Adverse Selection and the Accelerator

Christopher L. House

November 2002

Abstract

This paper reexamines the relationship between financial market imperfections and economic instability. I present a model in which *financial accelerator* effects come from adverse selection in credit markets. Unlike other models of the financial accelerator, the model I present has the potential to *stabilize* the economy rather than destabilize it. The stabilizing forces in the dynamic model are closely related to forces that cause overinvestment in static models. Consequently, the stabilizing properties of the model are not specific to adverse selection but rather are present in any environment in which credit market distortions cause overinvestment. When investment projects are equity financed, or when contracts are written optimally, the only equilibria that emerge are stabilizer equilibria. Thus, stabilizing outcomes are more robust in this model. Finally, the empirical distinction between accelerator equilibria and stabilizer equilibria is subtle. Many statistics used to test for financial accelerators are observationally equivalent in stabilizer equilibria.

JEL No: E22, E32, E44, G14

Christopher House
University of Michigan
Department of Economics
238 Lorch Hall
Ann Arbor, MI 48109-1220
chouse@umich.edu

I thank John Leahy, Russell Cooper, Simon Gilchrist, Robert Barsky, Matthew Shapiro, and Jeff Miron for comments, insights and suggestions.

1. Introduction

The *financial accelerator* hypothesis is that credit market distortions magnify economic shocks. Disturbances that would be small in a world with perfect markets, become exaggerated and prolonged due to imperfections in the credit and loan markets. In other words, credit market distortions destabilize the economy. The financial accelerator is an important idea because standard business cycle models require large and persistent disturbances to mimic the business cycles we observe in the data. Without large shocks, these models would generate business cycles that were small and short lived. The financial accelerator amplifies and propagates shocks and, therefore, can potentially explain why business cycles are so significant even though the shocks we observe are relatively small.

This paper reexamines the relationship between credit market imperfections and economic instability. I present a model in which adverse selection distorts the loan markets. I embed the adverse selection problem in a dynamic equilibrium model of business cycle fluctuations. The paper has three central messages. First, although there are cases in which these distortions are destabilizing, there are other cases in which the distortions cause the economy to be excessively stable. The stabilizing outcomes in the dynamic model are closely related to overinvestment outcomes in static models of credit market failure. Second, if investments are equity financed or if borrowers and lenders write optimal contracts, the *only* equilibria that emerge are the stabilizer equilibria. Finally, in the adverse selection model, the empirical distinction between accelerators and stabilizers is subtle. I show that many of the standard statistics used to detect financial accelerators are also consistent with stabilizer equilibria.

One important contribution of this paper is that it decomposes the total amplification caused by the credit market distortion into separate channels. Moreover, each channel, or effect, has economic meaning. This decomposition clarifies the way that credit market distortions amplify shocks.

Specifically, in the adverse selection model, a shock that increases entrepreneurs' net worth has three separate effects on investment. First, the increase in internal funds causes the premium on borrowed funds to fall. With a lower premium, investors have a greater incentive to invest. This is the "agency cost" channel that is emphasized in much of the existing literature.

Second, since borrowers internalize more of the costs and benefits of their projects when their net worth is higher, the *level* of investment is closer to the efficient level. In some settings this causes investment to increase; in others investment may fall. This second effect is the dynamic counterpart of over- or underinvestment in static adverse selection models. If there is underinvestment in the static environment, investment will rise when internal funds increase. In the dynamic model, this will cause shocks to be amplified. If there is overinvestment in the static environment, investment falls when internal funds increase. Consequently, in the associated dynamic model, the financial market imperfections mitigate shocks.

Finally, the allocation of investment becomes more efficient when internal funds rise. Investment increases for projects with high expected returns and falls for projects with low expected returns. So, even if the total volume of investment does not change, shocks will be amplified because investment is allocated more appropriately.

The total effect on investment is the sum of these three effects. I show that it is possible for the second effect to be negative and to dominate the other two. In such cases, the adverse selection problem inefficiently *stabilizes* the economy. This duality between stabilization in dynamic models, and overinvestment in static models, has not been pointed out by the existing literature.

I show that accelerator equilibria are not robust to other forms of financing. Specifically, when I allow for either equity finance or for optimal contracting by borrowers and lenders, the only equilibria that occur are stabilizer equilibria. Furthermore, the stabilizer equilibria do not have any overtly counterfactual implications (such as a procyclical interest rate spread). The empirical distinction between stabilizers and accelerators, in this model, is subtle. Many well known empirical findings that have been cited as evidence for a financial accelerator are consistent with the stabilizer equilibria in this model. This suggests that stabilizing outcomes are not mere curiosities.

Understanding the dynamic adverse selection model is easiest if we first examine two static adverse selection environments. These static models are the building blocks for the dynamic model that is analyzed later.

2. Static Models of Adverse Selection in Credit Markets

In general, credit market imperfections can result in either overinvestment or underinvestment. In the adverse selection model, over- or underinvestment is determined by the distribution of investment opportunities. The basic intuition can be seen by comparing two polar cases: the Stiglitz and Weiss [1981] model (hereafter 'SW') and the De Meza and Webb [1987] model (hereafter 'DW'). This section contains a brief analysis of these models since the behavior of these simple static models will provide important insights into the behavior of the dynamic model analyzed later.

2.1. Basic Setup

I start by describing the features of the models that are common to both SW and DW. Consider a two period world in which entrepreneurs interact with savers. Normalize the number of entrepreneurs to be 1 and assume that savers supply $S > 1$ inelastically. The savers have a safe outside option that yields a gross rate of return of $\bar{\rho} > 0$. Competition ensures that the rate of return in the credit market will also be $\bar{\rho}$. Let R be the rate of interest charged to the entrepreneurs. The only difference between $\bar{\rho}$ and R is default risk, Δ; thus, Δ is the interest rate spread, $\bar{\rho} = R[1 - \Delta]$. I will refer to $\bar{\rho}$ as the "safe" interest rate and R as the "risky" interest rate.

Entrepreneurs are *risk neutral* and care only about consumption in the second period. Each entrepreneur has a project which either succeeds or fails. There are three numbers associated with each project; the probability of success p, the payoff in the event of success x, and the expected payoff $r = px$. The distribution of projects can be described by a joint distribution f over any two of these numbers since the third is redundant.

Activating a project requires an investment of one unit in the first period. Entrepreneurs have personal, "internal" funds of w. Assume that $w < 1$ so that they cannot self-finance. If the entrepreneurs want to activate a project, they have to borrow $1 - w$ ("external" funds) in the credit market.

Importantly, entrepreneurs know the characteristics of their projects while savers do not; this is the source of asymmetric information in the model. In addition, borrowers have limited liability. If a project fails, the lenders cannot extract further payments from the entrepreneur. For the time being, I assume that all credit market interactions are described by standard debt contracts. Optimal contracting is discussed later.

Note that as the risky interest rate (R) changes, the pool of borrowers changes. An increase in R will discourage some entrepreneurs from investing. It could be the case that relatively more safe borrowers leave the loan pool so that Δ increases as R increases. If more risky borrowers leave, then Δ will fall as R rises. Writing $\Delta(R)$ as a function of R allows explicitly for this effect. In equilibrium $\bar{\rho} = \rho(R) \equiv R[1 - \Delta(R)]$. One can view $\Delta(R)$ as a function that captures the important features of the adverse selection problem. As a technical matter, the derivative of $\rho(R)$ will be positive in any equilibrium. Let ρ' denote this derivative.[1]

The equilibrium will depend critically on the distribution of projects. It is along this dimension that SW and DW differ.

2.2. Stiglitz and Weiss go to the bank

In Stiglitz and Weiss [1981], all of the projects have the same expected return r but differ in their success probability p. The expected return to an entrepreneur to activating their project is $r - pR(1-w)$. This is decreasing in p, so payoffs are higher if the agent has a riskier project. Thus, there is a cutoff probability, $\hat{p}$, such that all agents with $p < \hat{p}$ choose to apply for credit. If there is anyone at all in the loan pool, it is the "risky tail" of the distribution. See figure 1.A.

Since the entrepreneurs have the option to save w at the safe rate $\bar{\rho}$, the cutoff probability, $\hat{p}$, solves $w\bar{\rho} = r - \hat{p}R(1-w)$. In equilibrium

$$\bar{\rho} = R(1-\Delta) = \frac{R\int_0^{\hat{p}} pf(p)dp}{F(\hat{p})}$$

Typically, there is underinvestment in the SW model.[2] The reason for the underinvestment is simple. Consider the entrepreneur at the cutoff $\hat{p}$. This is the safest project in the pool. If you could identify this entrepreneur, you would offer him a low interest rate since it is relatively unlikely that he will default. Unfortunately, this project is lost among the other riskier projects and gets an interest rate that is appropriate for the average riskiness of the loan pool. Thus the marginal entrepreneur's incentive to invest is too low.

Notice that investment rises as the level of internal funds increases. For any given R, the cutoff probability, $\hat{p}$, is increasing in w. Since total investment consists of all entrepreneurs with $p < \hat{p}$, investment increases with w.

[1] There will *never* be credit rationing in this economy. The safe saving option pins down the rate of return in the credit market and effectively rules out rationing. For a formal proof of this and that $\rho' > 0$ in equilibrium, see House [2000]. As in Mankiw [1986], it *is* possible for the credit market to be completely shut down. I restrict my analysis to equilibria in which this is not the case.

[2] If $r < \bar{\rho}$ then it is optimal to have no investment and this will be the case. If $\hat{p} > 0$ then $\bar{\rho} \leq \hat{p}R$ implies $\bar{\rho}(1-w) \leq r - w\bar{\rho} \Rightarrow \bar{\rho} \leq r$ which contradicts $\bar{\rho} > r$. If $r > \bar{\rho}$ then let $\mu_p = \int_0^1 pf(p)dp$ and $r^* = \bar{\rho} + (1-w)\bar{\rho}\frac{1-\mu_p}{\mu_p}$. If $r > r^*$ then $\hat{p} = 1$ and all projects are activated (which is optimal since $r > \bar{\rho}$. If $\bar{\rho} < r < r^*$ then $0 < \hat{p} < 1$ and there is underinvestment.

The main points about the SW model are summarized below:

In the SW economies, the equilibria involve underinvestment. Only the riskiest projects are undertaken. Furthermore, increases in internal financing increase investment.

2.3. De Meza and Webb go to the bank

At the other extreme is the distribution considered by De Meza and Webb [1987]. Here, all projects have the same actual outcome x if they succeed. As in the SW model, projects differ in their probability of success p. The expected payoff to an entrepreneur who activates his project is $p\,[x - R(1-w)]$ which is *increasing* in p. Again there will be a cutoff $\hat{p}$ but now the projects that activate are those with $p \geq \hat{p}$ so that we get the "safe tail". See figure 1.B. The cutoff satisfies $\hat{p}\,[x - R(1-w)] = w\bar{\rho}$. In this case,

$$\bar{\rho} = R\frac{\int_{\hat{p}}^{1} pf(p)dp}{1 - F(\hat{p})}$$

It is easy to show that $\bar{\rho} \geq \hat{p}x$ so that the expected return on the marginal project is below its social opportunity cost. Thus, in DW, there is overinvestment. This intuition is similar; the marginal project is the riskiest project and "deserves" a high interest rate. This entrepreneur is hiding among the other safer projects and thus gets an unreasonably low interest rate. Consequently, the incentives to invest for the projects at the margin are too high.

Unlike the SW model, increases in internal funds cause reductions in investment. Again, $\hat{p}$ is increasing in w but since investment consists of all entrepreneurs with $p > \hat{p}$, investment falls as w rises.

In the DW economies, equilibria involve overinvestment. Selection is toward the safer projects and increases in internal funds reduce investment.

2.4. General Distributions

General distributions have mixed results. Nevertheless, it is useful to ask how to distinguish underinvestment equilibria from overinvestment equilibria.

Consider any joint density function $f(r,p)$. For any p define $\hat{r}(p)$ as:

$$\hat{r}(p) = \bar{\rho} + (1-w)\left[pR - \bar{\rho}\right] \tag{2.1}$$

This is the cutoff expected return for projects that are successful with probability p given the interest rate R. Any entrepreneur with a project (r,p) for which $r \geq \hat{r}(p)$ will find it profitable to invest. In equilibrium, the diversified rate of return in the credit market must be equal to the safe rate of return.

$$\bar{\rho} = R\frac{\int_0^1 \left\{\int_{\hat{r}(p)}^{\infty} pf(r,p)dr\right\} dp}{\int_0^1 \left\{\int_{\hat{r}(p)}^{\infty} f(r,p)dr\right\} dp} = R\left[1 - \Delta(R, \bar{\rho}, w)\right]$$

Δ depends on $R, \bar{\rho}$, and w since the cutoffs $\hat{r}(p)$ depend on those variables.

