zero-remunerated reserve requirement and a remunerated liquidity requirement as three potential interventions. Our results indicate that remunerated liquidity requirements may be a superior intervention than non–remunerated reserves or pure inflow taxes.

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Contents

1 Introduction

The past two years or so of economic crisis in many major emerging countries, and the more Latin American orientated 1995 Tequila crisis, have attracted a significant amount of debate in the academic literature. This debate has considered the causes and propagation mechanisms of crises and how they may best be resolved. The analysis as to how countries might avoid such events in the future has rightly received much attention from both the official and non-official sector.

Perhaps the two most repeated recommendations from analysis of the various emerging countries that have fallen into deep recession is on the one hand that countries should adopt more flexible exchange rate arrangements and secondly that prudential arrangements to reduce risk should be improved. The debate on exchange rate arrangements remains highly controversial but in this paper we essentially abstract from this debate. Rather, our focus is on prudential aspects. Here, arguably, there is more agreement especially with regard to the need for strong financial regulation and supervision (although there is one camp which continues to argue in favour of methods to enhance market discipline). One area which certainly remains controversial however is the role of capital inflow taxes or other interventions on capital flows for a prudential motive.

Related to this controversy, the perceived imperfections of domestic credit markets, the collapse of domestic asset prices and the deep impact on economic activity that appears to follow has attracted renewed attention on the balance sheet channel as a potential important explanation of why these crises have been so deep in some countries. According to this view, high debt collateralized on falling asset prices (either directly intermediated or through the banking system), was central to explaining the deep problems in credit markets, the consequent credit crunch, and hence the deep decline in economic activity experienced in affected countries. An extremely useful recent analytical model in this regard is that of Kiyotaki and Moore (1997). The K&M model shows, via a simple assumption regarding imperfect credit markets (i.e.: that borrowing must be fully collateralized), the potential propagation of a small shock to fundamentals through the credit market causing a sharp decline in real output.

Our view is then that if capital inflow taxes or other capital market interventions are to play a prudential role, then it is to prevent the build-up of "excessive" debt levels and hence make the economy less prone to these kinds of balance sheet effects. Our intuition is then that the potential role of capital market interventions can be studied effectively in a K&M world in order to investigate whether, given the assumed credit market imperfection, the multiplication effect of a small shock to fundamentals on economic activity can be reduced.

An important observation is that the K&M model is a closed economy model and hence there appears to be nothing particularly special about foreign debt in propagating a negative shock. It might be argued that in a floating exchange rate regime where debts are in local currency then if the economy is subject to a negative external shock (e.g.: a fall in the terms of trade) then an exchange rate depreciation might assist to correct the problem without suffering a significant impact on domestic asset prices. However, if debts are in foreign currency (and in general virtually all emerging country external debt and much of long term domestic debt is in foreign currency or indexed), then an exchange rate depreciation will lead to very similar problems as a decline in domestic asset prices as in the K&M model (see Calvo (1999) and Hausmann, Gavin, Pages-Sierra and Stein (1999)Hausmann et al for further discussions of the effect of liability dollarization).

Moreover, if the shock is a domestic one (i.e.: to productivity in a non-traded sector), then exchange rate depreciation may not help and again a decline in domestic asset prices (as in the K&M model) will occur. For these motives we consider the K&M model, even though it is a closed economy model, a very useful starting point for the discussion of the value of different capital market interventions. In fact in our extension of the K&M framework below we do consider an open economy version but we do not in this paper incorporate exchange rate changes. We do believe however that the framework could be extended to a floating exchange rate world and that different assumptions regarding, for example, the currency composition of debt could then be analyzed.. Another highly related issue is if the capital market intervention has a reserve component (e.g.: as in the Chilean style zero remunerated reserve requirement), whether this reserve is maintained in domestic or in foreign currency. We leave these as topics for future research.

Rather, the issue in which we chose to focus is how different types of capital market interventions affect the economy both in the steady state ('the good times') and when confronted with a negative shock which is then multiplied through a K&M style credit market imperfection. The motivation behind this analysis is that even though there is an extremely extensive literature on the emerging country financial crises and prominent economists have pronounced either strongly in favour or against "capital controls", there is a surprising lack of models which attempt to find what "capital control" or perhaps more clearly stated, what capital market intervention might be optimal. Many cite the Chilean-style model of a zero remunerated reserve requirement which is indeed one possible intervention and ask the question whether this intervention may be welfare improving. However, we suggest that the correct approach is to consider a spectrum of potential interventions and attempt to rank these in some meaningful way.

The analogy to trade policy is illuminating here. The welfare comparison of tariffs and quotas and other trade interventions is to be found in any elementary text book and more advanced texts consider welfare orderings of trade interventions depending on existing distortions i.e.: first best vs. second best worlds etc. However, not only do we lack a 'capital market theory' along the lines of 'trade theory' which considers different forms of capital market intervention but there has also been a surprising lack of an attempt to create one (an interesting exception is Goldfajn and Valdés (1999)).

This paper is then an attempt to develop a model which might be used to compare different types of interventions. The next section refreshes the reader regarding the basic set-up of the K&M model. A fundamental assumption is that credit is only extended on the basis of collateral and that there is one sector which is credit constrained (farmers) and a second non credit-constrained sector (gatherers). The critical assumption is that the collateral, land, is also an input to production. In this model, the credit constrained sector (farmers) borrows as much as possible to finance purchases of land. A small negative shock to the productivity of land, then causes a fall in the price of land reducing the value of available collateral. This then implies a reduction in the availability of credit, reducing land purchases further and hence further reducing the price of land. This multiplication effect causes a sharp fall in the price of land and a deep decline in production for a small productivity shock.

In section 3, we then extend the model to include consumers and formally open the economy - subject to a fixed exchange rate - such that consumption is not necessarily the same as production. In a first version we model a generalized capital market intervention which might represent a reserve requirement or a liquidity requirement. There are three variables associated with this intervention. First, its rate, second, whether the requirement is remunerated and finally a variable which governs how much of the requirement can itself be used as collateral. A Chilean-style zero remunerated reserve requirement would then consist of a positive tax rate, a zero rate of remuneration and (perhaps more arguably) the lack of the use of this reserve as collateral. On the other hand we suggest that a positive rate of remuneration corresponds more closely to an Argentine-style liquidity requirement (Argentina imposes a remunerated liquidity requirement on virtually all banking sector liabilities). In Section 5, we present a third version of the model which has a pure tax on debt. In other words, for each unit of debt raised a tax must be paid which it is assumed is consumed by the Government (not modelled directly). We argue that this is similar to a pure tax on capital inflows which has no reserve component.

In section 5 we then present some simulation results for the different versions of the model and discuss the implications of alternative ways to instrument capital market interventions. We attempt to provide a ranking of these different interventions depending on various criteria. Finally, our conclusions are presented in section 5.

2 The basic KM Model

In this section we briefly sketch the Kiyotaki and Moore 1997's (K&M) model of credit cycles. which consists of a relatively simple economy composed of two types of agents.

