ASYMMETRIC INFORMATION, INVESTMENT FINANCE AND REAL BUSINESS CYCLES

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ABSTRACT

This paper surveys the literature on the role of financial factors in explaining economic fluctuations. We begin by discussing the views of some prominent early macroeconomists and then examine the recent literature on the role of asymmetric information in the market for investment finance. This literature shows that in the presence of informational asymmetries, financial factors may affect real variables like investment and output. In dynamic models real variables may also affect financial factors and may generate persistent effects of shocks even in models which would not display persistence in the absence of the informational asymmetry.

Preliminary: Comments welcome.

"It is not money that makes the world go round, but credit."

J E Stiglitz (1988, p.320)

1. Introduction

This paper surveys the literature on the role of financial factors in explaining economic fluctuations. We place special emphasis upon the recent literature on the implications for economic fluctuations of asymmetric information in the market for investment finance.[1] The basic argument of this literature is that, in the presence of informational asymmetries and agency costs, financial factors may affect real variables like investment and output. In dynamic models these real variables may also affect financial factors and may generate persistent effects of shocks even in models which would not display persistence in the absence of the informational asymmetry.

The plan of the paper is as follows. Section 2 provides a brief discussion of the views of some earlier writers on the importance of financial factors in the determination of economic activity. Section 3 reviews the microeconomic arguments concerning informational asymmetries and their implications for investment finance. Section 4 shows one way in which these microfoundations have been used to provide a real business cycle model based on informational asymmetries and agency costs. Section 5 reviews the literature and Section 6 concludes.

2. Background

The idea that the role of the financial system is important in explaining the cyclical behaviour of the economy has a long history. Fisher (1933) in his theory of 'debt-deflation' coupled the collapse of the financial system with the collapse of real economic activity in the Great Depression. According to Fisher the high level of borrowers' debt built up during the period of prosperity preceding 1929 made the economy vulnerable to the ensuing downturn which led to a wave of bankruptcies which, in turn, enhanced the downturn. Furthermore deflation reduced the net worth of borrowers and led them to cut back on their expenditures which, without any offsetting rise in the expenditures of creditors, served to exacerbate the recession. A similar idea is suggested by Keynes who wrote that "if the fall of wages and prices goes far, the

[1] For a general survey of the role of asymmetric information in the market for credit see Hillier and Ibrahimo (1993). An excellent earlier review with an emphasis upon the macroeconomic issues is Gertler (1988).

embarrassment of those entrepreneurs who are heavily indebted may soon reach the point of insolvency - with severely adverse effects on investment." (*General Theory,* p.264, 1936). Keynes used this idea as one of his arguments to explain why the market economy is not returned to full employment equilibrium by falling money wages and prices[2]. In much of the *General Theory*, however, he takes the failure of the price mechanism as given and so works out the equilibrium of the economy for arbitrary values of money wages and prices. This latter exercise, although in many ways less interesting than his arguments about the inefficacy of price and wage flexibility for stabilizing the economy, was much easier to formalise and it provided the foundation stone for much of Keynesian economics and the misguided view that Keynes relied upon the liquidity trap or wage rigidities to explain involuntary unemployment. The subsequent debate between the Keynesians, Monetarists and New Classical economists also tended to blur or ignore the fact that Keynes felt that the major source of economic fluctuations was to be found in highly volatile demand for investment and instead attention focused upon the monetary sector and developments of the theory of liquidity preference.[3] Two important reasons for the relative neglect of the investment sector were the forceful advocacy by Milton Friedman of the importance of the money supply, and the Modigliani-Miller theorem, which formally showed that in a perfect markets setting real investment decisions and the value of the firm did not depend upon the method of finance.

Despite being out of the limelight, interest in the role of investment and in its mode of finance persisted in attracting the attention of macroeconomists. Notable among these were Gurley and Shaw (see, for example, 1955) who noted the role of financial intermediation in the credit supply process and called attention to the importance of 'financial capacity'. Financial capacity was an aggregate indicator of borrowers' ability to support debt without having to cut back current or future spending in order to avoid default or rescheduling. The role of financial and balance sheet variables on investment and output was thus emphasized in a manner similar to Fisher and Keynes.

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[2] Recently Bohn and Gorton (1993) have presented a model of coordination failure which explains the use of non-indexed debt.

[3] See the *General Theory* pages 149-155, and 319-325 for support for the claim that Keynes saw the volatility of investment to be the prime cause of output fluctuations. Chapters 2, 3 and 4 of Hillier (1991) offer further discussion of these and related issues.

Another important writer was Rosa who put forward the so called Availability Doctrine that "in essence, it is not necessarily interest rates as a cost to the borrower, nor as an inducement to the saver, but rather interest rates as a reflection of underlying changes in credit availability, that have an important (though certainly not always a decisive) impact upon the generation of business cycles" (p. 276, 1951). Rosa's arguments focused attention on the issue of credit rationing and stimulated attempts to provide a sound theoretical explanation for the failure of interest rates to rise to equate supply and demand in the market for loanable funds. These attempts in time led to the development of a substantial literature on the role of asymmetric information in the credit market. This literature provides the microeconomic foundations for the models of the business cycle which we review in this paper. The next section looks at these microfoundations.

3. Asymmetric Information and Investment Finance

Developments in the economics of information and incentives have been applied to both the equity and debt markets for investment finance and have been used to explain the forms of financial contracts and intermediation.[4]

Consider the market for debt. There are three types of informational asymmetry dealt with in the literature, either singly or in combination:

(a) borrowers may be indistinguishable ex ante. This may give rise to adverse selection and Akerlof's (1970) 'lemons' problem.

(b) banks may be unable to observe the use to which borrowers put their funds. This may give rise to the problem of moral hazard with hidden actions as in Arrow (1963, 1968).

(c) banks may be unable to observe the returns to a project without incurring a cost as in Townsend's (1979) model of costly state verification. This may give rise to the problem of moral hazard with hidden information since the borrower has an incentive to declare a project return so low as to make him unable to repay his debt to the bank even if the return is in fact much greater than would be needed to do so. In response to this problem banks commit themselves to monitoring, either for sure or with some given probability, borrowers who default.[5]

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[4] For surveys of the literature examining the implications of agency costs for optimal contracts and the financial structure of the firm see Dowd (1993) and Harris and Raviv (1990).

[5] The asymmetry of information identified in (a) is clearly ex ante because it exists before the

Any of the above asymmetries of information may yield the result that an increase beyond a certain level of the interest rate on loans may adversely affect the rate of return to banks. In the first case this happens by driving borrowers with safer projects out of the market which, given the asymmetry in payoffs induced by the standard debt contract, is undesired by even risk neutral banks. In the second case it happens by driving borrowers to choose riskier projects, and in the third it happens by causing a rise in bankruptcies and an increase in monitoring costs. In each case the non-monotonic relationship between the rate *charged* by banks and the return *received* by banks may be used to explain the phenomenon of credit rationing: banks may wish to hold the interest rate below the market clearing level since raising the rate would lower bank returns.

The early literature on asymmetric information and credit rationing placed the emphasis on adverse selection and assumed that borrowers issue standard debt contracts that pay lenders a fixed yield if the project return is sufficiently high, or pay the entire project return if this is below the required fixed yield; see, for example, Jaffee and Russell (1976), Keeton (1979) and Stiglitz and Weiss (1981). However a problem with this literature is that the results are sensitive to the nature of the distributions from which project returns are drawn; see, for example, de Meza and Webb (1987) who replace the assumption used by Stiglitz and Weiss (1981) that the distributions differ across projects in variances but not means by the assumption that project distributions differ in expected returns. Another problem is that the results are sensitive to the nature of the financial contracts; see, for example, Bester (1985) who showed how the introduction of collateral requirements may be used by banks to induce borrowers to self-select themselves into different categories and eliminate rationing, or de Meza and Webb (1987) who showed that the optimal form of financial intermediation given the Stiglitz and Weiss (1981) framework was equity and not debt.

Nevertheless even if equity is the optimal form of finance it is possible to show that the agency problems which beset the debt market have their counterparts in the market for equity; see, for example, Myers and Majluf (1984), Stiglitz and Weiss (1981), Greenwald, Stiglitz and Weiss (1984) and Stiglitz (1988). Problems of a moral hazard or incentive type occur because

(..continued)
debt contract is signed. That in (b) is ex post in the sense that the hidden action occurs after the contract is signed but ex ante in the sense that it arises before the project return is observed. That in (c) is clearly ex post since it arises after the contract and after the return is observed by the borrower.

when a firm is equity financed managers receive only a small fraction of any extra profit so their incentive to expend effort on making profits is attenuated. Alternatively, since the owners or managers of firms have private information about their firms' expected returns, it may be those with the lowest expected returns who are most willing to sell their shares, thus leading to adverse selection problems.

These informational asymmetries in either the credit or equity market show that investment may be constrained. The next section examines the dynamic macroeconomic implications of these constraints and attempts to find some microeconomic foundations for the ideas of the earlier writers which were presented in section 2. Given the variety of informational asymmetries there are modelling choices to be made and we follow the route of Bernanke and Gertler (1989). They introduce a costly state verification problem where debt and retained earnings or net worth play important roles. There are good reasons for adopting this approach.

