Adverse Selection and the Accelerator

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Abstract

I construct a dynamic model in which adverse selection in credit markets causes a financial accelerator. I answer three questions: Does the financial system stabilize or destabilize the economy; how large are these effects; and how can we empirically distinguish between amplifiers and stabilizers? I contrast my model with the costly state verification model. Unlike the costly state verification mechanism, the adverse selection model has the potential to stabilize shocks rather than amplify them. I show that the adverse selection forces are much more powerful than the amplifier effects in the costly state verification framework. Although accelerators and stabilizers are observationally equivalent along many dimensions, I present a statistic that can distinguish between them.

1. Introduction

Many macroeconomists have turned their attention to financial market imperfections as a source of business cycle propagation. Bernanke and Gertler [1989], Bernanke, Gertler and Gilchrist [1999], Carlstrom and Fuerst [1997] and Fuerst [1995] all construct models in which credit market imperfections amplify and propagate otherwise small economic disturbances. The theory that financial market imperfections exacerbate economic shocks is known as the *financial accelerator*.

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The original example in Bernanke and Gertler [1989] considers a costly state verification problem in which lenders incur costs to monitor the behavior of borrowers.[1] Although Bernanke and Gertler emphasize that costly state verification is only one of many possible sources of credit market failure, the subsequent literature has continued to focus almost exclusively on this case.

In this paper, credit markets are distorted by adverse selection. I embed the adverse selection problem in a dynamic general equilibrium model of business fluctuations. I use the model to answer three questions: Does the financial system stabilize or destabilize the economy; what are the magnitudes of these effects; and how can we empirically distinguish between amplifiers and stabilizers? I contrast my model with the costly state verification model. Adverse selection has greater potential to amplify shocks than the standard costly state verification mechanism. Also, in contrast to the standard model, the adverse selection model can stabilize rather than amplify shocks. Finally, although, in my model, accelerators and stabilizers are observationally equivalent along many dimensions, I present a method that can distinguish between them in practice.

The basic intuition of the financial accelerator is that when borrowers' internal funds increase, they internalize more of the costs and benefits of their investment activities. Therefore, in expansions, market distortions are low while in recessions, distortions are more significant. In the Bernanke-Gertler example, a shock that increases the entrepreneurs' net worth causes the premium on borrowed funds to fall. With a lower premium, investors have additional incentives to invest. Higher investment today causes future net worth to be higher and, thus, propagates the shock.

The adverse selection model that I present shares the standard accelerator mechanism described by Bernanke and Gertler. However, In the adverse selection setting, increases in net worth have two additional effects. First, there is an improvement in the efficient use of current investment. That is, even if the total volume of investment does not change, shocks are amplified because current investment is allocated more appropriately. Second, since borrowers internalize more of the costs and benefits of their projects, the *level* of investment is "closer" to an efficient allocation. In some settings this causes investment to increase; in others to fall. This second effect is the dynamic analog of over- or underinvestment in static adverse selection models. If there is underinvestment in the static environment, higher internal funds increase investment in the dynamic model and causes amplification. If there is overinvestment in the static environment, higher

[1] See Townsend [1979] and Gale and Hellwig [1985].

internal funds reduce investment and, in the associated dynamic model, the financial markets mitigate shocks. These two additional source of amplification account for my model's ability to generate pronounced accelerator dynamics and, in some cases, to cause stabilization dynamics.

In the simulations, the standard accelerator mechanism (i.e. the one stressed by Bernanke and Gertler [1989]) is typically one of the weaker propagation effects. There is also reason to believe that this effect is relatively weak in reality. The reason is that the standard accelerator channel relies on a high interest elasticity of investment. In my simulations, this elasticity is close to -1. In these cases, the standard accelerator effect accounts for as little as 10% of the overall increase in investment. In actual data, the estimated elasticity is even lower (some estimates are as low as -0.05) so we should not expect this effect to be particularly important in reality.

In the stabilizer equilibria, the model does not have any overtly counterfactual implications (such as a procyclical interest rate spread). This suggests that many of the empirical results on accelerator effects should be reexamined. Many well known empirical findings that suggest the presence of a financial accelerator are, in the context of my model, observationally equivalent to a stabilizer. The difference between stabilizers and accelerators, in my model, is subtle and depends crucially on the underlying distribution of projects.

I use two models to illustrate the results. The first is simple enough to permit an analytical solution. I use this model to decompose the adverse selection effect and to clearly illustrate how this model differs from the standard accelerator mechanism. The second model I consider is more fully articulated than the first and must be analyzed numerically. This more elaborate setting affords comparisons with existing business cycle models and with actual data. Because the properties of the dynamic models are closely related to the behavior of static adverse selection models, I make comparisons between the static models and the dynamic models throughout the paper.

The remainder of the paper is set out as follows: In Section 2 I briefly review the related literature. In Section 3, I present the static models that are the basic building blocks for the dynamic models that are analyzed later. Section 4 contains the main results of the paper. Here I present the two dynamic models and I analyze their behavior under various assumptions. Section 5 considers empirical evidence pertaining the financial accelerator. Section 6 concludes.

2. Related Literature

The literature on credit market frictions in dynamic settings has grown significantly since the paper by Bernanke and Gertler [1989]. Fuerst [1995] is an early attempt to quantify the effect described by Bernanke and Gertler. His results suggested that the mechanism was not particularly strong. In fact, in many of his simulations, the full information model seemed to imply a more pronounced response to disturbances. Carlstrom and Fuerst [1997] expanded on this work by allowing the entrepreneurs in their model to be infinitely 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.[2] The fact that the entrepreneurs lived for more than one period implied that they could wait until credit market conditions were sufficiently good before they invested. Although this enabled their model to generate "hump - shaped" dynamics, the model was still incapable of causing much amplification. Kiyotaki and Moore [1997] and Bernanke, Gertler and Gilchrist [1998] provide models that are able to obtain the significant accelerator effects that eluded the previous quantitative models. One important feature of these models is that the agents who face the incentive problem own the entire capital stock. Thus, changes in the value of capital exert a large influence over net worth. This increases the responsiveness of internal funds to business conditions and generates the accelerator effect.

Although to my knowledge, there are no other models of financial stabilizers, Eisfeldt [1999] presents a framework in which a stabilizer would be easy to achieve.[3] In her model, there is adverse selection in the market for claims to ongoing projects. She assumes that in booms, income becomes more volatile. Consequently, agents will sell claims to good projects more often. This reduces

[2] See Cogley and Nason [1995].

[3] 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 credit constrained economy is below the response of the full information model. This is because the framework that delivers the accelerator also introduces an adjustment cost. The telling feature of an accelerator is how increases in internal funds affect investment. In both of these models, increases in cash flow cause increases in investment. Thus, these models are accelerators. They look like stabilizers because the adjustment cost feature is overpowering the accelerator. 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. Their model therefore has only the standard accelerator effect. In all of these "artificial" stabilizers, the models have the conterfactual implication that the spread moves procyclically.

the lemons premium, increases liquidity and increases investment. The accelerator she proposes depends on the assumption that as investment expands, income becomes more volatile. The opposite assumption could be justified just as easily.[4] In that case, expansions would entail reduced liquidity, constrained asset sales and presumably would stabilize shocks.

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 countercylically. Calomiris, Himmelberg and Wachtal [1995] provide evidence on the countercyclicality of commercial paper issues. They suggest that the surge in commercial paper issues during recessions is partly to finance trade credit for firms that do not have access to bond markets.[5] Using data from the Department of Commerce's *Quarterly Financial Report (QFR)*, Gertler and Gilchrist [1994] show that small firms are much more sensitive to macroeconomic fluctuations than larger firms. They report that, following a monetary shock, approximately 1/3 of the variation in manufacturing can be traced to the difference between the behavior of small firms and large firms.[6]

3. Static Models of Adverse Selection in Credit Markets

Many economists assume that the informational problems in credit and equity markets cause investment to be too low. While this intuition is prevalent, the conclusion is not general. Whether or not there is over- or underinvestment depends critically on how investment opportunities are distributed in the economy. The basic mechanism can be seen by comparing the model in Stiglitz and Weiss [1981] (hereafter 'SW') with the model in De Meza and Webb [1987] (hereafter 'DW'). In this section, I present a brief analysis of these models since they are

[4] Say, for instance, due to increased diversification of individual risk over more projects.

[5] See also Gertler and Gilchrist [1993]. Boissay [2000] argues that trade credit reduces the accelerator. In a recession, firms lose access to their normal sources of funding due to low internal funds. Without trade-credit, the firm would cut back production and we would have the standard accelerator effect. However, if they can borrow from their suppliers, they can use these funds to substitute for bank loans. This partially offsets the accelerator effect.

[6] In subsequent work, Bernanke, Gertler, and Gilchrist [1996] confirm these results using firm-level data from the *QFR*.

the building blocks for the more elaborate models presented later. The behavior of these simple static models will provide important insights into the behavior of the dynamic models.

3.1. Basic Setup

I will 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 the 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 $\bar{\rho}$. The rate of interest charged to the entrepreneurs is R. The only difference between the safe option and the risky loans 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. The projects I consider are simple, success or failure projects. There are three numbers associated with every project; the probability of success p, the payoff in the event of success x, and the expected payoff $r = px$. I can describe the distribution of projects over the entrepreneurs with 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. I assume that $w < 1$ so that they cannot self-finance. If they want to activate a project, they have to borrow $1 - w$ ("external" funds) in the credit market.

There is asymmetric information in the credit market. Entrepreneurs know the characteristics of their projects while savers do not. There is also limited liability. If a project fails, the lenders cannot extract further payments from the entrepreneur. I assume that all credit market interactions are described by standard debt contracts.[7]

As the risky interest rate, R, changes, the pool of borrowers changes. An increase in R will discourage some entrepreneurs from investing. It may be the case that relatively more safe borrowers leave the loan pool so that Δ increases

[7]This assumption is made for simplicity. In this environment, matters would be improved if interest payments were set contingent on the observed outcome. I will return to these considerations later. For the time being, assume that such contracts are not allowed.

as R increases. If more risky borrowers leave, then Δ will fall as R rises. In the equilibrium we must have $\bar{\rho} = \rho(R) \equiv R[1 - \Delta(R)]$ where I now explicitly allow for this selection by writing Δ as a function of R. One could view $\Delta(R)$ as a "selection function" that captures the important features of the adverse selection problem. As a technical matter, the derivative of $\rho(R)$ with respect to R will be positive in any equilibrium. When I need to, I will refer to this derivative as ρ'.[8]

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

3.2. 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 from activating a project is $r - pR(1 - w)$. This is decreasing in p, so the payoff is higher if the agent has a riskier project. The intuition for this is that as p decreases, the probability of repayment falls but because of the distributional assumption, the expected gross payoff remains the same. Therefore, 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.