2.1 Collateral Constrained Firms/Consumers

The budget constraint of constrained firms/consumers [1] is given by:

$$q_t(k_t^c - k_{t-1}^c) + R_{t-1}b_{t-1}^c + x_t^c = y_t^c + b_t^c$$

where q is the price of land at the beginning of time t, k is land, b is debt, y is production, x is consumption and R is the gross interest rate.

Production is given by:

$$y_t^c = (a_t + c)k_{t-1}^c \tag{1}$$

The KM assumption regarding credit market imperfections is that debt repayment cannot exceed the value of collateral:

$$b_t^c R_t \leq q_{t+1}k_t^c \tag{2}$$

The constrained firms' problem is then to maximize present discounted utility:

$$\sum_0^\infty x_t^c \left(\beta'\right)^t$$

[1] Credit constrained firms/consumers are termed farmers or borrowers in the KM model.

where $\beta' R < 1$.

To ensure that these firms do not postpone consumption indefinitely, K&M assume that a fraction c of all production cannot be sold. Therefore, consumption must satisfy:

$$x_t^c - ck_{t-1}^c \geq 0 \tag{3}$$

It can be shown that in the neighborhood of the steady state the constrained consumer consumes only the non–tradable fruit and the credit constraint is binding – i.e. equations (2) and (3) hold with equality. Consequently, we have:

$$k_t = \frac{NW_t}{q_t - \frac{q_{t+1}}{R_t}} \tag{4}$$

where:

$$NW_t = (a_t + q_t)\, k_{t-1}^c - R_{t-1} b_{t-1}^c \tag{5}$$

is net worth.

Equation (4) says that a constrained firm uses all his net worth NW_t to finance land purchases. The opportunity cost of land is given by:

$$q_t - \frac{q_{t+1}}{R_t}$$

which is the difference between the purchase value of land at time t and the present value of its resale price one period later.

2.2 Unconstrained Firms/Consumers

The budget constraint of unconstrained firms/consumers [2] is given by:

$$q_t(k_t^u - k_{t-1}^u) + R_{t-1} b_{t-1}^u + x_t^u = y_t^u + b_t^u$$

where the superscript u denotes an unconstrained firm/consumer.

Production is given by:

$$y_t^u = G(k_{t-1}^u)$$

where G satisfies the usual conditions.

The unconstrained firm/consumer's problem is to maximize present discounted utility:

$$\sum_{t=0}^{\infty} x_t \beta^t$$

It is shown in KM that the first order conditions are:

$$\begin{aligned} R_t \beta &= 1 \\ q_t - \frac{q_{t+1}}{R_t} &= \frac{1}{R} G'\left(k_t^u\right) \end{aligned}$$

[2] Unconstrained firms are termed gatherers or lenders in the KM model.

The last equation says that the return from buying a unit of land from time t to time $t+1$ must equal its discounted marginal product.

Given land market clearing ($k_t^c + k_t^u = \bar{k}$), we have:

$$u(k_t^c) = q_t - \frac{q_{t+1}}{R_t} \tag{6}$$

where:

$$u(k_t^c) \equiv \frac{1}{R_t} G'\left(\bar{k} - k_t^c\right) \tag{7}$$

2.3 Steady state Equilibrium

Using (6) in the steady state we have:

$$q^{KM}\left(1 - \frac{1}{R}\right) = \frac{1}{R} G'\left(\bar{k} - k^{KM}\right) \tag{8}$$

where q^{KM} and k^{KM} are, respectively, the price of land and land holdings by the credit constrained firms in the steady state for the KM model. Intuitively, this equation says that the marginal return from holding land must equal the marginal product for the unconstrained firms. Consequently, if the price of land increases, the marginal product for the unconstrained firms must increase which implies that holdings by credit constrained firms must increase. It is important to keep in mind that since all the models we discuss below do not modify the unconstrained firms maximization problem, equation (8) will hold in all these models.

Equations (**??**), (4) and (5) imply that:

$$q^{KM}\left(1 - \frac{1}{R}\right) = a$$

i.e. the marginal return from holding land for the constrained firms must equal its marginal product. This equation will only hold in the KM model.

Finally, since the (2) holds with equality:

$$B^{KM} = \frac{q^{KM} k^{KM}}{R} = \frac{a}{R-1} k^{KM}$$

2.4 Temporary Productivity Shocks and Equilibrium

Consider an unexpected temporary decrease in the productivity of land at time t. Formally, starting from a steady state $a_t = a$ it is announced at time t that the path of production is given by:

$$a_s = \begin{cases} a & \text{for} \quad s < t \\ a - \Delta a & \text{for} \quad s = t \\ a & \text{for} \quad s > t \end{cases}$$

where $\Delta > 0$.

Since the productivity shock occurring at time t was unexpected (at time $t-1$), the price of land is different than the one which would have prevailed in the absence of the shock. This implies that $q_t \neq q_t^e = q$, where q_t^e is the $t-1$ expected value of q_t Consequently, using (5) we get the equilibrium equation for unexpected shocks:

$$u(k_t)k_t = (a - \Delta a)\, k + (q_t - q)k$$

Remark 1 *As can be seen from this equation the decrease in a has two effects on net worth:*

1. The direct effect. Since productivity falls, the value of land holdings falls in the amount $|\Delta ak|$ so that net worth falls.

2. The indirect effect. The decline in net worth induces a decline in farmers expenditures of land: $u(k_t)k_t$. This decrease is translated into lower holdings of land by farmers so that their collateral declines even more. This induces a fall in the price of land (unexpected capital losses) in the amount $(q - q_t)k$ in the first period.

On the other hand, since for $s > t$ there are no unexpected productivity shocks, the assumption of perfect foresight implies that $q_s = q_s^e$ for all $s > t$. We obtain the equilibrium equation for expected shocks:

$$u(k_s)k_s = ak_{s-1}$$

It is shown in K&M that the proportional change in land prices and landholdings by farmers at time t are given by:

$$\hat{q}_t = \frac{1}{\eta}\Delta \tag{9}$$

$$\hat{k}_t = \frac{1}{1+\frac{1}{\eta}}\left(1 + \frac{1}{\eta}\frac{R}{R-1}\right)\Delta \tag{10}$$

where a hat over a variable denotes percentage changes with respect to its steady state value and:

$$\frac{1}{\eta} = \frac{u'(k)k}{u(k)}$$

is the elasticity of the user cost of land. In addition the path of land prices and capital for $s > t$ is given by:

$$\hat{k}_s = \left(1 + \frac{1}{\eta}\right)^{-(s-t)} \hat{k}_t$$

$$\hat{q}_s = \frac{1}{\eta}\frac{1}{1 - \frac{1}{R}\frac{\eta}{1+\eta}}\left(1 + \frac{1}{\eta}\right)^{-(s-t)} \hat{k}_t.$$

Notice the effect of the shock on land prices and land holdings for farmers is of the same order of magnitude as the shock and has a permanent effect although the shock lasts for one period only.

2.5 Welfare Analysis

The economy's total production or GDP is given by:

$$GDP(a_t, k_t^c, k_t^u) \equiv (a_t + c)k_t^c + G(k_t^u) \tag{11}$$

Consequently, given market clearing in the land sector, the first best level of land holdings by the farmers k^* in the steady state satisfies:

$$a + c = G'(\bar{k} - k^*) = u\,(k^*)\,R \tag{12}$$

However, in the steady state, we have:

$$a = \frac{G'(\bar{k} - k^{KM})}{R} = u(k^{KM})$$

where k^{KM} is the steady state level of consumption in the KM model.

