

FINANCIAL MARKET IMPERFECTIONS AND BUSINESS CYCLES*

BRUCE C. GREENWALD AND JOSEPH E. STIGLITZ

Because of financial market imperfections, such as those generated by asymmetric information in financial markets, which lead to breakdowns in markets, like that for equity, in which risks are shared, firms act in a risk-averse manner. The resulting macroeconomic model accounts for many widely observed aspects of actual business cycles: (a) cyclical movements in real product wages, (b) cyclical patterns of output and investment including inventories, (c) sensitivity of the economy to small perturbations, and (d) persistence. More downward flexibility in wages and prices may exacerbate the plight of an economy that is in a deep recession.

This paper describes a simple model of macroeconomic fluctuations based upon the kinds of informational imperfections that are chiefly related to adverse selection and moral hazard and that have received substantial attention in the recent microeconomic literature. A major consequence of these informational imperfections already studied extensively in connection with insurance, labor, and financial markets is that they interfere with the proper distribution of risk among economic agents. In extreme cases, markets for sharing risk may break down completely.

The fact that firms can only partially diversify out of the risks that they face leads them to act in a risk-averse manner. This has two important implications. (1) In making all of their economic decisions—investment, production, and pricing—they take into account the risk consequences. (2) Firms' willingness to undertake risks is affected both by their total net worth and their stock of liquid assets, which can quickly be converted into cash. These asset balances can act as buffer stocks to absorb risks.

The various decisions that the firm makes are obviously interrelated: a general theory requires a portfolio approach to firm

*Support from the Lynde and Harry Bradley Foundation, the National Science Foundation, and the Hoover Institution is gratefully acknowledged. The authors are indebted to participants in seminars at the Bank of Norway; the Federal Reserve Board, Washington; the Bank of Italy; the University of Arizona; the National Bureau of Economic Research; University of San Diego; Harvard Business School; Princeton University; Center for Economic Policy Research, London; Stanford University; the Far Eastern Meetings of the Econometric Society, Seoul, 1991; and the Symposium on Monetary Theory held at Taipei, Taiwan, at which earlier versions of this paper were presented. We are grateful for helpful comments from Michael Woodford, Lawrence Summers, and an anonymous referee. Research assistance from John Williams, Thomas Hellmann, and Marco Da Rin is gratefully acknowledged.

decision making which takes the various correlations into account.¹ This paper is more modest in its ambition. We focus our attention on how risk considerations affect firms' production decisions. We argue that changes in firms' perceptions of the risks which they face and in their net worth position can have potentially large effects on their willingness to produce. The shifts in one firm's supply curve get translated into shifts in the demand curves facing other firms, and through this mechanism shocks to one agent in the economy get transmitted to others.

We derive a risk-based aggregate supply curve, which leads to the kind of persistence frequently observed in macroeconomic time series, and may even generate business fluctuations whose characteristics bear a striking resemblance to those observed.

In emphasizing problems of risk distribution, this paper can be thought of as continuing the line of research initiated by Kalecki [1939]. Our paper, however, is based on the microfoundations provided by recent work on financial markets with imperfect information, and attempts to integrate that approach into other, more recent macroeconomic traditions.²

The central role of information imperfections is to restrict a firm's ability to raise equity funds in external capital markets. The empirical evidence suggests that firms simply do not resort to equity markets for raising working capital; overall, new equity issues represent a small fraction of capital raised by firms. (In recent years, net equity issues have actually been negative both in the United States and United Kingdom [Mayer, 1990].) There is good reason for this: new equity issues normally have a large negative effect on the value of outstanding shares [Asquith and Mullins, 1986]. And these negative effects on market value have, in

1. For a beginning of such a theory, see Greenwald and Stiglitz [1989].

2. This paper is thus in the same spirit as that of Bernanke and Gertler [1989], as well as both older [Kuh and Meyer, 1959] and more recent [Fazzari, Hubbard, and Peterson, 1988; Hubbard, 1990] work emphasizing the importance of cash flow and balance sheet variables in determining investment. Also see Lindbeck [1963].

Within the macroeconomics literature Hicks [1988] (see Klamer [1989]) shortly before his death, recanted on the IS-LM framework that he had introduced and argued in favor of the kind of model that we have attempted to develop here. Other macroeconomists who have taken similar positions (without developing the kind of formal model presented here) include Leijonhufvud [1968] and Minsky [1975].

Our work differs from the Bernanke and Gertler analysis in the explanation of the source of the limitations on equity markets (they employ the costly state verification model; for a critique of that model, see Hart [1990]). The macroeconomic model that they construct appears heavily dependent on their specific formulation. The model presented here is constructed to illustrate the general properties of aggregate behavior in economies with risk-averse firms with limited recourse to equity (for whatever reason).

turn, been explained in terms of adverse selection, moral hazard, and signaling models.³

Because we are concerned in this paper with exploring the macroeconomic implications of these financial constraints, we simplify by assuming that firms cannot raise new equity, and that they always pay a fixed dividend on existing shares.⁴ At the same time, in order to separate the risk distribution issues that are at the heart of the model from traditional credit restriction questions, we assume that there is a perfect loan market. The output decisions of firms are assumed to be made by managers who are averse to the possibility of bankruptcy.⁵ Finally, we assume that futures markets do not exist and inputs must be paid for significantly before outputs are sold.⁶ Thus, any decision to produce is inherently a risky investment decision.

3. For formal models of this phenomenon see Greenwald, Stiglitz, and Weiss [1984] and Myers and Majluf [1984]. The basic argument is that if the managers of firms, who are better informed about a firm's future prospects than equity investors at large, are willing to issue stock at the current market price, then "outside" investors ought to be unwilling to buy at that price. Hence, an equity issue announcement ought to be associated with a decline in a firm's current stock price which should in turn inhibit equity issues. Agency considerations reinforce these arguments.

Shleifer [1986] has argued that, in addition, there is evidence that the market as a whole acts in a risk-averse manner; i.e., firms face downward sloping demand curves for their securities. For a theoretical model consistent with this observation, see Stiglitz [1972, 1989b].

4. The latter assumption, like the assumption of no (or limited) equity issues, can be justified as an approximation to a long-standing stylized fact: there is a large empirical literature, dating back at least to Lintner [1971] showing that firms adjust dividends relatively rarely. This behavior can also be related to information problems: reducing dividends is taken to be a very negative signal of the firm's prospects, having a correspondingly large negative effect on the firm's market value (see Bhattacharya [1979]).

In this paper the catastrophe facing the firm that we model is that it is not able to pay back its debts and accordingly it goes into bankruptcy. We could have, as well, modeled the catastrophe as that the firm is not able to maintain its dividends, and accordingly must reduce or eliminate them, with a correspondingly disastrous effect on market value. The analysis is the same, whatever the interpretation one takes.

5. The justification for this kind of assumption is again informational. When a firm becomes financially distressed, it is usually impossible to tell whether this is due to bad luck with projects that were a priori properly undertaken or to bad management. Thus, managers will inevitably suffer a stigma associated with financial distress. Concepts like "financial distress" and "bankruptcy," while they have a clear intuitive meaning, are difficult to define precisely, at least in general terms. In the model presented below, they take on well-defined meanings. See, e.g., Eaton, Gersovitz, and Stiglitz [1986].

6. Again, this assumption rests ultimately on informational failures, typically associated with product quality and terms of delivery, which inhibit the development and use of future markets. In practice, futures markets are far from complete.