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

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

If $r < \bar{\rho}$ it is optimal to have no investment and in equilibrium this will be the case.[9] If $r > \bar{\rho}$ then it is optimal for *every* project to be undertaken. Let $\mu_p = \int_0^1 pf(p)dp$ and $r^* = \bar{\rho} + (1 - w)\bar{\rho}\frac{1-\mu_p}{\mu_p}$. If $r > r^*$ we have $\hat{p} = 1$ and the economy efficiently allocates resources. If $\bar{\rho} < r < r^*$ then in equilibrium $0 < \hat{p} < 1$. If this is the case, there is underinvestment.

Note that investment increases as the level of internal funds increases. For any given R, the cutoff probability, $\hat{p}$, is increasing in w. This implies that for

[8] Unlike the SW model, there will *never* be credit rationing in this economy. This is because there is a safe alternative available to the savers which pins down the rate of return in the credit market and rules out rationing. For a formal proof of these claims 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.

[9] $\rho \leq \hat{p}R$ implies $\rho(1-w) \leq r - w\rho$ so that $\rho \leq r$ which is a contradiction since by assumption $\rho > r$.

higher levels of internal financing, R will be lower and $\hat{p}$ will be higher. Since total investment consists of all entrepreneurs with $p < \hat{p}$, investment increases with w.

The main points about the SW model are summarized in the following:

> *In the SW economies, the equilibria are either efficient or they involve underinvestment. The selection results in only the riskiest projects being undertaken. Furthermore, increases in internal financing cause increases in investment demand.*

3.3. De Meza and Webb go to the bank.

At the other extreme is the distribution considered by De Meza and Webb [1987]. In this case all projects have the same actual outcome x if they succeed. As in the SW model, projects differ in their probability of success p.[10] The expected payoff to an entrepreneur who activates her project is $p\,[x - R(1-w)]$. Since an entrepreneur will invest only when $x - R(1-w) > 0$, the payoff is *increasing* in p. Again there will be a cutoff $\hat{p}$ but now we will get all $p \geq \hat{p}$ so that we will get the "safe tail". 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 the social opportunity cost. Thus, in the DW model, we can only have overinvestment. The low return projects are subsidized by the high return projects and are consequently "too attractive" to the entrepreneurs.

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

> *In the DW economies, equilibria involve systematic overinvestment. Selection is toward the safer projects and increases in internal funds imply reductions in investment demand.*

[10] The DW economy is more robust to contracting criticisms than the SW economy. In SW, lenders could charge different interest rates based on differences in outcome. In DW the successful projects all have the same outcome so this is not an option.

3.4. General Distributions

Obtaining conclusions for a general distribution of projects $f(r,p)$ is difficult. Without more information, a policy maker would have no reason to believe *a priori* that investment should be increased, as in the SW case, or decreased, as in the DW case. It is useful to ask what information a policy maker would need to make the right decision.

Assume that the policy maker can set an instrument τ that affects payoffs (a subsidy or a tax, etc.). The policy maker wants to maximize the social return on investment, Y, and is assumed to be subject to same informational constraints that the market faces.

One can show that near the market equilibrium $\frac{\partial Y}{\partial \tau} = -I \frac{\partial \Delta}{\partial \tau} R$ where I is total investment.[11] This says that policies improve welfare if they make the loan pool safer. Knowing this can effectively guide policy. In the SW model, making the pool safer means bringing in high p projects; in DW it means getting rid of low p projects. In either case, making the pool safer pushes investment in the right direction.

One special case is a subsidy or tax to the safe rate of return ρ. The important statistic in this case is $\frac{\partial \Delta}{\partial \rho}$. If $\frac{\partial \Delta}{\partial \rho} > 0$ then the safe rate should be taxed to encourage investment. If $\frac{\partial \Delta}{\partial \rho} < 0$ then a subsidy to the safe rate of return will improve efficiency. We can view $\frac{\partial \Delta}{\partial \rho}$ as a statistic that differentiates overinvestment models from underinvestment ones.

It is easy to show that $\frac{\partial \Delta}{\partial w} < 0$ in both cases. A policy that increases internal funds *always* makes the pool safer and therefore will necessarily improve efficiency. If internal funds increased to the point where the entrepreneurs could self-finance, the equilibrium would be fully efficient.

We can now begin to see how the accelerator would manifest itself in a dynamic version of this model. A shock that causes internal funds to rise will cause the loan markets to become more efficient since $\frac{\partial \Delta}{\partial w} < 0$. This does not imply that investment increases however. In the SW economies, investment rises; which causes further increases in w and amplifies the shock. In the DW economies however, investment falls; the lower investment reduces w and mitigates the shock. This basic intuition will carry over to the dynamic models in the next section.

[11] This is a generalization of the efficiency derivative in Mankiw [1986] and in House [2000].

4. Dynamic Models of Adverse Selection in Credit Markets

In this section, I focus on dynamic models of credit market failure. The first model I present is a simple model that allows me to isolate the effects that adverse selection has on the system. The second model is more fully articulated and allows me to make more meaningful comparisons with other business cycle models.

4.1. A Simple Model

The first dynamic environment I consider is similar in spirit to the model set out by Bernanke and Gertler [1989]. The economy consists of overlapping generations of agents that live for two periods. Within each generation there are savers and entrepreneurs. Normalize the number of each type to be 1. Entrepreneurs are the only agents that contribute to the capital stock. Thus market imperfections will have a large effect on capital accumulation. In a model with an additional capital market that is free of the adverse selection problem, we would expect a significant degree of substitution between the two markets. This would offset the accelerator/ stabilizer effects of the model. The only agents that supply labor are again the entrepreneurs. Thus any increase in wage income will go entirely to the entrepreneurs. These features are not desirable for a realistic model. However, at this point, I want to illustrate the basic effect and this setup allows me to do so.

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 it's 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. As before, each project requires an initial investment of one unit of the consumption good. Entrepreneurs supply one unit of labor in youth and receive wage payments w_t.

All agents have access to a safe investment technology that yields $\bar{p}$ goods in period $t+1$. Note that I am assuming 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 that is affected by the selection problem.

In period t, the entrepreneurs each have w_t. They can either save this to get $w_t\bar{p}$ or they can borrow $1 - w_t$ and finance their project. I will restrict attention to equilibrium in which w is strictly less than 1 so that the entrepreneurs cannot self finance.

Consider a group of projects with the same probability of success, p. This is just a cross section of the joint density f. For any probability p, the cutoff project will satisfy

$$\bar{p}w_t = r_{t+1}\hat{k} - pR_t(1 - w_t)$$

Here, r_{t+1} is the marginal product of capital in the next period. I can rewrite this as:

$$\hat{k}_t(p) = \frac{1}{r_{t+1}} [\bar{p} + (1 - w_t)\{pR_t - \bar{p}\}] \tag{4.1}$$

There is a different cutoff for every $p \in [0, 1]$. All entrepreneurs with projects (k, p) with $k > \hat{k}(p)$ demand funding. This cutoff rule can illustrate several features of the selection mechanism and deserves some discussion.

The efficient cutoffs would be $\hat{k} = \frac{\bar{p}}{r}$ for all p. This is not the case here; the critical values differ from the efficient cutoffs by an amount that is proportional to the amount of external financing needed. As internal funds increase, the cutoffs move towards the efficient cutoffs. Note that projects that are pulling the average payoff up (i.e. for which $pR_t > \bar{p}$) set a cutoff that is too high. Projects that have expected returns that are less than the average return $\bar{p}$ have cutoffs that are too low. Projects for which $p = (1 - \Delta)$ are the only ones for which $\hat{k} = \frac{\bar{p}}{r}$.

Figure 1 plots equation (4.1) in k, p space. With a higher p, it is more likely that you will have to payback your loan so as p rises, the entrepreneurs set higher cutoffs. Since all projects in SW have the same expected return, we can represent a SW economy by a horizontal line at $k = \bar{k}$. In DW, the projects all have the same actual outcome when they succeed, $x = \bar{x}$. Since $k = p\bar{x}$ we can represent a DW economy by a ray extending out of the origin. In the figure, the shaded parts of the lines 'SW' and 'DW' illustrate the projects that demand funding. As in the static model, in the DW case the market selects the safer tail while in the SW case the market gets the risky tail. A general distribution f will imply a mix of these effects.

The capital stock next period is:

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

Firms produce output according to a Cobb-Douglas technology:

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

If firms are competitive in input markets then (recall that $N_t = 1$):

$$w_t = (1 - \alpha)z_t K_t^{\alpha}$$

$$r_t = \alpha z_t K_t^{\alpha-1}$$

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

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

I assume the existence of a steady state equilibrium characterized by the constant values K, w, r, A, I, Δ.[12] To generate dynamics in the model, I will assume that the economy is subjected to shocks to the technology parameter z and that this process follows an AR(1) process:

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

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

Since I want to analyze the dynamic behavior of the model, I will take a log-linear approximation of these equations in the neighborhood of a (stable) steady state. This gives:

$$\tilde{K}_{t+1} = \frac{-1}{K}\int_0^1 \hat{k}(p) f(\hat{k}(p), p)\left[\frac{\partial \hat{k}}{\partial R_t} R \tilde{R}_t + \frac{\partial \hat{k}}{\partial r_{t+1}} r \tilde{r}_{t+1} + \frac{\partial \hat{k}}{\partial w_t} w \tilde{w}_t\right] dp \qquad (4.2)$$

where '$\tilde{x}$' denotes the percent deviation of the variable x from it's steady state value. Since $\rho_t = \bar{\rho}$ in every period we have:

$$\tilde{\rho}_t = \tilde{R}_t + \tilde{A}_t - \tilde{I}_t = 0 \qquad (4.3)$$

which implies that:

$$\tilde{R}_t = \frac{\frac{\partial \Delta}{\partial w} w \tilde{w}_t + \frac{\partial \Delta}{\partial r} r \tilde{r}_{t+1}}{1 - \Delta - \frac{\partial \Delta}{\partial R} R} \qquad (4.4)$$

[12] Existence is not guaranteed in this setting. 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. It is possible that the mapping $K \to K'$ is not monotone. Thus existence arguements using continuity or monotonicity are not workable.

The denominator of this expression is simply ρ', the derivative of $R[1-\Delta(.)]$ with respect to R. I have already argued that in equilibrium, this term must be positive. Finally we have:

$$\tilde{w}_t = \tilde{z}_t + \alpha \tilde{K}_t \tag{4.5}$$

$$\tilde{r}_t = \tilde{z}_t + (\alpha - 1)\tilde{K}_t \tag{4.6}$$

$$\tilde{z}_t = q\tilde{z}_{t-1} + v_t \tag{4.7}$$

The equations: (4.2), (4.4), (4.5), (4.6), and (4.7), characterize the local dynamics of the system.