Consider the change in output caused by increasing investment by a small amount $dI > 0$. The opportunity cost of activating a project is $\bar{\rho}$. At the margin, the expected payoff of a project is $\hat{r}(p)$. The change in output is then

$$\left[\int_0^1 \hat{r}(p)f(\hat{r},p)dp - \bar{\rho}\int_0^1 f(\hat{r},p)dp\right] dI.$$

Since $\hat{r}(p) - \bar{\rho} = (1-w)\left[pR - \bar{\rho}\right]$, the change in output can be expressed as:

$$\left\{(1-w)\int_0^1 \left[pR - \bar{\rho}\right] f(\hat{r},p)dp\right\} dI$$

The derivative of $\Delta(\cdot)$ with respect to ρ is:

$$\frac{\partial \Delta}{\partial \rho} = \frac{w}{IR}\left[\int_0^1 \left(pR - \bar{\rho}\right) f(\hat{r}(p),p)dp\right]$$

where total investment is $I = \int_0^1 \left\{\int_{\hat{r}(p)}^{\infty} f(r,p)dr\right\} dp$ and $\frac{\partial \hat{r}(p)}{\partial \rho} = w \ \forall p$. Consequently, the sign of $\frac{\partial \Delta}{\partial \rho}$ distinguishes overinvestment models from underinvestment ones.[3] If $\frac{\partial \Delta}{\partial \rho} > 0$ investment should be increased while if $\frac{\partial \Delta}{\partial \rho} < 0$ investment should be restrained.

Increases in $\bar{\rho}$ discourage investment. In SW, the marginal investors have the safest projects so an increase in $\bar{\rho}$ increases the default rate by "chasing away" the

[3] Mankiw [1986] derives a similar efficiency condition.

safe projects. In DW, the marginal projects are the riskiest ones so increasing $\bar{\rho}$ lowers the default rate.

In general, any change in investment improves welfare only if the loan pool becomes safer. It is easy to show that $\frac{\partial \Delta}{\partial w} < 0$ for any distribution. Increasing internal funds *always* makes the pool safer and therefore necessarily improves efficiency. If internal funds increased to the point where entrepreneurs could self-finance, the equilibrium cutoffs would be $\hat{r}(p) = \bar{\rho}$ and the market would be efficient.

3. Adverse Selection and Credit Markets Dynamics

This section presents a dynamic model of credit market failure. One of the nice features of the model is that it permits a decomposition of the dynamic effects of the adverse selection problem into components that have economic meaning. Specifically, an increase in internal funds has three separate effects on dynamics. More internal funds reduces the interest premium, which stimulates investment; it causes more efficient use of investment and, more internal funds causes the *level* of investment to move towards the efficient level.

3.1. Setup

The economy consists of overlapping generations of two period lived agents. Each generation has savers and entrepreneurs. The number of entrepreneurs is normalized to 1.

As before, entrepreneurs are risk neutral and only value consumption in the second period of life. The entrepreneurs invest in projects that, if successful, yield productive *capital* in the following period. Capital fully depreciates after use, so the payoff to having one unit of capital is just its marginal product. The project distribution is described by $f(p, k)$, where k is the expected capital payoff and p is the probability of success. Each project requires an initial investment of one unit of the consumption good. Entrepreneurs supply one unit of labor in youth and receive wages w_t. Entrepreneurs are the only agents who supply labor.

All agents have access to a safe investment technology that yields $\bar{\rho}$ goods in period $t + 1$. Note that the safe savings technology does not produce capital. Rather it simply yields units of consumable output the period after the saving took place. This implies that the entire capital stock comes from the market with the adverse selection problem. In a model with additional capital markets that are free of distortions, one would expect a significant amount of substitution between the two markets which would partially offset the dynamic effects of the credit market frictions.

Entrepreneurs can either save their income (w_t) to get $w_t\bar{\rho}$ or they can borrow $1 - w_t$ and finance their project. I restrict attention to equilibria in which w is strictly less than 1 so that entrepreneurs cannot self finance.

Consider a group of projects with the same probability of success, p (a cross section of the joint density f). The cutoff project for this group, $\hat{k}(p)$, will satisfy

$$\hat{k}_t(p) = \frac{1}{r_{t+1}} \left[\bar{\rho} + (1 - w_t)\{pR_t - \bar{\rho}\}\right] \tag{3.1}$$

where r_{t+1} is the marginal product of capital in the next period. This is the dynamic version of equation (2.1) in the general static model. As before, there are different cutoffs for each $p \in [0, 1]$. All entrepreneurs with projects (k, p) with $k > \hat{k}(p)$ demand funding. The efficient cutoffs are $\hat{k} = \frac{\bar{\rho}}{r}$ for all p but these are not the equilibrium cutoffs. The critical values differ from the efficient cutoffs by an amount that is proportional to the amount of external financing. As internal funds increase, the cutoffs "move towards" the efficient cutoffs. Projects that are pulling the average payoff up (i.e. for which $pR_t > \bar{\rho}$) set a cutoff that is too high. Projects that have expected returns that are less than the average return $\bar{\rho}$ have cutoffs that are too low. Projects for which $p = (1 - \Delta)$ are the only ones for which $\hat{k} = \frac{\bar{\rho}}{r}$.

Consider again a cross-section of the distribution f for a given p. All projects for which $k > \hat{k}(p)$ are activated. By the law of large numbers the contribution to the capital stock next period from this slice of the distribution is $\int_{\hat{k}(p)}^{\infty} kf(k, p)dk$. To get the total capital stock next period, simply sum over all of the p's to get:

$$K_{t+1} = \int_0^1 \int_{\hat{k}_t(p)}^{\infty} kf(k, p)dkdp \tag{3.2}$$

Competitive firms produce output according to a Cobb-Douglas technology:

$$Y_t = z_t K_t^{\alpha} N_t^{1-\alpha}$$

where z_t is productivity at date t. Factor demands satisfy:

$$\begin{aligned} w_t &= (1 - \alpha) z_t K_t^{\alpha} \\ r_t &= \alpha z_t K_t^{\alpha - 1} \end{aligned}$$

Finally, the no-arbitrage condition is:

$$\bar{\rho} = \rho(R_t) = R_t\left[1 - \Delta_t\right] = R_t \frac{A_t}{I_t}$$

where

$$I_t = \int_0^1 \int_{\hat{k}_t(p)}^{\infty} f(k,p)dkdp$$

and

$$A_t = \int_0^1 \int_{\hat{k}_t(p)}^{\infty} pf(k,p)dkdp$$

are the total investment (I) and the total measure of successful projects (A) respectively.

I assume the existence of a steady state equilibrium characterized by the constant values K, w, r, A, I, Δ.[4]

3.2. Dynamics

To generate dynamics in the model, assume that the economy is subjected to shocks to the technology parameter z and that this process follows an AR(1) process:

$$z_t = (1-q)z + qz_{t-1} + v_t$$

where q is the autoregressive root and v_t is i.i.d.

To analyze the dynamic behavior of the model, I take log-linear approximations of these equations in the neighborhood of a (stable) steady state. Linearizing (3.2) gives:

$$\tilde{K}_{t+1} = \frac{-1}{K}\int_0^1 \hat{k}(p) f(\hat{k}(p),p)\left[R\frac{\partial \hat{k}}{\partial R_t}\tilde{R}_t + r\frac{\partial \hat{k}}{\partial r_{t+1}}\tilde{r}_{t+1} + w\frac{\partial \hat{k}}{\partial w_t}\tilde{w}_t\right]dp \qquad (3.3)$$

where '$\tilde{x}$' denotes the percent deviation of the variable x from its steady state value. Since $\rho_t = \bar{\rho}$ in every period we have $\tilde{\rho}_t = \tilde{R}_t + \tilde{A}_t - \tilde{I}_t = 0$. This implies:

$$\tilde{R}_t = \frac{w\frac{\partial\Delta}{\partial w}\tilde{w}_t + r\frac{\partial\Delta}{\partial r}\tilde{r}_{t+1}}{1 - \Delta - \frac{\partial\Delta}{\partial R}R} \qquad (3.4)$$

[4]Existence is *not* guaranteed. Given K we have w, r, and $\Delta(R,w,r)$ that are continuous in K but the equilibrium interest rate R is the *minimum* R such that $\bar{\rho} = R[1-\Delta(\cdot)]$. In general, this R will not be continuous in K. In addition, it is possible that the mapping $K \to K'$ has downward jumps; thus existence arguments using continuity or monotonicity do not work.

The denominator is the derivative of $R\left[1-\Delta(\cdot)\right]$ with respect to R which is simply ρ' and in equilibrium must be positive. Finally:

$$\tilde{w}_t = \tilde{z}_t + \alpha \tilde{K}_t \tag{3.5}$$

$$\tilde{r}_t = \tilde{z}_t + (\alpha - 1)\tilde{K}_t \tag{3.6}$$

$$\tilde{z}_t = q\tilde{z}_{t-1} + v_t \tag{3.7}$$

The equations: (3.3), (3.4), (3.5), (3.6), and (3.7), characterize the local dynamics of the system.

Appendix A.1. shows that this system can be reduced to the following expression in which the total effect of a productivity shock is decomposed into five components:[5]

$$\begin{aligned} \tilde{K}_{t+1} = & \underbrace{\frac{\bar{\rho}}{K} \cdot \left.\frac{\partial I}{\partial r_{t+1}}\right|_{\mathrm{PI}}}_{\text{“Perfect Information Dynamics”}} \cdot \tilde{r}_{t+1} + \underbrace{\frac{I}{K}\frac{\bar{\rho}}{r}\frac{w}{\rho'}\frac{\partial \Delta}{\partial w}}_{\text{“Agency Cost Effect”}} \varepsilon_{IR} \cdot \tilde{w}_t \\ & + \underbrace{\frac{I}{K}\frac{\bar{\rho}}{r} R \frac{\partial \Delta}{\partial \rho}}_{\text{“Investment Effect”}} \cdot \tilde{w}_t \underbrace{- (1-w)\frac{I}{K}\frac{\bar{\rho}}{r}\frac{w}{\rho'}\frac{\partial \Delta}{\partial w}}_{\text{“Efficiency Gain”}} \cdot \tilde{w}_t \\ & \underbrace{+ \frac{\bar{\rho} I}{K}\left[\frac{1}{\rho'}\frac{\partial \Delta}{\partial r}\left(\varepsilon_{IR} - (1-w)\right) + \frac{(1-w)}{w} R \frac{\partial \Delta}{\partial \rho}\right]}_{\text{“Payoff Effects”}} \cdot \tilde{r}_{t+1} \end{aligned} \tag{3.8}$$

Here $\varepsilon_{IR} < 0$ is the interest elasticity of investment demand. In the static models, the function $\Delta(\cdot)$ described the relevant adverse selection effects in the environment. Not surprisingly, the dynamic system is also governed by the first order properties of this function.

Equation (3.8) describes the dynamic evolution of the capital stock. The first term in the equation is the normal change in investment that occurs under full information. The other terms represent deviations from the full information path caused by the adverse selection problem.

The additional terms are grouped according to whether they result from changes in internal funds ($\tilde{w}_t$) or changes in the expected future marginal product of capital ($\tilde{r}_{t+1}$). Because financial accelerator theories emphasize changes in internal

[5] To complete the solution to the model one would substitute for $\tilde{w}_t$ and $\tilde{r}_{t+1}$using (3.5) and (3.6). This would reduce the system to two equations in the state variables $\tilde{K}_t$ and $\tilde{z}_t$.

funds, I focus on the terms that interact with $\tilde{w}_t$ and only briefly discuss the effects of changes in $\tilde{r}_{t+1}$.

The second term in equation (3.8) is the *Agency Cost Effect*. As cash flow increases, the pool becomes safer and the premium on external finance falls. The lower interest rates stimulate investment which amplifies the shock. The sign of the coefficient is positive since for any distribution, $\frac{\partial \Delta}{\partial w}$ is negative (increases in internal funds always make the pool safer) as is the interest elasticity of investment, ε_{IR}. As a result, this channel always serves to amplify disturbances. This term captures the effect emphasized by Bernanke and Gertler [1989].[6] The magnitude of the agency cost effect depends on the absolute values of $\frac{\partial \Delta}{\partial w}$ and ε_{IR}. If investment is very sensitive to interest rate changes and if the interest rate is very sensitive to changes in internal funds then the agency cost effect will contribute significantly to dynamics.

The third term in equation (3.8) represents the direct affect of additional internal funds on investment even if the interest rate (R) stays the same. I call this the *Investment Effect* since it is the dynamic analog of the effect that internal funds had on investment in the static model. The sign of this effect is the same as the sign of $\frac{\partial \Delta}{\partial \rho}$. This is the same moment that differentiated overinvestment settings from underinvestment settings in the static models. Distributions that give rise to underinvestment in equilibrium will have $\frac{\partial \Delta}{\partial \rho} > 0$. If there is overinvestment in a static model (like DW) then $\frac{\partial \Delta}{\partial \rho} < 0$. For models like the SW model, this channel will impart additional accelerator dynamics to the system. In environments similar to DW, this effect will cause entrepreneurs to reduce investment and will have a stabilizing effect on the economy.

I call the fourth term an *Efficiency Gain*. Like the agency cost effect, this effect depends on $\frac{\partial \Delta}{\partial w}$. Since $\frac{\partial \Delta}{\partial w}$ is always negative, this effect will be positive and will amplify shocks. Intuitively, even if there is no change in the *level* of investment, there is a beneficial change in the *composition* of investment. More precisely, $\frac{\partial \Delta}{\partial w}$ quantifies the increase in efficiency that comes from an increase in internal funds (see Appendix A.2).