A relatively small proportion of goods in our economy are "made to order," and even when they are, there remains a positive probability of default; that is, that the firm placing the order does not fulfill its contract. In most cases where goods are produced to order, a relatively small fraction of the payment is made by the purchaser up front. This, in turn, can be related to informational problems: the chance that the producer will default on his part of the bargain.

I. THE BASIC AGGREGATE SUPPLY QUANDARY AND THE RISK RESOLUTION: HEURISTICS

Standard competitive economic theory argues that, in the absence of risk, firms produce up to the point where price P equals marginal costs. If we assume aggregate output q is a function of labor l alone, then

$$(1) \quad q = \Phi(l), \quad \Phi' > 0, \Phi'' < 0,$$

and we obtain

$$(2) \quad P = \omega/\Phi',$$

where ω is the (nominal) wage. If we divide both sides by P , define $\omega/P = w$ as the real wage, and note that $w/\Phi' =$ marginal cost of production (in real terms). Equation (2) can be rewritten as

$$(2') \quad 1 = w/\Phi' = MC.$$

Equation (2) implies that as the economy goes into a recession, l is reduced significantly, and accordingly real wages should rise significantly (see Figure Ia). The fact that they do not was an early objection raised to Keynes's use of the competitive supply model. Previous attempts to reconcile the data with the theory have taken three forms.

1. The production function is made a function of time, so that

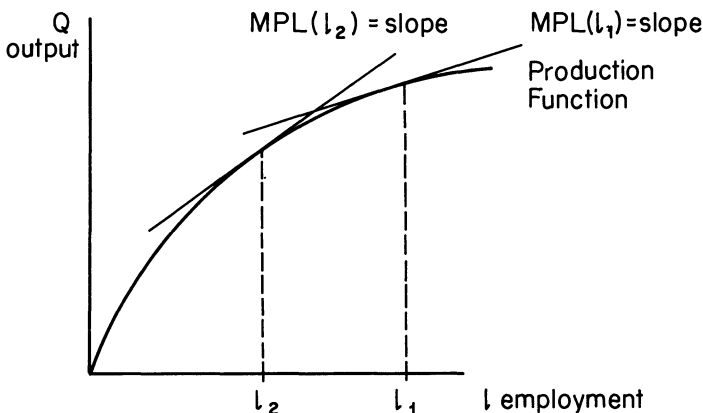


FIGURE Ia

With a given technology a reduction in employment from l_1 to l_2 is associated with an increase in the marginal product of labor. In competitive labor and product markets this means that real wages should rise.

while l was reduced, there was technical regress which reduced the marginal productivity of labor (see Figure Ib). This view, popularized by the real business cycle literature, is both on its face implausible, and has a number of other counterfactual implications. See Mankiw [1989] or Greenwald and Stiglitz [1988a].

2. The data do not accurately reflect the real (product) wage that is relevant for the theory. This is the view taken by the implicit contract literature; but this literature argues that in a recession *observed* real wages are actually higher than “shadow” real wages, exacerbating the quandary. Moreover, much of the standard data refer to average wages, while what is relevant for the theory is marginal wages, i.e., taking into account overtime. Real marginal wages in booms exceed those in recessions by more than the conventional data suggest, again making the quandary more puzzling.

3. Most markets are imperfectly competitive, and so we must replace (2) with

$$(2'') \quad P = \frac{\omega/\Phi'}{1 - (1/\eta)},$$

where η is the elasticity of demand. If the elasticity of demand is

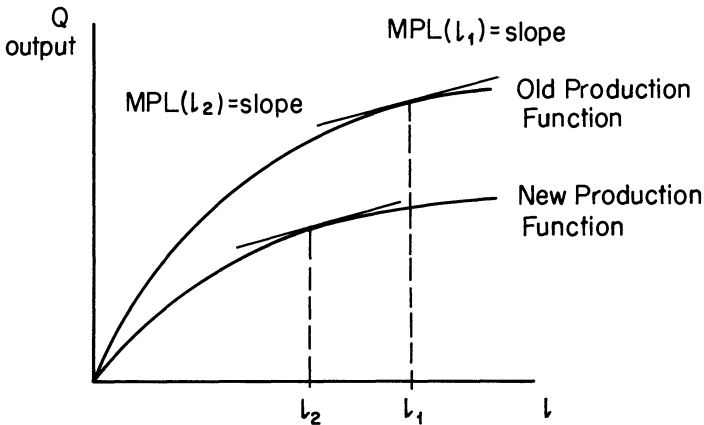


FIGURE Ib

Real business cycle theory explains the apparent lack of variability in real product wages by assuming technological regress. The downward movement in the production function lowers the marginal product of labor, just offsetting the effect of the reduced employment.

lower in a recession, then firms' markups will increase.⁷ But there is little evidence for the marked changes in demand elasticities over the cycle that would be required, and indeed, some have argued that markets become even more competitive (elasticities become higher) in recessions, as collusive arrangements break down (see Rotemberg and Saloner [1987]).⁸

We argue that as firms produce more, they must bear more risk. We focus on a model with bankruptcy in which as firms produce more, the probability of bankruptcy increases. Bankruptcy is costly, and firms take these costs into account in their production decisions. Thus, we replace (1) by the equation,

$$(3) \quad P = \omega/\Phi' + MBC,$$

where *MBC* is the marginal bankruptcy cost.⁹

Alternatively, we can divide by *P* and thus replace (2') with

$$(3') \quad 1 = w/\Phi' + \rho,$$

where ρ equals real marginal bankruptcy costs.

Given ρ and w , (3') defines the equilibrium output of the firm. In Figure II we have drawn the marginal costs of production, ignoring bankruptcy, and then added to that the marginal bankruptcy cost. Production occurs at the level of output where price equals marginal cost of production (including bankruptcy costs). By plotting the value of output corresponding to different values of *P*, we can translate (3) into an aggregate supply schedule, as in Figure IIb. The problem posed earlier can be put: since real wages seem to vary so little over the business cycle, how can we account for the large changes in output? The real business cycle school claims that the aggregate supply schedule shifts to the left because of technological regress. We claim that the aggregate supply schedule shifts because the marginal bankruptcy risk increases. In the next section we show why this is so, by constructing a model that allows us to calculate explicitly this marginal bankruptcy cost.

7. For a survey of alternative imperfect competition models, see Stiglitz [1984]. For an econometric study arguing that price exceeds marginal costs, see Hall [1988]. He attributes the discrepancy to imperfect competition, but his empirical findings are equally consistent with the theory that we develop here.

8. Greenwald, Stiglitz, and Weiss [1984] explain why with a Phelps-Winter [1970] imperfect competition model and imperfect capital markets, we would expect cyclical movements in markups. For other models in which changes in the cost of capital have a direct effect on markups, see Stiglitz [1989a].