Since $u' > 0$ and given the KM assumption that:

$$\frac{c}{a} > R - 1$$

it follows that in the steady state, the constrained producers end up purchasing a suboptimal amount of land ($k^{KM} < k^*$). In other words, the collateral constraint reduces welfare (production) hence relaxing the collateral constraint would increase welfare in the steady state. This suggests that policies which reduce the amount of debt by farmers will not lead to higher welfare in the steady state although they might make the economy less vulnerable to productivity shocks.

In addition, since following a negative temporary shock to production land purchases by farmers GDP falls, this means that a negative productivity shock lowers permanent income and hence welfare. In fact, KM show that the percentage change in GDP relative to its steady state value equals

$$\widehat{GDP_t} = \Delta \frac{ak^{KM}}{GDP^{KM}} < 0$$

at time t and:

$$GDP_{t+s} = \frac{a + c - Ra}{a + c} \frac{(a + c)}{GDP^{KM}/k^{KM}} \hat{k}_{t+s-1} < 0 \text{ for } s > 0.$$

3 Reserve and Liquidity Requirements in KM

The following model is an extension of the KM model to an open economy which also introduces liquidity/reserve requirements. Specifically, we separate consumers from firms, introduce a government and a liquid asset in which credit constrained firms must invest.

3.1 Consumer

The consumer maximizes present discounted utility:

$$\sum_{0}^{\infty} \beta^t v(c_t) \tag{13}$$

The instantaneous utility function $v(\cdot)$ is assumed to exhibit constant elasticity of substitution:

$$v(c) = \frac{c^{1-\frac{1}{\varepsilon}} - 1}{1 - \frac{1}{\varepsilon}} \tag{14}$$

The consumer's flow constraint is given by:

$$R_{t-1} b^h_{t-1} + c_t = b^h_t + x^c_t + x^u_t + \tau_t \tag{15}$$

where b^h is the household sector net foreign debt, c is consumption, x^c are dividends from constrained firms, x^u are dividends from non–constrained firms, τ_t are net transfers from the government and the superscript h denotes consumers (or households).

The consumer's problem is to maximize (13) subject to (14), (15) and the non–Ponzi game condition that $\lim_{t\to\infty} b^g_t D(t)^{-1} \leq 0$ where $D(t) \equiv \prod_0^t (1 + r_s)$.

The corresponding first order conditions are:

$$\begin{aligned} c_{t+1}^{\frac{1}{\varepsilon}} &= c_t^{\frac{1}{\varepsilon}} \beta R_t \\ \lim_{t\to\infty} u'(c_t) b^h_t \beta^{-t} &\geq 0. \end{aligned} \tag{16}$$

were λ is the lagrange multiplier in the inter–temporal resource constraint.

3.2 Credit Constrained Firms

Credit constrained firms are subject to the following budget constraint:

$$q_t(k^c_t - k^c_{t-1}) + R_{t-1} b^c_{t-1} + z^c_t + x^c_t = y_t + b^c_t + R^z_{t-1} z^c_{t-1}$$

where z are liquid asset holdings, R^z is the return on the liquid asset and the superscript c now stands for constrained firms.

We maintain the K&M assumptions that:

1. the production function of the constrained firm is linear in capital and given by equation (1) repeated here for convenience:

$$y^c_t = (c + a_t) k^c_{t-1}$$

2. dividends canot be less than a fraction $\psi = c/(a_t + c)$ of total production:

$$x^c_t \geq \psi y^c_t = c k^c_{t-1} \tag{17}$$

We depart from K&M in two ways.

1. Firms can only borrow up to the value of their collateral which may include liquid and illiquid assets:
$$R_t b_t^c \leq q_{t+1} k_t^c + \phi R_t^z z_t^c \tag{18}$$
where ϕ is the percentage of liquid asset which may be used as collateral.

2. We impose a liquidity requirement of the form:
$$z_t^c \geq \delta q_{t+1} k_t^c \tag{19}$$
In other words, we assume that borrowers must set aside, in the form of a liquid asset, a fraction δ of the value of their investments in land.

The problem of the credit constrained firm is to maximize the present discounted value of dividends.
$$\sum_0^\infty x_t^c \left(\beta'\right)^t$$
subject to (1), (17), (18) and (19) and $\beta' R < 1$.

It is shown in the Appendix that:

1. Since $\phi < 1$ and $R_t^z < R_t$ for all t, the collateral constraint is certain to bind. There are three reasons for this. First, consider a firm which decides on its financial mix (i.e. the proportion of bonds and cash for a given level of total net financial assets $-b_t + z_t$). Even if the collateral constraint were not binding, and since the rate of return on assets is lower than the rate of return on debt (i.e. $R > R^z$), it is optimal to borrow as less as possible (by setting $z_t = 0$). For the same reason, an increase in cash at the expense of bonds makes the collateral in advance constraint more binding. Finally, since illiquid assets are at least as productive as collateral than liquid ones (i.e. $\phi <= 1$), the borrower would like to hold as little cash as possible.

2. If $a > \left(\frac{1}{\beta} - 1\right) c$ and $\beta' R < 1$, in the neighborhood of the steady state the dividend constraint and the credit constraint are binding – i.e. equations (17) and (19) hold with equality. Consequently, we have:
$$k_t^c = \frac{NW_t}{q_t - q_{t+1}\frac{1}{R} + q_{t+1}\delta\left(1 - \phi\frac{R_t^z}{R_t}\right)} \tag{20}$$
where:
$$NW_t \equiv \left(a_t + q_t\right) k_{t-1}^c + R_{t-1}^z z_{t-1}^c - R_{t-1} b_{t-1}^c, \tag{21}$$

Equation (20) says that the credit constrained firm uses all his net worth NW_t to finance capital purchases. The denominator in (20) can be thought as the downpayment required to purchase a unit of land. The first two terms in this denominator indicate the difference between the purchase value of land at time t and the present value of its resale price one period later. The last term is the opportunity cost of the liquidity requirement (in time t units). If the firm employs k_t^c units of land, it has to set aside $z_t = \delta q_{t+1} k_t^c$ for the liquidity requirement. If $\phi > 0$, however, it can use a fraction $\phi z_t = \phi \delta q_{t+1} k_t^c$ as collateral which has a present value of $\phi \delta q_{t+1} \frac{R_t^z}{R_t}$.

3.3 Unconstrained Firms

Unconstrained firms are not subject to the collateral in advance constraint (as before) nor to the liquidity requirement (for simplicity). Consequently, their problem is the same as of the unconstrained consumer/firm of the KM model and equations (6) and (7) continue to hold:

$$\begin{aligned} u(k_t^c) &= q_t - \frac{q_{t+1}}{R_t} \\ u(k_t^c) &\equiv \frac{1}{R_t} G'\left(\bar{k} - k_t^c\right) \end{aligned}$$

3.4 Government

The government sets the liquidity requirement, issues the liquid asset and taxes the consumer in a lump sum fashion:

$$R_{t-1} b_{t-1}^g + R_{t-1}^z z_{t-1} + \tau_t = b_t^g + z_t.$$

where the superscript g stands for government.