In the appendix I show that this system can be reduced to the following expression in which I have decomposed the aggregate effect into five components:

$$\begin{aligned}\tilde{K}_{t+1} \;=\; & \underbrace{\frac{\rho}{K}\cdot\left.\frac{\partial I}{\partial r_{t+1}}\right|_{PI}}_{\text{“Perfect Information Dynamics”}}\cdot\tilde{r}_{t+1} \;+\; \underbrace{\frac{I}{K}\frac{\rho}{r}\frac{w}{\rho'}\frac{\partial \Delta}{\partial w}\varepsilon_{IR}}_{\text{“Bernanke-Gertler Effect”}}\cdot\tilde{w}_t \\ & + \underbrace{\frac{I}{K}\frac{\rho}{r}\frac{\rho}{1-\Delta}\frac{\partial \Delta}{\partial \rho}}_{\text{“Static Adverse Selection Effect”}}\cdot\tilde{w}_t \;-\; \underbrace{(1-w)\frac{I}{K}\frac{\rho}{r}\frac{w}{\rho'}\frac{\partial \Delta}{\partial w}}_{\text{“Static Efficiency Gain”}}\cdot\tilde{w}_t \\ & + \underbrace{\frac{\rho I}{K}\left[\frac{1}{\rho'}\frac{\partial \Delta}{\partial r}\left(\varepsilon_{IR}-(1-w)\right)+\frac{(1-w)}{w}\frac{\rho}{1-\Delta}\frac{\partial \Delta}{\partial \rho}\right]}_{\text{“Dynamic Adverse Selection Effects”}}\cdot\tilde{r}_{t+1}\end{aligned} \tag{4.8}$$

where $\varepsilon_{IR} < 0$ is the elasticity of investment with respect to changes in R. Recall that the function $\Delta(\cdot)$ summarized the relevant selection effects in the static models. Therefore, it is not surprising that the behavior of the dynamic system is governed by the first order properties of the selection equation $\Delta(R, \rho, r, w)$.

4.1.1. Discussion

The first term in equation (4.8) is the normal change in investment that would happen under full information.[13] The other terms represent the adverse selection effects and cause the actual response to differ from the full information path.

I have grouped the additional terms according to whether they result from changes in internal funds ($\tilde{w}_t$) or changes in the expected future marginal product

[13] Technically this is not the full-information response, since the correct dynamics depend on the steady state values of the density f at the cutoffs which differ from the cutoffs in the adverse selection equilibrium.

of capital ($\tilde{r}_{t+1}$). Typically, the "financial accelerator" refers to the way that changes in internal funds affect investment decisions, therefore, I will focus my attention on the terms that interact with $\tilde{w}_t$ and only briefly discuss the "Dynamic Adverse Selection Effect".

I call the second term the "Bernanke-Gertler Effect" since it captures the effect emphasized in Bernanke and Gertler [1989]. In their model, increases in internal funding implied that the premium on external finance fell.[14] Investment responds positively to the decrease in interest rates and the shock is amplified. The sign of the coefficient is positive since for every 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} (recall that in any equilibrium, $\rho' > 0$). Thus, this channel always serves to amplify disturbances. The magnitude of the Bernanke-Gertler 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 Bernanke-Gertler effect will be significant. Bernanke and Gertler also argue that higher internal funds cause investment to increase due to the fact that the entrepreneurs have to rely less on expensive external finance. This part of their story is not present in my model. In fact, some of the entrepreneurs in my model have an external finance *subsidy*. They would prefer to have more of the project funded by borrowed money.

The third term in equation (4.8) represents the direct affect of additional internal funds on investment *even if the interest rate on loans R stays the same.* I have labeled this effect a "Static Adverse Selection Effect" since it is the dynamic analog of the effect that internal funds had on investment in the static model. The direction of this effect is governed by only one moment of the selection function: $\frac{\partial \Delta}{\partial \rho}$. In figure 1, I have drawn an increase in ρ.[15] For the SW distribution, the projects that leave are the low risk ones so the default rate increases and $\frac{\partial \Delta}{\partial \rho} > 0$. For the DW economy, we flush out the risky projects so the default rate falls and $\frac{\partial \Delta}{\partial \rho} < 0$. Therefore, for models like the SW model, this channel will impart additional accelerator effects. In DW economies, this effect will cause entrepreneurs to reduce investment and will have a stabilizing effect on output.

[14] The decline in the premium is due to different reasons however. In Bernanke and Gertler [1989], the premium falls because the bank finances less of the loan (the entrepreneur finances more). This implies that it is less likely for the bank to engage the monitoring so the average monitoring costs are lower. In my model, the premium falls because the adverse selection problem is tempered.

[15] I am ignoring the equilibrium feedback of a change in ρ on R but the intuition is correct.

Recall that this moment was used in the static model to determine if there was under or over-investment in equilibrium. Accordingly, if there is underinvestment in the static model, the dynamic model will cause shocks to be amplified while the overinvestment economies stabilize shocks.

I call the fourth term a "Static Efficiency Gain". Like the Bernanke-Gertler effect, this effect depends on $\frac{\partial \Delta}{\partial w}$; since this is always negative, this effect will be positive and will cause amplification of a shock. The intuition for this channel is that, even if there is no change in the volume 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.

The last term, the "Dynamic Adverse Selection Effect", represents the selection effects due to changes in 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 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 r.

The final effect on dynamics is going to be the sum of these components. In previous work, the only effect considered was the "Bernanke-Gertler Effect" which is always positive. Consequently financial market imperfections *always* amplify shocks in those papers. In my model, it is immediately apparent that the other components in equation (4.8) may work to further magnify a shock (as in a SW example) or may work to dampen the effect of a shock (as in a DW case). There is also a sense that the Bernanke-Gertler effect may not be particularly strong since empirical estimates of ε_{IR} are typically low. If this is the case, we should expect the other channels to be more important in shaping the economy's actual response to a shock. In fact, it is entirely possible to have a stabilizing effect that is so strong that the overall effect is one of a reduced capital stock in response to a positive productivity shock. This implies that the impulse response in such a case is below that of the full information economy.

Although this model has the virtue of admitting an analytical solution and is capable of laying out the important effects simply, it is impossible to think that this model can used to make statements about actual data. There is no intertemporal decision making, no labor supply decision, and the entire capital stock must be completely rebuilt each period. This last feature places a great deal of pressure on the market with the adverse selection problem. In the next subsection, I construct a model that is expanded to include features that make it more comparable to existing business cycle models and to actual data.

4.2. A Quantitative Model

To compare the predictions of the adverse selection accelerator with standard business cycle models, I make two major modifications to the basic model set out in the previous subsection.

First I introduce an infinitely lived agent who does not have any projects and will serve as the "saver" in the model. This agent can lend to the entrepreneurs and as before can invest in a safe asset. This time however, the safe asset will also be capital and therefore will be a substitute for the entrepreneurial capital. Aggregate capital will simply be the sum of the entrepreneurial capital and the "safe" capital. I maintain the assumption that the entrepreneurs live for only two periods.

The introduction of the infinitely lived agent is done for two reasons. First, together with the assumption that they can invest in the safe capital stock, the presence of an infinitely lived agent allows me to solve several aspects of the steady state without solving for equilibrium in the credit market. This significantly simplifies the computational problem. Secondly, having an infinitely lived agent allows me to make more meaningful comparisons with the benchmark RBC model. If I only had two period lived agents, such a comparison would be severely strained.

The second major modification to the model is that I assume that the distribution of projects, f, is a member of a parametric family of distributions. This allows me to consider a large group of distributions while only varying a small set of parameters.

4.2.1. Setup

I assume that there are e entrepreneurs and $1-e$ infinitely lived agents. As a matter of notation, I will refer to the infinitely lived agents with a superscript i and I will refer to the entrepreneurs with a superscript e.

As in the standard RBC model, infinitely lived agents solve:

$$\max E_0 \left[\sum_{t=0}^{\infty} \beta^t \left\{ \ln(c_t^i) + \phi \ln(1-n_t^i) \right\} \right]$$

subject to:

$$w_t n_t^i + r_t^i K_t^i + \rho_{t-1} L_{t-1}^i = c_t^i + I_t^i + L_t^i$$

and

$$K_{t+1}^i = K_t^i(1-\delta) + I_t^i$$

Here, L_t represents loans made to entrepreneurs in the credit market. The final constraint is the standard law of motion for capital where δ is the depreciation rate.

The entrepreneurs in the quantitative model behave exactly as they did in the previous case with the exception that they also get to consume the undepreciated portion of their capital in the event that their project succeeds. I also introduce some additional flexibility by assuming that projects are of size G rather than normalizing the project size to be 1. This allows me to change the size of the capital provided by the entrepreneurs without changing the number of entrepreneurs. With these modifications the equilibrium cutoffs are:

$$\hat{k}(p) = \frac{1}{r_{t+1} + (1-\delta)} \left[\rho_t + \left(\frac{G - w_t}{G} \right) (pR_t - \rho_t) \right] \tag{4.9}$$

Entrepreneurial capital next period is given by:

$$K^e_{t+1} = G \int_0^1 \int_{\hat{k}_t(p)}^{\infty} k f(k,p) dk dp$$

I assume that entrepreneurs supply their labor inelastically so that

$$n^E = e$$

As before firms produce output according to

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

so that the marginal product conditions give the real wage and the real rental price of capital as before.

The aggregate capital stock at any date is:

$$K_t = eK_t^e + (1-e)K_t^i$$

so that capital from the perfect information sector (the infinitely lived agents) and capital produced by the entrepreneurial sector are perfect substitutes. Aggregate labor supply is:

$$N_t = e + (1-e)n_t^i$$

and equilibrium in the loanable funds market requires:

$$(1-e)L_t^i = e \left[G \int_0^1 \int_{\hat{k}_t(p)}^{\infty} f(k,p) dk dp - w_t \right]$$

In the steady state,

$$\frac{1}{\beta} = \rho = \left[(1-\delta) + \alpha Z \left(\frac{K}{N}\right)^{\alpha-1}\right]$$

Note that at this point, without any reference to the distribution of projects, I have determined the steady state values of w, r, ρ, and $\frac{K}{N}$. If there were no infinitely lived agents or if that agent did not have access to a safe technology, I would not be able to pin down any of these parameters without grappling with the distribution.