9. Our theory works equally well with imperfect competition, in which case we replace (3) with

$$P(1 - 1/\eta) = \omega/\Phi' + MBC.$$

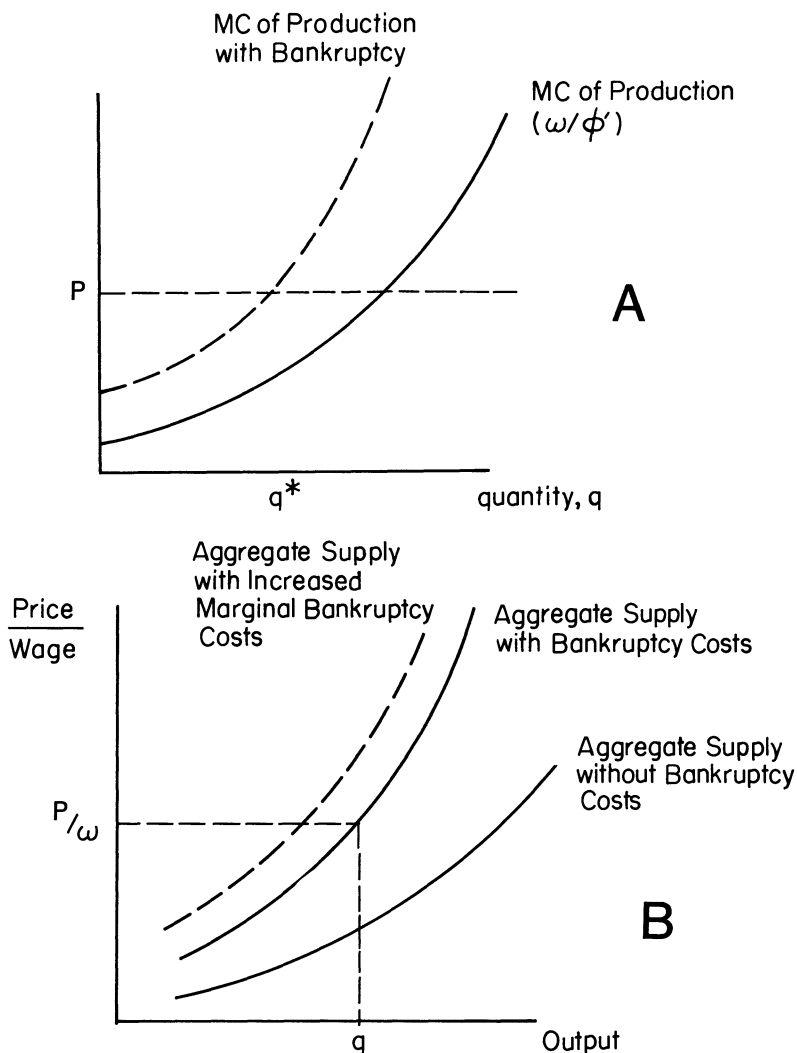


FIGURE II

Panel A. Without bankruptcy firms produce up to the point where price equals marginal cost of production, ω/Φ' . With bankruptcy the marginal costs of bankruptcy must be taken into account.

Panel B. Without bankruptcy the aggregate supply curve is given by $q = \Phi(\Phi^{-1}(\omega/P))$. Shifts in the supply curve must be related to shifts in Φ . With bankruptcy the aggregate supply curve is the solution to $1 = \omega/\Phi' + \rho$. Shifts in ρ , the marginal bankruptcy cost, give rise to shifts in the aggregate supply curve.

II. FIRM BEHAVIOR AND AGGREGATE SUPPLY

Firms, identified by an index $i = 1, \dots, I$, will be assumed to make decisions at discrete intervals: $t = 1, \dots, T$. At the beginning of each period a firm inherits both a nominal level of debt, B_{t-1}^i , and the previous period's output, q_{t-1}^i . We assume that there is a one-period lag between the use (and payment) of inputs and the availability of output. Thus, q_{t-1}^i results from production decisions made at the beginning of period $t - 1$, but becomes available for sale only at the beginning of period t . For simplicity, we assume also that output is perishable and q_{t-1}^i must all be sold at the beginning of period t . We assume that the nominal debt B_{t-1}^i was incurred at the beginning of period $t - 1$ in order to pay for the inputs that were required for producing q_{t-1}^i . Associated with this debt is a nominal contractual rate of interest R_{t-1}^i determined at that time. Thus, nominal contractual repayments owed to debt-holders by firm i on entering period t are $(1 + R_{t-1}^i) B_{t-1}^i$.

At the beginning of period t competitive goods markets open and clear. This determines the price P_t^i at which firm i sells its inherited output q_{t-1}^i . The price P_t^i also determines the nominal equity position of firm i at the beginning of period t since

$$(4) \quad A_t^i \equiv \text{Nominal Equity Position of firm } i \text{ at the beginning of period } t \\ \equiv P_t^i q_{t-1}^i - (1 + R_{t-1}^i) B_{t-1}^i.$$

The level of A_t^i then determines the solvency of firm i . For some level of A_t^i sufficiently low (or negative), firm i would presumably be declared bankrupt and reorganized with appropriately negative consequences for the managers (or owners, if owner-managed) of the firm. For simplicity, we shall assume that $A_t^i < 0$ implies bankruptcy, although a nonzero (either positive or negative) threshold could have been used without fundamentally altering the implications of the model.¹⁰

We assume that firms face a real wage w and at that wage, they can hire as much labor as they wish. We also assume that firms can borrow as much as they want, but at terms which must yield the lender an expected real return of r_t . The expected real return r_t then determines the terms at which loans will be made available to individual firms, typically a schedule relating R_t^i to q_t^i and A_t^i for a

10. The comparative static analysis of a bankruptcy threshold below zero is more complicated than that of a zero or positive threshold.

given expected real return and expected rate of inflation. Combined with expectations concerning future output prices and A_t^i , these factor prices lead managers to select a level of output, q_t^i , which, once workers have been paid, leads to a level of debt, B_t^i , and a contractual nominal return, R_t^i , that firm i inherits at the beginning of period $t + 1$, when the entire process is repeated.

Within this temporal context we shall make the following assumptions.

A1. Firms produce output using only labor as an input with $l_t^i = \phi(q_t^i)$, where ϕ is a labor requirements function¹¹ with $\phi' > 0$ and $\phi'' \geq 0$.

A2. The price level P_t^i faced by an individual firm is determined by a sectoral random variable \bar{u}_t^i , and the overall price level P_t , where

$$(5) \quad P_t^i = \bar{u}_t^i P_t, \quad E(\bar{u}_t^i) = 1$$

and \bar{u}_t^i , the relative price of the output of firm i , is i.i.d. with a distribution function $F(\cdot)$, and density $f(\cdot)$.

A3. If $A_t^i < 0$, firms go "bankrupt," and the entire proceeds from the sale of q_{t-1}^i are distributed without further loss to debtholders (i.e., there are no reorganization or liquidation costs to debtholders).¹²

Firms borrow to supplement initial equity to pay production costs. Since the real wage is w_t , nominal wage payments are $P_t w_t \phi(q_t^i)$, and

$$(6) \quad B_t^i = P_t w_t \phi(q_t^i) - A_t^i.$$

Given A2 and A3, lenders to firm i at the beginning of period t earn returns that are a random variable whose value is resolved only when prices are revealed at the beginning of period $t + 1$. Firms go bankrupt if what they promise to pay exceeds their

11. ϕ could, of course, easily be made to vary across firms. However, doing this would merely complicate the notation without significantly altering the implications of the model. Note that ϕ^{-1} is a production function of the usual sort; i.e., $\phi^{-1} \equiv \Phi$.

12. Introducing reorganization costs has an impact on the results similar, but not quite identical, to the effect of a negative bankruptcy threshold. Also with reorganization costs firms will have an additional incentive (beyond the managerial penalty) to avoid bankruptcy.

income; that is, when (using (4) and A3)

$$(1 + R_t^i)B_t^i \geq P_{t+1}^i q_t^i$$

or, using (5) and (6),

$$(7) \quad \bar{u}_{t+1}^i \leq (1 + R_t^i) \left(\frac{P_t}{P_{t+1}} \right) \left(\frac{w_t \phi(q_t^i) - a_t^i}{q_t^i} \right) \equiv \bar{u}_{t+1}^i,$$

where

$a_t^i \equiv A_t^i / P_t \equiv$ real equity level of firm i at the beginning of period t

and

\bar{u}_{t+1}^i is the level of relative price in period $t + 1$

at which firm i is just solvent.