First it is possible to show that in models with costly state verification the optimal form of financial contract is a standard debt contract and that this contract is best intermediated by banks; see, for example, Diamond (1984), Gale and Hellwig (1985), Boyd and Prescott (1986) and Williamson (1986). The intuition for this result is simple. Given the informational asymmetry the non-default payoff is a constant because no borrower would ever choose to pay to the lender more than the minimum amount necessary to prevent monitoring. The default payoff will equal the return to the project since if it was less then it would be possible to raise it whilst lowering the non-default payoff so that the borrower's expected repayment remains the same; this would leave the borrower no worse off but yield a gain to the lender by reducing expected monitoring costs. Lenders monitor whenever entrepreneurs claim to be unable to repay their loan since if they did not do so entrepreneurs would have an incentive to default and keep returns to themselves even when projects were successful. Intermediation dominates direct lending since banks economize on monitoring costs; a bank monitors a defaulting loan only once compared with each lender needing to monitor individually under direct lending.

Secondly, debt and retained earnings are empirically by far the major sources of investment funds especially for small and medium sized firms (see Fazzari, Hubbard and Peterson, 1988 and Stiglitz, 1992 for some convincing evidence). According to Stiglitz this is partially a result of agency problems in the equity market. Thus he claims that "the cost of issuing equity is sufficiently great that most firms act as if they were equity rationed. When they are denied credit, they do not raise capital by issuing new equity, but rather constrain their capital expenditures to retained earnings" (Stiglitz, 1988, p. 313).

4. A Real Business Cycle Model

4.1. Overlapping generations model

In this section we present a slightly modified version of Bernanke and Gertler (1989) who show how monitoring costs can produce low investment equilibria and real business cycles. Their model introduces intragenerational heterogeneity and an asymmetry of information into the overlapping generations model of Samuelson (1958). There are infinitely many periods but in any one period there are two equally sized cohorts, one in its youth and the other in its old age. Each cohort, distinguished by its date of birth, consists of a continuum of risk neutral agents called entrepreneurs who live two periods, their youth and old age, but consume only in their old age.

There are two produced goods, an output or consumption good and a capital good. The capital good is produced using the output good as an input and the output good is produced by a constant returns to scale technology using the capital good and labour as inputs. Capital goods depreciate completely after one period in use. There is also a constant returns to scale storage technology to which everyone has access and which transforms one unit of the output good at the start of the period into $r \geq 1$ units of the output good at the end of the period. We call r the gross rate of interest.

In their youth entrepreneurs are endowed with a single unit of labour which they supply inelastically to a competitive labour market which pays a wage w (i.e. they receive w units of the output good) equal to the marginal product of labour at the end of the period. They save this w units of output which then becomes their initial wealth or savings at the start of their old age. Entrepreneurs must then decide whether to become capital goods producers. It is at this stage that heterogeneity is introduced: entrepreneurs have access to different capital good production technologies. In particular each entrepreneur has access to an investment project which yields Z units of capital goods, where Z is a random variable, but requires a fixed input of x units of the output good. The random variable Z is the same for each entrepreneur independent of x, but x varies across entrepreneurs. Thus entrepreneurs with low values of x are more likely to undertake investment projects.

There is also a simple asymmetry of information: when an entrepreneur undertakes an investment project only he can observe costlessly the actual number of units z of capital goods produced. Any other agent must pay a monitoring cost to observe the number of units of the capital good produced. It is assumed that monitoring of any project uses up m units of the capital good independent of z or x. We thus have a costly state verification model of the Townsend (1979) type. As we have seen in section 3 financial intermediaries or banks arise naturally in such an environment (see Diamond, 1984 and Williamson, 1986) in order to economise on monitoring costs. These banks take in funds from entrepreneurs who decide not to invest or have excess savings and lend to others who wish to invest but have insufficient funds. It is assumed that the banking sector is perfectly competitive so that each bank will make zero profits in equilibrium and that each bank has a well diversified portfolio of loans. In addition it is assumed that there is always sufficient funds in the economy to finance any level of investment which the banks wish to fund so the gross rate of interest paid on deposits at banks is r.

Capital goods produced but not used up in monitoring will be supplied to a perfectly competitive capital market at a relative price q in terms of the output good. Let k be the aggregate[6] quantity of capital supplied. In aggregate one unit of labour is supplied. Hence aggregate output is given by f(k) where f( ) is the aggregate production function which is increasing and concave in k. As there is constant returns to scale in output good production, the capital price equals the marginal revenue product of capital, f'(k) and wages are equal to the marginal revenue product of labour, f(k)-f'(k)k. There are no profits in the output good sector.

The economy then proceeds as follows: At any date t the current old have savings of s_t (the same for every member of the cohort). Old entrepreneurs invest or save and this determines the amount of capital goods produced some of which may be used up in monitoring defaulting loans[7]. The net amount of capital goods and the fixed amount of labour supplied by the young are then used as inputs to produce the output good. Because the marginal product of labour increases with capital a larger net capital stock will produce higher wages and hence higher savings for next period. The key role in Bernanke and Gertler (1989) is played by monitoring costs which provide a link between the entrepreneur's wealth and capital goods production and it is to this relationship that we now turn.

[6] All aggregate quantities are measured in per cohort terms.

[7] Initially it may seem puzzling that it is the old generation who may invest rather than the young, but it is notationally convenient to keep investment and the returns to investment in the same period. Thus the young enter the economy with no wealth and must work in the labour market to acquire wealth. As they enter old age they make their investment choices and consume only at the end of their old age.

4.2. *First-best case*

As a benchmark we shall consider the first-best case where there is perfect information, i.e. no private information, so that the outcome of the investment process is observable to any agent at no cost, m=0. Assume that the random variable Z has a continuous, differentiable probability distribution function $G(z)=\text{prob}\{Z\leq z\}$ with support $[z_{min},z_{max}]$ and density function $g(z)$[8]. Let $z^e=\int zdG$ denote the expected value of Z. Then an individual entrepreneur, taking q as given and borrowing if necessary at the rate r, will undertake his investment project if $z^e\geq rx/q$, i.e. if the expected return exceeds the opportunity cost of investment in terms of capital goods. Write $x(q)=qz^e/r$, since z^e and r are given parameters of the model but q is an endogenous variable. We shall assume that agents have perfect foresight so the capital goods price q they expect is the equilibrium price. An entrepreneur with $x\leq x(q)$ will undertake his investment project but an entrepreneur with $x>x(q)$ will put any savings in the storage technology or on deposit at a bank. Let $H(x(q))$ denote the proportion of entrepreneurs with $x\leq x(q)$ where we assume $x\in[0,x_{max}]$. We can treat $H(x)$ as a distribution function which we assume has a continuous density function $h(x)$ with $h(x)>0$ on $(0,x_{max})$. Hence aggregate investment in the economy is

(4.2.1) $$i(q) = \int_0^{x(q)} x \, dH.$$

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[8] As stated above this section presents a slightly modified version of Bernanke and Gertler (1989). The main differences are: (i) they assume Z is a discrete random variable; (ii) they allow for stochastic monitoring of returns in the case of default whereas here we consider only deterministic monitoring: although the macroeconomic properties of the model are unaffected by this change it allows us to interpret the optimal financial contract as a standard debt contract; (iii) they introduce a class of lenders in their model, who do not have access to a project of their own: this allows them to consider redistributions between borrowers and lenders and show that such redistributions "that may affect borrowers' balance sheets (as may occur in a debt-deflation) will have aggregate real effects" (p.28).

We refer to i(q) as the perfect information investment schedule. Although there is uncertainty about the production of capital goods at an individual level, since there is a continuum of entrepreneurs the law of large numbers can be invoked so that at an aggregate level capital goods production is non-stochastic and given by

(4.2.2) $$k(q) = z^e H(x(q))$$

where H(x(q)) is the proportion of entrepreneurs who undertake their investment projects and z^e is the average capital goods production of every project. We refer to k(q) as the perfect information supply of capital goods schedule. The demand for capital goods $k^d(q)=f'^{-1}(q)$ is given by the equation of the capital goods price to the marginal product of capital. As $f''(k)<0$ and H(x) is increasing there is a unique equilibrium capital goods price where $z^e H(x(q))=f'^{-1}(q)$ which we shall denote q*, with $x^*=x(q^*)$, $i^*=i(q^*)$ and $k^*=k(q^*)$ denoting the first-best levels. In order to maintain the assumption that r is fixed it is necessary to assume that there is always an excess supply of savings, i.e. $s_t \geq i^*$ for each time period t. The dynamics in the perfect information case are trivial. In period 0 with savings s_0, i* is invested producing a capital stock k* which commands a price q*. The wages of the young are $w^*=f(k^*)-f'(k^*)k^*$, the marginal product of labour. This becomes next period's wealth or savings, $s_1=w^*$ so that i* is again invested, the capital stock is k* and output is f(k*), i.e. the equilibrium level of savings $s_t=w^*$ is attained after one period.

4.3. Optimum financial contract

Now consider the situation with the asymmetry of information where the outcome z is private information of the entrepreneur but can be observed by other agents at a monitoring cost of m>0. First consider an entrepreneur entering his old age with savings s who requires x units of the output good to undertake his investment project and who expects a capital goods price of q. Note that since the entrepreneur is small relative to the market, q will be independent of his realised production level z. As in the perfect information case we maintain the perfect foresight assumption that the q which each entrepreneur expects turns out to be the equilibrium q[9].