I don't want to make strong assumptions regarding the distribution of projects. At the same time, I want to be able to choose a set of distributions that are easy to work with. I assume that the distribution of projects is drawn from a parametric family of distributions over p, k. Specifically I will assume that $\left\{\ln\left(\frac{p}{1-p}\right), \ln(k)\right\}$ is distributed according to a bivariate normal distribution; this is a five parameter family. This distribution restricts the marginal distribution of k to lie on $[0, \infty)$ and restricts p to $[0, 1]$.

$$\left\{\ln\left(\frac{p}{1-p}\right), \ln(k)\right\} \sim BVN(\mu_p, \mu_k, \sigma_p^2, \sigma_k^2, \sigma_{pk})$$

The complete steady state of the model is given by the equilibrium loans L to the entrepreneurs and by the interest rate R charged to them; these are complicated functions of the project distribution and are solved numerically.[16]

4.2.2. Simulations

When I can, I set parameters according to their usual values in the business cycle literature. I assume that the model generates quarterly data. Consequently, I set the discount factor (β), capital's share (α), the depreciation rate (δ), the standard deviation of the technology shock (σ_z), and it's autoregressive root (q) as follows:

"Standard" RBC parameters

Parameter:	β	α	δ	q	σ_z
Value:	.99	.35	.025	.95	.01

There are additionally several parameters that are not in standard business cycle models. The value of ϕ could be set to match the long term average labor supply of an individual but this will differ from the standard RBC model due

[16] See appendix B for details.

to the presence of the entrepreneurs who supply their labor inelastically. The number e of each type is also not implied by the data. For these parameters, I set $\phi = .35$ and $e = .3$. The value of ϕ is typical of past RBC models and e is set to match the fraction of credit constrained firms in Gertler and Gilchrist [1994]. Parameterizing the distribution itself is extremely difficult since many features of the distribution are not observable. I will choose parameters to illustrate features of the model.

For any given set of distributional parameters, the corresponding "full-information" version of the model can be obtained by setting the variance of p to be sufficiently low. This effectively eliminates the adverse selection effects by making all entrepreneurs the "same" type.[17] This does not affect the marginal distribution of k which is all that matters under full information. I will refer to the full-information version of a model as the RBC version of the model and I will use it as a benchmark.

The first two simulations illustrate the models power to generate large amplifier effects. The third set of simulations presents stabilizer equilibria. For all of the simulations, the settings for the distributional parameters are given in the appendix.

I start with a "SW case". Table 1 reports summary statistics for this model.

[17]Their expected returns will still be different but there will be no adverse selection. If they all had the same p (i.e. if the variance of p were 0) then in equilibrium $R = \rho[p]^{-1}$ and equation (4.9) would imply efficient cutoffs.

Table 1.

	(1) $RBC_{G=1.7}$	(2) $SW_{G=1.7}$	(3) $SW_{G=2}$
σ_y	4.46	4.88	6.26
$\frac{k^e}{K}$	.11	.11	.13
Δ	-	.09	.09
Corr(Δ, y)	0	-.99	-.99
amp: $\frac{\sigma_y\|\text{AI}}{\sigma_y\|\text{PI}}$	1.00	1.09	1.40
$\frac{\partial\Delta}{\partial w}$	-	-.03	-.03
$\frac{\partial\Delta}{\partial\rho}$	-	.17	.15
$\frac{\partial\Delta}{\partial r}$	-	-.33	-.29
$\frac{\partial\Delta}{\partial R}$	-	.04	.04
ε_{IR}	0	-.89	-.95
ρ'	-	.93	.93

Column (1) gives results for the full information version of the model. For this version, the standard deviation of output is 4.46 percent. Now consider column (2). These statistics are from the adverse selection version of the same economy. The volatility of output is roughly 9% higher than the full information version (notice the statistic "amp" in row 6). Note that this acceleration does not require particularly high default rates (9%) nor does it require a large amount of entrepreneurial capital (it is only 11% of the total capital stock in steady state). In column (3) I report results for a specification in which the entrepreneurs require a larger loan (i.e. $G = 2$ rather than 1.7). This has the effect of increasing the adverse selection problem since it requires a greater amount of external finance. Output volatility has risen to 6.26%. This is a 40% increase over the perfect information economy.

I call this example a "SW case" because the normal accelerator channel is not particularly important. Investment is not particularly interest elastic (ε_{IR} =-.95) and the improvement in the loan pool is small ($\frac{\partial\Delta}{\partial w} = -.03$). Thus even though increases in internal funds do improve the loan pool and cause lower interest rates, they do so only to a limited extent and only with limited effect. The important effects here are the static and dynamic adverse selection effects. In particular $\frac{\partial\Delta}{\partial\rho} = .15 > 0$ so that the economy is similar to the SW static model and $\frac{\partial\Delta}{\partial r} = -.29$ so that as the rental price of capital increases (as it does initially) the pool gets even safer.

The standard version of the financial accelerator can also generate amplification effects. Table 2 gives statistics for a "Bernanke-Gertler" specification (BG) in which even though $\frac{\partial\Delta}{\partial\rho} < 0$ (so that the static adverse selection effect is similar to a DW-stabilizer case), there is still a great deal of amplification due to the Bernanke-Gertler effect.

Table 2

	(1) RBC	(2) $BG_{G=1.7}$
σ_y	4.47	5.87
$\frac{k^e}{K}$	.02	.02
Δ	-	.02
$Corr(\Delta, y)$	0	-.99
amp: $\frac{\sigma_y\|_{AI}}{\sigma_y\|_{PI}}$	1.00	1.31
$\frac{\partial\Delta}{\partial w}$	-	-.12
$\frac{\partial\Delta}{\partial\rho}$	-	-.58
$\frac{\partial\Delta}{\partial r}$	-	.97
$\frac{\partial\Delta}{\partial R}$	-	-.12
ε_{IR}	0	-38.09
ρ'	-	1.10

As before, column (1) gives the fully efficient version of the model. The properties of this model are similar to the previous one with the major exception that the amount on entrepreneurial capital is very small here, only about 2% of the total capital stock. The first order effects of the selection function Δ suggest that the economy is most similar to a DW economy; $\frac{\partial\Delta}{\partial\rho}$ is negative so increases in the safe rate of return cause the loan pool to be come safer. The "Static Adverse Selection" effect documented in the previous discussion will thus be negative and will restrain the system's response to shocks. The ratio of the volatility of output in the asymmetric information equilibrium to the full information volatility is nevertheless greater than 1 implying that the system is an accelerator. The reason that this economy amplifies shocks even though it looks like a stabilizer is that investment is very interest sensitive. Also, the term $\frac{\partial\Delta}{\partial w}$ is significantly negative. This implies that an increase in internal funds causes the pool to become much safer, lowering interest rates and encouraging a large amount of additional investment. This is exactly the channel that Bernanke and Gertler and others emphasize when they discuss the financial accelerator. This mechanism requires an investment sector that is very interest elastic and requires that the quality of loan applicants improve sufficiently.

Finally, I present a stabilizer version of the model. Table 3 gives the results.

Table 3

	(1)	(2)	(3)
Model:	RBC	$DW_{G=1}$	$DW_{G=1.7}$
σ_y	4.47	4.11	3.82
$\frac{k^e}{K}$	.05	.06	.10
Δ	-	.22	.27
Corr(Δ, y)	0	-.99	-.99
amp: $\frac{\sigma_y\|_{AI}}{\sigma_y\|_{PI}}$	1.00	.92	.85
$\frac{\partial\Delta}{\partial w}$	-	-4.36	-2.62
$\frac{\partial\Delta}{\partial\rho}$	-	-2.48	-1.43
$\frac{\partial\Delta}{\partial\tau}$	-	2.58	.85
$\frac{\partial\Delta}{\partial R}$	-	-.02	-.01
ε_{IR}	0	-.06	-.02
ρ'	-	1.01	.98

The full information model behaves much as it did in previous cases. Note that the Bernanke-Gertler effect is small since investment responds only slightly to changes in the interest rate ($\varepsilon_{IR} = -.06$) even though the pool does improve significantly due to changes in internal funds. This example has been constructed so that the static selection effect is the most powerful influence on dynamics. Thus with $G = 1$ the adverse selection model causes output to be roughly 8% less volatile. With a greater external financing burden, the adverse selection model causes even more significant stabilizer effects, reducing output volatility to only 85% of what it was under full information.

Intuitively, a stabilizer is harder to construct than an accelerator. There are two forces that always work to amplify shocks (the "efficiency-gain" and "Bernanke-Gertler" effects) while there is only one channel that can potentially cause stabilization. Thus, to get a stabilizer, we must choose parameters that minimize the former effects and accentuate the third channel.

Figure 2a and 2b show impulse response functions to a 1% technology shock for the SW accelerator and for the DW stabilizers respectively.[18] Figure 3 shows additional impulse responses for the SW model. In each figure the solid line is for the model with imperfect information while the dotted line represents the response of the full information economy.

The top left panel shows the response of output in the SW model. In the full information case, the initial response of output is roughly 1.2% above trend and the response has inherited the shape of the technology shock (an AR(1)). This is a standard feature of RBC models although it is not typical of the data. In actual data, output growth exhibits a positive autocorrelation (sometimes called a "hump-shaped" response). For the adverse selection economy the output response is dramatically different in both size and shape. At it's peak, output rises to nearly 2% above trend; this is almost double the response in the full information case. The response of output also displays a "hump-shaped" profile. This is due entirely to the large accelerator effect in the model.

Matters are quite different for the DW model. The top right panel shows this stabilizer. Again, the response of output under full information is roughly 1.2% initially. In this economy however, the adverse selection effect causes significant overinvestment in the steady state. As internal financing rises, investment falls toward the efficient level. The effect is so strong that output actually falls below the full information path.

Below these panels are the responses of the spread, the stock of entrepreneurial capital, and the ratio of "safe" capital to "risky" capital. The spread declines in both the accelerator case and the stabilizer case reflecting the fact that there is less adverse selection in the expansion.

Changes in entrepreneurial capital are significant in both cases. In the SW accelerator, entrepreneurial capital increases by more than 10%; in the stabilizer, this capital falls by more that 2% in the first period. For the DW economy, this

[18] To make the effects large, I impose $G = 2.05$ (for the SW case) and $G = 1.9$ (for the DW case).

may seem like a small change (especially since entrepreneurial capital is such a small share of the total) but this is not the case. There is actually a substitution effect toward the entrepreneurial capital. In an expansion, it is a good time to invest with the entrepreneurs. Thus, some of the investment in the safe capital flows to the entrepreneurial sector. In this equilibrium however, it is not enough to overcome the large negative effects of the DW selection problem; there is much too much investment in the steady state.

The bottom panels depict the ratio of safe capital to entrepreneurial capital. For the perfect information models, the ratio rises modestly as the safe capital expands (the entrepreneurs are setting efficient cutoffs so there should be no change in entrepreneurial capital under full information). In the SW case, the ratio plummets. This reflects the fact that the market is being flooded with entrepreneurial capital. For the stabilizer, the effect is just the opposite. The risky, entrepreneurial capital falls leaving funds available for safe investment. Therefore, during a recession, there is a "flight to quality" in the accelerator model while there is a "flight to risk" in the stabilizer model.