If the firm i cannot meet its debt obligations, its total income $p_t^i q_t^i$ is divided equally among debtors. Thus, using (5) and (6), real returns to lenders are

$$(8) \quad (1 + \bar{R}_t^i) \left(\frac{P_t}{P_{t+1}} \right) = \begin{cases} (1 + R_t^i) \left(\frac{P_t}{P_{t+1}} \right) & \text{if } \bar{u}_{t+1}^i \geq \bar{u}_{t+1}^i \\ \frac{\bar{u}_{t+1}^i \cdot q_t^i}{w_t \phi(q_t^i) - a_t^i} & \text{if } \bar{u}_{t+1}^i < \bar{u}_{t+1}^i \end{cases}.$$

Strictly speaking, P_{t+1} , looking forward from the beginning of period t , is a random variable. However, in order to simplify the exposition, we assume for the moment that there is relatively little uncertainty about future price levels (as opposed to the relative sectoral prices P_{t+1}^i) and, thus, that¹³

$$(9) \quad P_{t+1} \equiv P_{t+1}^e \equiv \text{Expected price level at the beginning of period } t + 1 \text{ looking forward from the beginning of period } t.$$

Given equation (9), the expected real return to lenders to firm i in

13. This assumption may appear extreme. However, it can be relaxed without affecting the conclusions of the model in any fundamental way. Unfortunately, the price of such relaxation is considerable notational complexity since it requires definition of a bivariate price distribution covering both aggregate and sectoral prices; hence the use of the present assumption.

period t is

$$(10) \quad E[(1 + \tilde{R}_t^i)] \left(\frac{P_t}{P_{t+1}^e} \right) = (1 + R_t^i) \left(\frac{P_t}{P_{t+1}^e} \right) \\ \times (1 - F(\bar{u}_{t+1}^i)) + \frac{q_t^i}{\omega_t \phi(q_t^i) - \alpha_t^i} \int_0^{\bar{u}_{t+1}^i} x dF(x),$$

where P_{t+1}^e can now be substituted for P_{t+1} in the expression for \bar{u}_{t+1}^i . The first expression on the right-hand side of equation (10) represents the expected real return to lenders from those situations in which firm i is solvent in period $t + 1$. The second expression then represents the expected real return to lenders from situations in which firm i is insolvent in period $t + 1$. For determining the appropriate contractual rate of return, R_t^i , we next assume that

A4. Lenders are perfectly informed¹⁴ and risk neutral, which implies that

$$(11) \quad E[1 + \tilde{R}_t^i] \left(\frac{P_t}{P_{t+1}^e} \right) = 1 + r_t,$$

where r_t is the t th period real interest rate.

Equations (7) and (11) can be solved for the equilibrium level of the contractual nominal interest rate R_t^i , and the solvency relative price, \bar{u}_{t+1}^i , as functions of q_t^i , α_t^i , ω_t , r_t , and P_t/P_{t+1}^e .¹⁵

14. Clearly, for the informational imperfections that interfere with the issue of equity to exist, lenders must not be able to use their information to purchase equity. The best way to interpret A4 is that lending is done through institutions that are legally enjoined from purchasing stock. In any event, imperfect information on the part of lenders would intensify rather than alleviate the problems embodied in the model.

15. We can substitute (7) and (11) into (10) to obtain

$$1 + r_t = \frac{q_t^i}{\omega_t \phi(q_t^i) - \alpha_t^i} \left\{ (1 - F(\bar{u}_{t+1}^i)) \bar{u}_{t+1}^i + \int_0^{\bar{u}_{t+1}^i} x dF \right\}.$$

The term in brackets is just a function of \bar{u}_{t+1}^i , $J(\bar{u}_{t+1}^i)$. Rearranging, we have

$$J(\bar{u}_{t+1}^i) = (1 + r_t) \left(\frac{\omega_t \phi(q_t^i) - \alpha_t^i}{q_t^i} \right)$$

or

$$\bar{u}_{t+1}^i = J^{-1} \left(\frac{(1 + r_t)(\omega_t \phi(q_t^i) - \alpha_t^i)}{q_t^i} \right)$$

$$(12) \quad \begin{aligned} R_t^i &= R_t^i(q_t^i, \alpha_t^i, w_t, P_t/P_{t+1}^e, 1 + r_t), \\ \bar{u}_{t+1}^i &= \bar{u}_{t+1}^i(q_t^i, \alpha_t^i, w_t, P_t/P_{t+1}^e, 1 + r_t). \end{aligned}$$

Then, substitution from (12) into $F(u)$ yields

$$\text{Probability of Bankruptcy} \equiv F[\bar{u}_{t+1}^i(q_t^i, \alpha_t^i, w_t, P_t/P_{t+1}^e, 1 + r_t)]$$

giving the probability of bankruptcy as a function of the decision variable q_t^i , the state variable α_t^i , and the parameters w_t (wages), P_t/P_{t+1}^e (the expected change in the price level), and r_t (the real interest rate).

In deciding upon a level of output, we shall assume that the objectives of a firm's managers are described by the assumption that

A5. Firms select q_t^i in order to maximize expected real profits (i.e., total sales revenues minus repayment to lenders) minus an expected real cost of bankruptcy; i.e.,

$$(13) \quad \max (1/P_{t+1}^e)E[P_{t+1}^i q_t^i - (1 + \tilde{R}_t^i)(P_t w_t \phi(q_t^i) - A_t^i)] \\ - c_t^i F(\bar{u}_{t+1}^i),$$

where c_t^i is the cost incurred in the event of bankruptcy and $F(\bar{u}_{t+1}^i)$ is the probability of bankruptcy.

Equation (13) is a simple way of capturing the hypothesis that firms act to avoid bankruptcy. As we shall see, this bankruptcy avoidance behavior induces a kind of risk aversion,¹⁶ similar results obtain whether these bankruptcy costs are viewed as real (managerial) reorganization costs associated with bankruptcy or if we view firms as maximizing the expected utility of profits with the utility function characterized by a declining marginal utility of profits and decreasing absolute risk aversion (see Greenwald and Stiglitz [1987]).

and

$$1 + R_t^i = J^{-1} \left(\frac{(1 + r_t)(w_t \phi(q_t^i) - \alpha_t^i)}{q_t^i} \right) \frac{P_{t+1}^e}{P_t} \frac{q_t^i}{w_t \phi(q_t^i) - \alpha_t^i}.$$

16. Strictly speaking, this is true only if $c_t^i F$ is appropriately convex in q_t^i and if α_t^i is not too small. See below and the appendix to Greenwald and Stiglitz [1988b].