To determine whether an entrepreneur will undertake his investment project it is necessary to know on what terms he can borrow to finance his project. Suppose that the entrepreneur undertakes his project and let $e \leq \min(x,s)$ be his equity stake, i.e. how much he

[9] In section 4.6 an aggregate shock is introduced into the model so the perfect foresight assumption will then be replaced by a rational expectations assumption.

himself invests in the project. If $e<x$ then he must borrow the difference $b=x-e$ from a bank[10]. We assume that the loan contract with the bank can specify the equity participation e and that the creditor can costlessly access the entrepreneur's savings $r(s-e)$, whether invested at another bank or invested in the storage technology, in the event of default on the loan. We can then appeal to the results of Gale and Hellwig (1985) that any loan contract with equity participation e is weakly dominated by a loan contract with maximum equity participation $e=s$ and that for the reasons described in the section 3 the optimum loan contract is a standard debt contract. A standard debt contract has the following features: (i) there is a fixed repayment R, (ii) the debtor repays R if he is able, i.e. if $z \geq R$ and (iii) if he is unable to repay R then the debtor is in default and the creditor monitors at a cost m but recovers the maximum amount of capital goods, i.e. z. Thus the optimum loan contract is entirely described by the repayment factor R.

Given the standard debt contract and with R specified, the borrower's expected repayment in terms of capital goods is

$$p(R) = \int_{zmin}^{R} z\, dG + \int_{R}^{zmax} R\, dG.$$

Integrating both terms (the first term by parts) and rearranging gives

$$p(R) = R - \int_{zmin}^{R} G(z)\, dz. \tag{4.3.1}$$

Likewise the creditor's expected return in terms of capital goods is

$$\begin{aligned} \rho(R) &= \int_{zmin}^{R} (z - m)\, dG + \int_{R}^{zmax} R\, dG \\ &= p(R) - mG(R). \end{aligned} \tag{4.3.2}$$

There are two points to notice here. First $\rho(R)$ is independent of x since the returns to investment are independent of x and second that the creditor's expected return is equal to the borrower's expected repayment less the expected monitoring cost, the later being m times the probability of default, $G(R)$. The function $\rho(R)$ is drawn in figure 1(a). We shall assume that it is a concave function, i.e. that $mg'(R)+g(R) \geq 0$, and let $R_{max} \in [0,z_{max}]$ denote the repayment factor which maximises $\rho(R)$ and let $\rho_{max}=\rho(R_{max})$ denote the maximum value of the function. Intuitively as R increases the creditor earns larger returns if the borrower does not default but expected

[10] We don't allow borrowers to borrow funds from several banks.

monitoring costs increase because there is a higher probability of default. Beyond R_{max} the latter effect begins to dominate and the creditor's return actually falls as R increases. Competition between banks means that R is never set above R_{max}, otherwise another bank could undercut and earn a higher return.

In a competitive equilibrium with free entry of banks and hence zero profits in the banking sector, the creditor's expected return on a loan of size b must equal the rate of return on a loan of size b available from the storage technology in terms of capital goods, i.e. r(x-s)/q. Hence

(4.3.3) $\rho(R) = p(R) - mG(R) = r(x - s)/q.$

This equation determines R as a function of x for a given s and q, i.e. the terms on which different entrepreneurs can borrow, which we denote R(x;q,s) (entrepreneurs differ only in x; each has the same s and expects the same q). Figure 1(b) illustrates R(x;q,s) for a given q and s. For $x \leq s$ there is no need for the entrepreneur to borrow as he has sufficient funds himself, so R=0. For $s<x\leq s+qz_{min}/r$, $R=r(x-s)/q\leq z_{min}$ so there is no probability of default, because the borrower can repay in full even in the worst possible outcome. The creditor therefore faces no risk at the individual level. For $s+qz_{min}/r<x\leq s+q\rho_{max}/r$ the creditor does bear some default risk, $G(R)>0$, and $R>z_{min}$ satisfies equation (4.3.3). For $x>s+q\rho_{max}/r$ there is no feasible repayment such that any lender does not prefer to place funds in the storage technology.

4.4 Within-period equilibrium

Having worked out the terms on which an entrepreneur can borrow it is now possible to determine whether he would wish to borrow and therefore the within-period equilibrium investment, capital goods production and prices. An individual entrepreneur will wish to invest if $z^e-p(R)\geq rs/q$, i.e. if the expected return less the expected payment is no less than the opportunity cost of his funds. But from equation (4.3.3), $p(R)=(r(x-s)/q)+mG(R)$ where R=R(x;q,s). That is the borrower's expected repayment must cover the opportunity cost of the loan in terms of capital goods available from the storage technology, plus the expected monitoring cost. Hence the entrepreneur will wish to invest if

(4.4.1) $z^e - mG(R(x;q,s)) \geq rx/q.$

We graph both sides of (4.4.1) against x in Figure 2 for given values of q and s and let x(q,s) denote the critical value of x beyond which investment is not undertaken. For $x\leq s+qz_{min}/r$,

$G(R(x;q,s))=0$ so the LHS is constant at z^e, but for $x>s+qz_{min}/r$ it declines until $z^e-mG(R_{max})$ at $x=s+q\rho_{max}/r$, where we have drawn Figure 2 assuming $z^e-mG(R_{max})>0$. Figure 2(a) shows the case where savings, s are large enough or q small enough, i.e. $s+qz_{min}/r\geq x(q)=qz^e/r$ or alternatively $s\geq q(z^e-z_{min})/r$, so that there is no need to monitor[11]. In this case there is no risk of default for any borrower and the asymmetry of information makes no difference. Projects are undertaken if $z^e\geq rx/q$ just as in the perfect information case.

Figures 2(b) and 2(c) illustrate cases which involve monitoring. Figure 2(b) shows the case where $x(q,s)<s+q\rho_{max}/r$. The marginal entrepreneur, $x=x(q,s)$, can obtain funds from a bank by offering the bank an expected return of $r(x-s)/q$ but will make an expected profit of zero from his project. The extra-marginal entrepreneur could also obtain funds but would make negative expected profits so would not undertake his investment opportunity at the terms available in the market. In Figure 2(c) on the other hand the marginal entrepreneur, $x=x(q,s)=s+q\rho_{max}/r$, will expect strictly positive profits but the extra-marginal entrepreneur is unable to obtain funds in the market because no lender will wish to lend to him. Since the extra-marginal entrepreneur would accept the loan contract of the marginal entrepreneur if offered to him, there is credit rationing[12]. The important point for what follows though is not that credit may be rationed but rather whether or not creditors expect to monitor, for if they do this will raise the cost of finance and reduce investment.

In the private information case the marginal investor has an investment cost of $x(q,s)$, which depends both on the expected price of capital goods and, because of its effect on the probability of default, the savings level of the entrepreneur. In the perfect information case the marginal investor has an investment cost $x(q)=qz^e/r$ independent of entrepreneurial savings. It follows from what was said above that $x(q,s)\leq x(q)$, with equality if $s\geq q(z^e-z_{min})/r$ (Figure 2(a)) but with strict inequality for $s<q(z^e-z_{min})/r$ (Figures 2(b) and 2(c)). For entrepreneurs with an investment cost of x such that $s+qz_{min}/r<x\leq x(q,s)$, the existence of monitoring costs does not

[11] If s is large or q is small the demand for funds will be low either because entrepreneurs can finance their own projects or because the expected return to investment in terms of output goods is low.

[12] Credit is rationed though according to observable borrower characteristics, i.e. x, and is therefore quite different from the rationing of typical adverse selection models (e.g. Stiglitz and Weiss, 1981).

change their investment decision but means that they must pay a higher cost to obtain finance. For entrepreneurs with $x(q,s)<x\leq x(q)$, monitoring costs mean that they do not invest where in their absence they would have done. Aggregate investment in the economy is then simply given by

$$(4.4.2) \qquad i(q,s) = \int_0^{x(q,s)} x \, dH \leq i(q)$$

with strict inequality for $s<q(z^e-z_{min})/r$. This means that for a given q investment is either at or below the first-best level[13].

Figure 3 shows the response of $x(q,s)$ to changes in q and s. It can be seen from the diagram, or implicitly differentiating (4.4.1), that x is increasing in q and is non-decreasing (increasing for $s<q(z^e-z_{min})/r$) in s. An increase in q has two effects (i) a direct effect on the value of the entrepreneur's return and (ii) an indirect effect through the reduction of monitoring costs: a rise in q reduces the repayment factor R for a given level of savings $s<q(z^e-z_{min})/r$ with the consequent reduction in the probability of default and hence monitoring costs. That is an increase in q both increases the entrepreneur's gross expected return, qz^e/r, and reduces his expected payment, p (see equation 4.3.1), since R is decreasing in q (see equation 4.3.3). Hence marginal projects become strictly profitable as q increases. An increase in s has only the indirect effect of reducing R and thus the probability of default and expected monitoring costs; when s is larger the loan size and repayment required for any given x is smaller.

As in the perfect information case, because there is a continuum of entrepreneurs, the law of large numbers can be invoked to show that even though capital goods production is random at the individual level, in the aggregate it is non-stochastic. Since all entrepreneurs with $x\leq x(q,s)$ undertake their investment projects, total capital goods production is $z^eH(x(q,s))$. Some of this capital goods production may, however, be dissipated in monitoring defaulting loans. Since default is a random event at the individual level the cost of monitoring an individual project will be a random variable[14] but again by the law of large numbers aggregate monitoring costs will be non-stochastic and the quantity of capital goods supplied as an input to the output market will be

[13] We make no statements about whether it is at, below or above the second-best level.

[14] If there is default then monitoring occurs for sure because we do not consider stochastic monitoring, but the event of default is a random variable.