3.5 Equilibrium

Combining (20), (21) and (7) we obtain:

$$\left[(1 - \gamma R) q_t + \gamma R u(k_t)\right] k_t = (a_t + q_t)\, k_{t-1} + R_{t-1}^z z_{t-1} - R_{t-1} b_{t-1} \tag{22}$$

where we have dropped the superscript c to economize on notation and:

$$\gamma_t \equiv \frac{1 + \delta \phi R_t^z}{R_t} - \delta \tag{23}$$

Consolidating the budget constraints of all the agents in this economy, we have:

$$R_{t-1} b_{t-1} + c_t = GDP_t + b_t$$

where:

$$b \equiv b^h + b^c + b^u + b^g$$

Integrating forward and employing the relevant Non-Ponzi game condition and the fact that $R\beta = 1$,

$$\sum_{s=t}^{\infty} R^{s-t} c_s = \sum_{s=t}^{\infty} R^{s-t} GDP_s - R b_t \tag{24}$$

Moreover, since $R = \beta^{-1}$ from (16) it can be seen that $c_s = c$ for all $s \geq t$ and so:

$$c = (R - 1) \left[\sum_{s=t}^{\infty} R^{s-t-1} GDP_s - b_s\right] \tag{25}$$

3.5.1 Steady State

In the steady state, equation (20) becomes:

$$MC(q,\delta,\phi)k = NWU\,(q,\delta,\phi)\,k$$

where:

$$\begin{aligned} MC(q,\delta,\phi) &= q\left[1-\frac{1}{R}+\delta\left(1-\frac{\phi R^z}{R}\right)\right]. && (26)\\ NWU\,(q,\delta,\phi) &= a+q\left[\delta(1-\phi)R^z\right]. && (27) \end{aligned}$$

which are, respectively, the marginal cost of holding land and net worth per unit of land both evaluated in the steady state. Consequently, in the steady state the marginal cost of land equals the net worth per unit of land.

Solving explicitly, we have

$$q=\frac{a}{1-\frac{1}{R}+\delta\left[\left(1-\frac{\phi R^z}{R}\right)+(1-\phi)R^z\right]} \tag{28}$$

whose value depends on the values of ϕ and δ.

To understand the effect of liquidity requirements on the steady state it is useful to distinguish the effect that the liquidity requirement has on the marginal opportunity cost of holding land and net worth per unit of land in the steady state for different values of ϕ.

1. When $\phi = 0$, inspection of (26) shows that a marginal increase in δ leads to an increase in marginal cost in the amount of the price of land q because the firm has to set aside more of the liquid asset for the liquidity requirement. On the other hand, as long as the liquid asset pays some interest (i.e. $R^z > 1$), a marginal increase in δ leads to an increase in the net worth per unit of land in the amount $R^z q$ because the issue of the bond increases the net worth of the firm next period – witness the right hand side of (27). This means that the effect on the net worth per unit of land outweighs the effect on marginal cost as long as the rate of return on the liquid asset is positive so that the price of land has to rise.

2. When $\phi = 1$, inspection of (26) shows that a marginal increase in δ leads to an increase in marginal cost in the amount of $q\left(1-\frac{R^z}{R}\right)$ because the firm has to set aside more of the liquid asset for the liquidity requirement but can use some part of the liquid asset as collateral. On the other hand, since all liquid assets are used as collateral, net worth per unit of land does not increase. This implies that the price of land has to fall as δ rises.

3. It can be shown that as ϕ rises it is more likely that the effect on the marginal cost outweighs the effect on the net worth per unit of land so that q falls with δ.

Manipulation of equation (6) evaluated at the steady states reveals that the steady state level of land holdings by borrowers solves:

$$G'\left(\bar{k}-k\right)=q\,(R-1)$$

Since G is concave, a higher q leads to a higher k. Intuitively, as the value of land increases the opportunity cost of holding land increases for the unconstrained firms so that they would like to hold less land. Since the total supply of land is fixed, this implies that landholdings by constrained firms must rise.

Gross domestic product, in turn, is given by:

$$GDP(a,k) = (a+c)k + G(\bar{k} - k)$$

which is increasing in q. Intuitively, as q increases, so does k. But since due to collateral in advance constraint the borrower land holdings were below the first best, an increase in k leads to higher GDP.

The fact that when $\phi = 0$, q, k and GDP are higher compared to their steady state values in the absence of the liquidity requirement is upsetting because:

1. the introduction of a distortion (i.e. the liquidity requirement) improves welfare in the steady state.
2. the former result is apparently counter-intuitive because it would seem to imply that unconstrained firms have an incentive to hold the liquid asset which is dominated by the bond.

With regards to point 1., it is well known from the theory of the second best that the imposition of a second restriction (the liquidity requirement) when an initial restriction is present (the collateral in advance constraint) can lead to an increase in welfare. With regards to point 2., land prices are higher in the steady state only because the government has the power to enforce the liquidity requirement. If the government did not have such power, each borrower would like to hold as little amount of cash as possible and we would be back to the KM world. It is precisely because the private incentive of each individual unconstrained firms is not aligned with the incentives of unconstrained firms as a group that the liquidity requirement improves welfare in the steady state.[3]

3.6 Temporary Productivity Shock and Equilibrium

Consider an unexpected temporary decrease in the productivity of land. Formally, starting from an steady state in which $a_s = a$ for all $s < t$ it is announced between time $t-1$ and time t that the path of a_t is given by:

$$a_s = \begin{cases} a & \text{for} \quad s < t \\ a - \Delta a & \text{for} \quad s = t \\ a & \text{for} \quad s > t \end{cases}$$

where $\Delta > 0$. For simplicity, assume that $R_t = R = \beta^{-1}$ and $R_t^z = R^z$ for all t.

At time t, the shock to a is unanticipated. Consequently, the value of land is not necessarily equal to its expected value prior to the shock:

$$q_t \neq q_t^e = q$$

[3] The situation faced by borrowers in this economy is analogous to that of the members of a cartel who have incentives to undercut the cartel price.

where q_t is the actual price at t, q_t^e is the expected as of time $t-1$ price of land at time t and q is the steady state value of q which is equal to q_t since the economy was suppose to be in a steady state prior to the announcement of the path of a.

Consequently using (21) we get the equilibrium equation in the presence of an unexpected shock:

$$[(1-\gamma R)q_t + \gamma R u(k_t)]\, k_t = NW_t = \{a - \Delta a + q_t - q + q\,[\delta(1-\phi)R^z]\}\, k \qquad (29)$$

where:

is the inverse of gross interest rate faced by farmer adjusted for the liquidity requirement.

For $s > t$ shocks are anticipated so $q_s^e = q_s$ hence the equilibrium equation is:

$$[(1-\gamma R)q_s + \gamma R u(k_s)]\, k_s = NW_s = \{a + q_s\,[\delta(1-\phi)R^z]\}\, k_{s-1} \qquad (30)$$

To understand the dynamics of the system after a shock it is convenient to distinguish between impact effects and the mechanism by which these shocks propagate..