The last term, the *Payoff Effect*, represents the adverse selection effects coming from expected changes in the future payoff to capital (the future marginal product of capital). The net effect is determined by the moments $\frac{\partial \Delta}{\partial r}$ and $\frac{\partial \Delta}{\partial \rho}$. Like changes

[6] The decline in the premium is due to different reasons however. In Bernanke and Gertler [1989], the premium falls because it is less likely for the bank to monitor so average monitoring costs fall. In the adverse selection model, the premium falls because risky firms leave the loan pool while safe ones enter.

in w, changes in r affect dynamics by causing changes in investment and by altering the composition of investment. Looking at the coefficient on $\tilde{r}_{t+1}$, the reader can see that for every term that interacts with $\tilde{w}_t$, there is an associated interaction with $\tilde{r}_{t+1}$.

The total effect on the system is the sum of these components. Previous models emphasized the agency cost channel which is always positive. In the adverse selection model, it is immediately apparent that the other components in equation (3.8) may work to further magnify a shock (as in a SW case) or may work to dampen the effect of a shock (as in a DW case). It is possible to have a stabilizing effect that is so strong that the overall adverse selection effect from a positive productivity shock is negative. One example of such a case would be when $f(k,p)$ corresponds to a pure DW distribution (i.e. all of the projects have the same actual payoff x when they succeed).[7] This implies that the impulse response function for the capital stock (and for output) is *below* that of the full information economy.

It should be pointed out that there is no reason to believe, *a priori*, that, in reality, the agency cost effect is larger than the investment effect and the efficiency gain. In fact, since empirical estimates of ε_{IR} are typically low, the agency cost effect may not be very strong in reality. If this is the case, one should expect the other channels to be at least as important in shaping the economy's actual response to a shock.

It is important to emphasize that the possibility of a financial stabilizer is general and does not depend on adverse selection *per se*. Only two conditions are required for stabilization. First, market imperfections must be able to cause overinvestment. Second, the behavior of the entrepreneurs must "improve" when their net worth rises. Many models with rational agents have this second property. When agents internalize more of the costs and benefits of their decisions, their actions are more efficient. The first property (overinvestment), is also not uncommon. Existing financial accelerator models have the second property but not the first (costly-state-verification always causes underinvestment). As a result, these models always amplify shocks.[8]

[7] Intuitively, in DW economies, the only way for the agency cost erfect and efficiency gain to have the right sign, is if the equilibrium volume of investment falls when internal funds rise. It is not difficult to verify this mathematically, a proof is available from the author by request.

[8] Jensen [1986] and Malmendier and Tate [2001] present models that have the first property but not the second. In these cases, firms behave worse when internal funds rise. In Jensen [1986], this is because managers incentives differ from the firm's incentives. In Malmendier and Tate [2001], managers are irrationally "overconfident".

3.2.1. Simulations.

For numerical simulations, one needs to specify the precise form of the distribution. To allow for some flexibility in distributional choice, assume that (p, k) is distributed according to a log bivariate normal distribution.

$$\left\{\log\left(\frac{p}{1-p}\right),\ \log k\right\} \sim BVN(\mu_1, \mu_2, \sigma_1, \sigma_2, \sigma_{12})$$

Although this is restrictive, it does allow for a considerable degree of flexibility in the distribution and is not too hard to work with.

The remaining parameters are $\bar{\rho} = 1.01$; $q = .95$ and $\alpha = .35$. Although these are standard values used in RBC models, the model here is much too stylized to afford a direct comparison with actual data. The details of the numerical simulations are contained in Appendix B.

The first example considers an underinvestment case similar to the SW model. The first order components of the function Δ are given in the following table together with the first order terms in the subsequent simulation:

first order component	$\frac{\partial\Delta}{\partial\rho}$	$\frac{\partial\Delta}{\partial R}$	$\frac{\partial\Delta}{\partial w}$	$\frac{\partial\Delta}{\partial r}$	ε_{IR}
"SW" Model	.240	.122	$-.075$	-1.152	-1.01
"DW" Model	$-.335$	.002	$-.507$	1.035	$-.372$

Table 1

The equilibrium response of the capital stock to a 1% improvement in technology is shown in figure 2, along with the response that would occur under perfect information. The equilibrium response of capital is much greater than the perfect information response. This is because all of the amplification forces are pushing in the same direction. The bottom two panels in figure 2. show the responses of the interest rate and investment. Investment increases by roughly 1% in response to the 1% improvement in productivity. Only *some* of this is due to the agency cost effect. Since the interest elasticity of investment demand is -1 (see the table above) and the loan rate R falls by roughly .23%, the agency cost effect causes total investment to rise by *at most* .23%. In fact it is less than this since the equilibrium fall in interest rates is only partially due to increased internal funds.[9]

[9] Since this is a "SW" example, the projects at the cutoffs are safer than the average project in the pool. Thus, even under perfect information, default rates fall as investment rises.

Figure 3 decomposes the total equilibrium effect on the capital stock into its various components. To find each piece, I use the equilibrium realizations of prices $\{R_t, w_t, r_t\}_{\forall t}$ and solve for the total amount of accumulation that comes from each part of equation (3.8) separately. The total response of the capital stock is the sum of these components. The agency cost effect in this example is significant. It causes the capital stock to rise by roughly .12% more than it would if the loan markets functioned efficiently. The largest amplification channel in this example is the "investment effect". This channel accounts for almost half of the equilibrium change in investment.[10] [11]

Figure 4 shows the equilibrium responses to the same 1% technology shock when there is overinvestment. The equilibrium response of the system is below the response in the perfect information environment. This is due to the overinvestment in the steady state (note that $\frac{\partial \Delta}{\partial \rho}$ is negative in Table 1). As their internal funds rise, managers and entrepreneurs think more carefully about which projects to activate. Since they were overinvesting in the steady state, they actually reduce investment as their cash flow rises.

Figure 5 decomposes the aggregate effect into its components. Stabilization in this example comes from both the negative payoff effect as well as the "investment effect". The "investment effect" causes capital to fall by .6% while the "payoff effect" reduces capital by .18%.[12]

It is worth pointing out that the interest rate on risky loans (R) falls in both cases. Increases in internal funds always reduces risk in the loan pool and consequently, always drives interest rates down. Thus the correlation between changes in output with changes in interest rate spreads and default risk cannot be used as evidence of either stabilizers or accelerators since both theories are consistent with this feature of the data.

[10] This is not a general result. In other cases (cases in which ε_{IR} is large) the "agency cost effect" can dominate the other effects.

[11] The alert reader will notice that the perfect information response in figure 3 differs from the perfect information response in the upper panel of figure 2. The discrepancy is due to the fact that I am using the "adverse selection" price path $\{R, w, r\}$ in figure 3 while in figure 2 I generate the actual equilibrium path under perfect information.

[12] In stabilizer cases it is common to have a negative "payoff effect". When the marginal product of capital (r) rises, investment should increase. Because the marginal projects are riskier than the average projects, the inflow of risky projects causes the default rate to rise which raises R and curtails investment. Recalling that "overinvestment" implies that $\frac{\partial \Delta}{\partial \rho} < 0$, the reader can verify that every term in the "payoff effect" in (3.8) is negative.

3.3. Equity Financing and Optimal Contracting

One objection to the model above is that the contracts are restricted to standard debt contracts. This subsection analyzes the equity financing as well as the optimal contracting problem. Allowing agents to issue equity or to write optimal contracts with their lenders will change the equilibrium dynamics of the system.

3.3.1. Equity

Suppose that entrepreneurs finance their projects with equity rather than debt. Let π_t be the price for a share of a project. The agent needs to raise $1 - w_t$ external funds to finance the project so he must sell $\zeta_t = \frac{1-w_t}{\pi}$ shares. The payoff to investing for any entrepreneur is $r_{t+1}k\left[1-\zeta_t\right]$ so for any project (k,p) all that matters for an investor is k. This payoff is clearly increasing in k so any $k > \hat{k}$ will issue shares and get financing. The critical $\hat{k}$ satisfies

$$r_{t+1}\hat{k}\left[1-\frac{1-w_t}{\pi_t}\right] = w_t\bar{\rho}$$

(note that the term in brackets must be positive otherwise no entrepreneur will invest). The efficient cutoffs are $\frac{\bar{\rho}}{r_{t+1}}$ and require $\pi_t = 1$

In equilibrium, the return on a diversified portfolio of stocks must be:

$$\bar{\rho} = \frac{r_{t+1}}{\pi_t}\frac{\int_{\hat{k}}^{\infty} k\xi(k)dk}{1-\Xi(\hat{k})}$$

where $\xi(k)$ and $\Xi\left(k\right)$ are, respectively, the marginal density of k and the cumulative marginal distribution of k associated with the joint density $f\left(k,p\right)$; $\xi\left(k\right) = \int_0^1 f\left(k,p\right)dp$, $\Xi\left(k\right) = \int_0^k \left\{\int_0^1 f\left(k,p\right)dp\right\}dk$.

In equilibrium, the diversified return is at least as great as the return on the marginal project.

$$\bar{\rho} > \frac{r_{t+1}}{\pi_t}\hat{k}$$

Using the definition of $\hat{k}$:

$$\bar{\rho}\left[\pi_t - \left(1-w_t\right)\right] > w_t\bar{\rho}$$

which implies that $\pi_t > 1$ and $\hat{k} < \frac{\bar{\rho}}{r_{t+1}}$ (there is overinvestment).

Note that the marginal project ($\hat{k}$) is the least productive project. Because the price of equity reflects the average return on investment, the marginal firm is able to raise funds to too easily. $\hat{k}$ is increasing in w so as internal funds increase, investment contracts (given r_{t+1}, and π_t). Thus in the simple equity model, there is overinvestment in the steady state and the adverse selection problem stabilizes the economy.

3.3.2. Optimal Contracts

Neither equity nor standard debt contracts are optimal in this model. This section analyzes the optimal contracting problem. Specifically, I consider an environment in which banks write contracts to screen potential borrowers. Two things are immediately apparent about the form of an optimal contract. First, since project outcomes are observable, an optimal contract will make interest payments conditional on the *ex post* realization of the project (x). Instead of repaying R if a project succeeds, the borrower will repay $R(x)$.

Second, the lenders may also attempt to screen borrowers *ex ante* by offering a menu of contracts $\{R(x), c\}$ where c is the entrepreneurs contribution to the funding of their own project. Intuitively, the adverse selection problem will be less severe if the borrower contributes more of their own funds to the project. Since entrepreneurs only have w, we require $c \leq w$ for every active contract.

Banks are competitive. In equilibrium, every active contract will earn the rate of return $\bar{\rho}$ per unit lent.

Appendix C shows that the optimal contract is given by $\{R(x), w\}$ for every x. The lenders condition the interest payment on the project outcome and require the entrepreneurs to contribute all of their internal funds to the project. Projects in outcome group x all get standard debt contracts with a common interest payment $R(x)$. Thus, the optimal contract has both debt and equity features.

This implies that for any distribution $f(\frac{x}{p}, p)$, the markets effectively separate the distribution into a set of distinct markets $\{f_x(p)\}_{\forall x}$ where each univariate distribution $f_x(p)$ is a "slice" of $f(\frac{x}{p}, p)$. Thus, optimal contracting breaks the original adverse selection problem (with distribution $f(\frac{x}{p}, p)$) into a set of De Meza-Webb economies each with distribution $f_x(p)$. Furthermore, we already know that the DW economies are stabilizers in the dynamic environment.

3.3.3. Discussion

The results of the optimal contracting problem and the model with equity finance are summarized below:

> *If the projects are equity financed or if borrowers and lenders write optimal contracts, then for any distribution of projects f, the only equilibria are stabilizers.*

Said another way, both equity financing and optimal contracting eliminate all of the accelerator equilibria. *Every equilibrium is a stabilizer.* This implies that, to a certain extent, the stabilizer equilibria are more robust than the accelerator equilibria.[13]

In reality, many small business loans are characterized by contracts that have both debt and equity features.[14] If the business "fails" the lenders are still the residual claimants. If the business "succeeds" then the financiers are paid an amount that increases with the degree of success. These contracts are *similar* to the optimal contracts in this model. The contracts here differ from equity because payoffs may be non-increasing in the outcome x. If the default rate for one group (x) is lower than another (x'), then $R(x) < R(x')$ even if $x' > x$.

In addition to the screening contracts considered here, one could consider a signaling game in which entrepreneurs choose their collateral and then the firms offer interest rates $R(x)$ once they have observed the collateral. This setup, in which the more informed parties choose the collateral, will also eliminate the accelerator equilibria.[15]

4. Evidence

Since credit market imperfections may stabilize rather than amplify shocks, it is worth considering if data can conclusively differentiate the two cases. This section

[13] Bernanke and Gertler [1990] considered a contracting problem in a model with both adverse selection and moral hazard (in the form of unobserved effort). In that model, the accelerator effects coming from the moral hazard problem overpowered the stabilizing effects coming from the adverse selection problem.

[14] I thank Robert Hall for bringing this to my attention.