(4.4.3) $$k(q,s) = z^eH(x(q,s)) - m\int_0^{x(q,s)} G(R(x;q,s))\, dH \leq k(q) = z^eH(x(q))$$

with equality for $s \geq q(z^e - z_{min})/r$ (where there is no risk of default) and strict inequality when $s < q(z^e - z_{min})/r$. We refer to k(q,s) as the private information supply of capital goods schedule. For $s < q(z^e - z_{min})/r$ the capital goods supply to the market is less than in the perfect information case, k(q), because (i) fewer projects will be undertaken, $x(q,s) \leq x(q)$ and (ii) some proportion of the loans made to finance projects will be in default and so must be monitored which dissipates some of the capital stock. Differentiation of (4.4.3) using (4.3.3) shows that k(q,s) is increasing in q and is non-decreasing (increasing for $s < q(z^e - z_{min})/r$) in s. An increase in q has the above mentioned direct effect of increasing the supply of capital goods but the indirect effect works in two ways; it reduces the the borrower's repayment R which encourages both more entrepreneurs to undertake projects and also decreases the probability of default and so the capital lost through monitoring. Increases in s have only these later indirect effects of decreasing capital dissipated in monitoring costs and increasing the proportion of projects undertaken.

The capital market equilibrium is illustrated in Figure 4. The demand schedule for capital, $k^d(q)=f'^{-1}(q)$, is drawn showing the equation of price and marginal product of capital. Also drawn is the perfect information supply schedule for capital, $k(q)=z^eH(x(q))$. The first-best occurs at the equilibrium (q*,k*). Also drawn are the private information supply schedules k(q,s) for three particular values of s. Higher values of s shift the schedule to the south-east. Let $s^*=q^*(z^e - z_{min})/r$ be the smallest value of s such that the equilibrium outcome is (q*,k*). It can be seen from the diagram how the equilibrium quantity of capital goods supplied to the market and the capital goods price depend upon the initial level of savings for s<s*. We can write these functions k=k(s) and q=q(s).

From Figure 4 it is easy to see that in equilibrium q is non-increasing in s and k is non-decreasing in s. Intuitively higher savings reduce monitoring costs so that there is a larger supply of capital for a given price q, i.e. an outward shift of the supply schedule which depresses price and increases quantity. Thus for $s \geq s^*$ the first-best outcome is sustainable even with private information but for s<s* there will be fewer capital goods used in output goods production and hence lower output. Once the capital goods price is determined for a given s, investment is determined by savings, i(s)=i(q(s),s). Similarly since the wage w equals the marginal product of labour and this increases with the amount of capital used in production, wages are a non-decreasing function of savings since k(s) is non-decreasing, that is w(s)=f(k(s))-f'(k(s))k(s) with $w'(s) \geq 0$. In principle it is necessary to check that there is an excess of savings over investment,

i.e. $s_t \geq i(q(s_t),s_t)$ at every time period in order to maintain the assumption that r is fixed, but following Bernanke and Gertler we shall simply assume that parameters are such that it is always satisfied.

4.5. Deterministic dynamics

As we have said even though capital goods production is random at the individual level it is deterministic at an aggregate level. Therefore we say the economy is deterministic. The only dynamics in the deterministic economy are provided by the savings variable; what entrepreneurs earn when young becomes their savings at the start of their old age (remember entrepreneurs do not consume until the end of their old age). But as we have seen wages in the current period depend upon savings in the current period, so savings evolve according to a simple first-order non-linear difference equation given by $s_{t+1}=w(s_t)$.

Figure 5 illustrates the possible steady-state equilibrium savings, s_e, where the function w(s) cuts the 45^0 line[15]. Once equilibrium savings are determined, steady-state values of investment, capital goods production, output and prices are determined from the analysis of section 4.4. There are a number of cases to consider depending on the relative magnitudes of w* and s* and whether or not there is a unique equilibrium. First imagine that savings at time t are no less than s*. Then the equilibrium capital supply is k* with equilibrium wages $w^*=f(k^*)-f'(k^*)k^*$, so that next period's savings will be $s_{t+1}=w^*$. Hence $w(s)=w^*$ for $s \geq s^*$. Since we have $s^*=q^*(z^e-z_{min})/r$ it is possible that either $w^*>s^*$ or $w^*<s^*$. In Figure 5(a) $w^*>s^*$ so that savings are sufficiently high in equilibrium to eliminate any possibility of default. Hence there is a steady-state equilibrium with investment at the first-best level and equilibrium savings $s_e=w^*$. In Figure 5(b) $w^*<s^*$ and there is a unique low investment equilibrium. Figures 5(c) and 5(d) illustrate the possibility of multiple equilibria[16]. Both illustrate a stable high investment equilibrium and a low investment equilibrium with an unstable equilibrium in the middle. The economy may tend to either stable equilibrium depending upon initial conditions. In Figure 5(c) the high investment equilibrium is below the first-best level but in Figure 5(d) the investment in the high equilibrium is equal to the first-best level.

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[15] The existence of an equilibrium is guaranteed since given our assumptions w(s) is continuous, $w(0) \geq 0$ and the maximum of w(s) is w*.

[16] Multiple equilibria appear to be a common feature of models of coordination failure in the new macroeconomics literature. See e.g. Cooper and John (1988) and Bohn and Gorton (1993) as well as Chamley, Frank and Silvestre in this book.

4.6. *Stochastic dynamics*

The dynamics in the deterministic case are monotonic: savings, prices, output and capital stock simply increase or decrease toward their equilibrium values. If however, there is a stochastic i.i.d. technological shock to output production then it is possible to show that monitoring costs can produce cycles or persistence and asymmetric responses. Suppose that there is a random variable Θ with expected value of unity which acts as a multiplicative shock to the output technology, so that output $y=\theta f(k)$. We follow Bernanke and Gertler and assume that debt contracts are made before θ is known, but that labour and capital are hired after θ is known. The capital goods price will then be a random variable and entrepreneurs must base their investment decisions upon their expectations of the price. Since they are risk neutral their investment decisions are taken as if capital goods price were sure to be the expected price. Therefore the capital goods supply curve will be exactly as in the deterministic case, i.e. $k(q^e,s)$ where q^e is the expected price. Given that the shock is unity on average, the expected demand curve is just that in the deterministic case and it can be seen from Figure 4 that for a given level of savings, s, the equilibrium price corresponding to the expected shock is q(s). Hence the rational expectations equilibrium supply of capital is k(s). Once θ is known prices will adjust to clear the market, i.e. $q(s,\theta)=\theta f'(k(s))$ since the supply of capital goods is fixed in the short-run, i.e. unresponsive to θ, and wages are $w(s,\theta)=\theta(f(k(s))-f'(k(s))k(s))=\theta w(s)$.

Consider first the perfect information case in this stochastic environment. In this case $w(s, \theta)=\theta w^*$ so a good shock produces higher output and higher wages. Despite the fact that wages and thus savings are stochastic, investment next period is unaffected; since in the perfect information case investment depends only on the expected capital goods price, q*, and hence is independent of savings. Thus i.i.d. shocks to productivity will cause i.i.d. shocks to prices and output but have no effects on investment or capital goods production.

Now consider the private information case. Since the first-best equilibrium capital goods supply is k* at an expected price of q*, it can be seen that s*, the smallest savings such that the first-best outcome is sustainable in the private information case, is independent of θ. A positive shock, $\theta>1$, then shifts the w(s) curve upward with no effect on s* and a negative shock, $\theta<1$, shifts it downward. In order to examine the possible implication of this stochastic environment consider the following simple thought experiment. Suppose that there is a sequence of $\theta=1$ shocks so that the economy settles down at the steady state equilibrium as if it were deterministic but then there is one positive shock, $\theta>1$, before again the economy experiences a sequence of

$\theta=1$ shocks. Figure 6(a) illustrates the case where there is a unique low investment equilibrium. The economy begins in the low investment equilibrium E when it is hit by a positive shock $\theta>1$, which shifts the curve upward for one period. Wages and output are higher than anticipated which feeds through to higher savings next period. By reducing total monitoring costs this allows more investment and capital goods production next period, resulting in higher output and wages than normal even though there is no new positive shock. There is persistence. In the words of Bernanke and Gertler "Strengthened borrower balance sheets resulting from good times expand investment demand, which in turn tends to amplify the upturn" (1989, p.27). There is also an obvious asymmetric response to shocks between an equilibrium with low investment and one with the first-best level of investment. If there were a unique equilibrium which sustained the first-best level of investment with $w^*>s^*$ then small shocks would have no effect upon investment next period, whereas if there is a unique low investment equilibrium even small positive or negative shocks will cause persistent changes in future investment and capital goods production. Furthermore, if there were a unique equilibrium which sustained the first-best level of investment with $w^*>s^*$, then whilst large negative shocks would have an effect on investment, large positive shocks would have no such effects.

An even more interesting possibility is shown in Figure 6(b) which shows multiple equilibria; a high level locally stable equilibrium at E', an unstable middle equilibrium at G, and a locally stable low equilibrium at E. It is now possible that the economy displays temporal agglomeration - once at either the high or low level equilibrium the economy tends to oscillate around it for quite a while until a big shock pushes it past the middle equilibrium at G and it then moves towards the other stable equilibrium. Suppose that the economy is at equilibrium E following a sequence of $\theta=1$ shocks when there is a large positive shock which shifts the w(s) curve upward. This generates higher output and higher savings for next period and this may push the economy beyond G and on toward the better equilibrium E' even though thereafter the economy experiences only shocks $\theta=1$. It is also possible that there may be asymmetries in the durations around high and low level equilibria; if G is nearer to the low level stable equilibrium than the high level stable equilibrium, the economy would tend to be shocked away from the low level equilibrium more easily than it would be shocked away from the high level equilibrium and so would tend to be more often around the high level equilibrium. Evidence for such asymmetric cyclical behaviour may be found in Neftci (1984), Hamilton (1989) and Diebold and Rudebusch (1990).