Figure 3 plots additional impulse response functions for the SW case. Note that the decline in R is significant; roughly -1.5% at it's lowest. The elasticity of investment with respect to R is $\varepsilon_{IR} = -.95$. Thus the standard accelerator effect (the "Bernanke-Gertler" effect) implies that investment in entrepreneurial capital should rise by roughly 1.4%. The bottom panel of figure 3 shows that investment in entrepreneurial capital actually rises by more than 15%. Thus, for the SW case, focusing on the standard accelerator story misses about 90% of the total amplification.[19] In reality, investment is probably even less interest sensitive than it is in the model. Chirinko et al. [1999] suggest that the elasticity is roughly -.2. The highest estimate they report is roughly -.75 and the lowest is -.06. Other studies suggest higher elasticities in the range of -.5 to at most -1. A typical decline in the spread during an expansion is .6 percent. If we attribute this decline entirely to changes in agency costs then even assuming an elasticity of -1 implies only a .6 percentage increase in investment. Actual capital expenditures vary by roughly 7% over the cycle. Thus, a "back of the envelope" calculation suggests that the standard accelerator channel can account for at most only a very small part of the total variation in investment.

[19] Actually it misses more than that since the efficiency gain implies that the capital stock increases beyond the increase in investment.

5. Evidence

Since credit market imperfections may stabilize rather than amplify shocks, it is worth considering if data can conclusively differentiate the two cases.[20] In this section, I review some of the well known empirical work on the financial accelerator and relate it to my model.

5.1. Interest Rate Spreads

Figure 4 plots the BAA interest rate spread verses detrended industrial production.[21] The spread is countercyclical. There could be many reasons for this pattern. When business conditions are unfavorable, it is more likely for firms to go bankrupt. Consequently, loans made during a recession will come with a higher risk premium. Also, in recessions, internal funds are lower. This increases the agency costs associated with lending and requires a higher premium.

Gertler, Hubbard, and Kashyap [1991] argue that "the countercyclical pattern in the spread may ... be symptomatic of a financial element in the business-cycle propagation mechanism". 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. 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.[22] In previous models, the cyclicality of the spread is evidence of such a propagation mechanism.

In my model, the correlation between the spread and economic activity is not useful in determining whether there is an accelerator or not. This is true even though changes in the spread are due entirely to changes in market distortion. 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. Figure 5a and 5b show two plots of simulated data using the same parameters used for the impulse responses. Figure

[20] This question is not quite correct in the first place. Many financial markets are segmented (by collateral, by credit rating, etc.). These markets should each be treated separately. It is entirely possible that some cause amplification while others stabilize. In asking whether an entire economy is an accelerator, I am essentially considering the "average response" of credit markets to shocks.

[21] The interest rate on the 10 year treasury bill is used as the safe rate.

[22] Azariadis and Shankha [1999] also discuss the cyclicality of interest rate spreads in dynamic models of credit markets.

5a shows the accelerator. Clearly, the default rate moves countercyclically. The stabilizer is in figure 5b and the default rate still moves in the right direction.

5.2. Access to Bond Markets

A more promising strategy is to compare the behavior of firms with different access to credit. In Gertler and Gilchrist [1994], the authors compare the cyclical behavior of firms using firm size as a proxy for credit market access. Small firms are more dependent on bank loans than are larger firms which have access to bond markets. This suggests that the credit markets for small firms have significant informational imperfections while the large firms have to overcome smaller informational hurdles. The authors find that sales for small firms are much more volatile than for large firms. Following a monetary shock, approximately 1/3 of the total variation in manufacturing is due to the difference in volatility in their sample. They conclude that financial accelerator effects are quantitatively significant.

There might be reasons to question this result if the data were generated by the model I have described. To reach their conclusion, Gertler and Gilchrist [1994] are implicitly assuming 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. In theory, it is possible that the bond markets are the ones with the market imperfection while the intermediated loans are not.[23] If this were the case, in my model, the Gertler and Gilchrist strategy might incorrectly attribute the stabilizing effects of large firms to an amplifying effect of small firms.

5.3. The Flight to Quality

The "flight to quality" refers to the tendency for the ratio of safe loans to risky loans to rise during recessions. The flight to quality is well documented and many researchers view it as evidence of a financial accelerator.[24] As with the Gertler and Gilchrist approach, the flight to quality is potentially able to distinguish between

[23] Suppose banks have a costly technology that reveals a firms type perfectly. Informational problems are severe for small firms so that all of their loans must be intermediated. It is not so severe for the large firms and they have acces to the bond market. In equilibrium, small firms get intermediated loans but behave efficiently while the large firms make decisions that are distorted.

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

the two cases. To do so, the econometrician must know which markets are the "high quality" ones and which ones are not. In particular, she must know if funds are flowing from markets with relatively high informational frictions to markets with relatively smaller frictions. It is theoretically possible that markets with high levels of equilibrium distortion are in fact markets with low default rates.

If the econometrician assumes that the low default rate markets are the ones with relatively less distortion, then the flight to quality suggests an accelerator. Figure 5a shows that investment in the safe capital technology is countercyclical for the accelerator. Figure 5b depicts the stabilizer and the flight to quality is reversed. This conclusion rests squarely on the identifying assumption however. If the high default rate markets have less distortion in them, then the conclusion would be wrong.

The Gertler and Gilchrist [1994] approach and the flight to quality approach are similar in spirit. Essentially the idea is to get two groups of firms that are more or less identical with the exception that one group raises funds in a distorted credit market. Once you have correctly identified the two groups, you look at the cyclical differences between them to draw your conclusion. If the undistorted group is less (more) volatile than the distorted group, then you have an accelerator (stabilizer). If the "high-quality" market expands (contracts) relative to the "low-quality" market in a recession then you have an accelerator (stabilizer).

5.4. Interest Rate Spreads Again

This last subsection presents an indirect way of identifying accelerator or stabilizer effects. I argued above that the correlation of interest rate spreads with output cannot be used to tell if my model is amplifying or stabilizing shocks. On the other hand, the correlation of the spread with the safe rate of return *is* potentially useful for identifying this relationship. Recall that, from equation (4.8), the important properties of the dynamic system are governed by the selection function $\Delta(\cdot)$. If we knew the relevant first order effects, we could guess the dynamic properties of the model. In principle these could be estimated from a regression of the form:

$$\Delta_t = \Delta_0 + \Delta_R R_t + \Delta_w w_t + \Delta_\rho \rho_t + \Delta_r r_t + \eta_t \tag{5.1}$$

To determine whether there is a stabilizer, we need to know Δ_ρ. If $\Delta_\rho > 0$ financial markets amplify shocks. If $\Delta_\rho < 0$ financial markets *might* stabilize shocks (if the other amplifier effects overpower the static selection effect, the overall effect would still be an accelerator).

The intuition is that if the spread contracts when rates are high then distribution is more similar to the DW distribution. The marginal project is riskier than the average project and there is overinvestment. In this case shocks would be stabilized. On the other hand, if the spread widens further as rates rise, then the marginal project is safer than average; in this case, the model is similar to the SW model which is unambiguously an accelerator.

Unfortunately, we don't have independent observations of Δ.[25] Rather we have equilibrium realizations of R and ρ which we can use to infer Δ. To be more specific, let i_t^S and i_t^R denote the net interest rates on safe loans and risky loans; thus, $i_t^S = \rho_t - 1$ and $i_t^R = R_t - 1$. Suppose that near the steady state, the selection function Δ is well described by (5.1). In equilibrium

$$i_t^R = i_t^S + \Delta_t$$

Then,

$$i_t^R = i_t^S + \Delta_0 + \Delta_R \cdot i_t^R + \Delta_w w_t + \Delta_\rho \cdot i_t^S + \Delta_r r_t + \eta_t$$

which suggests that the regression:

$$i_t^R = \zeta_0 + \zeta_\rho \cdot i_t^S + \zeta_r r_t + \zeta_w w_t + \eta_t \tag{5.2}$$

would give estimates:

$$\zeta_0 = \frac{\Delta_0}{(1-\Delta_R)}, \zeta_\rho = \frac{(1+\Delta_\rho)}{(1-\Delta_R)}, \zeta_w = \frac{\Delta_w}{(1-\Delta_R)}, \zeta_r = \frac{\Delta_r}{(1-\Delta_R)}$$

If $\zeta_\rho > 1$ then $\Delta_\rho + \Delta_R > 0$. Typically, $\text{sign}(\Delta_R) = \text{sign}(\Delta_\rho)$ (it can be shown that $\Delta_R \geq \Delta_\rho$ but generally the signs are the same (see Tables 1-3 and Appendix A)). Thus, if we estimate $\hat{\zeta}_\rho > 1$, we have evidence of an accelerator.

One might argue that default rates (and therefore spreads) should increase with the safe rate even under full information since a high interest rate is more difficult to pay back than a low rate. In reality this is true since projects have a continuum of possible outcomes rather than simple success or failure. I modify my approach to account for this. Let $g(x)$ be a distribution of potential outcomes for a project. Assume that if $x > R$ then the borrower pays back the entire amount while if $x < R$ then the borrower pays back λx where $\lambda \leq 1$ (this would be the

[25] It might be possible to use the ex post default rate data but this would require correctly associating the default rate at date t with relevant interest rate at some previous date $t-s$.

case if bankruptcy were costly). Then, under perfect information, a standard debt contract would solve:

$$\rho_t = [1 - G(R_t)]\, R_t + \lambda \int_0^{R_t} x g(x) dx$$

Linearizing this gives:

$$i_t^R = \zeta_0 + \zeta_\rho \cdot i_t^S$$

where

$$\zeta_\rho = \frac{1}{1 - \Delta - Rg(R)[1 - \lambda]}$$

So that $\zeta_\rho \geq \frac{1}{1-\Delta}$. Intuitively, because higher interest rates make repayment less likely, an increase in the safe rate of 1% must be matched by an increase in the risky rate of more than 1% to maintain equality. So, for an accelerator we should get estimates of ζ_ρ that are greater than $\frac{1}{1-\Delta}$. Estimates that are significantly less than $\frac{1}{1-\Delta}$ suggest a stabilizer.

This approach is immune to the identification problem that confronted the previous studies. The reason is that we only need to find a real rate of return, ρ, that is not affected by an informational problem. Any government bond will suffice for this purpose (unless we believe that there is some moral hazard or commitment problem with government bonds). However, there are new identification issues that do pose problems for this strategy.

One problem is that i^S and i^R need to be real *ex ante* interest rates. The only data we have are nominal interest rates or real *ex post* rates. Thus there is a measurement error problem.

To control for this, I use a linear forecast of inflation as an estimate of inflation expectations. If I have chosen a set of regressors that is a subset of the information used by the market, then under the rational expectations hypothesis, the difference between my inflation forecast and the market's forecast will be an error that is uncorrelated with my forecast. That is: $\pi^E_{\text{Market}} = \hat{\pi}^E + \mu_t$ where by construction μ_t is uncorrelated with $\hat{\pi}^E$. This type of measurement error (called a proxy variable) does not generate bias in the regression estimates.[26]

The second problem is more difficult. There are several reasons to expect the error term to be correlated with the regressors. If there are shocks to the pool of projects then we would have simultaneity bias. If interest rates Granger-cause output, then high interest rates today would imply low output and increased

[26] I would like to thank Dan Ackerberg for suggesting this construction.

chances of a recession tomorrow; this would cause a widening of interest rate spreads even if there were no selection (the spread would be "predicting" the recession). There is also the possibility that Δ may be significantly non-linear near the steady state.