[15] See Spence [1973], [1974]. Rothschild and Stiglitz [1976] give the original formulation and analysis of screening problems like the one considered in this paper. See also the discussion in Mas-Colell, Whinston and Green [1995], chapter 13.

reviews some of the empirical work on the financial accelerator and relates it to the adverse selection model.

4.1. Interest Rate Spreads

Figure 4 plots the interest rate spread between BAA rated bonds and 10 year treasury bills verses detrended industrial production. The spread is clearly countercyclical. There are many possible explanations for this pattern. When business conditions are unfavorable, it is more likely for firms to go bankrupt. As a result, loans made during a recession will come with a higher risk premium. In addition, in recessions, internal funds are lower. This exacerbates agency costs, adverse selection problems and moral hazard problems associated with lending and thus also requires a higher premium.

Some researchers argue that the countercyclicality of the spread may be indicative of a financial propagation mechanism.[16]

In the adverse selection model, the correlation between the spread and economic activity is not useful in determining whether there is a financial accelerator. This is true even when the changes in the spread are due entirely to changes in market distortions. When internal funds increase, the loan pool always becomes safer. Thus, even though the model can stabilize shocks, the default rate, and consequently the spread, always moves in the right direction.

4.2. Access to Bond Markets

Gertler and Gilchrist [1994] compare the behavior of small firms to large firms. They argue that small firms are more dependent on bank loans than larger firms which have access to bond markets. This suggests that small firms face significant market distortions while large firms have to overcome smaller informational hurdles. The authors find that sales for small firms are much more volatile than for large firms. They conclude that financial accelerator effects are quantitatively significant.

There would be reasons to question this result if the data were generated by an adverse selection model. To reach their conclusion, Gertler and Gilchrist [1994]

[16] See Gertler, Hubbard, and Kashyap [1991]. More recently, Bacchetta and Caminal [2000] argue that the cyclicality of the external finance premium is sufficient to tell whether the financial markets are accelerating or stabilizing. In his comments on Fuerst's [1995] paper, Gertler [1995] suggested that if the spread moved in the right direction, Fuerst's model would exhibit a financial accelerator. See also Azariadis and Shankha [1999].

assume that the equilibrium distortions in the provision of bank loans are more significant than the distortions in the bond markets. This may or may not be true in reality. It is possible that the bond markets are the ones with the market imperfection while the intermediated loans are not. Consider the following scenario: Banks have a costly technology that reveals a firms type perfectly. Informational problems are severe for small firms so that all of their loans are intermediated. These problems are not severe for large firms so they can issue bonds. In equilibrium, small firms get intermediated loans but behave efficiently while the large firms make decisions that are distorted. This would reverse Gertler and Gilchrist's conclusion.

4.3. The Flight to Quality

In recessions, the ratio of safe loans to risky loans increases. This pattern is called the "flight to quality" and some researchers see it as evidence of a financial accelerator.[17]

Again, the flight to quality is potentially able to distinguish between the two cases. But, to do so, the econometrician must know which markets are the "high quality" ones and which ones are not. Specifically, he must know if funds are flowing from markets with relatively high informational frictions to markets with relatively lower frictions.

If the low default rate markets are the ones with less distortion, then the flight to quality suggests an accelerator. However, it is possible that markets with high levels of distortion in equilibrium are markets with low default rates. If the high default rate markets have less distortion, then the distortions could be stabilizing.

4.4. Cash-Flow Sensitivity

One test that would be able to correctly discriminate between stabilizer equilibria and accelerator equilibria is cash-flow sensitivity analysis. In this model, if entrepreneurs received an *exogenous* increase in internal funds, one would only have to observe how they altered their investment behavior. If they increase investment then there is a financial accelerator.

An *endogenous* increase in cash flow has two separate effects on investment. First, increases in internal funds signal that there should be more investment

[17] See, among others, Kashyap, Stein and Wilcox [1993], Bernanke, Gertler, and Gilchrist [1996], Calomiris, Himmelberg, and Wachtel [1995] and Lang and Nakamura [1995].

even under perfect information. Second, there are the effects of financial market imperfections. Empirically, it is difficult to separate these two effects.

Fazzari, Hubbard and Peterson [1987] propose regressing a firm's investment on Tobin's Q and on cash flow.[18] If the coefficient on cash flow is significant then, they argue that this suggests that there are financial market imperfections. Most regressions of this type find positive cash flow effects.

Gilchrist and Himmelberg [1995] find evidence that firms that they identify *ex ante* as financially constrained have high cash flow sensitivities. However, among the unconstrained groups they find that firms that have access to the bond market have a negative cash flow sensitivity.

Kaplan and Zingales [1997] argue that cash flow regressions cannot shed any light on the presence of financial market imperfections. To support their claim they present detailed evidence showing that firms that were identified as financially unconstrained actually had the highest cash flow sensitivities. Erickson and Whited [2000] argue that, once one corrects for measurement error in Q, cash flow does not matter in investment regressions at all. As with Gilchrist and Himmelberg [1995], and Kaplan and Zingales [1997], Erickson and Whited also get several negative cash-flow sensitivity estimates and find that the firms that are classified as uncontstrained have greater cash flow sensitivity than the financially constrained firms.[19]

Although cash flow sensitivity is a direct test for financial accelerator effects, the results are mixed and the approach is somewhat controversial.[20]

4.5. Summary

The evidence pointing to the presence of a financial accelerator is mixed. While the cash flow sensitivity tests can, in principle, distinguish between stabilizers and accelerators, the results of these tests are not consistent across studies. In addition to the difficult task of correctly identifying exogenous shocks to cash flow, researchers occasionally obtain negative cash flow effects in these regressions. These results are often treated as aberrations. The other tests are either observationally equivalent in the stabilizer settings or they require some special knowledge on the part of the econometrician.

[18] See also Kashyap, Lamont and Stein [1994], Whited [1992], Hoshi, Kashyap and Scharfstein, [1991], Hubbard, Kashyap, and Whited [1995], and Calomiris and Hubbard [1995].

[19] See also Clearly [1999].

[20] See Fazzari, Hubbard and Peterson [2000] and Kaplan and Zingales [2000].

5. Related Literature

The term *financial accelerator* was coined by Bernanke and Gertler [1989]. In their model, costly state verification problems cause the distortions in the credit market. In costly state verification models, lenders incur costs to monitor the behavior of their borrowers.[21] Although Bernanke and Gertler emphasized that costly state verification is only one possible source of credit market failure, most of the subsequent literature has continued to focus on this case.[22]

The literature on credit market frictions in dynamic settings has grown significantly since the paper by Bernanke and Gertler [1989]. Fuerst [1995] was an early attempt to quantify the financial accelerator. Carlstrom and Fuerst [1997] expanded on this work by allowing the entrepreneurs in their model to be long lived. This modification (suggested by Gertler [1995]) introduced a positive autocorrelation to output growth that is not usually found in business cycle models but that does appear in the data. Although the model could generate "hump-shaped" output dynamics, it was still incapable of causing much amplification.[23] Kiyotaki and Moore [1997] and Bernanke, Gertler and Gilchrist [1998] provide models with significant accelerator effects. The crucial feature of these models is the role of leverage in increasing the volatility of internal funds.

Eisfeldt [1999] considers adverse selection in the market for claims to ongoing projects. She assumes that in expansions, idiosyncractic income becomes more volatile. Consequently, agents sell claims to good projects more often. This reduces the "lemons premium", and increases investment.

[21] See Townsend [1979] and Gale and Hellwig [1985] for the original analysis of costly state verrification model.

[22] Bernanke and Gertler [1990] and Kiyotaki and Moore [1997] are important departures from the costly state verification framework.

[23] One might argue that stabilizers have been present in some of the earlier models but this is not really the case. In Fuerst [1995] and Carlstrom and Fuerst [1997], for some parameters the impulse response for the constrained model is below the that of the full information model. This is because their accelerator mechanism also introduces an adjustment cost. The telling feature of an accelerator is how increases in internal funds affect investment. In both of these models, exogenous increases in net worth cause increases in investment. These models look like stabilizers because the adjustment cost feature is overpowering the accelerator feature. Baccetta and Caminal [2000] claim to have a model with a financial stabilizer. In their stabilizers, shocks that cause output to expand in the full information environment are constructed to have a negative influence on internal funds. Thus, their model has only the standard accelerator effect. In all of these "artificial" stabilizers, the models have the conterfactual implication that the spread moves procyclically.

Jensen [1986] offers a different rationale for "cash flow sensitivity" findings. He argues that firm's managers are tempted to invest when the firm has cash on hand even if the projects are not economically viable. Thus, rather than appealing to credit market distortions, Jensen argues that principal-agent problems within the firm cause cash flow sensitivity.

In addition to the theoretical literature their is also a large, and growing body of empirical work on credit markets and business cycles. Good summaries are found in Bernanke, Gertler, and Gilchrist [1996] and Gertler [1988]. Kashyap, Stein and Wilcox [1993] show that following a monetary contraction, the ratio of commercial paper issuances to bank loans rises. More broadly, Lang and Nakamura [1992] show that the ratio of low risk loans to high risk loans moves countercyclically. Calomiris, Himmelberg and Wachtel [1995] provide evidence on the countercyclicality of commercial paper issues. They argue that this is partly to finance trade credit for firms without access to bond markets.

In a recent paper, Malmendier and Tate [2001] argue that CEO's overinvest in their own projects. They show that many CEO's in Fortune 500 companies repeatedly buy stock in their own company for their personal portfolios. This suggests that these CEO's are too confident and have a tendency to overinvest.[24]

6. Conclusions

This paper analyzes a model in which adverse selection causes credit market distortions. These distortions have several effects on the dynamic response of the model to economic shocks. The total effect of the adverse selection problem can be broken down into components that have economic interpretations. This decomposition provides a window into the workings of dynamic models of financial market imperfections. In particular, the decomposition shows that there is a direct connection between overinvestment and underinvestment in static models and stabilizers and accelerators in dynamic models. This possibility for inefficient stabilization of economic shocks is not present in existing dynamic models of credit market imperfections. In the model I consider, equity financing, or optimal contracting between borrowers and lenders, eliminate all of the accelerator equilibria

[24] The combination of overinvestment and destabilization in both Jensen [1986] and in Malmendier and Tate [2001], conflicts with the results of my model (in which overinvestment implies stabilization, not destabilization). In both of these cases, some pathological behavior on the part of the firm is required. Rather than behaving better when their net worth increases, firms behave worse.

for *any* specification of the model. In these cases, the stabilizer outcomes are the only possible equilibria under such contracting.

Empirically, the evidence in favor of a financial accelerator is mixed. Although suggestive, none of the statistics considered so far can be offered as conclusive evidence of a financial accelerator.

Financial market imperfections can cause the economy to be inefficiently stable. The potential for a stabilizing outcome is present in any setting with overinvestment in the steady state. The fact that it is difficult to distinguish the stabilizers from the accelerators in data suggests that more care should be taken before concluding that credit market frictions are a destabilizing feature of the economy.

Appendices

Appendix A.1 : Deriving Equation (3.8)

Combining equation (3.3) with (3.4) we get:

$$\begin{aligned}\tilde{K}_{t+1} &= \frac{-1}{K}\int_0^1 \hat{k}(p) f(\hat{k}(p),p)\left[\frac{\partial \hat{k}}{\partial R_t} R\frac{1}{\rho'}\left(w\frac{\partial \Delta}{\partial w}\tilde{w}_t + r\frac{\partial \Delta}{\partial w}\tilde{r}_{t+1}\right)\right.\\ &\quad \left. + r\frac{\partial \hat{k}}{\partial r_{t+1}}\tilde{r}_{t+1} + w\frac{\partial \hat{k}}{\partial w_t}\tilde{w}_t\right] dp\end{aligned}$$

Gathering the coefficients on $\tilde{r}_{t+1}$ and $\tilde{w}_t$ gives:

$$\begin{aligned}\tilde{K}_{t+1} &= \left[\frac{-1}{K}\int_0^1 \hat{k}(p) f(\hat{k}(p),p)\left(\frac{\partial \hat{k}}{\partial R_t} R\frac{1}{\rho'} r\frac{\partial \Delta}{\partial r} + r\frac{\partial \hat{k}}{\partial r_{t+1}}\right) dp\right]\tilde{r}_{t+1}\\ &\quad + \left[\frac{-1}{K}\int_0^1 \hat{k}(p) f(\hat{k}(p),p)\left(\frac{\partial \hat{k}}{\partial R_t} R\frac{1}{\rho'} w\frac{\partial \Delta}{\partial w} + w\frac{\partial \hat{k}}{\partial w_t}\right) dp\right]\tilde{w}_t\end{aligned}$$