4.7. Conclusions

Bernanke and Gertler (1989) have developed an equilibrium business cycle model in which financial intermediation plays a crucial role in explaining cyclical behaviour. The intermediation which takes place in the model fits well with some of the features of real world financial markets. Intermediaries carry out the task of monitoring defaulting projects, they borrow from large numbers of depositors and lend to large numbers of borrowers, writing debt contracts with borrowers and offering depositors financial assets which pay an expected return equal to the safe rate. The main implications of their model are:

(a) absent informational asymmetries, investment is unaffected by i.i.d. shocks to productivity and output responses are non-cyclical.

(b) with informational asymmetries i.i.d. shocks to productivity produce cyclical responses in investment and output. The reason for the persistence is that a good shock increases borrower net worth, reducing monitoring costs and increasing investment and future net worth, and *vice versa* for a bad shock.

(c) the model may yield multiple equilibria with the possibility of temporal agglomeration or, in other words, the possibility that the economy tends to oscillate around either a high output or a low output equilibrium with a big shock needed to push it away from one equilibrium to the other.

The next section reviews a number of similar models which can be found in the literature.

5. Financial Factors and Business Cycles

Apart from Bernanke and Gertler (1989) there are a number of other models of business fluctuations in which financial factors play a role. Bernanke and Gertler (1990) pursues the same theme of the importance of borrower net worth, in a model where the asymmetric information problem is based not upon costly state verification but upon moral hazard with hidden actions; entrepreneurs borrow in order to evaluate projects but lenders cannot observe whether they actually do evaluate (moral hazard) nor can they observe the information revealed by evaluation (which reveals the success probability associated with a project to the evaluating entrepreneur).

Despite the differences the critical role of net worth in easing agency problems remains essentially the same as in their earlier paper, although the latter paper does not emphasise its role in propagating business cycles. In an important development, Gertler (1992) returns to the problem of costly state verification but extends the analysis to allow for multi-period financial arrangements. This makes agency costs depend upon the present discounted value of future project earnings as well as upon the borrower's current net worth. Thus a small change in macroeconomic conditions may have substantial effects upon expected future earnings and produce large short-run shifts in financial constraints.

Farmer (1984) and Williamson (1987) also embed a costly state verification problem in an overlapping generations framework similar to Bernanke and Gertler (1989). In Williamson projects differ in terms of the monitoring costs in the case of default, rather than the cost of funding, and there are some agents who have no investment projects of their own. As in Bernanke and Gertler (1989), and for similar reasons, credit may be rationed in equilibrium; although in Williamson the allocation of credit is based upon the cost of monitoring if a project fails, with credit going to borrowers with the lower monitoring costs. Net worth, however, has no role to play since he assumes that individuals with projects have zero net worth. The type of shock considered by Williamson also differs from the shocks considered in section 4. In Williamson there are shocks to the riskiness of investment projects; he assumes there are two possible states of the world, where one differs from the other by applying a mean preserving spread to the distribution of project returns. With risk-neutral agents such a shock would have no macroeconomic consequences in the absence of information problems, but with costly state verification the riskier state increases agency problems and leads to less investment in projects. Since there is a one period lag between making an investment and the resulting production of output, this has a negative effect on investment the following year too, producing cyclical dynamics or persistence as in the model of section 4. The difference is that Williamson's model formalises the idea that business confidence is important in explaining output fluctuations.

In Williamson (1987) an important role is played by the demand for money. He assumes that the consumption good is perishable between periods so that his lender class, who supply labour when young but not when old, must either invest in projects (via intermediaries) or hold money if they wish to consume when old, thus yielding a role for money (ie valued, unbacked government securities). His model yields a positive correlation between the price level and real output and negative correlations between real output and business failures and real output and risk premia. It predicts that intermediary loans and a nominal monetary aggregate Granger cause output. The results concerning the price level and nominal monetary aggregates cannot be derived from Bernanke and Gertler (1989) which neglects monetary factors, but clearly the two models are complements rather than substitutes.

Greenwood and Williamson (1989) develop a two-country version of Williamson's model which examines the role played by financial factors and exchange rate systems in the international transmission of business cycles. The model displays monetary nonneutrality and positive comovements among national outputs, inflation and interest rates. The correlation between output and prices depends upon the source of disturbances, monetary shocks yielding a positive correlation and technological shocks a negative one. Exchange rate regimes matter for the variance of output, but which yields the lower variance depends on the source of shocks, for example a flexible exchange rate regime yields a lower output variance in response to foreign monetary shocks than either of the two fixed exchange rate regimes considered.

There are also a number of other papers in the literature which include important roles for financial factors in the propagation of business cycles. One approach adopted by Kiyotaki and Moore (1993) is to provide a dynamic model of the enforcement problems in the credit market considered by Hart and Moore (1989)[17]. Although the model is rather different from the models of asymmetric information discussed so far the results are similar. As borrowers may repudiate their debt, creditors protect themselves by securitizing loans and never allowing the size of the debt to exceed the value of the collateral. Investment and therefore output is determined by collateral values which in turn determines future collateral values yielding multiplier and cyclical effects.

Another approach is presented in an interesting series of papers by Greenwald and Stiglitz (1987, 1988, 1993) and Stiglitz (1992) who develop a model which produces a role for net worth or retained earnings in propagating cycles very much like that in Bernanke and Gertler (1989) but without any credit rationing or explicit modelling of informational asymmetries. Greenwald and Stiglitz rule out equity sales by using the type of arguments discussed in Section 3 above and assume a perfect credit market; agency costs and asymmetric information, therefore, are used to justify their model but have no formal role to play within it. The role for net worth or retained earnings is introduced by assuming that the managers of firms are risk averse. Risk

[17] Scheinkman and Weiss (1986) referred to such enforcement problems in their paper on borrowing constraints and aggregate activity but did not present detailed microfoundations.

aversion is introduced either by placing a cost on bankruptcy in the utility function of managers or making their utility a concave function of profits. In either case this makes managers wary of debt financing, since this increases the probability of bankruptcy. Hence managers increase investment and output if net worth or retained earnings increase, as this enables a substitution of retained earnings for debt. Increased investment and output in turn maintain relatively high retained earnings and so shocks have persistent effects in much the same way as in Bernanke and Gertler (1989). Investment is also sensitive to the riskiness of the environment in a similar way to that discussed with respect to Williamson (1987) above, but now directly due to risk aversion rather than agency costs[18].

Yet another approach is taken by Blinder (1987) who, like Greenwald and Stiglitz, assumes that there is no equity market but allows for credit rationing. Firms unable to obtain credit are unable to hire factors of production and there is a failure of effective supply. Whilst the models he uses are rather more ad hoc than those we have examined, he is able to take advantage of their relative simplicity to integrate issues of aggregate supply and aggregate demand. It would be interesting to do this in the models with richer microfoundations which have so far tended to focus more on the supply side; this is clearly an important task for future research.

6. Conclusions

We have reviewed the recent literature which provides microeconomic foundations for the long-established idea that financial factors are important in explaining business cycles. Agency costs, enforcement problems or risk aversion have been shown to offer possible explanations of cycles. In this concluding section it is useful to compare these explanations with others, briefly review the available evidence and offer a general evaluation.

It is possible to discern four major theories of business cycles (see Stiglitz, 1992): the theory we have reviewed here based on asymmetries of information, the standard real business cycle model (without informational asymmetries), the New Classical model of price forecast errors, and models of imperfect competition The standard real business cycle model has been much criticised on the grounds that it relies too much on large technological shocks as the primary source of economic fluctuations (it is difficult to find negative shocks to productivity of

[18] Stiglitz (1992) extends the analysis to argue that banks are a specialized kind of firm and that the principles which have been applied to other firms should also be applied to them. Thus, 'a reduction in the net worth of banks and an increase in the riskiness of their environment will lead them to contract their output, i.e. to make fewer loans' (Stiglitz, 1992. p.290).

the size required to explain the Great Depression) and too much on intertemporal substitution effects to explain fluctuations in employment (see Mankiw, 1989, p79). Furthermore it might be expected that changes in investment are dampened rather than exacerbated as entrepreneurs take advantage of the reduced costs of investment in recessions. The New Classical model introduces the extra element that agents may mistake general price level changes for relative price changes and respond accordingly but this still fails to explain the cyclical volatility of investment. Similarly whilst the degree of competition might decrease in a downturn causing further reductions in output, such effects also have unrealistic implications, e.g. that profit margins are countercyclical.

The view that financial factors are important in propagating business cycles might be viewed as complementary to the above three approaches. But it also has some advantages. First, as we have seen it is not necessary that average productivity be affected since a small change in the perceived riskiness of the economic environment can have significant effects via agency costs (Williamson, 1987) or risk averse behaviour (Greenwald and Stiglitz, 1992). Second it has been suggested by Gertler (1992) that small disturbances can induce large output fluctuations when borrowers and lenders enter into long-term debt contracts. In that case net worth includes the present discounted value of anticipated future project returns and since this may be quite volatile it is possible that small shocks produce large changes in the cost of external finance.

We have so far concentrated upon theoretical issues but there is some empirical evidence which offers some support to the importance of financial factors in explaining business fluctuations. Fazzari, Hubbard, and Petersen (1988) examine evidence from the USA and conclude that financial constraints are important for many firms and that their investment is positively related to retained earnings or cash flow. An important aspect of their analysis is that they study investment behaviour in groups of firms with different financial characteristics and so offer a potential reconciliation of the mixed results of earlier studies on financial factors in investment: financial factors may well matter more for some firms (new and small ones) than for others (established and large ones). Fazzari and Petersen (1993) present further evidence of financial constraints on investment and consider the role of working capital. On a more macroeconomic level Mishkin (1978) and Bernanke (1983) marshal evidence in support of the hypothesis that financial factors contributed to the depth and persistence of the Great Depression in the USA.