3.6.1 Impact Effects

Since agents learn about the existence of the shock before time t arrives and prior to t the economy was in the steady state we have $k_{t-1} = k$. In addition, since the economy was in a steady state, they expected that the price of land at time t would be equal to the current price so that $q_t^e = q$. Consequently, using (**??**):

$$[(1-\gamma R)q_t + \gamma R u(k_t)]\, k_t = NW_t = \{a - \Delta a + q_t - q + q\,[\delta(1-\phi)R^z]\}\, k \qquad (31)$$

Using (31) we can observe the shock in land expenditures gives rise to an impact decline in land purchases in three ways:

1. The direct net worth effect. Since productivity falls, production falls in the amount $|\Delta a k|$ so that net worth falls.

2. Multiplier effects. The decline in net worth induces a decline in farmers expenditures of land: $[(1-\gamma R)q_t + \gamma R u(k_t)]\, k_t$. The fall in the amount spent on land gets translated into lower land purchases and a lower price for land. This induces an unexpected fall in the value of collateral equal to $(q - q_t)$ in the first period which induces an even larger fall in net worth.

3. The decrease in the opportunity cost of land. Since

$$1 - \gamma R = \delta\,(R - \phi R^z)$$

the induced decrease in q_t decreases the opportunity cost of purchasing land. This tends to offset the previous two effects.

3.6.2 Propagation Mechanism

After time t, since there are no unexpected shocks, the following two equations govern the path of q and k :

$$[(1-\gamma R)q_{t+s}+\gamma Ru(k_{t+s})]\,k_{t+s} = \{a+q_{t+s}\,[\delta(1-\phi)R^{z}]\}\,k_{t+s-1} \quad (32)$$

$$q_{t+s} = Rq_{t+s-1}-Ru(k_{t+s-1}) \quad (33)$$

The behavior of the system depends on the values of ϕ and δ.

1. For any k_{t+s-1}, any fall in the price of land will bring about a lower cost of purchasing land which will increase the demand for land. The higher δ and ϕ are, the more responsive is the opportunity cost of holding land to land prices. This implies that land demand will be more negatively elastic with respect to q_{t+s}.

2. Also, for any given k_{t+s-1}, the higher δ is and the lower ϕ is, the higher net worth will be for any q_{t+s} (since $\delta(1-\phi)R^{z}$ is increasing in δ and decreasing in ϕ). Consequently, land purchase will be more positively elastic with respect to land prices as δ increases and ϕ falls.

3. Finally, since the opportunity cost of purchasing land is an increasing function of the amount of land consumed (notice the term $\gamma Ru(k_{t+s})$ in equation), the higher ϕ and δ are, the lower the increase in the opportunity cost of land as land purchases by borrowers rise.

Since ϕ and δ influence the above mentioned factors in different ways, the behavior of the dynamic system depends on the relative strengths of these effects.

This discussion implies that the propagation of shocks is determined by the values of ϕ and δ in an intuitive way. The caveat is that these since these effects counteract each other the exact behavior of the system can only be determined by numerical calculation. We will postpone the numerical simulations until Section 5. In section 4 we will analyze the case of a tax on short term capital inflows.

4 Tax on Capital Inflows

For simplicity, we assume that the problem faced by consumers, unconstrained firms and the government is the same as before. Constrained firms, however, have to pay a tax per dollar issued.

4.1 Credit Constrained Firms

We introduce a tax on short term debt such that for any dollar of debt issued, the lender has to pay a tax in the amount $b_t\tau$ where τ is the tax. The borrowers budget constraint is given by:

$$q_t(k_t^c-k_{t-1}^c)+R_{t-1}b_{t-1}^c-x_t^c=y_t+b_t^c(1-\tau)$$

The rest of the setup is the same as the one in the previous section except that we do not impose the liquidity requirement (i.e. equation 19) and the government does not issue the liquid asset.

Since a firm that issues a bond in the amount b_t only receives $b_t(1-\tau)$ after tax, but still has to pay $b_t R_t$ next period, this means that the after tax cost of debt is $R_t/(1-\tau)$. so that the model in this section is similar to the KM model with a higher cost of debt. Consequently, it is still the case that the credit constraint is binding so that:

$$k_t^c = \frac{NW_t}{q_t - q_{t+1}\frac{1-\tau}{R_t}} \tag{34}$$

where:

$$NW_t = (a_t + q_t)\, k_{t-1}^c - R_{t-1} b_{t-1}^c \tag{35}$$

is net worth. The denominator in (34) can be thought as the opportunity cost of holding a unit of land. The first terms in this denominator is the price of land at time t, and the second is (minus) the present value of its resale price one period later discounted at the after tax cost of interest $R_t/(1-\tau)$.

4.2 Unconstrained Firms

The problem faced by unconstrained firms is the same as in the previous section.

4.3 Government

The government sets the tax rate, collects the tax and returns the gains in a lump sum fashion:

$$R_{t-1} b_{t-1}^h + \tau_t = \tau b_t^c + b_t^g + z_t^g.$$

where b_t^g is the government debt and z_t^g is the supply of the liquid asset outstanding.

4.4 Temporary Productivity Shock and Equilibrium

Consider, again an unexpected temporary decrease in the productivity of capital. Starting from a steady state equilibrium in which $a_t = a$ the path followed by production is given by:

$$a_s = \begin{cases} a & s < t \\ a - \Delta a & s = t \\ a & s > t \end{cases}$$

where $\Delta > 0$.

This implies $q_t \neq q = q_t^e$. Consequently using (35) we get the equilibrium equation in the presence of an unexpected productivity shock:

$$[(1-\gamma R) q_t + \gamma R u(k_t)]\, k_t = \{a - \Delta a + q_t - q_t^e\}\, k \tag{36}$$

where:

$$\gamma = \frac{1-\tau}{R}.$$

For $s > t$ shocks are anticipated, hence $q_s^e = q_s$. The equilibrium equation at time $s = t$ is:

$$\left[(1-\gamma R)q_t + \gamma R u(k_t)\right] k_t = a_t k_{t-1} \tag{37}$$

4.5 Steady state

In the steady state the marginal opportunity costs of holding land for borrowers is:

$$q\left[1 - \frac{1-\tau}{R}\right]$$

which is increasing in τ and increasing in for any land price q. On the other hand, the net worth per unit of land equals. Consequently, we have:

$$q^{Tax} = a\left[1 - \frac{1-\tau}{R}\right]^{-1} < a\left[1 - \frac{1}{R}\right]^{-1} = q^{KM}$$

A tax on short term debt lowers the price of land. Intuitively, since the tax increases the opportunity cost of holding land, the demand for land by the unconstrained firm falls so that the price of land falls.

Knowing q it is possible to solve for k^{Tax} using:

$$u(k^{Tax}) = q\frac{R-1}{R}$$

Since $u(\cdot)$ is increasing, a lower tax lowers land purchases by constrained firms with respect to the KM model.

4.6 Dynamics

Again, we distinguish between impact effects and the mechanism by which these shocks propagate in order to better understand the effects of the shock.