Notice that for any variable x:

$$\int_0^1 \hat{k}(p) f(\hat{k}(p),p)\frac{\partial \hat{k}}{\partial x} dp = \int_0^1 \left[\frac{\bar{\rho}}{r} + \frac{(1-w)}{r}(pR-\bar{\rho})\right] f(\hat{k}(p),p)\frac{\partial \hat{k}}{\partial x} dp$$

and

$$\frac{\partial \Delta}{\partial x} = \frac{1}{IR}\int_0^1 [Rp-\bar{\rho}]\, f(\hat{k})\left[\frac{\partial \hat{k}}{\partial x}\right] dp$$

$$\frac{\partial I}{\partial x} = -\int_0^1 f(\hat{k}(p),p)\frac{\partial \hat{k}}{\partial x} dp$$

so that:

$$\int_0^1 \hat{k}(p) f(\hat{k}(p),p)\frac{\partial \hat{k}}{\partial x} dp = -\frac{\bar{\rho}}{r}\frac{\partial I}{\partial x} + \frac{(1-w)}{r} IR\frac{\partial \Delta}{\partial x}$$

Then, the coefficient on $\tilde{r}_{t+1}$ is given by:

$$\frac{-1}{K}\left[R\frac{r}{\rho'}\frac{\partial \Delta}{\partial r}\left(-\frac{\bar{\rho}}{r}\frac{\partial I}{\partial R_t} + \frac{(1-w)}{r} IR\frac{\partial \Delta}{\partial R_t}\right) + r\left(-\frac{\bar{\rho}}{r}\frac{\partial I}{\partial r_{t+1}} + \frac{(1-w)}{r} IR\frac{\partial \Delta}{\partial r_{t+1}}\right)\right]$$

and the coefficient on $\tilde{w}_t$ is:

$$\frac{-1}{K}\left[R\frac{w}{\rho'}\frac{\partial \Delta}{\partial w}\left(-\frac{\bar{\rho}}{r}\frac{\partial I}{\partial R_t} + \frac{(1-w)}{r} IR\frac{\partial \Delta}{\partial R_t}\right) + w\left(-\frac{\bar{\rho}}{r}\frac{\partial I}{\partial w_t} + \frac{(1-w)}{r} IR\frac{\partial \Delta}{\partial w_t}\right)\right]$$

Combining these and factoring out I, gives:

$$\begin{aligned}\tilde{K}_{t+1} &= \frac{I}{K}\left[\frac{R}{\rho'}\frac{\partial \Delta}{\partial r}\left((1-\Delta)\varepsilon_{IR} - (1-w)R\frac{\partial \Delta}{\partial R_t}\right) + \left(\frac{\bar{\rho}}{I}\frac{\partial I}{\partial r_{t+1}} - (1-w)R\frac{\partial \Delta}{\partial r_{t+1}}\right)\right]\tilde{r}_{t+1}\\ &\quad + \frac{I}{K}\frac{w}{r}\left[\frac{R}{\rho'}\frac{\partial \Delta}{\partial w}\left((1-\Delta)\varepsilon_{IR} - (1-w)R\frac{\partial \Delta}{\partial R_t}\right) + \left(\frac{\bar{\rho}}{I}\frac{\partial I}{\partial w_t} - (1-w)R\frac{\partial \Delta}{\partial w_t}\right)\right]\tilde{w}_t\end{aligned}$$

using the fact that $\rho' = \left[1-\Delta-R\frac{\partial \Delta}{\partial R_t}\right]$ gives:

$$\begin{aligned}\tilde{K}_{t+1} &= \frac{\bar{\rho} I}{K}\left[\frac{1}{\rho'}\frac{\partial \Delta}{\partial r}\left(\varepsilon_{IR} - (1-w)\right) + \frac{1}{I}\frac{\partial I}{\partial r_{t+1}}\right]\tilde{r}_{t+1}\\ &\quad + \frac{\bar{\rho} I}{K}\frac{w}{r}\left[\frac{1}{\rho'}\frac{\partial \Delta}{\partial w}\left(\varepsilon_{IR} - (1-w)\right) + \frac{1}{I}\frac{\partial I}{\partial w_t}\right]\tilde{w}_t\end{aligned}$$

Note that:

$$\frac{\partial I}{\partial r_{t+1}} = \int_0^1 f(\hat{k}(p),p)\frac{\hat{k}(p)}{r}dp = \int_0^1 f(\hat{k}(p),p)\frac{\bar{\rho}}{r}dp + (1-w)\int_0^1 f(\hat{k}(p),p)\frac{[Rp-\bar{\rho}]}{r}dp$$

and

$$\frac{\partial I}{\partial w_t} = \int_0^1 f(\hat{k}(p),p)\frac{(pR-\bar{\rho})}{r}dp$$

Recalling the expression for $\frac{\partial \Delta}{\partial \rho}$ implies:

$$\frac{\partial I}{\partial r_{t+1}} = \left.\frac{\partial I}{\partial r_{t+1}}\right|_{\mathrm{PI}} + \frac{(1-w)}{w}I\frac{\bar{\rho}}{1-\Delta}\frac{\partial \Delta}{\partial \rho}$$

and

$$\frac{\partial I}{\partial w_t} = \frac{I}{w}\frac{\bar{\rho}}{1-\Delta}\frac{\partial \Delta}{\partial \rho}$$

so that:

$$\begin{aligned}\tilde{K}_{t+1} \quad &= \quad \frac{\rho I}{K}\left[\frac{1}{\rho'}\frac{\partial \Delta}{\partial r}\left(\varepsilon_{IR}-(1-w)\right)+\frac{1}{I}\left(\left.\frac{\partial I}{\partial r_{t+1}}\right|_{\mathrm{PI}}+\frac{(1-w)}{w}I\frac{\bar{\rho}}{1-\Delta}\frac{\partial \Delta}{\partial \rho}\right)\right]\tilde{r}_{t+1} \\ &+\frac{\rho I}{K}\frac{w}{r}\left[\frac{1}{\rho'}\frac{\partial \Delta}{\partial w}\left(\varepsilon_{IR}-(1-w)\right)+\frac{1}{I}\frac{I}{w}\frac{\bar{\rho}}{1-\Delta}\frac{\partial \Delta}{\partial \rho}\right]\tilde{w}_t\end{aligned}$$

which is rearranged to get equation (3.8).

Appendix A.2. : The Efficiency Gain Effect.

Assume that the increase in internal funds does not increase investment, then:

$$\frac{\partial I}{\partial w} = -\int_0^1 f(\hat{k}(p),p)\left\{\frac{\partial \hat{k}}{\partial w}+\frac{\partial \hat{k}}{\partial R}\frac{\partial R}{\partial w}\right\}dp = 0$$

This implies that:

$$\frac{\partial K_{t+1}}{\partial w} = -\int_0^1 \frac{1}{r}(1-w)\left(Rp-\rho\right)f(\hat{k}(p),p)\left\{\frac{\partial \hat{k}}{\partial w}+\frac{\partial \hat{k}}{\partial R}\frac{\partial R}{\partial w}\right\}dp$$

Note

$$\frac{\partial \hat{k}}{\partial w} = -\frac{1}{r}(pR-\bar{\rho}),\ \frac{\partial \hat{k}}{\partial R} = \frac{1}{r}p(1-w)$$

Since $\bar{\rho} = R\left[1-\Delta\right]$ we have:

$$R_w\left[1-\Delta\right] - R\left[\Delta_w + \Delta_R R_w\right] = 0$$

so that $R_w = \frac{R}{1-\Delta-R\Delta_R}\Delta_w = \frac{R}{\rho'}\Delta_w$. Then:

$$\frac{\partial K_{t+1}}{\partial w} = -\int_0^1 \frac{1}{r}(1-w)\left(Rp-\bar{\rho}\right)f(\hat{k}(p),p)\left\{-\frac{1}{r}\left(pR-\bar{\rho}\right)+\frac{1}{r}p(1-w)\frac{R}{\rho'}\Delta_w\right\}dp$$

For any x we have:

$$\frac{\partial \Delta}{\partial x} = \frac{1}{IR}\int_0^1 \left[Rp-\rho\right]f(\hat{k})\left[\frac{\partial \hat{k}}{\partial x}\right]dp$$

using the expression for $\frac{\partial \hat{k}}{\partial R}$, the second term in the sum is:

$$-\frac{R}{\rho'}\Delta_w(1-w)\frac{1}{r}IR\Delta_R$$

and the first term is:

$$-(1-w)\frac{1}{r}IR\Delta_w$$

Thus:

$$\frac{\partial K_{t+1}}{\partial w} = -(1-w)\frac{1}{r}IR\Delta_w\left[1+\frac{R\Delta_R}{\rho'}\right]$$

Using the definition of ρ',

$$\begin{aligned}\frac{\partial K_{t+1}}{\partial w} &= -(1-w)\frac{1}{r}IR\Delta_w\frac{1}{\rho'}\left[1-\Delta\right] \\ &= -(1-w)\frac{1}{r}I\bar{\rho}\Delta_w\frac{1}{\rho'}\end{aligned}$$

so the percentage change in K due to a percentage change in w conditional on $dI = 0$ is

$$\frac{\partial K_{t+1}}{\partial w}\frac{w}{K} = -(1-w)\frac{I}{K}\frac{\bar{\rho}}{r}\Delta_w\frac{w}{\rho'}$$

which is the efficiency gain effect.

Appendix B: Numerical Simulations.

The settings for the parameters used in the quantitative model are given in the table below. Keep in mind that this is a bivariate normal in the log odds ratio and log returns : $\left\{\ln\left(\frac{p}{1-p}\right), \ln(k)\right\}$, so that μ_p is the mean of $\ln\left(\frac{p}{1-p}\right)$ rather than the mean of p.

	Distributional parameters				
Model	μ_p	μ_k	σ_p^2	σ_k^2	σ_{pk}
SW:	4	1	1	-.1	-3
DW:	3.5	1	2.5	.2	3

To solve the model, I employ an *ad hoc* two dimensional quadrature procedure. Given the parameters of the distribution, the marginal distribution of $\ln\left(\frac{p}{1-p}\right)$ is normally distributed with mean μ_p and variance σ_p^2. I divide this marginal distribution into 20 cross sections or "strips". I take the .05 percentiles of the distribution as the strips and assume that all the projects in a strip all have the same success probability. So for instance, the first strip will be characterized by a number $v = -1.6449$ so that:

$$\frac{\ln\left(\frac{p}{1-p}\right)-\mu_p}{\sigma_p} = -1.6449$$

and the success probability for the strip is:

$$p = (1-p)\left[\exp\left\{\mu_p+\sigma_p v\right\}\right]$$

$$p = \frac{\exp\left\{\mu_p+\sigma_p v\right\}}{1+\exp\left\{\mu_p+\sigma_p v\right\}} = \frac{\exp\left\{\mu_p-\sigma_p 1.6449\right\}}{1+\exp\left\{\mu_p-\sigma_p 1.6449\right\}}$$

The "mass" for each strip is .05 (by construction).

Within each strip $\ln k | \ln\left(\frac{p}{1-p}\right) \sim N(\mu_{k|p}, \sigma^2_{k|p})$ where

$$\mu_{k|p} \equiv \mu_k - \frac{\sigma_{pk}}{\sigma_p^2}\mu_p + \frac{\sigma_{pk}}{\sigma_p^2}\ln\left(\frac{p}{1-p}\right)$$

and

$$\sigma^2_{k|p} \equiv \sigma_k^2 - \left(\frac{\sigma_{pk}}{\sigma_p^2}\right)^2 \sigma_p^2$$

Conditional on the success probability p, the conditional distribution obeys:

$$\frac{\ln k - \mu_{k|p}}{\sigma_{k|p}} \sim N(0,1)$$

Since there are 20 cross-sections:

$$\rho(R_t) = R_t\left(\frac{\sum_{t=1}^{20} p_t I_t^t(R_t)}{\sum_{t=1}^{20} I_t^t(R_t)}\right)$$

where

$$I_t^j = I_t(p^j) = .05 \cdot \left[1 - \Phi\left(\frac{\ln(\hat{k}_t^j) - \mu_j}{\sigma_j}\right)\right]$$

where Φ is the standard normal distribution. Then K is governed by:

$$K_{t+1} = .05 \cdot \left[\sum_{j=1}^{20}\left(\int_{\hat{k}_t^j}^{\infty} k f_j(k) dk\right)\right]$$

where f_j is the p.d.f. of the j^{th} log normal (i.e. $f_j(x) = \phi\left(\frac{\ln x - \mu}{\sigma}\right)\frac{1}{x}\frac{1}{\sigma}$ where ϕ is the normal density).

Given R, w, r, ρ one can construct $\hat{k}(p_j)$ from (3.1). I can then use MATLAB quadrature subroutines to find the 20 I's and the value for K as described above. Clearly w and r (and indirectly R) will all depend on the capital stock. Thus the problem becomes finding a fixed point in K. The solution proceeds as follows.

First guess a value for the steady state capital stock K. This will imply w and r. With these values I perform a grid search to find the associated equilibrium R. Specifically, I pick R and form $\hat{k}(p_j)$ for $j = 1...20$. These imply a real rate of return $\rho(R) = R\left(\frac{\sum_{j=1}^{20} p_j I_j(R)}{\sum_{j=1}^{20} I_j(R)}\right)$. The equilibrium will be the smallest R such that $\rho(R) = \rho$ (the exogenously specified safe rate of return). With this R I can construct the an associated I', and K'. If $K' = K$ then we have an equilibrium. If $K' \neq K$ then I revise my initial guess for the steady state capital stock.