We assume further that

A6. Bankruptcy costs increase with the level of a firm's output:

$$(14) \quad c_t^i = cq_t^i.$$

This assumption is made largely for analytic reasons; similar results hold for other bankruptcy cost functions as long as expected bankruptcy costs are convex in q_t^i . There are, however, three economic justifications which suggest that A6 represents a plausible simplification. First, as firms become larger, they presumably involve more managers whose loss of position, income, and power in the event of insolvency is likely to increase. Bankruptcy should, therefore, be a more serious matter for General Motors than for a local grocery store. Since q_t^i is the only scale variable in the model, having bankruptcy costs increase with q_t^i is the only way to capture these scale effects. Second, a significant role of managers is choosing a level of output (in the model this is their only role). Bankruptcy with high levels of output should reflect unfavorably on their ability to do this. Since bankruptcy in this model is due to low prices, a high level of output in the face of these low prices may, retrospectively at least, imply unusually bad judgment by managers and may thus be unusually costly to their future prospects. Third, having bankruptcy costs depend on q_t^i is necessary in order to ensure that the possibility of bankruptcy is never ignored. If there were a fixed cost of bankruptcy independent of the level of output, then profits, which are increasing in output, may grow so large relative to bankruptcy costs that bankruptcy becomes a negligible consideration.¹⁷ Since the purpose of this paper is to investigate the macroeconomic implications of conditions in which managers (or owners) are penalized for bad outcomes and are affected by the possibility of these penalties, Assumption A6 is a convenient way of ensuring that these conditions are met. Moreover, with the addition of fixed bankruptcy costs, there are reasonable circumstances under which the fundamental implications of the model continue to hold.¹⁸

17. In any case, we must assume that there is an upper limit on output (or that ϕ' increases sufficiently rapidly) and the bankruptcy costs coefficient c is sufficiently large that a maximum for the objective function in A5 exists. These technical assumptions are discussed in the appendix to Greenwald and Stiglitz [1988b].

18. The implied restriction in A5 to a single-period horizon is a matter of expositional convenience. The multiperiod maximization problem as well as the consequences of fixed bankruptcy costs are examined in Greenwald and Stiglitz [1988b].

Given A2 and A4, the objective function of A5 can be written as

$$(15) \quad \max_{q_t^i} [q_t^i - (1 + r_t)(w_t \phi(q_t^i) - a_t^i) - c_t^i F(\bar{u}_{t+1}^i)].$$

Under these assumptions, a firm's real output is, therefore, determined by real wages, real interest rates, real equity holdings, and relative price uncertainty. The first-order condition¹⁹ for an interior maximum can now be written as

$$(16) \quad 1 - (1 + r_t)w_t \phi' = \rho_t^i,$$

where ρ_t^i is the *marginal bankruptcy cost* of firm i in period t ; i.e.,

$$(17) \quad \rho_t^i = \left(\frac{dc_t^i}{dq_t^i} \right) F + c_{if}^i(\bar{u}_{t+1}^i) \frac{d\bar{u}_{t+1}^i}{dq_t^i}.$$

If ρ were zero, equation (16) would be the standard result that employment should be increased to the point where the marginal product ($1/\phi'$) equals the wage, taking into account the fact that the wage is paid the period before the output is received (and hence in present value terms, viewed at the time output is sold, wage costs are $w_t(1 + r_t)$). Equivalently, price (here, normalized at unity) is set equal to marginal costs ($(1 + r_t)w_t \phi'$). Since ρ is positive, the impact of bankruptcy risks is to restrict output; these risks drive a wedge between expected prices and marginal costs in the traditional sense.

More importantly, the variables on the left-hand side of equation (16)—real interest rates, real wages, and technology—have historically shown substantial stability over time, changing only slowly at relatively predictable rates. In contrast, the variables that affect the right-hand side of equation (16)—such as the financial position of firms, a_t^i , and the degree of uncertainty concerning future prices (i.e., the distribution function F)—may change rapidly and unpredictably. It is these variables, many of which may be difficult to observe, that account for cyclical fluctuations in the model.

Figure III depicts the solution to (16) graphically. Taking output as our numeraire, for small q , price is just equal to marginal cost, since $\rho = 0$. As q increases, so does ρ . Price exceeds marginal cost by the amount of the marginal bankruptcy costs.

19. There are several restrictions that have to be imposed to ensure that the second-order conditions are satisfied. These are discussed in the appendix to Greenwald and Stiglitz [1988b].

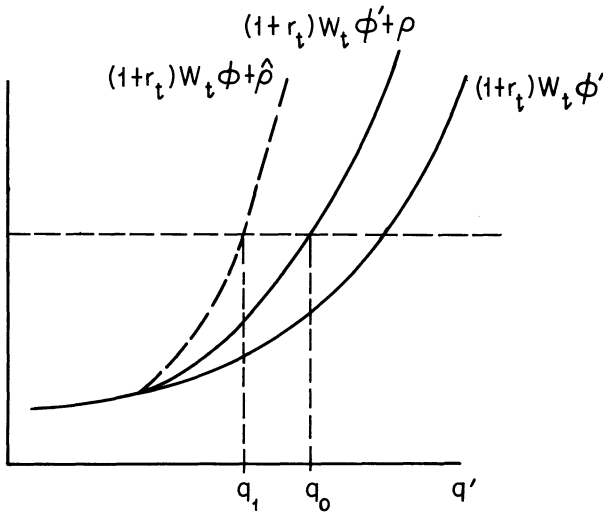


FIGURE III

Determination of Equilibrium Output and Employment

A decrease in equity or an increase in perceived risk increases the marginal bankruptcy cost; ρ increases to $\hat{\rho}$, leading output to fall.

A. The Determinants of Marginal Bankruptcy Risk and Individual Firm Supply

An increase in the real wage or real interest rate has two effects: the direct effect on the left-hand side of (16), and the indirect effect of increasing the marginal bankruptcy cost, at each level of output. The higher real wage means that the firm must borrow more to produce any given level of output, and the higher real interest rate means that the firm must pay back more (on average) for any amount it borrows. Both effects lead to reduced equilibrium output. Thus, it is easy to derive the labor demand or the output supply curve.

The marginal bankruptcy cost ρ_t^i depends, of course, on the level of output. In addition, it is a function of the real wage, the real interest rate, the level of equity of the firm (α_t^i) as well as the subjective probability distribution of the random variable \tilde{u}_{t+1}^i . We can thus represent the supply function of a firm (the solution to (16)) and its demand curve for labor by an equation of the form,

$$(18) \quad \begin{aligned} q_t^i &= g^i(w_t, r_t, \alpha_t^i, v_t^i) \\ l_t^i &= \phi(q_t^i) = \phi(g^i(w_t, r_t, \alpha_t^i, v_t^i)), \end{aligned}$$

where v_i^j represents a measure of the riskiness of the distribution F .

$g_w^i < 0$: real wage increases depress supply;

$g_r^i < 0$: real interest rate increases depress supply.

Our main concern, however, is with the effect of equity levels and uncertainty (risk) on production. It is possible to verify

PROPOSITION 1. The higher the level of equity, the lower the marginal bankruptcy cost (risk premium) ρ_i^j , and hence the higher the level of production.

PROPOSITION 2. Increases in the degree of uncertainty result in an increase in the marginal bankruptcy cost (risk premium) and hence in a lower level of investment.²⁰

Under the assumption that ϕ is linear, up to a capacity constraint, we can show that production, as a function of the equity level a_i^j , appears as in Figure IV. For the range within which the constant returns assumption holds, the elasticity of supply with respect to firm equity is unity.²¹

Accordingly,

PROPOSITION 3. At least near the capacity level, output is a concave function of equity levels.

These three propositions are the heart of the analysis. Proposition 1 implies that, if for some reason, a firm's equity is reduced (e.g., because the prices at which the firm is able to sell its goods are lower than anticipated) then, in subsequent periods, the firm's output will be reduced. Diagrammatically in Figure III a reduction of equity increases ρ , reducing output from q_0 to q_1 .