4.6.1 Impact Effects

At $s = t$, we have:

$$\left[\tau q_t + (1-\tau)\, u(k_t)\right] k_t = \{a - \Delta a + q_t - q\}\, k \tag{38}$$

Using (38) we can observe the shock in land expenditures gives rise to an impact decline in land purchases in three ways:

1. The direct net worth effect. Since productivity falls, the value of land holdings falls in the amount $|\Delta ak|$ so that net worth falls.

2. The indirect net worth effect. The decline in net worth induces a decline in farmers expenditures of land: $[\tau q_t + (1-\tau) Ru(k_t)] k_t$. The fall in the amount spend on land gets translated into lower land purchases and a lower price for land. This induces an unexpected fall in the value of collateral equal to $(q - q_t)$ in the first period which induces an even larger fall in net worth.

3. The increase in the opportunity cost of debt. For any $k,$ the larger Notice that since land is expected to depreciate (i.e. $q_t - q < 0$). This tends to offset the above two effects.

4.6.2 Propagation Mechanism

1. After time t, since there are no unexpected shocks the following two equations govern the path of q and k :

$$\begin{aligned} [\tau q_{t+s} + (1-\tau)u(k_{t+s})] k_{t+s} &= ak_{t+s-1} \\ q_{t+s} &= Rq_{t+s-1} - Ru(k_{t+s-1}) \end{aligned}$$

   The behavior of the system depends on the value of τ.

2. For any k_{t+s} (and k_{t+s-1} which determines net worth), any fall in the price of land will bring about a lower opportunity cost lower cost of purchasing land in the amount τk_{t+s}.

3. Finally, since the opportunity cost of purchasing land is an increasing function of the amount of land consumed (notice the term $(1-\tau)\, u(k_{t+s})$ in equation), the higher τ is, the lower the fall in the opportunity cost of land as land purchases by borrowers rise.

The higher τ, the higher is the weight given to land prices. But since land prices are autoregressive, this tends to give more persistence to the shocks.

5 Comparative analysis of capital market interventions

In this section we present a comparison of the different policies. We focus on three specific policies a) a pure tax, b) a zero-remunerated liquidity requirement and c) a remunerated liquidity requirement. 5.1 we compare the effect of different policies on the respective steady states and in Section 5.2 we compare the dynamic adjustment to a productivity shock under the three policies. In both sections we assume that the percentage of the liquidity requirement that can be used as collateral is nil (i.e. $\phi = 0$) for the following reason. We will see below that for any δ or R^z, setting $\phi = 0$ is the policy that maximizes the steady state level of GDP. In addition numerical simulations show that this is also the policy that minimizes macro–economic fluctuations for a given δ and R^z. On the other hand, recall that from our discussion of liquidity requirements, constrained firms have the incentive to avoid the requirement and to use the liquid asset as collateral. In Section 5.3 we analyze what happens when unconstrained firms are able to circumvent the liquidity requirement.

Before proceeding, however, we define the "Output loss relative to the first best" as:

$$l \equiv \frac{GDP^* - GDP}{GDP^*}$$

where GDP^* is the first best level of gross domestic product. This concept will be very useful when comparing the different policies.

5.1 Policy Intervention and the Steady State

The first issue we consider is how the different policies affect the steady state variables. We will study this issue both qualitatively and quantitatively.

5.1.1 Qualitative Analysis

Perhaps not surprisingly, it can be shown that the pure tax gives the lowest holdings of capital for the constrained sector an the lowest GDP. The non-remunerated reserve requirement does better than the tax but is dominated by the remunerated reserve requirement. In fact one can prove the following:

Proposition 1 *Assume that $\phi = 0$ and that*

$$\frac{a}{1 - \frac{1}{R} + \delta(1 - R^z)} \leq \frac{a + c}{R - 1} \tag{39}$$

Then,

- $$x^{Tax} < x^{KM} = x^{NLiq} < x^{RLiq} \leq x^* \tag{40}$$
  where $x = q, k$, GDP and $-l$ and the superscripts $RLiq$, $NLiq$, KM, Tax and $*$ stand for renumerated liquidity requirement (i.e. $R^z > 1$), non–renumerated liquidity requirement (i.e. $R^z = 1$), no intervention (i.e. the original KM model), the pure tax and the first best level respectively.

- *The weak inequality in (40) is strict iff the weak inequality in (39) is strict.*

Proof. See Mathematical Appendix.

Although the intuition for this result was given in previous sections, we repeat it here for completeness. We start with the price of land. A tax on debt increases the opportunity cost of debt for the constrained firm as compared to the KM model so that they demand less land and the price drops. When $R^z > 1$, the liquidity requirement increases the net worth per unit of land in the steady state more than it does the opportunity cost of land vis–á–vis the KM model so that the price of land increases. Condition 39 insures that the price of land does not exceed that of the first best. When $R^z = 1$ and $\phi = 0$, the marginal

Table 5.1: Benchmark Parameters

Description	Symbol	Value
Total Factor Productivity of Borrowers	$a+c$	1
Proportion of Production paid as Dividend	$c/(a+c)$	0.2
Total Factor Productivity of Lenders	ψ	1.5
Elasticity of Production for Lenders	θ	.5
Gross Real interest rate	R	1.10
Labor Endowment	$\bar{k}$	30
Shock to Productivity	Δ	10%
Percentage of Reserve Component Used as Collateral	ϕ	0

cost of land increases in the same proportion as the net worth per unit of land when the liquidity requirement is positive so that the price of land is the same as in the KM model.

With respect to k, as the price of land increases, the opportunity cost of land rises for the unconstrained firms so that it uses less land. Given market clearing, land use by constrained firms increases. Finally, since land use by constrained firms is below the first best, any policy which increases k increases GDP and lowers the output loss relative to the first best (again, condition 39 guarantees this is the case for the liquidity requirement).

5.1.2 Quantitative Analysis

Before we proceed with the analysis proper, one needs to posit a production function for the unconstrained sector and present our benchmark parameters.

As to the former, we assume that the production function is given by:

$$G(x) = \psi x^{\theta}$$

The benchmark parameters for the simulations are given in Table 5.1.

We are now in position to discuss the numerical results which are shown in Table 5.2. The table illustrates that although liquidity requirements barely improve upon the original KM model they clearly dominate the pure tax (specially with regards to land holdings and output loss). In effect the pure tax entails a whopping 6% output loss.

5.2 Policy Intervention and Dynamics

The second issue we consider is how each policy does when confronted with a negative shock. Here, analytical results are more difficult to come by. Hence we present a set of numerical simulations.[4]

Table 5.3 summarizes the results for two particular simulations (various simulations were tried with different parameter values). Figures 2–4 (below) illustrate the complete path of q, k, GDP and $l(GDP)$ following an unexpected shock for the policy parameters given in Panel A of Table 5.3.

[4] In order to solve the model we linearize it around the steady state. Details regarding the calculation of the linearized path are available upon request.