With the steady state capital stock, I numerically evaluate the first order components of the function Δ: Δ_r, Δ_w, Δ_R, and Δ_ρ. This completes the solution.

Appendix C: The Optimal Financial Contract.

Since the *ex post* realization of the project is costlessly observable we can assume that there are separate menus of contracts offered to each outcome group (x). Within any outcome group there are many different projects all of which have the same x but differing p's. Let p_j be an arbitrary project in such a group. I will consider contracts of the form $\{R, c\}$ where c is the amount of resources that an individual contributes toward their own project. Clearly $c \leq w$. The payoff, P, to an entrepreneur for accepting a contract $\{R, c\}$ and activating their project is

$$P(p, \{R, c\}) = p\left[x - R(1-c)\right] + \bar{\rho}(w - c)$$

Note that since they only "put up" c they save the remaining $w - c$ and earn $\bar{\rho}$. (The payoff to not investing is simply $w\bar{\rho}$).

The indifference curves for an individual with project p_j are shown in figure 7.A. Notice that at the interest rate $R = \frac{\rho}{p_j}$ the entrepreneur is indifferent between different values of the contribution c. At $R = \frac{\rho}{p_j}$ they are being charged a "fair" interest rate and as a result, they don't care how much of the investment comes from c and how much comes from bank loans. If $R > \frac{\rho}{p_j}$ then they are facing an interest rate that is "too high" and they would prefer to finance more of the project themselves. If R is too low then they will prefer to borrow heavily and finance as little of the project as possible.

A competitive equilibrium is a set of contracts $C \equiv \{\{R, c\}\}$ such that for all active contracts $\{R, c\} \in C$ we have $\rho(\{R, c\}) = \bar{\rho}$ and for all projects p_j that accept $\{R, c\}$ we have $P(p_j, \{R, c\}) \geq P(p_j, \{R', c'\})$ $\forall \{R', c'\} \in C$.

Result C.1: *In any equilibrium, there can only be 1 R offered (and accepted) in C.*

To see this, suppose that this were not the case and that there were two interest rates $R^H > R^L$ (with associated contributions c^H, c^L). Then we must have $\rho(\{R^H, c^H\}) = \rho(\{R^L, c^L\})$. Since both are active contracts there must be some projects j applying at $\{R^H, c^H\}$ for which $p_j \geq \frac{\bar{\rho}}{R^H}$ (if this were not the case then $\rho(\{R^H, c^H\}) < \bar{\rho}$). Such projects will all wish to deviate to R^L.[22] There will be no such deviations in equilibrium so we conclude that there is only one equilibrium R offered. Denote this equilibrium interest rate $\bar{R}$.

Result C.2: *In any equilibrium the contribution is $c = w$.*

If this were not the case then the equilibrium would have $c_1 < w$ in the equilibrium. One of two things must be true: (1) there are both $p_j > \frac{\bar{\rho}}{\bar{R}}$ and $p_k \leq \frac{\bar{\rho}}{\bar{R}}$ applying at c_1 or (2) there is only $p_j = \frac{\bar{\rho}}{\bar{R}}$ applying at c_1. (Again this follows since $\rho(\{\bar{R}, c\}) = \bar{\rho}$ for all active contracts).

If there are both high and low probability projects at c_1 then consider the contract in figure 7.B. Clearly the high types would prefer contract c_2. Furthermore, a creditor offering such a contract would earn economic profit (i.e. $\rho(\{R_2, c_2\}) > \rho(\{\bar{R}, c_1\})$). This type of profitable deviation can not be present in a competitive equilibrium.

If there is just $p_j = \frac{\bar{\rho}}{\bar{R}}$ applying at c_1 then either there are other p_k applying at other contracts c' or p_j is the only type in existence. Since the latter case is trivial (such an equilibrium has no selection problem and has $R = \frac{\bar{\rho}}{p_j}$ with any $c \leq w$) I will proceed under the assumption that there exist other types $p_k \neq p_j$. These entrepreneurs apply at contracts $\{\bar{R}, c'\}$ where $c' \neq c$. Since $p_k \neq p_j$ there must be both $p_k > \frac{\bar{\rho}}{\bar{R}}$ and $p_l < \frac{\bar{\rho}}{\bar{R}}$ applying at $\{\bar{R}, c'\}$.

Assume that $c' > c$. Then it is easy to show that type p_l will strictly prefer contract c and will deviate. An analogous argument applies for $c' < c$. I conclude that the only equilibrium has $c = w$.[23]

Results C.1 and C.2 imply that the optimal contract takes the form given in the text.

[22] It is easy to show that for any $p \geq \frac{\bar{\rho}}{R}$, the entrepreneur will strictly prefer any contract for which $R' < R$ regardless of c (as long as $0 \leq c \leq w$).

[23] It is *possible* that the candidate equilibrium I have offered could be broken by a bank that offered multiple contracts some of which earned profits and some of which did not. If I were to allow such deviations it is possible that an equilibrium might not exist.

References.

Azariadis, Costas and Chakraborty, Shankha. "Agency Costs in Dynamic Economic Models." *The Economic Journal*, April 1999, pp. 222-241.

Azariadis, Costas and Smith, Bruce. "Financial Intermediation and Regime Switching in Business Cycles." *American Economic Review*, June 1998 88(3) pp. 516-536.

Bacchetta, Philippe and Caminal, Ramon. "Do Capital Market Imperfections Exacerbate Output Fluctuations?" *European Economic Review*, 2000, 44, pp. 449-468.

Bernanke, Ben and Blinder, Alan. "Credit, Money, and Aggregate Demand." *American Economic Review,* May 1988, 79, pp. 435-439.

Bernanke, Ben and Gertler, Mark. "Agency Costs, Net Worth, and Business Fluctuations." *American Economic Review,* March 1989, 79(1), pp. 14-31.

Bernanke, Ben and Gertler, Mark. "Financial Fragility and Economic Performance." *Quarterly Journal of Economics,* February 1990, 105(1), pp. 87-114.

Bernanke, Ben and Gertler, Mark. "Inside the Black Box: The Credit Channel of Monetary Policy Transmission." *Journal of Economic Perspectives,* Fall 1995, 9(4), pp. 27-48.

Bernanke, Ben; Gertler, Mark and Gilchrist, Simon. "The Financial Accelerator and the Flight to Quality." *Review of Economics and Statistics,* February 1996, 78(1), pp. 1-15.

Bernanke, Ben; Gertler, Mark and Gilchrist, Simon. "The Financial Accelerator in a Quantitative Business Cycle Framework." NBER working paper #6455, March 1998.

Calomiris, Charles; Himmelberg, Charles and Wachtel, Paul. "Commercial Paper, Corporate Finance, and the Business Cycle: A Microeconomic Perspective." *Carnegie-Rochester Conference Series on Public Policy* 1995, 42 pp. 203-250.

Calomiris, Charles and Hubbard, R. Glenn. "Firm Heterogeneity, Internal Finance, and 'Credit Rationing'." *Economic Journal,* March, 1990, 100, pp. 97-104.

Carlstrom, Charles and Fuerst, Timothy. "Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis." *American Economic Review,* December 1997, 87(5), pp. 893-910.

Chirinko, Robert; Fazzari, Steven, and Meyer, Andrew. "How Responsive is Business Capital Formation to it's User Cost? An Exploration with Micro Data." *Journal of Public Economics,* October 1999, 74(1), pp. 53-80.

Cleary, Sean. "The Relationship between Firm Investment and Financial Status." *Journal of Finance,* April, 1999, 54, pp. 673-692.

Cogley, Timothy and Nason, James. "Output Dynamics in Real-Business Cycle Models." *American Economic Review*, June 1995 85(3), pp. 492-511.

Cooper, Russell and Ejarque, Joao. "Financial Intermediation and Aggregate Fluctuations: A Quantitative Analysis." forthcoming in *Macroeconomic Dynamics*, 2000.

De Meza, David and Webb, David. "Too Much Investment: A Problem of Asymmetric Information." *Quarterly Journal of Economics,* May 1987, 102(2) pp. 281-292.

Eisfeldt, Andrea. "Endogenous Liquidity in Asset Markets." unpublished manuscript, University of Chicago 1999.

Friedman, Benjamin and Kuttner, Kenneth. "Money, Income, Prices, and Interest Rates." *American Economic Review,* June 1992, 82(3) pp. 472-492.

Fuerst, Timothy. "Monetary and Financial Interactions in the Business Cycle." *Journal of Money, Credit and Banking,* November 1995, Part 2, 27(4) pp. 1321 - 1338.

Gale, Douglas and Hellwig, Martin. "Incentive-Compatible Debt Contracts I: The One Period Problem." *Review of Economic Studies,* October 1985, 52 pp. 647-664.

Gertler, Mark. "Financial Structure and Aggregate Economic Activity: An Overview." *Journal of Money Credit and Banking,* August 1988, 20(3).

Gertler, Mark. "Comment on Monetary and Financial Interactions in the Business Cycle." *Journal of Money Credit and Banking,* November 1995, 27(4).

Gertler, Mark and Gilchrist, Simon. "The Role of Credit Market Imperfections in the Monetary Transmission Mechanism: Arguments and Evidence." *The Scandinavian Journal of Economics,* 1993, 95 (1) pp. 43-64.

Gertler, Mark and Gilchrist, Simon. "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms." *Quarterly Journal of Economics,* May 1994, 109 (2) pp. 309-340.

Gertler, Mark; Hubbard, R. Glenn, and Kashyap, Anil. "Interest Rate Spreads, Credit Constraints, and Investment Fluctuations: An Empirical Investigation." *Financial Markets and Financial Crises*, ed. R. Glenn Hubbard, NBER, University of Chicago Press, 1991.

Greenwald, Bruce; Stiglitz, Joseph and Weiss, Andrew "Informational Imperfections in the Capital Market and Macroeconomic Fluctuations." *American Economic Review,* May 1984, 74 (2) pp. 194-199.

House, Christopher. "Monetary Policy and Credit Market Failure." working paper, Boston University, August 2000.

Jensen, Michael "Agency Costs of Free Cash Flow, Corporate Finance and Takeovers." *American Economic Review,* May 1986, 76 (2) pp. 323-329.

Kashyap, Anil; Stein, Jeremy, and Wilcox, David. "Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance." *American Economic Review,* March 1993, 83(1) pp. 78-98.

Keenan, Sean; Shtogrin, Igor and Sobehart, Jorge. "Historical Default Rates of Corporate Bond Issuers, 1920-1998." Moody's Investors Service Special Comment. January 1999.

King, Robert and Rebelo, Sergio. "Resuscitating Real Business Cycles." NBER working paper #W7534, February 2000.

Kiyotaki, Nobuhiro and Moore, John. "Credit Cycles." *Journal of Political Economy,* April 1997, 105, pp. 211-48.

Lang, William and Nakamura, Leonard. "'Flight to Quality' in Bank Lending and Economic Activity." unpublished, Federal Reserve Bank of Philadelphia, 1992.

Mankiw, N. Gregory. "The Allocation of Credit and Financial Collapse." *Quarterly Journal of Economics,* May 1986, 101 pp. 455-470.

Stiglitz, Joseph and Weiss, Andrew. "Credit Rationing in Markets with Imperfect Information." *American Economic Review,* June 1981, 71 pp. 393-410.

Townsend, Robert. "Optimal Contracts and Competitive Markets with Costly State Verification." *Journal of Economic Theory,* 1979, 21 pp. 265-293.

Williamson, Stephen. "Financial Intermediation, Business Failures and Real Business Cycles." *Journal of Political Economy*, 1987, 95(6) pp. 1196-1216.