Moreover, our analysis suggests that for high leverage economies, the output multipliers associated with equity injections may be substantial. For example, if, in equilibrium, equity represents one third of total capital (which in this circulating capital world is slightly less than output), then with constant returns to scale a \$1 increase in equity will yield \$3 of increased output. Note that there are a variety of ways that such equity injections may occur, most

20. The precise meaning of increases in uncertainty and the conditions under which Proposition 2 is valid are discussed in the appendix to Greenwald and Stiglitz [1988b].

21. More generally, with diminishing returns the elasticity of supply is less than or equal to unity. This is, of course, a partial-equilibrium result. To the extent that increases in a lead to increases in labor demand, and these increases lead to wage increases, the net effect on output will be smaller.

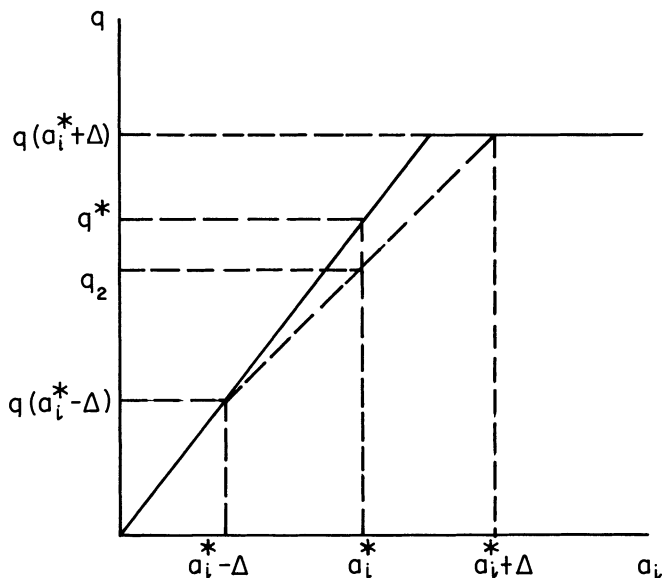


FIGURE IV

Firm output increases with firm equity, up to capacity. The reduction in output from a reduction in equity by Δ exceeds that gain in output from an increase in equity by Δ .

importantly larger than anticipated increases in prices, whether a result of monetary or fiscal policy, can result in substantial increases in the equity base of firms.²²

Later, we shall show the not surprising result that losses in equity will not instantaneously be restored, and thus the model has the immediate implications of *persistence*; a loss of equity at time t results in lower output, not only at time t , but in subsequent periods as well.

Proposition 2 means that a sudden change in perception concerning the uncertainty of future prices will be translated directly into a contraction in production. In Figure III the marginal

22. In the model of this paper, sales at t are fixed, and thus the only source of variability in equity is prices (see equation (4)). If, on average, costs including interest payments represent 90 percent of the value of sales, a mere 5 percent reduction in sales price from the expected level translates into a 50 percent reduction in equity from its expected level, and a correspondingly large reduction in output. In a more general model, with firms selling out of inventory, and with prices possibly being chosen by firms, levels of demand have a direct effect on firms' financial positions.

bankruptcy cost rises from ρ to $\hat{\rho}$, and output is accordingly reduced.

The fact that the output function is concave (Proposition 3) means that redistributions of wealth within the production sector may have deleterious consequences for production. Thus, unanticipated increases in prices (say oil) may have negative effects, and, at the same time, unanticipated decreases in prices of the same commodity may have negative effects. The oil price shocks increase the real equity of oil producers and decrease that of oil users. Figure IV illustrates that the reduction in output of the firm losing equity (equity goes from a^* to $a^* - \Delta$) is greater than an increase in output of the firm with increased equity (equity goes from a^* to $a^* + \Delta$). Average output of the two firms falls from q^* before the disturbance to q_2 afterwards. More generally, the magnitude of the fall in output is greater the greater is the disturbance and the greater is the curvature of g^i . Propositions 2 and 3 together imply that increased uncertainty, both ex ante (anticipated) and ex post, depresses production. This will be true whether the uncertainty is due to concerns about real shocks or to concerns regarding the instabilities of macroeconomic policy including monetary policy.

B. Aggregate Supply

An aggregate supply function can be derived straightforwardly by summing the supply functions of individual firms. For simplicity, we assume that all firms have the same production function (Φ) and face the same uncertainty (F). We can then write aggregate output as

$$q_t = \hat{g}(w_t, r_t, a_t^1, \dots; v).$$

We can approximate the expression by taking a Taylor series expansion around the average level of firm equity holdings, a_t , (under our symmetry assumptions), giving us an aggregate supply function of the form,

$$q_t = g(w_t, r_t, a_t; v, \sigma),$$

where σ^2 is the variance of firm equity levels. The comparative static properties of this aggregate supply function will, in general, mirror those of a representative firm's output (with the additional effect noted that an increase in the dispersion of equity ownership will generally lower output). Thus, Figure V shows the aggregate demand for labor (which can be directly translated into an aggregate supply of goods). The curve shifts with changes in a , v , or σ :

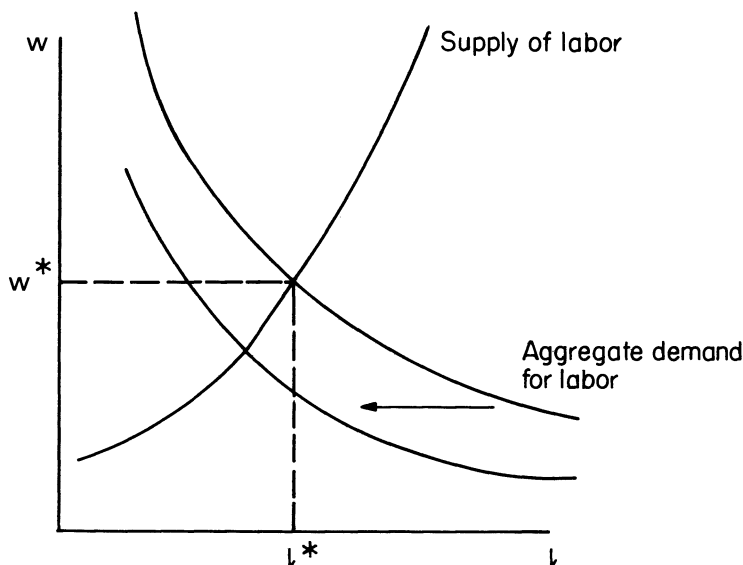


FIGURE V

The aggregate demand for labor shifts down as a result of a reduction in α , an increase in perceived risk, and an increase in the dispersion of equity.

decreases in average equity, increases in its dispersion, or increased perception of risk all shift the demand for labor curve or the output supply curve to the left.

III. CLOSING THE MODEL: COMPETITIVE EQUILIBRIUM

To explore the implications of this new aggregate supply curve, we need to embed it in a model of the economy. To highlight the central features of our theory of the risk-averse firm, we wish to model the rest of the economy in standard ways. In this section we present a competitive equilibrium model, in which the labor market always clears. In the next we present an efficiency wage model.