Table 5.2: Policy Comparison – Steady States

Steady State Values

Panel A: δ or τ equal 10%						
Policy	Policy Parameter			Endogenous Variable		
	δ	R^z	τ	q^a	k^a	l
Renumerated Liquidity Requirement	10%	1.08	-	105	101	0.01
Zero Renumerated Liquidity Req.	10%	1	-	100	100	0.09
Pure Tax	-	-	10%	67	73	6.26
Panel B: δ or τ equal 20%						
Policy	Policy Parameter			Endogenous Variable		
	δ	R^z	τ	q^a	k^a	l
Renumerated Liquidity Requirement	20%	1.08	-	110	103	0.03
Zero Renumerated Liquidity Req.	20%	1	-	100	100	0.10
Pure Tax	-	-	20%	50	23	26.48

[a]As a percentage of the KM model.

Table 5.3: Policy Comparison – Dynamics

Panel A: δ or τ equal 10%							
Policy	Policy Parameter			Endogenous Variable			
	δ	R^z	τ	q^a	k^a	GDP^a	l^b
K&M	-	-	-	-28.4	-47.0	-13.5	13.2
Renumerated Liquidity Requirement	10%	1.08	-	-18.6	-23.7	-6.7	6.7
Zero Renumerated Liquidity Req.	10%	1	-	-16.2	-23.2	-6.6	6.6
Pure Tax	-	-	10%	-6.0	-22.6	-5.1	11.0
Panel B: δ or τ equal 20%							
Policy	Policy Parameter			Endogenous Variable			
	δ	R^z	τ	q^a	k^a	GDP^a	l^b
Renumerated Liquidity Requirement	20%	1.08	-	-14.2	-13.5	-6.7	6.8
Zero Renumerated Liquidity Req.	20%	1	-	-10.7	-14.3	-6.5	6.6
Pure Tax	-	-	20%	-0.8	-11.6	-2.1	28.0

[a]Percentage Change with respect to steady state value after the shock.
[b]Percentage loss with respect to first best after the shock.

We find that our original intuition is correct in that a pure tax reduces the vulnerability of the economy to a negative shock in the sense that the percentage change with respect to the steady state of q, k and GDP is slower than in the KM model (and the other policies for that matter). One way to think about this is that the tax reduces the ratio of debt to land holdings in the steady state. When a negative shock arrives, although the multiplication effect is still present, the firm is less leveraged so that percentage fall in land prices, land holdings and GDP is lower. We also find that the speed by which land is subsequently accumulated again by the constrained sector to get back to the steady state is much slower than in the original model. The results show, however, that no intervention dominates the pure tax in one important sense. In effect, we know from Proposition 1 and the numerical simulations above that the output loss in the steady state is, for the pure tax, is significantly lower than that of the KM model. Consequently, although the percentage change in GDP for the pure tax is relatively small the steady state the value from where we start is also relatively low. Hence, the output loss for the pure tax along the equilibrium path is consistently below that of the KM model.

The liquidity requirement policies, on the other hand, clearly dominate no intervention. It can be seen from Table 5.3 and the figures. Specifically, not only are the percentage changes in q, k and GDP lower than in the KM model but their absolute values are consistently higher. The reason is that the liquidity requirement attacks the cause of the problem directly. The problem with the KM model is that when a negative shock hits the economy, the net worth of the constrained firms suffers a large hit not only because productivity falls but because land depreciates. When unexpected shocks occur, the liquidity requirements provides net worth cushion that is independent of productivity and land prices. Consequently, the percentage fall in net worth is smaller than in the KM model. The renumerated liquidity requirement dominates the non–renumerated requirement because this buffer is larger.

5.3 Policy Circumvention

One issue regarding reserve or liquidity requirement policies is the extent to which they can be arbitraged or 'undone' by the private sector. For example, a borrower forced to make a reserve/liquidity requirement might use those funds as collateral for a further loan. In our set-up above we can model this as a positive ϕ. As expected from our discussion in Section 3.5.1, an increase in ϕ decreases land holdings in the steady state by the constrained sector and decreases GDP. The numerical simulations show that a positive ϕ reduces the mitigating effect of these policies when confronted by a negative shock. The reason is that the more the firm can use as collateral, the smaller the net worth cushion. However, an interesting result is that even if 100% of these funds can be used as collateral (which implies that the net worth buffer is nil), there is still a mitigating effect compared to the original model and these polices with a reserve element continue to dominate the pure tax.

We suspect that when $\phi = 1$, the liquidity requirement works in a similar manner to the tax in the sense that it also reduces the proportion of net debt with respect to land holdings. As regards to the steady state, the liquidity requirement with $\phi = 1$ leads to a lower increase in the cost of debt than the pure tax so that the steady state levels of q, k and GDP are higher for the former. With respect to the dynamic results, the liquidity requirement also reduces the ratio of net debt to land holdings in the steady state but in a lower proportion than the tax so that the vulnerability of the economy is larger (in the sense that the percentage change in GDP with respect to the steady state level is lower). However, since the effect on the steady state for the tax is relatively larger, it is still the case that the liquidity requirement continues to dominate the tax.

6 Conclusion

In this paper we have attempted to present an ordering of different capital market interventions to reduce the vulnerability of an economy to a balance sheet channel transmission mechanism of a small shock to fundamentals. The motivation for this analysis was that although there is a controversial debate and extensive literature surrounding the issue of 'capital controls' or more specifically 'capital inflow taxes' there is very little literature indeed which attempts to model the efficacy of capital market interventions nor attempt an ordering of different interventions.

We suggest here that although the original Kiyotaki and Moore (1997) framework is that of a closed economy, it provides a very useful starting point to consider the issues involved. In our extension of the KM model, we consider a pure capital tax, a zero-remunerated reserve requirement and a remunerated liquidity requirement as three potential interventions. We find that the pure tax policy is dominated by the policies that have a reserve element and that the policy of a remunerated liquidity requirement, for many parameter values, dominates that of a non remunerated reserve requirement (steady state GDP is always higher and the negative shock is essentially of the same proportions).

Naturally, there are some caveats to attach to these results. First, we only consider the prudential motives for these interventions. We do not consider other motives such as attempting to gain greater monetary control to effect an independent monetary policy. Second, we do not consider exchange rate movements in this paper. Our view is however, that this approach could be extended to a floating exchange rate world and our intuition is that, especially if debts are in foreign currency, many of the results will carry through. Indeed we view this as an important issue for future research.

Our aim in this paper is to bring more clarity to the debate about 'capital market interventions'. We consider that simple statements either in favour or against 'capital inflow controls', or a Chilean style non-remunerated reserve requirement, have served to confuse many of the issues involved and that the debate should be concerned with finding 'optimal capital interventions' given the nature of the perceived distortion. In this paper we choose to anneals a credit market imperfection which gives rise to a strong 'balance sheet effect' following KM. If this is the distortion then our ordering of policy interventions favours a remunerated liquidity requirement. We trust that others may wish to analyze if this result is more general in the presence of other types of distortions.