We close with a few words on policy implications and directions for future research. The literature is, in fact, rather light on detailed derivations of policy implications. Williamson, for example, concluded that 'there appears ...to be no obvious role for "stabilization policy" ' (1987, p.1215). Stiglitz, on the other hand, concluded that 'an effective stabilization policy of the government should be directed at overcoming the limitations of (this) rationing' (1988, p.320) after discussing agency problems but without offering a detailed analysis of such policy. Hillier and Worrall (1994) have examined a static version of Williamson's (1986) model and found the result that if rationing does occur then investment is likely to be excessive. The reason is that the market outcome produces too much monitoring, so that a cut in loan quantity increases welfare by cutting total monitoring costs. This result, whilst special to the model considered, illustrates that the policy implications of such models may be quite different from the aggregate demand management policies one might have expected from models with Keynesian features like interest rate rigidities. This is perhaps not so surprising once one remembers that the models do not so much explain rigidities, but explain why prices which could move are sometimes held constant by rational optimising agents. Nevertheless, there is a clear need for further examination of policy, preferably within versions of the models extended to contain a government sector.

One way in which macroeconomic policy can have an effect in these models has been examined by Farmer (1984, 1985), who showed that it is possible for government debt and spending to generate real effects by changing the real interest rate and affecting the level of investment. The real interest rate is often fixed exogenously in the literature (it is given by the return on storage in the model of section 4, and by the imposed rate of time preference in the Greenwald and Stiglitz models discussed above) and it might be interesting to endogenize it to examine Farmer's arguments in other models. Another obvious implication of the models where retained earnings matter for investment is that the average as well as marginal rate of profits tax matters for investment, a lower average tax rate raising retained earnings and investment. This implication would appear to be testable.

We conclude that the literature on financial factors in macroeconomic models is interesting and promising. Further theoretical work is needed to examine the policy implications of this sort of model and to introduce roles for imperfect competition, monetary surprises and other incentive contracts. Empirical work in this area is still relatively rare and more would be useful.

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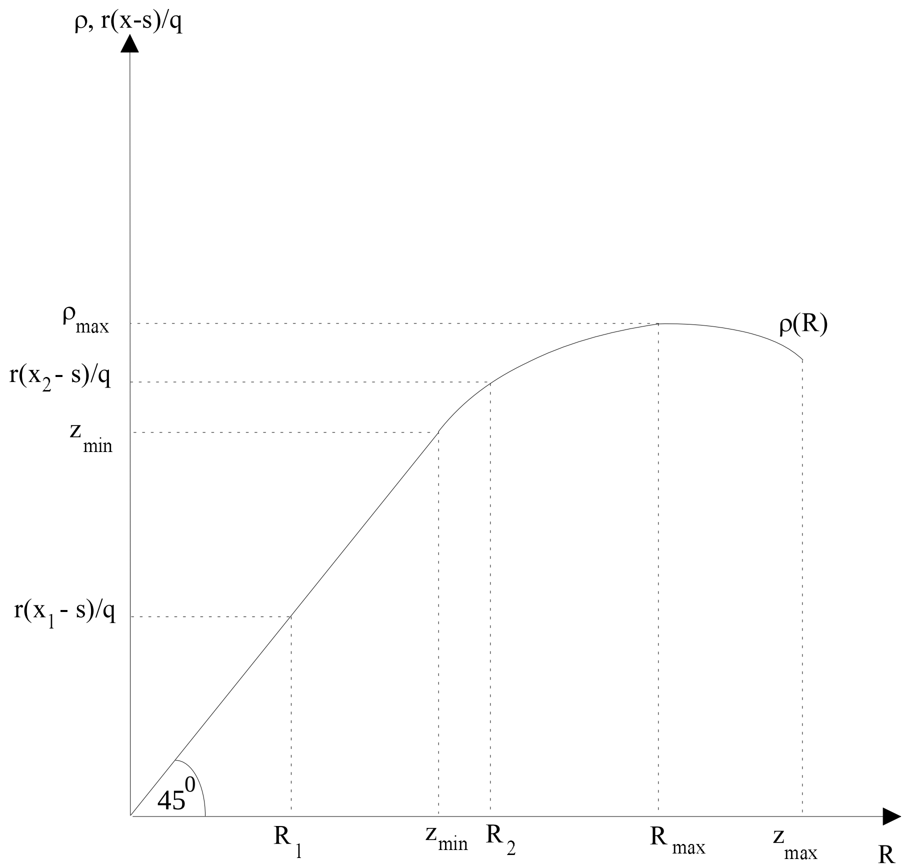