In order to embed the supply function of the previous section in a model which is as simple as possible, we assume that consumer behavior can be described by the behavior of a single, infinitely lived representative consumer. Furthermore, we shall assume that this representative consumer may borrow and lend freely at the competitive real rate of interest, r_t , and consequently faces a single

lifetime budget constraint of the form,

$$\sum_{j=0}^{\infty} (z_{t+j} - w_{t+j}l_{t+j})\pi_{t,j} = n_t,$$

where

$z_{t+j} \equiv$ real consumption in period $t + j$,

$l_{t+j} \equiv$ hours worked in period $t + j$,

$$\pi_{t,j} \equiv \prod_{i=0}^j \left(\frac{1}{1 + r_{t+i-1}} \right) \quad (\text{and } 1 \text{ for } j = 0),$$

and

$n_t \equiv$ real wealth in period t .

Finally, we assume that the representative consumer has a utility function of the form,²³

$$\sum_{j=0}^{\infty} \left(\frac{1}{1 + \delta} \right)^j (z_{t+j} - v(l_{t+j})),$$

where $v' > 0$ and $v'' < 0$.

Under these circumstances, equilibrium in the aggregate market for goods and services is characterized by the following conditions.²⁴

(a) The real interest rate will always be equal to the individual's pure rate of time discount, δ :²⁵

$$r_t = \delta.$$

(b) Consumption equals output:

$$z_t = q_{t-1}.$$

(c) The supply of labor, denoted by S , is an increasing function only of the wage in the current period, w_t .

Strictly speaking, the demand for labor is the sum of the demands of the individual firms. However, in order to simplify the

23. We are suppressing the role of product heterogeneity. There are several alternative specifications that might allow this to be brought in.

24. That is, the utility function ensures that since the individual is willing to trade off a dollar of consumption at time $t + 1$ for $1 + \delta$ at t , regardless of the levels of consumption of goods or leisure, the market rate of interest must be δ .

25. Though we do not wish to argue strongly for this assumption (other than on grounds of analytic simplicity, and its ability to allow us to focus on the central issues of concern in this paper), we note that for long periods of time, there has been relatively little variability in real interest rates.

notation, we write this as $\phi(q_t)$, where q_t is aggregate output and ϕ now represents an aggregate labor requirements function. The real wage is then determined by an equilibrium in the labor market of the form,

$$(19) \quad \phi(q_t) = s(w_t), \quad s' > 0.$$

The aggregate supply of output equation is equivalent to an aggregate demand for labor equation, and since the aggregate supply function depends on the value of equity, so does the aggregate demand for labor equation.

The equilibrium in the labor market is depicted in Figure V as the intersection of the labor demand and supply equations. Accordingly, the high sensitivity of the aggregate supply equation to variations in a (which itself depends on price shocks) means that employment and output can be highly variable. *Small shocks can lead to large aggregate consequences.*

More formally, we solve (19) for real wages as a function of aggregate output of the form,

$$(20) \quad w_t = \psi(q_t),$$

where $\psi' = (\phi'/s') > 0$. Finally, substitution from the labor and capital market equilibria into the aggregate supply function yields a relationship of the form,

$$(21) \quad q_t = g(\psi(q_t), \delta, a_t),$$

which can be solved to yield (recalling that d is a constant)

$$(22) \quad q_t = H(a_t).$$

Thus, *in each period output is determined by the level of equity, and movements in output over time will be driven by movements in the level of equity* (see Figure VIa).

Note that

$$\frac{d \ln q}{d \ln a} = \frac{d \ln g/d \ln a}{1 - (d \ln g/d \ln w)(d \ln w/d \ln q)}.$$

Thus, in general, the general-equilibrium volatility of output to changes in equity will be smaller than the partial-equilibrium volatility; wage adjustments help stabilize the economy.

A. Dynamics

Equity in period $t + 1$ consists of equity in period t plus earning on that equity plus new equity sales less dividends paid.

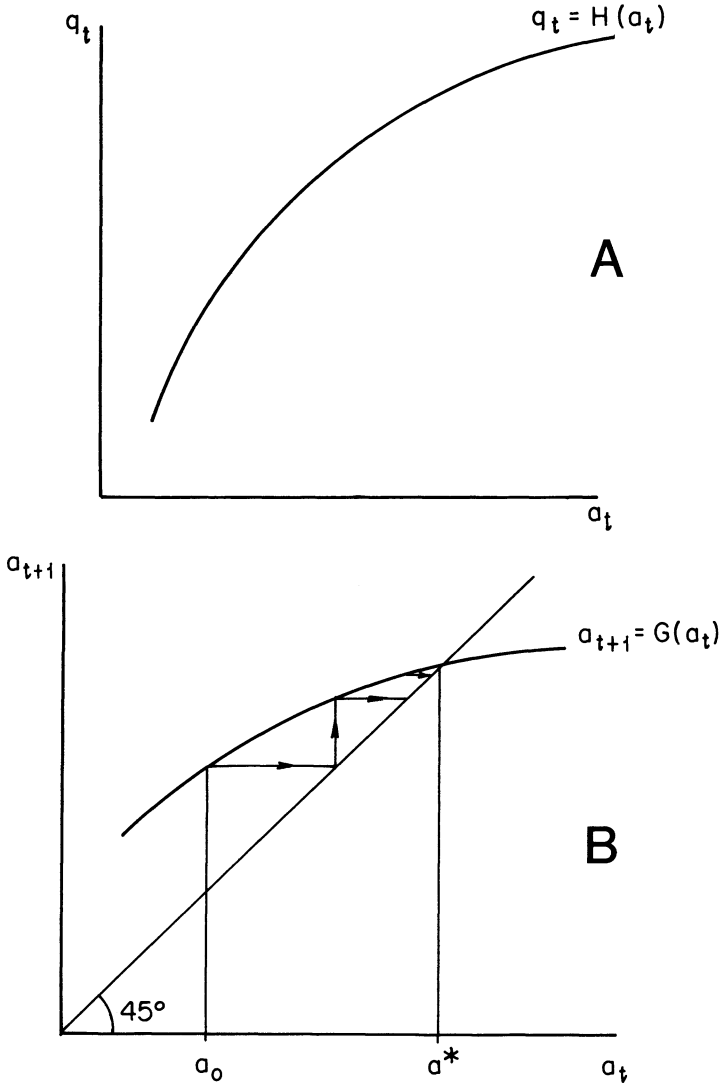


FIGURE VI

In nominal terms,

$$\bar{A}_{t+1}^i = \bar{P}_{t+1}^i q_t^i - (1 + \bar{R}_t^i)(P_t w_t \phi(q_t^i) - A_t^i) - \bar{M}_{t+1}^i,$$

where \bar{M}_{t+1}^i is a random variable representing the nominal value of dividends paid less new equity issued. Summation and averaging over firms and the taking of expected values, assuming that the law

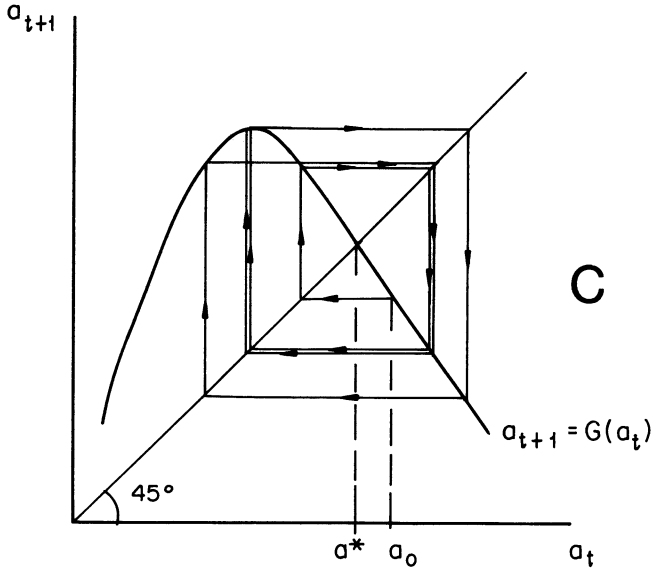


FIGURE VI

Panel A. Aggregate output increases with aggregate equity.
 Panel B. Aggregate equity at time $t + 1$ depends on aggregate equity at time t .
 a^* is the steady state. If the economy gets perturbed, say to a_0 , it takes several periods to restore equilibrium.
 Panel C. The model can also give rise to cycles.