To correct these problems, I make the following modifications: First, I instrument for i^S. Intuitively, we need an exogenous variable that shifts the supply of funds or the safe rate of interest. I will use indicators of monetary policy (the federal funds rate and the discount rate) and indicators of fiscal policy (total government spending, military spending, and the deficit/GDP ratio) as instruments for the safe rate of return. Second, to account for the feedback of current interest rates on future output, I include leads of output in the estimating equation. I also include lags of output to account for the fact that yesterday's income could contribute to internal funds today.

I also include squared terms and interactions to account for non-linearities in the function $\Delta(\cdot)$. The equation I estimate is in differences:

$$Di_t^R = \zeta_0 + \zeta_{\rho 1} \cdot Di_t^S + \zeta_{\rho 2} \cdot \left(Di_t^S\right)^2 + \sum_{s=-q}^{q} \left[\zeta_{w1} Dy_{t+s} + \zeta_{w2} Dy_{t+s}^2\right] + \mu_t \quad (5.3)$$

where Dx_t denotes the difference $x_t - x_{t-1}$. Equation (5.3) is estimated by instrumental variables. Note that the monetary policy instruments will not work for all types of correlation. The instrument will correctly control for simultaneity bias arising due to shocks to the distribution of projects. However, if monetary policy is set in part according to current interest rate spreads then the instrument is invalid. The fiscal policy variables are less likely to be correlated with the error but are probably weak in the sense that they are not highly correlated with interest rates.

I use quarterly data on bond rates for AAA, AA, A and BAA rated bonds. Detrended output is used to proxy for internal funds. Tables 4.a - 4.b contain the estimates of the first order effects of i_t^S on i_t^R.

Table 4.a presents estimates from equation (5.3). For AAA, AA, A, and BAA rated bonds, eight year cumulative default rates are roughly .5%, .6%, 1.2%, and 2.4% respectively.[27] The first row gives estimates of the "full information" first order effect. Below, the table provides estimates of the first order effect in the sample. The right hand column lists the instruments used. Surprisingly, almost

[27] See Keenan et al. [1999] exhibit 32. For bonds rated Baa2 and lower, the default rates are 5% and more.

all of the point estimates are less than one. That is, an increase of 1% in the safe rate implies less than a 1% increase in the risky rate. Instrumenting with the fiscal policy variables alone (which should have the least bias) gives the lowest point estimates (roughly .5 to .8). The standard errors are large due in part to the fact that the instruments are weak and that the estimation of expected inflation is noisy. Most of the estimates are one standard deviation below the predicted full information effect.

To control for the imprecision with which expected inflation is measured, I reestimate equation (5.3) under the assumption that inflation expectations are a low frequency component of interest rates. This allows me to "remove" these expectations with the band pass filter. Table 4.b reports the revised estimates. Again, the first order effects are less than 1. The precision of the estimates is greater though the estimation of expected inflation is suspect.

On the whole, the estimates of the first order effects are low. The imprecision of the estimates does not afford a sharp conclusion. Since almost all of the estimates are less than one the results suggest that either the accelerator effects are weak or that there may be a slight stabilization tendency in these bond markets.

6. Conclusions

I present a model in which adverse selection causes a financial accelerator. This framework is much richer than the version of the financial accelerator that has been considered in the literature so far. The standard model of the accelerator only allows changes in internal funds to affect investment indirectly through interest rates. The adverse selection framework not only includes this channel but also introduces additional sources of dynamics. I present an example in which the traditional accelerator channel accounts for only 10% of the total impact on investment; the remainder of the change in investment comes from other accelerator forces. Another feature of my framework is that the model is capable of displaying a financial stabilizer; this is not a possibility for the traditional version of the accelerator.

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. The correlation between interest rate spreads and output is not informative in the model I have presented. The flight to quality evidence and the Gertler and Gilchrist [1994] evidence are both indicators of an accelerator effect but each approach requires an identifying assumption. Both assume that their sample separation (by bond market access or by loan quality) is effectively dividing the firms by the degree of credit market friction they face. Without this assumption, accelerators and stabilizers in my model would be observationally equivalent. The covariance of interest rate spreads with changes in the safe rate of interest can potentially be used to uncover relevant features of the economy. If the spread contracts in response to an increase in the safe interest rate, this is evidence of a stabilizer; if the spread widens, then this suggests the presence of an accelerator. The evidence pertaining to this covariance is not conclusive.

In future work, I intend to construct a quantitative model that is more comparable to a real economy. Such a model would incorporate asset prices, money, and inventories as well as a more plausible treatment of the labor market. This would enable me to estimate the deep parameters of my model and potentially quantify the actual accelerator effects.

7. Appendix A: Analytic Derivations

Combining equation (4.2) with (4.4) we get:

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

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

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

Notice that for any variable x:

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

and

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

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

so that:

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

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

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

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

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

Combining these and factoring out I, gives:

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

collecting the $\frac{\partial\Delta}{\partial r}$ terms in the first coefficient, the $\frac{\partial\Delta}{\partial w}$ terms in the second, and using the fact that $\rho' = \left[1-\Delta-R\frac{\partial\Delta}{\partial R_t}\right]$ gives:

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

Note that:

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

and

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

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

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

and

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

so that:

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

which is rearranged to get equation (4.8).

8. Appendix B: Numerical Model

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 odd 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:	5.8274	0.3879	20.0855	0.0224	-0.2712
BG:	3.8651	-0.0816	1.1939	0.0159	0.4678
DW:	2.7965	0.9374	33.4817	1.6458	0.9885

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 $\ln k | \ln\left(\frac{p}{1-p}\right) \sim N(\mu_{k|p}, \sigma_{k|p}^2)$ 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

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

So that, 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 such 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 normal distribution. Then k^e is governed by:

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

where f is the pdf of the j^{th} log normal (i.e. $f(x) = \phi\left(\frac{\ln x - \mu}{\sigma}\right) \frac{1}{x} \frac{1}{\sigma}$ where ϕ is the normal density). Note that the demand for credit is not simply the mass of people above the cutoff. They demand $1 - w_t$ units. The entrepreneurs who do not activate their project will lend their labor income. The supply of credit from the entrepreneurs who don't invest (i.e. those below the cutoff) is w_t. Therefore the demand for credit by the entrepreneurs is:

$$D_t = e \left[I_t(p^1) + I_t(p^2) + ... + I_t(p^{20}) - w_t \right]$$

Given R, w, r, ρ one can construct $\hat{k}(p)$ from (4.9). To find the 20 I's and the value for k^e I use MATLAB quadrature subroutines.

The solution proceeds by first performing a grid search on R as follows: Since w, r, ρ are implied by the steady state conditions, pick R and form $\hat{k}(p)$ for p_i ($i = 1...20$). Use these to get $\rho'(R) = R\left(\frac{\sum_{i=1}^{20} p_i I_i(R)}{\sum_{t=1}^{20} I_i(R)} \right)$. Find the smallest R such that $\rho'(R) = \rho$. This is the unique equilibrium R. With this R (and the associated I, k^e) the total capital stock and labor supply of the infinitely lived agents can be computed in a standard fashion.

With the steady state values complete, these equations can be log linearized to describe the behavior of the system. Each $\hat{k}(p_{it})$ and $I(p_{it})$ is treated separately. The complete system is given by 63 equations in 63 variables. The solution procedure is the Anderson and Moore (AIM) algorithm.

9. 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.

Baxter, Marianne and King, Robert. "Measuring Business cycles: Approximate Band-Pass Filters for Economic Time Series." *Review of Economics and Statistics*, November 1999, 81(4) pp. 575-593.

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. "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.

Boissay, Frederic. "Trade Credits, Corporate Finance, and the Business Cycle." unpublished manuscript, University of Paris, August 2000.

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.

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 Internediation 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.

De Meza, David and Webb, David. "Efficient Credit Rationing." *European Economic Review,* August 1992, 36(6) pp. 1277-1290.

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

Fisher, Jonas. "Credit Market Imperfections and the Heterogeneous Response of Firms to Monetary Shocks." Federal Reserve Bank of Chicago, working paper, June 1998.

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.

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.

Table 4.a[28]

Increase in the Risky Rate due to a 1% Rise in the Safe Rate

	AAA	AA	A	BAA	Instrument[29]
Perfect Information:	1.005	1.006	1.012	1.025	
Model					
linear	.998	.968	.952	.978	all
	(.026)	(.031)	(.035)	(.037)	
quadratic	.960	.927	.929	.976	all
	(.090)	(.108)	(.124)	(.132)	
quadratic- lead/lag	.962	.918	.897	.950	all
	(.101)	(.118)	(.133)	(.142)	
linear	1.008	.979	.964	.987	discount/fiscal
	(.027)	(.031)	(.036)	(.037)	
quadratic	.968	.944	.937	.956	discount/fiscal
	(.099)	(.118)	(.136)	(.143)	
quadratic-lead/lag	.974	.942	.913	.931	discount/fiscal
	(.110)	(.129)	(.145)	(.153)	
linear	.813	.840	.804	.739	fiscal
	(.144)	(.143)	(.161)	(.191)	
quadratic	.564	.495	.567	.663	fiscal
	(.406)	(.415)	(.437)	(.498)	
quadratic - lead/lag	.508	.421	.414	.578	fiscal
	(.467)	(.471)	(.509)	(.510)	

[28] Standard errors are in parenthesis.

[29] The government spending variables are log-detrended. 'discount/fiscal' indicates that the discount rate, as well as all fiscal policy variables were used as instruments. 'fiscal' only includes the fiscal policy variables. 'all' includes the federal funds rate, the discount rate and fiscal instruments.