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A Appendix

A.1 Proof that the liquidity constraint is binding for constrained firms in liquidity requirement case

The Bellman equation for this problem is:

$$
\begin{aligned}
V(h_{t-1}, z_{t-1}, k_{t-1}) \quad = \quad & \left[h_t + (a_t + c)\, k_{t-1} - q_t I_t - R_{t-1} a_{t-1} + (R^z_{t-1} - R_t) z_{t-1}\right] \\
& + \beta V(a_t, z_t, I_t + k_{t-1}) \\
& + \mu_t \left[(I_t + k_{t-1})\, q_{t+1} + \phi\,(R^z_t - R_t)\, z_t - h_t R_t\right] \\
& - \lambda_t \left(q_t I_t + R_{t-1} h_{t-1} - (R^z_{t-1} - R_t) z_{t-1} - a_t k_{t-1} - h_t\right) \\
& + \eta_t \left[z_t - \delta q_{t+1}\,(k_{t-1} + I_t)\right]
\end{aligned}
$$

subject to

$$z_t \geq 0$$

where:

$$h_t \equiv b_t - z_t$$

The FOC's are:

$$
\begin{aligned}
I_t \quad &: \quad 0 = -(1 + \lambda_t) q_t + \beta V_k(t) + \mu_t q_{t+1} - \eta_t \delta q_{t+1} && (41) \\
a_t \quad &: \quad 0 = 1 + \lambda_t + \beta V_b(t) - \mu_t R_t && (42) \\
z_t \quad &: \quad 0 \geq \mu_t \phi (R^z_t - R_t) + \beta V_z(t) + \eta_t && (43) \\
k_{t-1} \quad &: \quad V_k(t-1) = a_t(1 + \lambda_t) + c + \beta V_k(t) + \mu_t q_{t+1} - \delta \eta_t q_{t+1} && (44) \\
a_{t-1} \quad &: \quad V_b(t-1) = -(1 + \lambda_t) R_{t-1} && (45) \\
z_{t-1} \quad &: \quad V_z(t-1) = (1 + \lambda_t)\left(R^z_{t-1} - R_{t-1}\right) && (46)
\end{aligned}
$$

We will show by contradiction that the liquidity requirements will always be binding. First, notice that in all the equilibria we will consider we have that both q_t and k_t are positive. Consequently, as long as $\delta \geq 0$, we will have $\delta q_{t+1} k_t \geq 0$. But if the liquidity requirement is not binding, we have: $z_t > \delta q_{t+1} k_t \geq 0$ and $\eta_t = 0$. But if $R^z_t < R_t$ for all t, equation (46) implies that $V_z(t) < 0$. But this implies that the right hand side of equation (43) is negative which implies that $z_t = 0$, a contradiction.

A.2 Proof that holdings of liquid assets are nil in the tax case.

It is easily shown that the maximization problem faced by the borrower when there is a tax is the very similar to the one faced by the borrower when the liquidity requirement is $\delta = 0$ and the borrowing rate equals $R^\tau_t = R_t/(1 - \tau)$. Consequently, the proof that we employed when analyzing liquidity requirements also works here.

A.3 Proof of Proposition 1

Equation (28) evaluated at $\phi = 0$ gives the following the steady state value of q for the liquidity requirement case:

$$\frac{a}{1 - \frac{1}{R} + \delta(1 - R^z)}$$

Consequently,

$$q^{Rliq} = \frac{a}{1 - \frac{1}{R} + \delta(1 - R^z)} > \frac{a}{1 - \frac{1}{R}} = q^{NLiq} = q^{KM}$$

In the tax case we have:

$$q^{Tax} = \frac{a}{(1 - \frac{1}{R}) + \frac{\tau}{R}} < q^{KM}$$

As to the steady state value for k, notice that for all the policies we consider, its value is given by:

$$q\left(1 - \frac{1}{R}\right) = u\left(k\right)$$

where u is an increasing function.

With respect to GDP, since the production function of the unconstrained firms is concave it can be shown that GDP is increasing in k as long as $k \leq k^*$ where k^* is the first best level of land holdings by farmers. Since $k^{Tax} < k^{KM}$ it follows that $GDP^{Tax} < GDP^{KM}$. Condition (39) assures that $k^{RLiq} \leq k^*$ so that k^{Rliq} is in the increasing portion of GDP so that $GDP^{Rliq} > GDP^{KM}$. A similar argument holds for l. ■

Figure 2: Path of Land Prices for Alternative Policies

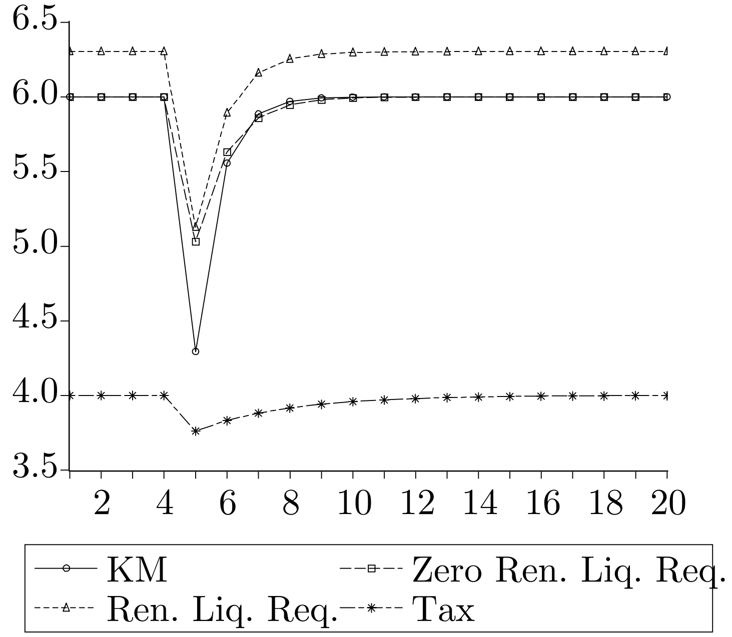

Figure 3: Path of Land Holdings for Alternative Policies

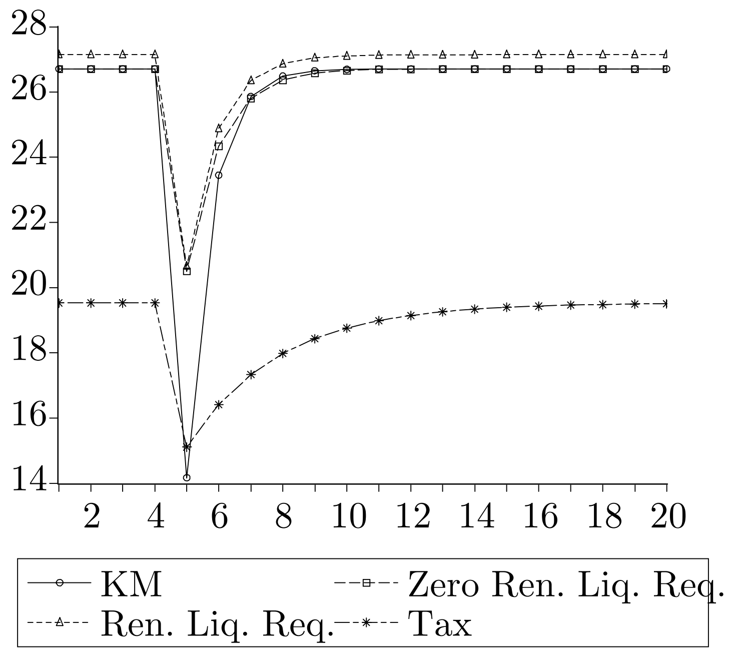

Figure 4: Path of GDP for Alternative Policies