Figure 1a: Lender's return function

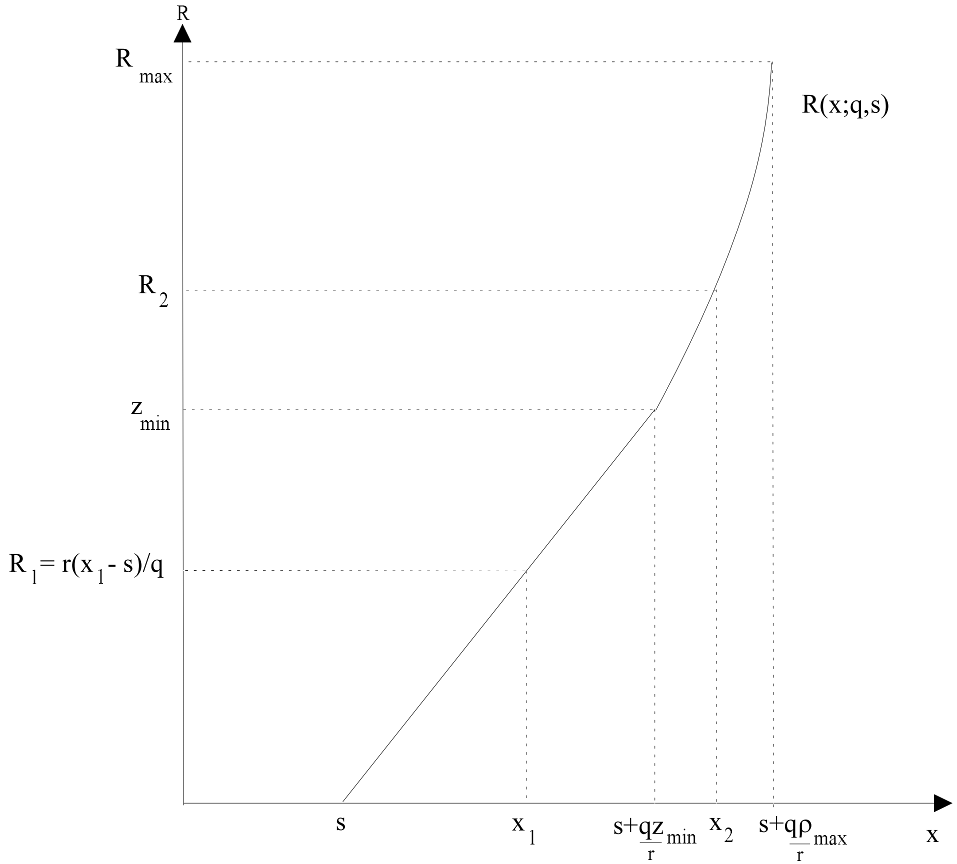

Figure 1b: Repayment function

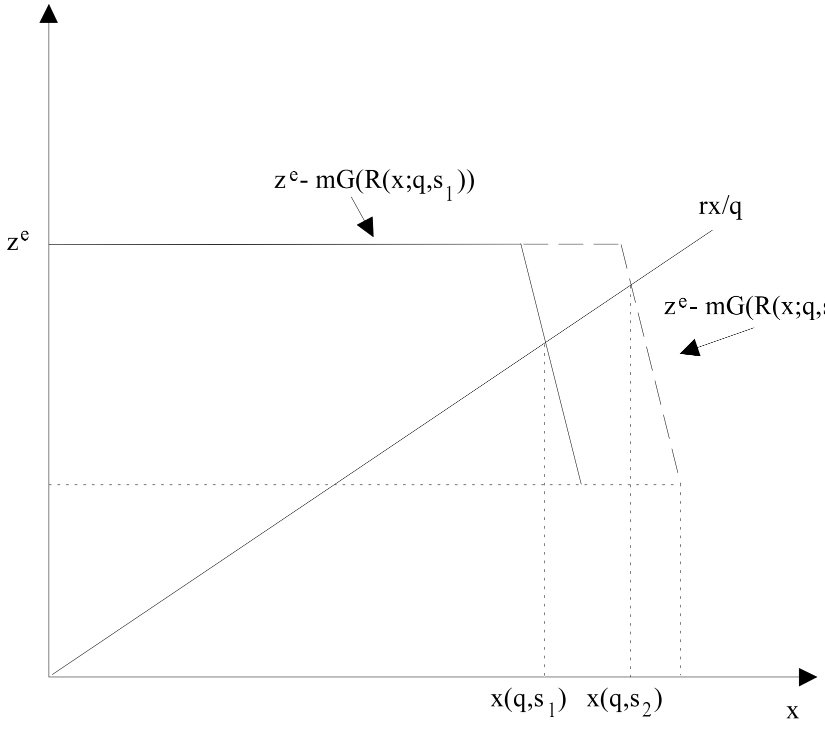

Figure 3a: The effect of an increase in s: $s_1 > s_2$

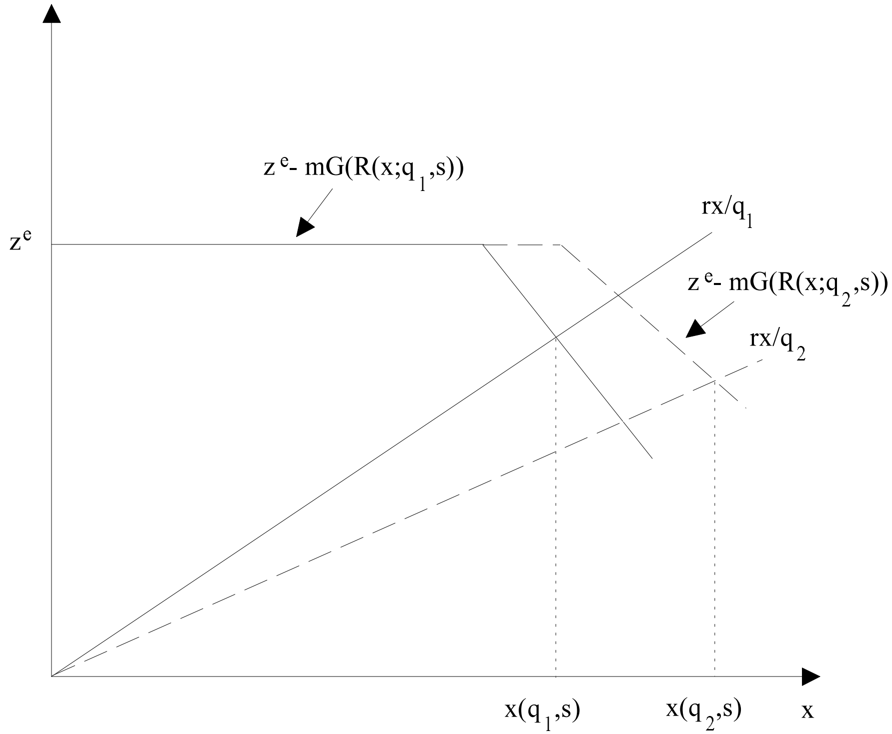

Figure 3a: The effect of an increase in q: $q_1 > q_2$

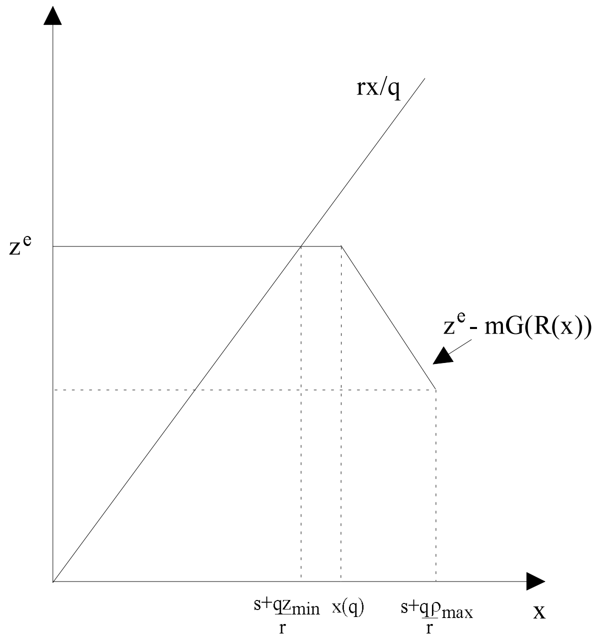

Figure 2a: No Montoring

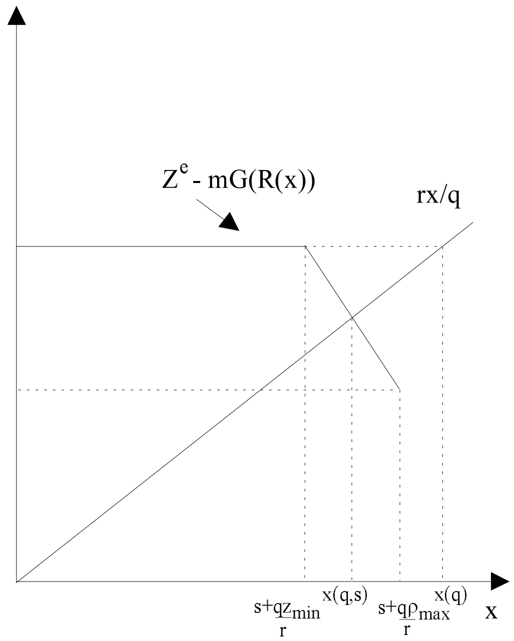

Figure 2b: Monitoring

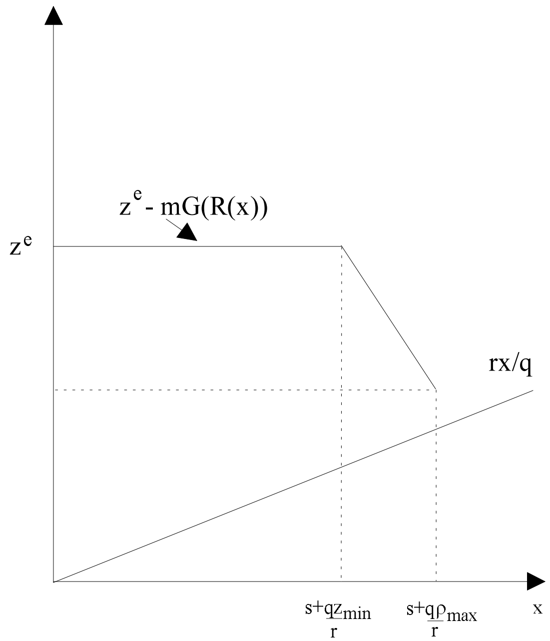

Figure 2c: Monitoring and Credit Rationing

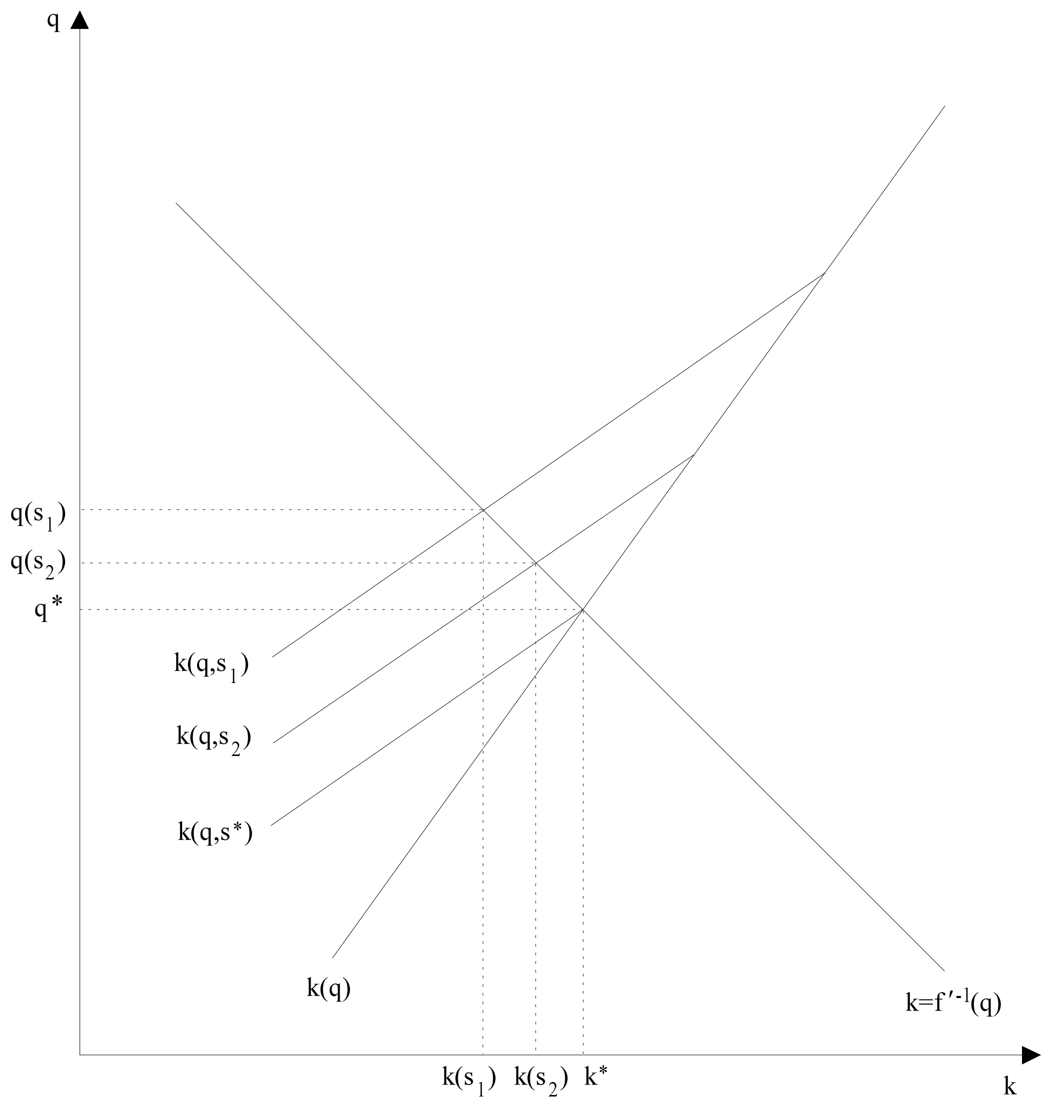