Table 4.b

Increase in the Risky Rate due to a 1% Rise in the Safe Rate

	AAA	AA	A	BAA	Instrument
Perfect Information:	1.005	1.006	1.012	1.025	
Model					
linear	.881	.886	.881	.898	all
	(.044)	(.049)	(.067)	(.068)	
quadratic	.810	.824	.824	.897	all
	(.037)	(.043)	(.060)	(.063)	
quadratic- lead/lag	.796	.807	.802	.912	all
	(.039)	(.045)	(.062)	(.063)	
linear	.706	.605	.498	.336	fiscal
	(.109)	(.150)	(.205)	(.293)	
quadratic	.740	.616	.571	.454	fiscal
	(.102)	(.150)	(.201)	(.296)	
quadratic - lead/lag	.917	.854	.933	.946	fiscal
	(.175)	(.213)	(.303)	(.314)	

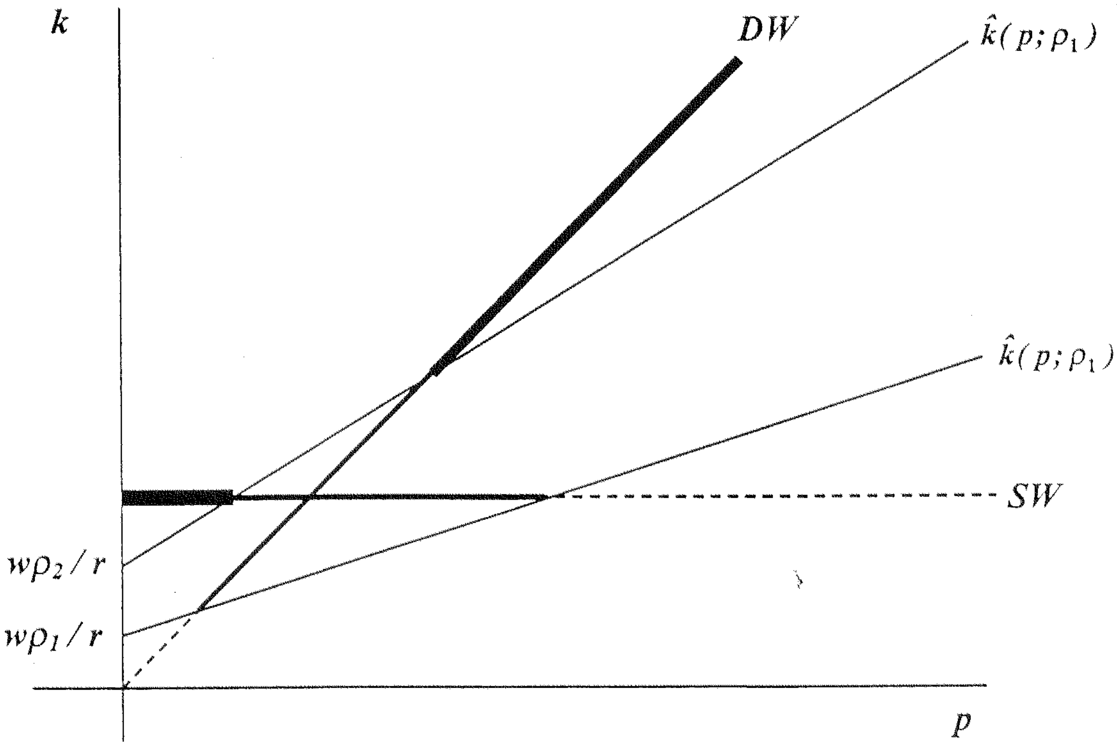


Figure #1

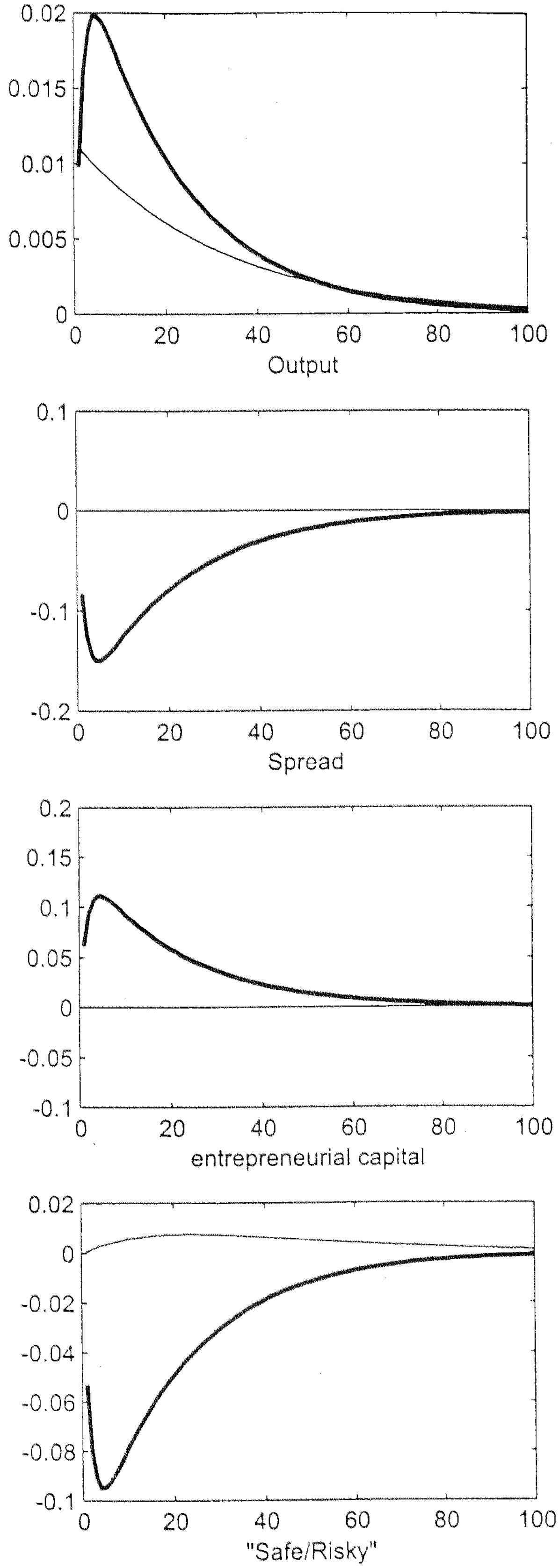


Figure 2a

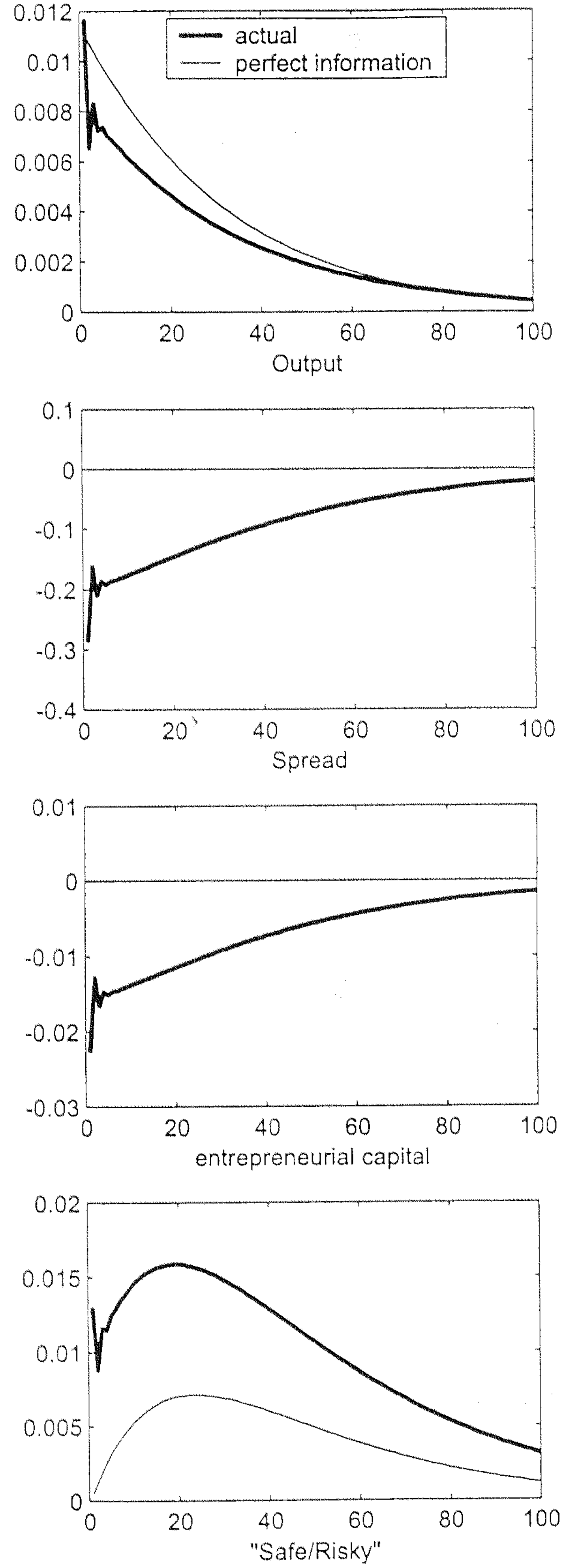
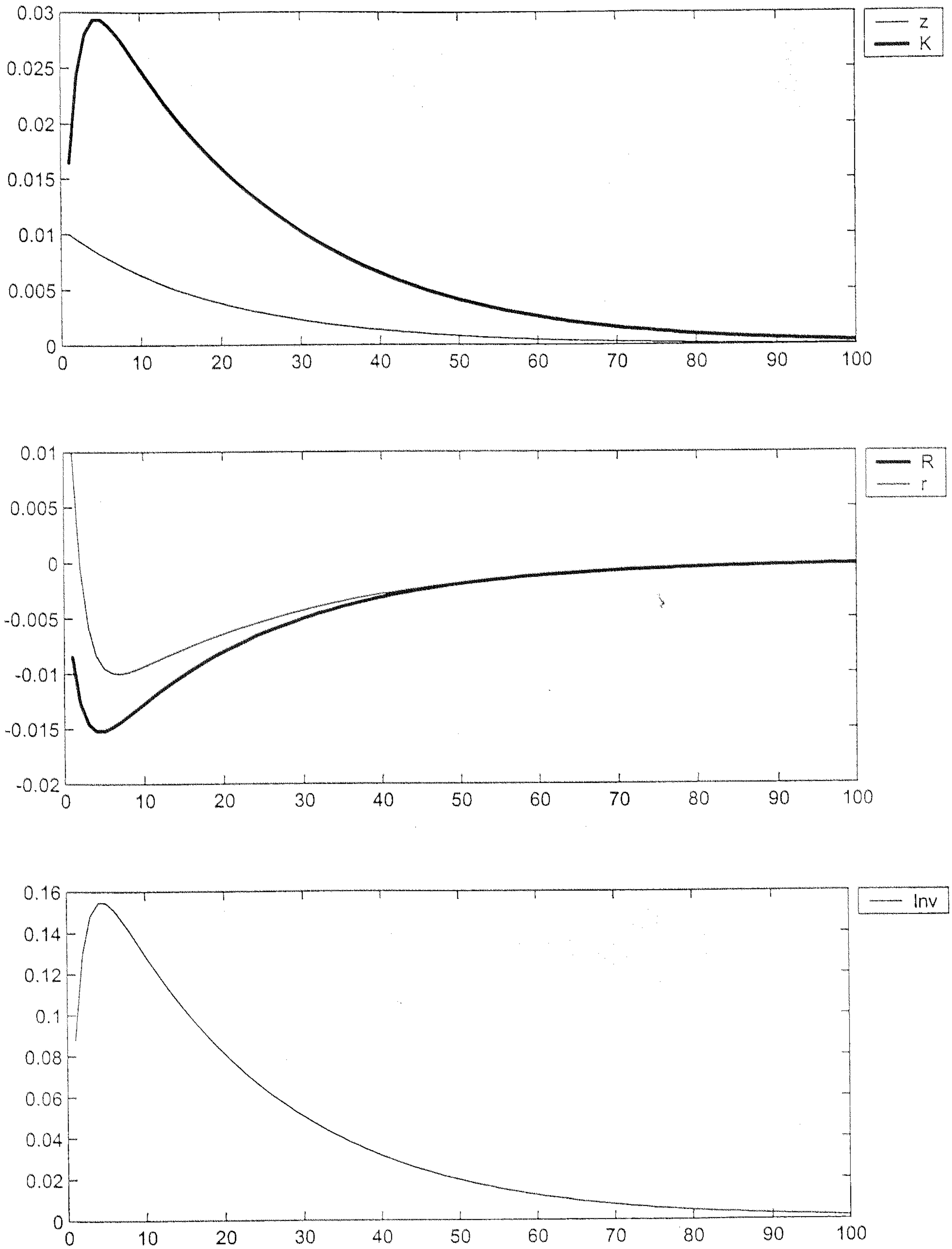