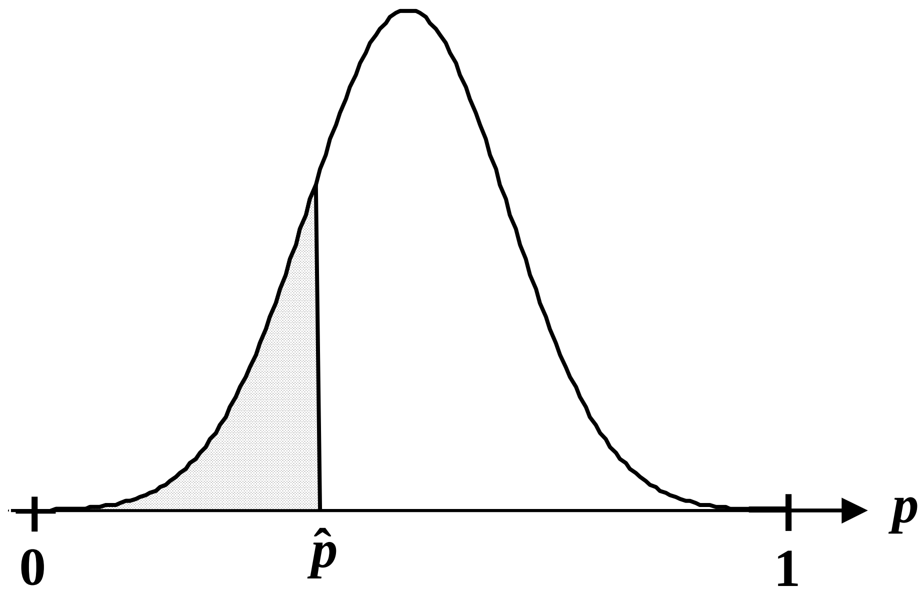


Figure 1.A
Projects undertaken in the Stiglitz and Weiss Model

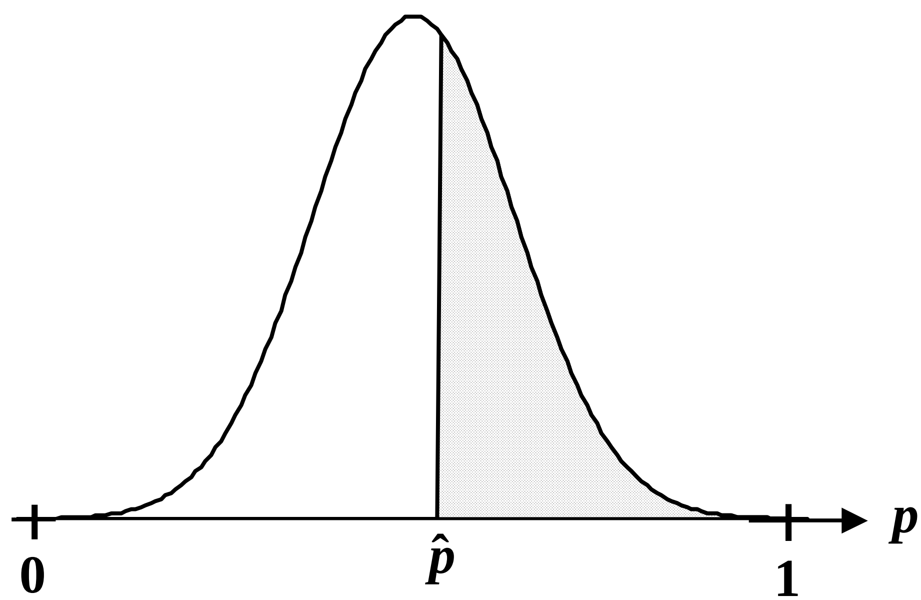


Figure 1.B
Projects undertaken in the De Meza and Webb Model

Figure 2

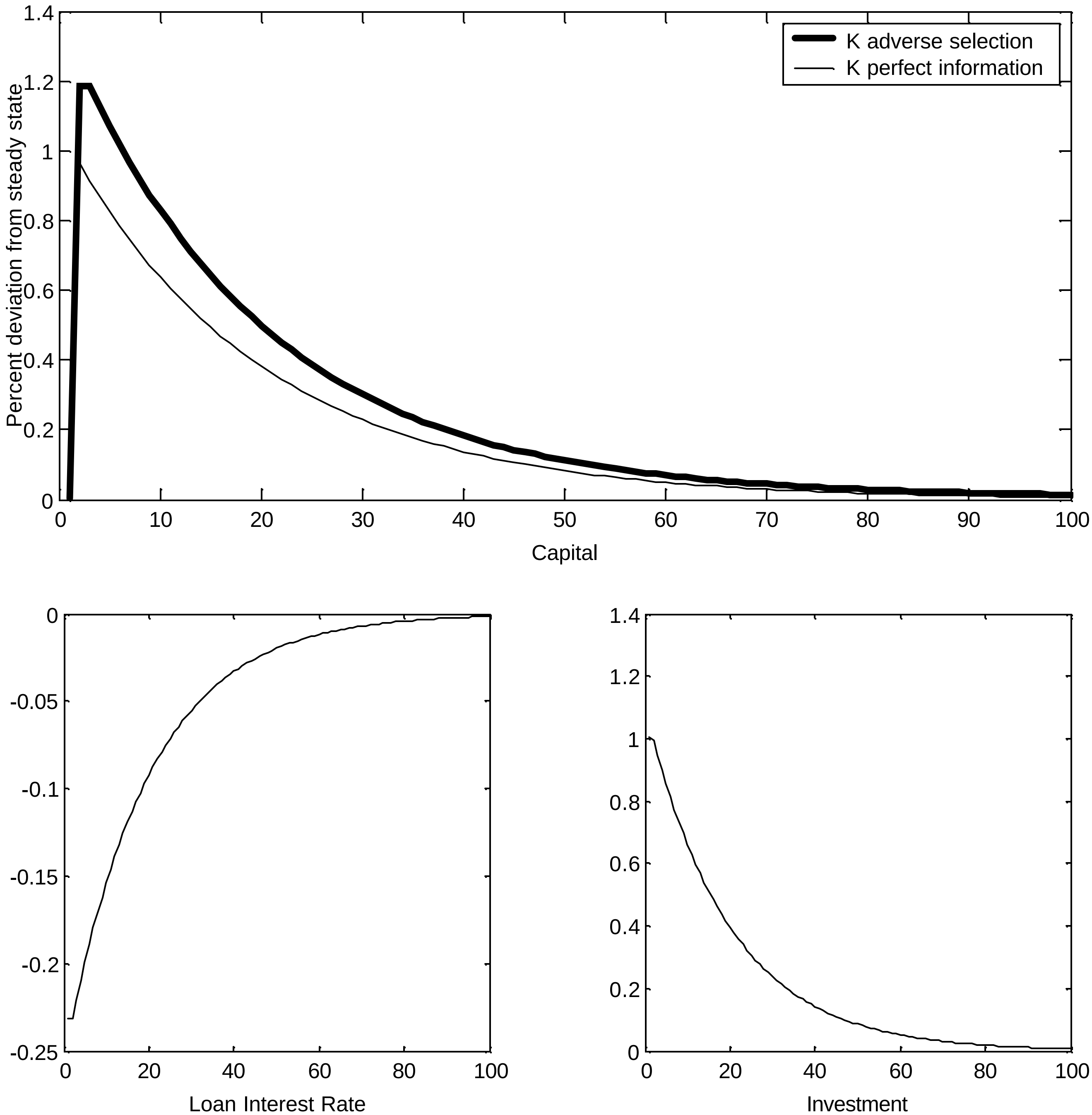
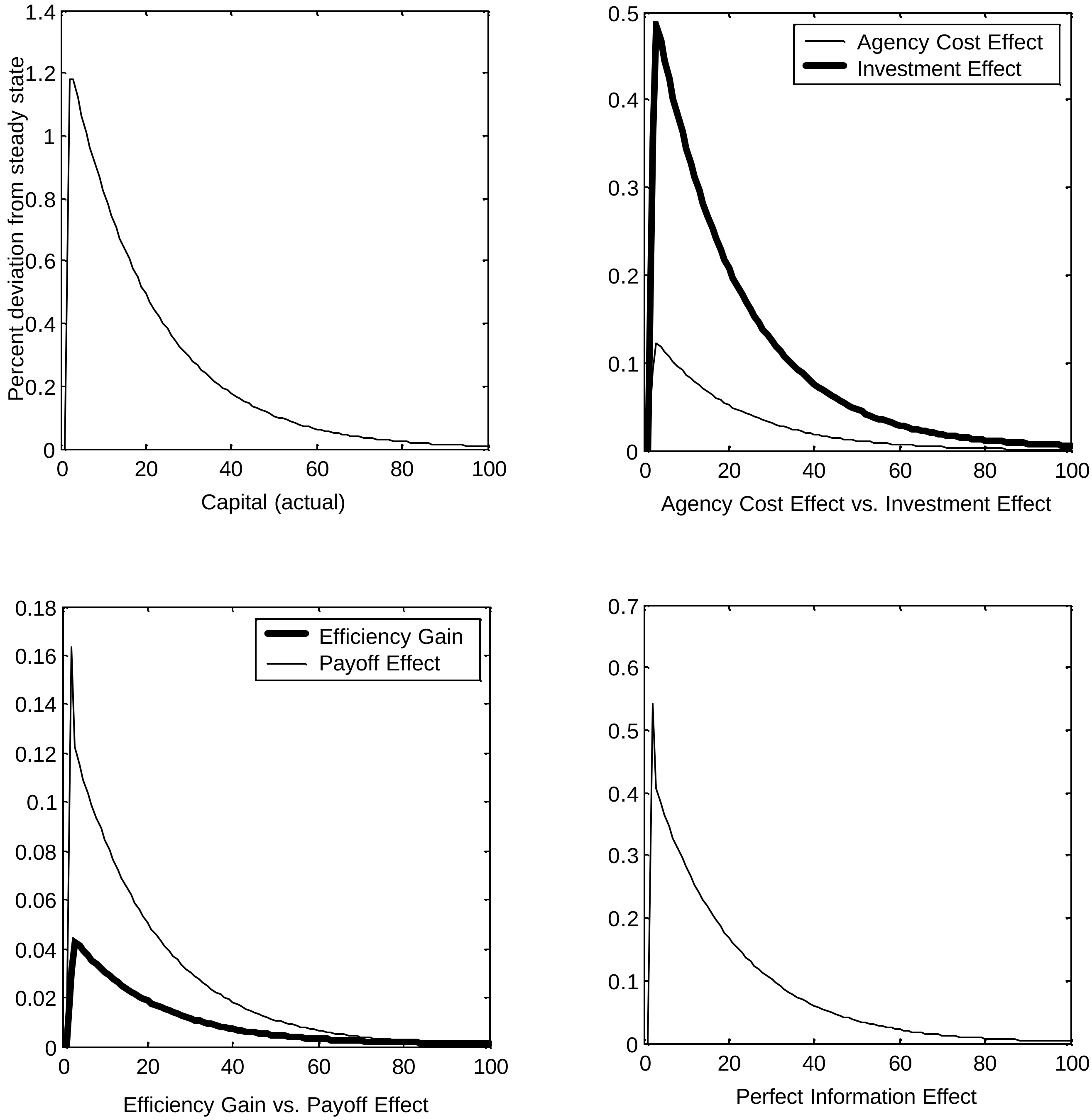

K adverse selection
K perfect information
Percent deviation from steady state
Capital
Loan Interest Rate
Investment

Figure 3



Percent deviation from steady state
Capital (actual)
Agency Cost Effect
Investment Effect
Agency Cost Effect vs. Investment Effect
Efficiency Gain
Payoff Effect
Efficiency Gain vs. Payoff Effect
Perfect Information Effect