Figure 4: Capital market equilibrium: $s^* > s_1 > s_2$

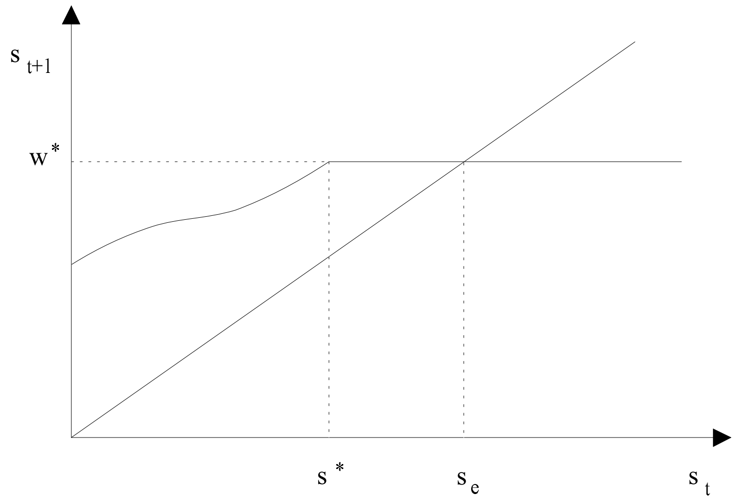

Figure 5a - unique full investment equilibrium

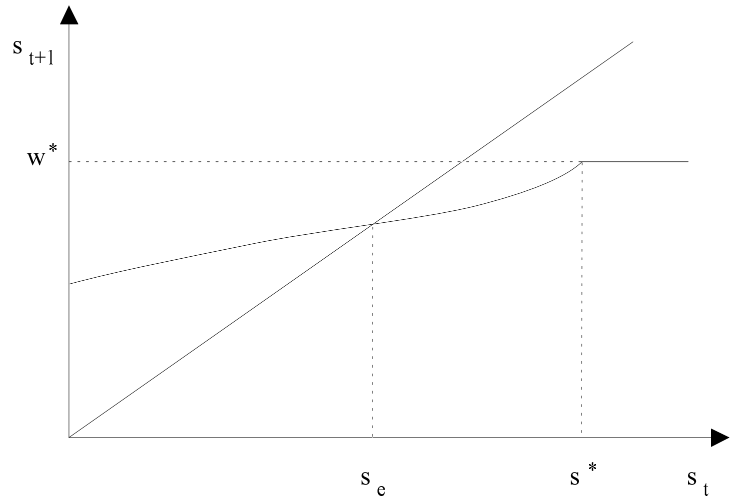

Figure 5b - unique under-investment equilibrium

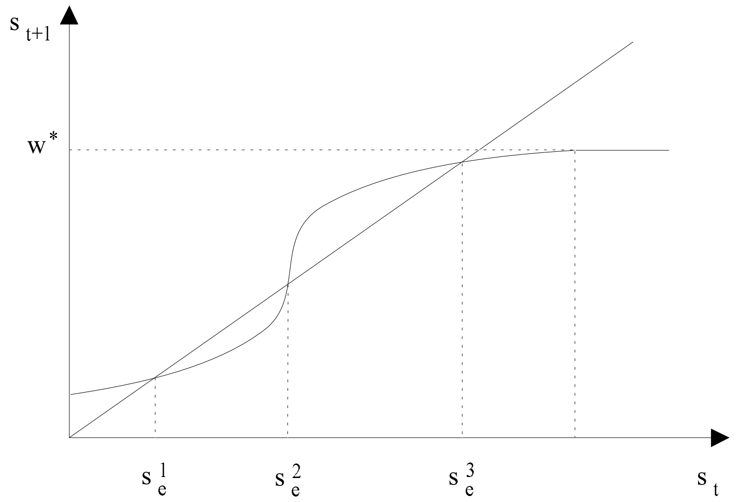

Figure 5c - multiple under-investment equilibria

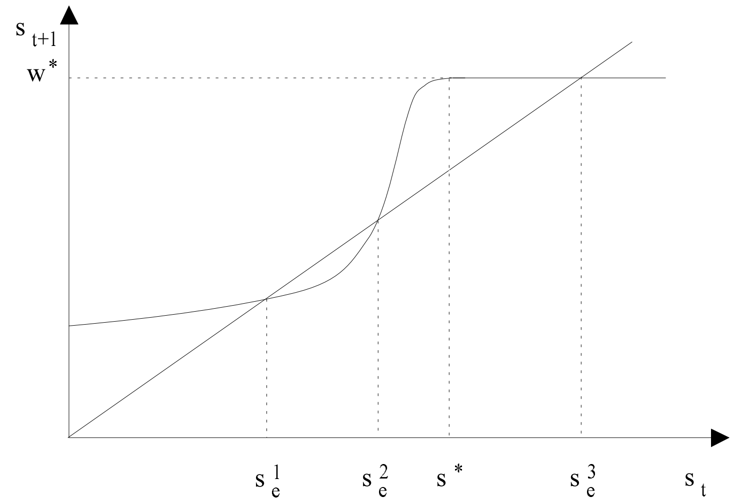

Figure 5d - multiple mixed equilibria

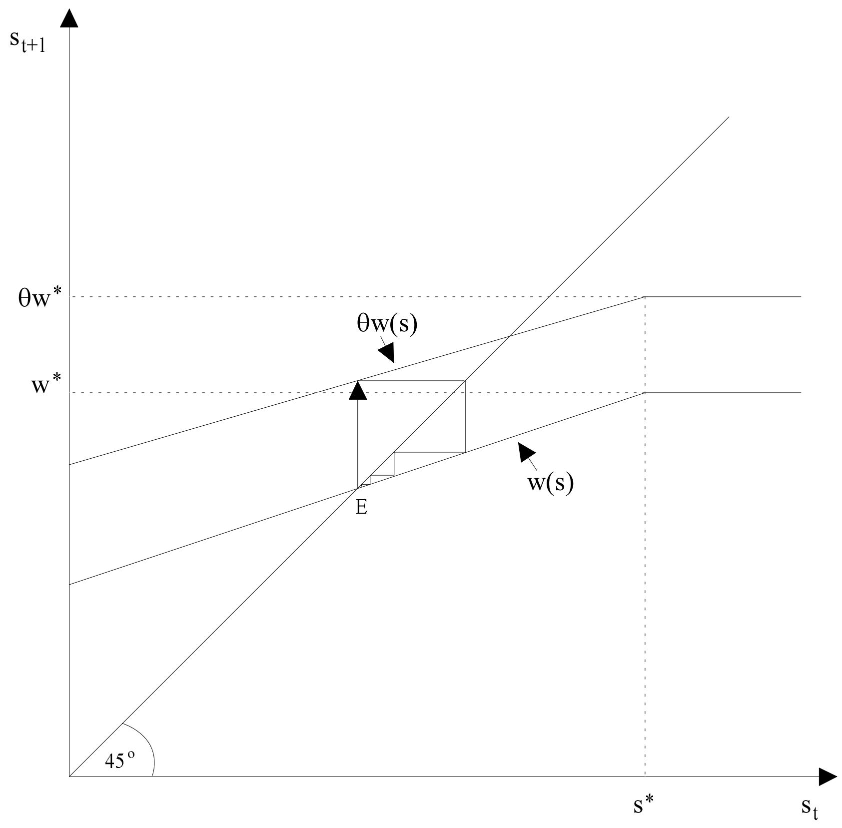

Figure 6a Unique equilibrium with positive shock θ

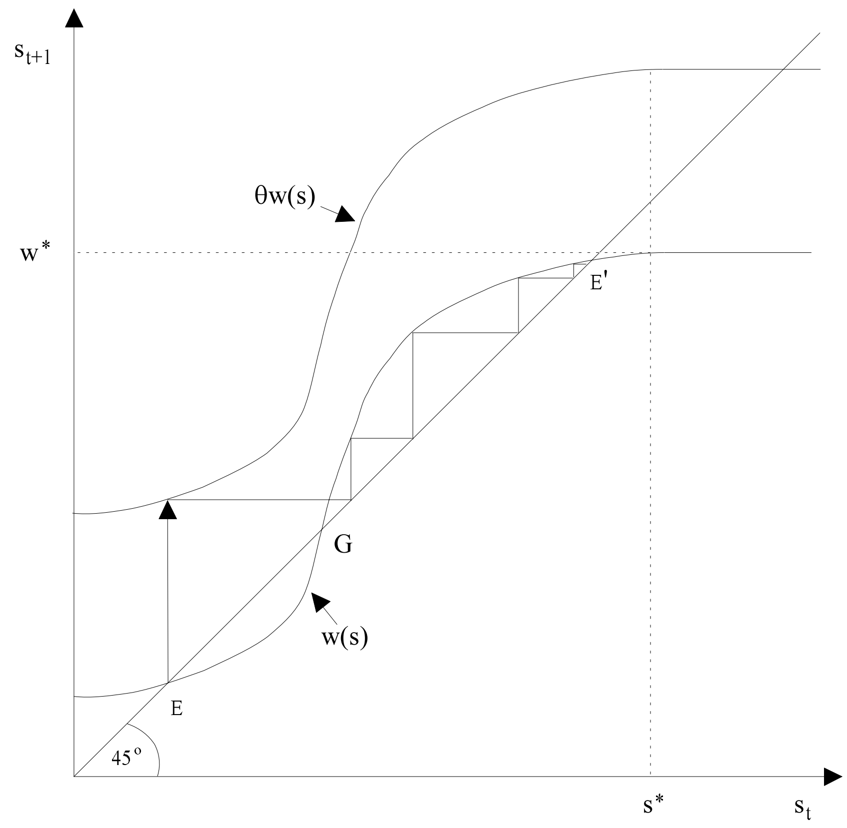

Figure 6b Multiple equilibria with positive shock θ