Figure 2b

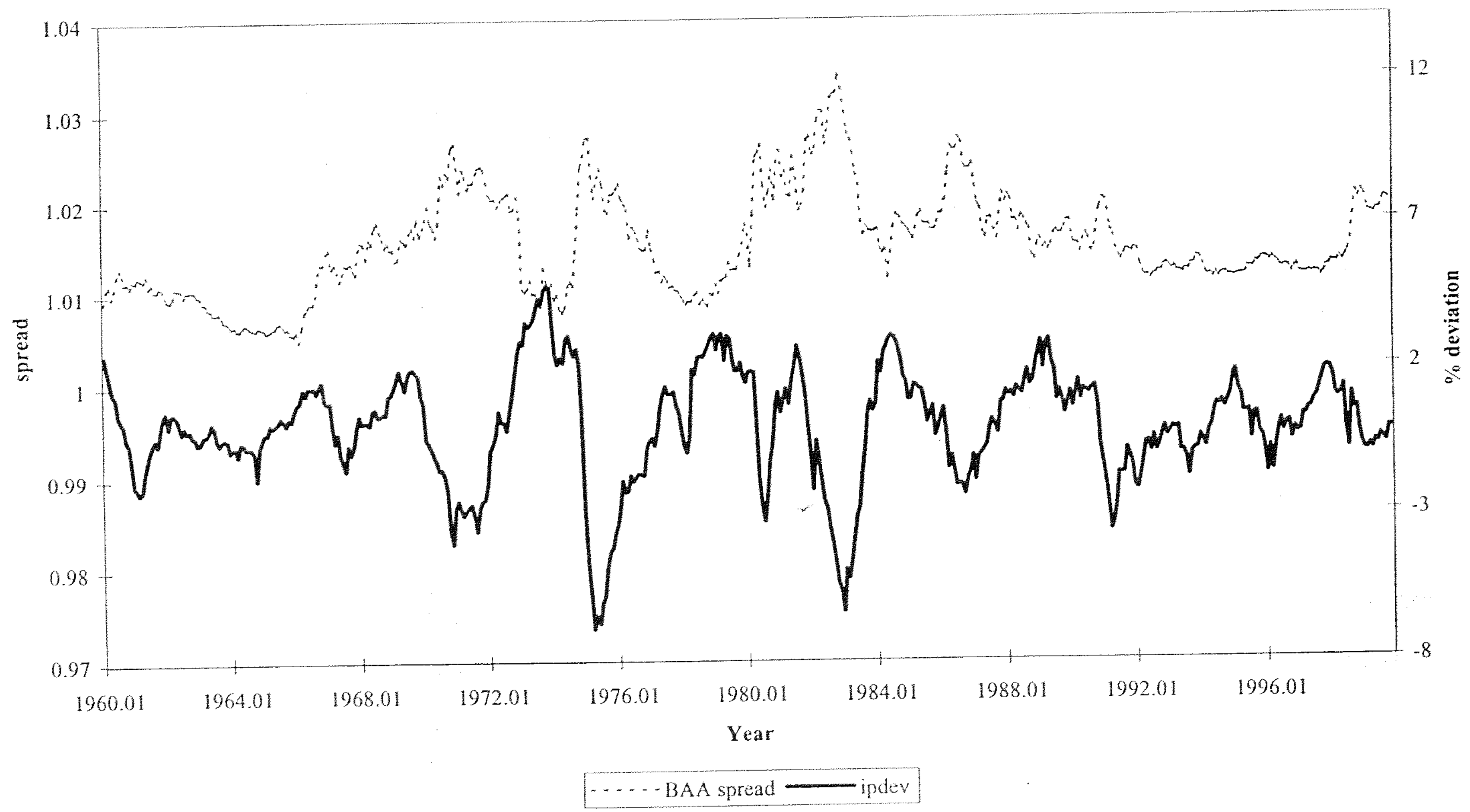


z
K
0.03
0.025
0.02
0.015
0.01
0.005
0
0 10 20 30 40 50 60 70 80 90 100
R
r
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
0 10 20 30 40 50 60 70 80 90 100
Inv
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0 10 20 30 40 50 60 70 80 90 100

Figure 3

Figure 4

Spread (BAA) vs. IP index (HP detrend)



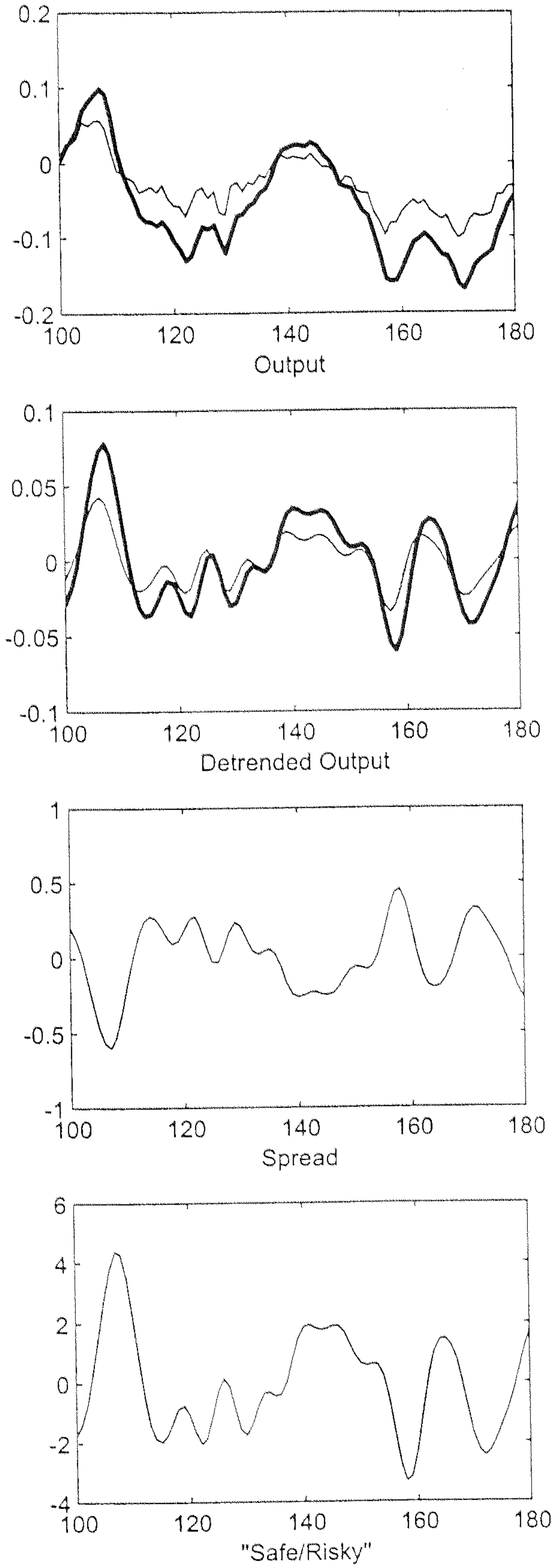


Figure 5a

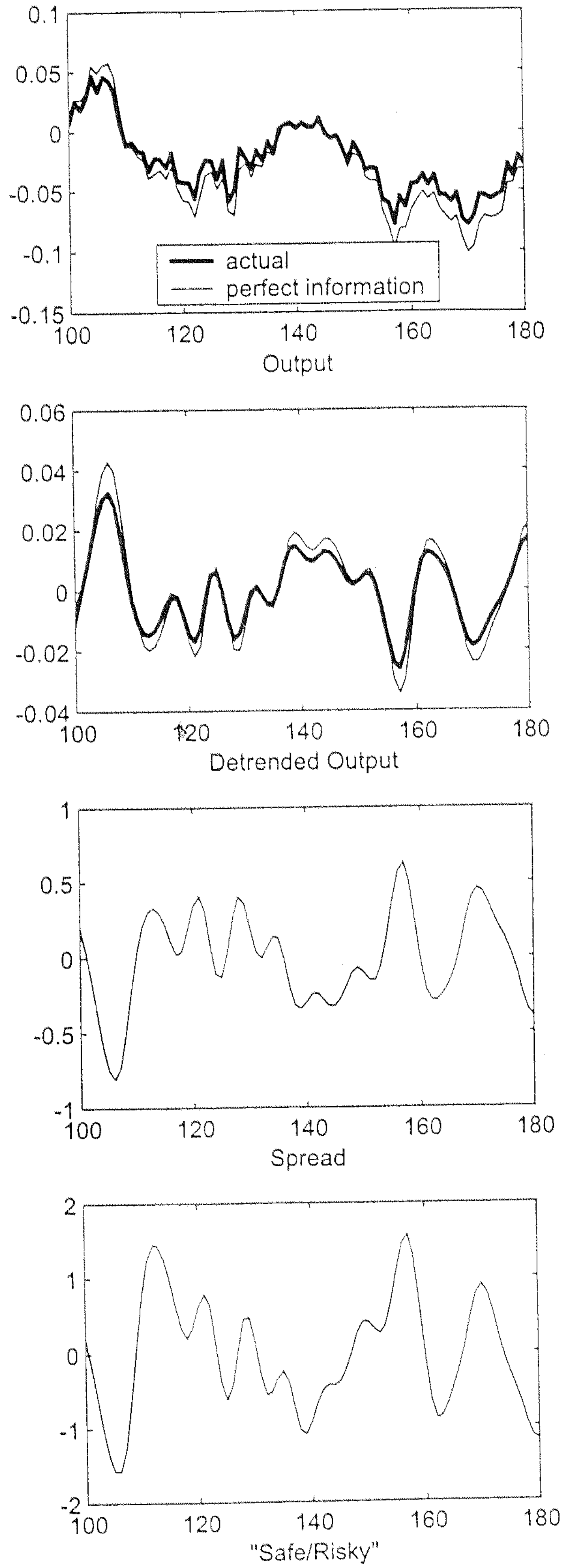


Figure 5b