Figure 4

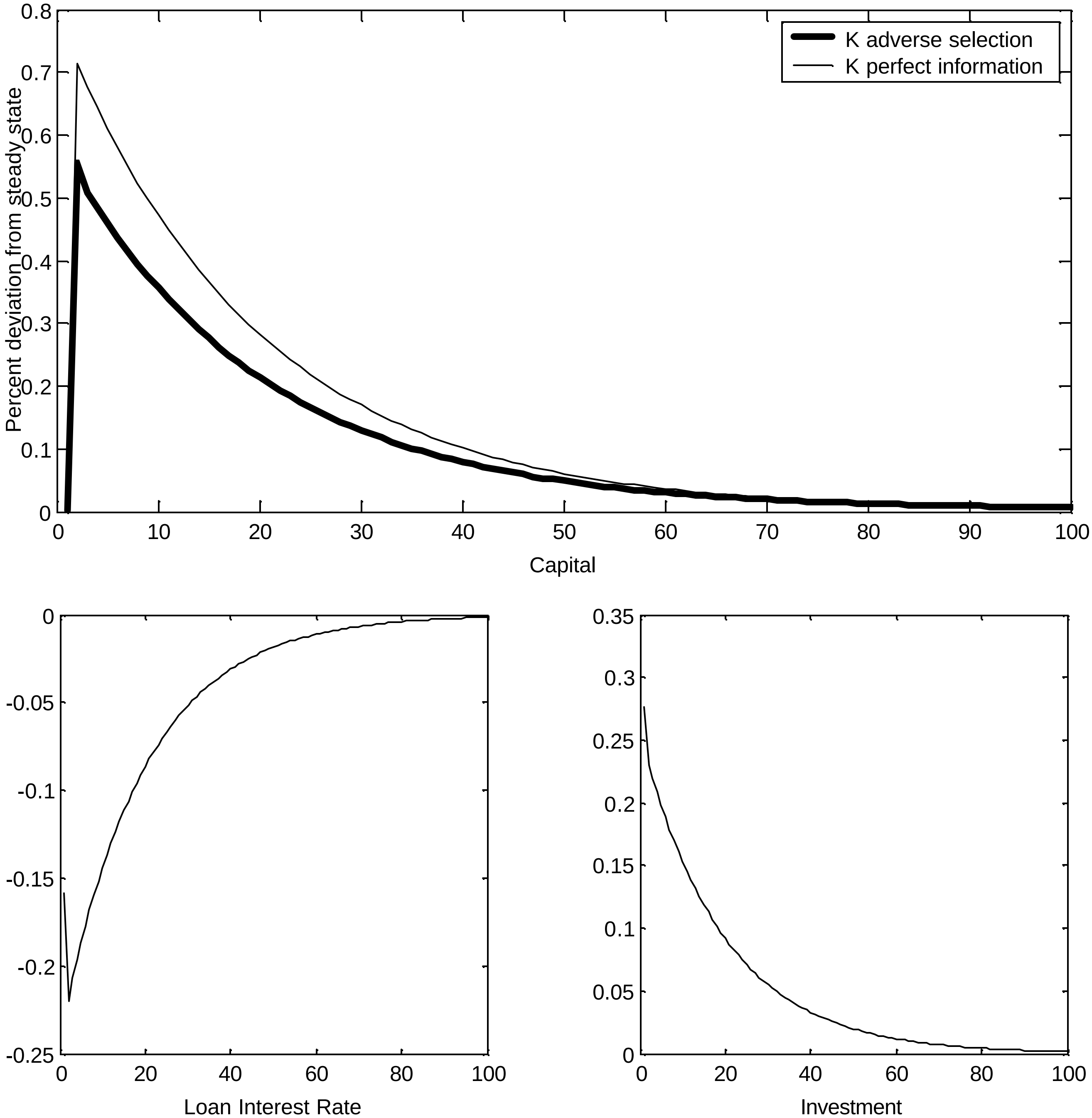
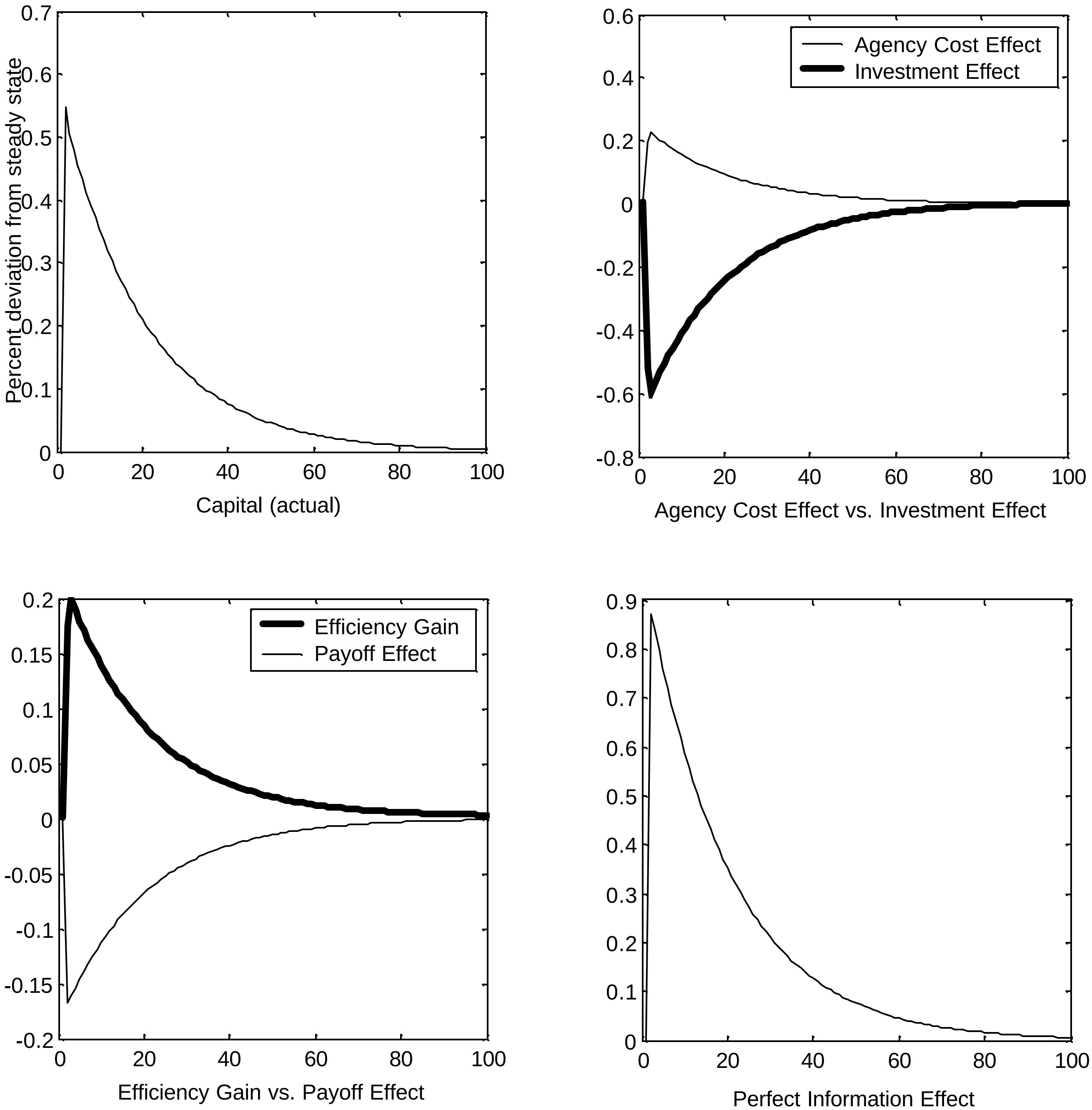

K adverse selection
K perfect information
Percent deviation from steady state
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
100
Capital
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
20
40
60
80
100
Loan Interest Rate
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100
Investment

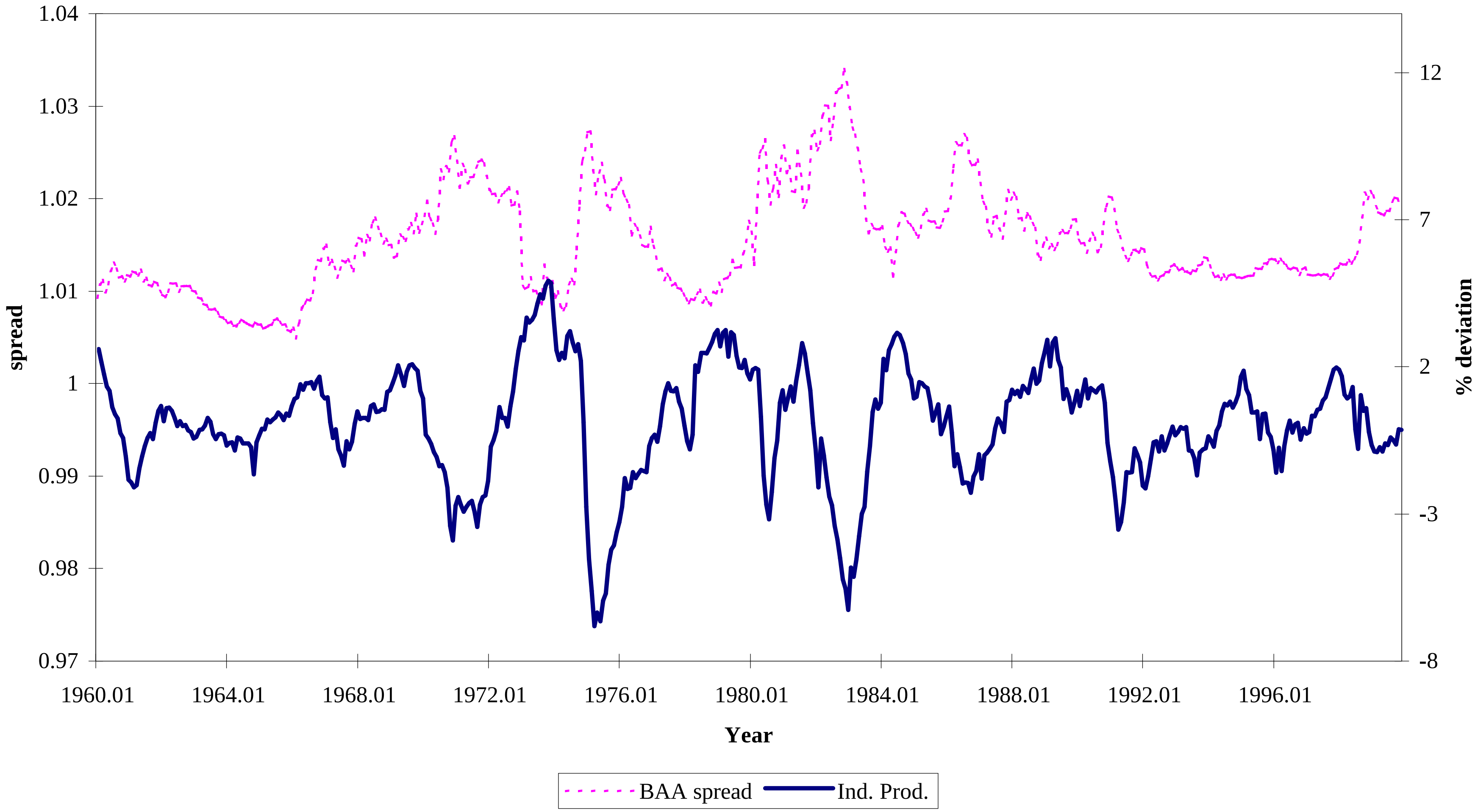
Figure 5



Percent deviation from steady state
Capital (actual)
Agency Cost Effect
Investment Effect
Agency Cost Effect vs. Investment Effect
Efficiency Gain
Payoff Effect
Efficiency Gain vs. Payoff Effect
Perfect Information Effect

Figure 6

Spread (BAA) vs. Industrial Production Index (HP detrended)



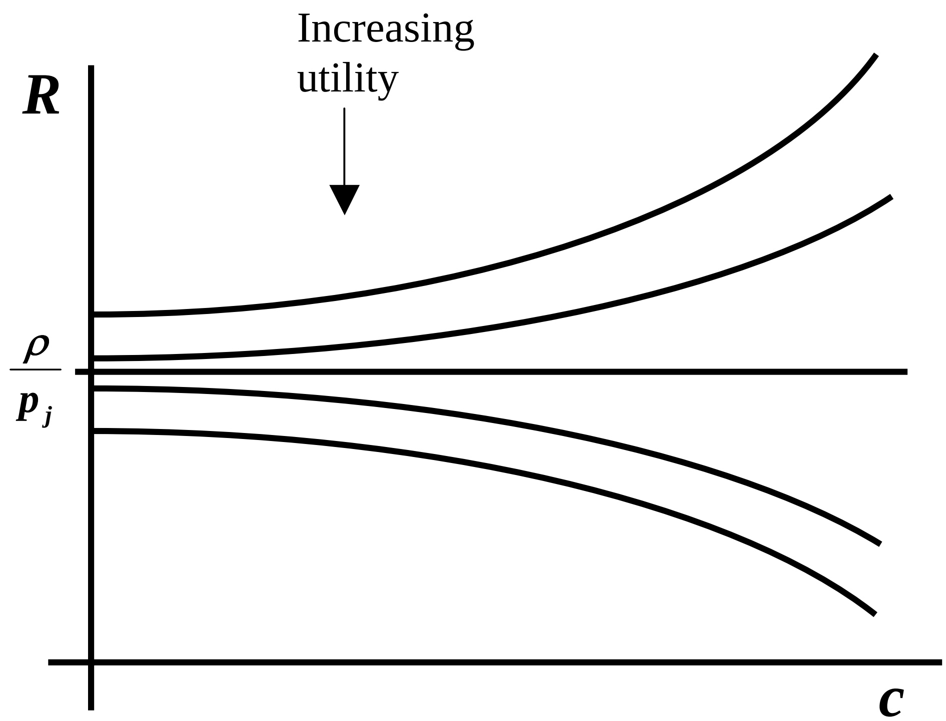


Figure 7.A

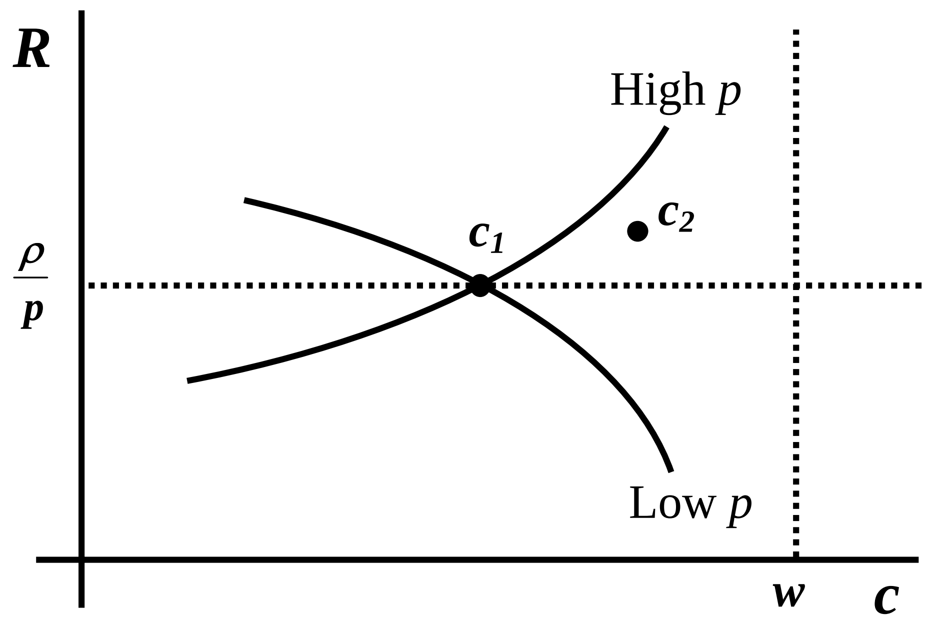


Figure 7.B