of large numbers applies, yields

$$\begin{aligned}
 A_{t+1} &= E[\tilde{A}_{t+1}] = P_{t+1}q_t - (P_{t+1}^e)E\left[\frac{(1 + \tilde{R}_t^i)P_t}{P_{t+1}^e}\right](w_t\phi(q_t) - a_t) - M_{t+1} \\
 &= P_{t+1}q_t - (P_{t+1}^e)(1 + \delta)(w_t\phi(q_t) - a_t) - M_{t+1},
 \end{aligned}$$

where unsuperscripted variables now denote aggregate quantities. Division by P_{t+1} to convert to real terms yields an equation for real equity levels in period $t + 1$ of the form,

$$(23) \quad a_{t+1} = q_t - (P_{t+1}^e/P_{t+1})(1 + \delta)(w_t\phi(q_t) - a_t) - m_{t+1},$$

where m_{t+1} now denotes the real value of dividends less equity sales, which we assume is simply a function of the state variable a_t .²⁶ Equations (22) and (23) together with whatever determine

26. As noted earlier, adverse selection and signaling arguments similar to those used to argue that firms will not, in general, have recourse to equity markets have also been used to explain why dividend levels change so infrequently. For the short-run analysis on which this paper focuses, we can accordingly take these as related to the state variables of the system, in particular, to a_t .

“price shocks” (i.e., the variable P_{t+1}^e/P_{t+1}) now completely determines the dynamic behavior of output in the model.

In order that this dynamic behavior be at least minimally interesting, the level of net equity outflows (i.e., m_{t+1}) must be sufficiently large—especially at high levels of a_t —so that the real equity level in the economy does not simply increase without bound. We assume that m is a function of a , such that when a_{t+1} is plotted as a function of a_t (see Figure VIb), the curve must at some point fall below the 45-degree line (it must also at some point obviously lie above that line). Formally, therefore, we shall assume that

$$(24) \quad a_{t+1} = q_t - (P_{t+1}^e/P_{t+1})(1 + \delta)(w_t\phi(q_t) - a_t) - m(a_t)$$

cuts the 45-degree line from above as shown in Figure VIb.²⁷

B. Cycles

Cycles (in the sense of persistent fluctuations) may occur in this model for two reasons. First, even with $P_{t+1} = P_{t+1}^e$ in every period, deterministic cycles of multiple periodicity may occur if the slope of the curve,

$$(25) \quad a_{t+1} = q_t - (1 + \delta)(w_t\phi(q_t) - a_t) - m(a_t) \equiv G(a_t),$$

is sufficiently highly negative when it crosses the 45-degree line (see Figure VIc).²⁸ Since

$$G' = (1 + \delta) - m' - ((1 + \delta)(\psi'\phi + \phi'w) - 1)H'$$

and $(1 + \delta)\phi'w < 1$ (from the first-order condition of firms), this requires that m' be large or that the impact of increased output on wages (i.e., $\psi'\phi$) be large. However, if these conditions are met, the resulting “real” cycles bear at least a casual resemblance to the “wage-shock” models that have been discussed, at least informally, in the empirical literature. Prosperity in the form of rising output and firm equity levels leads to both rising wages, which reduces profits and internal funds flows, and rising dividends. These in turn ultimately reduce equity levels and output, which both

27. If we treat P_{t+1} as a random variable, equation (24), together with equation (22), defines a stochastic difference equation. The limiting properties of the stochastic process are studied elsewhere. Here, we simply note that along each sample path, the property of persistence, to be described in the next subsection, will be observed.

28. See Grandmont [1985] for a discussion of the mathematics of these cycles. We believe that the model formulated here provides a more satisfactory account of the structure of actual business cycles than the model of the Grandmont paper. Also see Woodford [1988].

restores profitability (as wages fall) and reduces dividends, causing the cycle to begin again (see Figure VIc).

If G' is always greater than zero, then no such cycles are possible and convergence to the steady state is monotone. For future reference, we shall denote this steady-state level of equity by a^* , where

$$(26) \quad a^* = G(a^*).$$

C. Persistence

Second, random price shocks, which lead to unexpected fluctuations in the real value of debtor obligations and hence in real equity levels, will lead to output fluctuations that persist over several periods. Consider, for example, an unexpectedly low level of P_{t+1} (i.e., $P_{t+1} < P_{t+1}^e$). From equation (24) this will lead to an immediate and substantial drop in equity levels away from the steady-state level, a^* (assuming that the economy started at a^*), with an associated drop in output. The economy will return to a^* (and the associated "full-employment" level output) only slowly as a result of successive positive increments to a_t (see Figure VIb). Moreover, these increments (and the associated increments in wages) will be fully anticipated. They may not, however, be arbitrated away nor the process shortcut because doing so would involve levels of economic activity that require firms to bear unacceptably high levels of risk. Firms will do this only as they acquire equity funds which, for information (risk) reasons, they are assumed to do only slowly over time.

In the model presented in this section, while it generated volatility in the level of economic activity, there was (by assumption) no unemployment. In a sense, this model is very much in the spirit of the real business cycle literature, with one important distinction. Those models typically attribute economic variability to exogenous technology shocks. It has been difficult to identify changes in technology of the appropriate magnitudes to generate observed patterns of aggregate behavior; moreover, cross-country and intracountry correlations among industries make it clear that it is not changes in particular technologies that are driving economic behavior, but events within countries.

In our model the shifts in the supply functions are a result of changes in perceptions, e.g., of risk, and changes in equity. Small disturbances can have large macroeconomic effects.

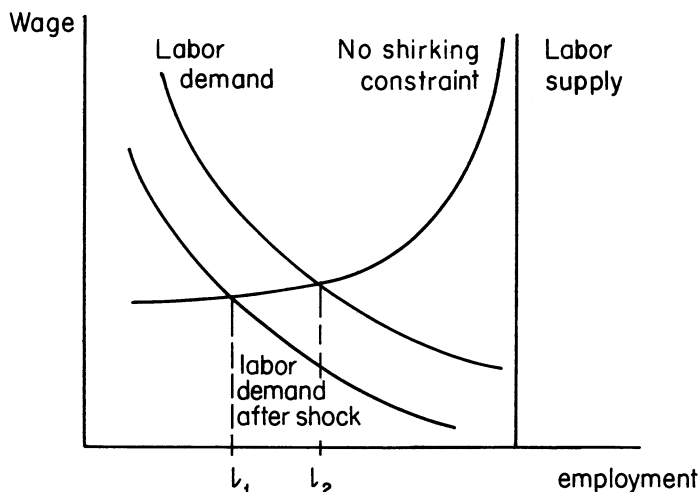


FIGURE VII

Labor Market Equilibrium in a New Keynesian Model

Equilibrium occurs at the intersection of the labor demand curve and the no-shirking constraint. Shocks to the economy shift the demand curve for labor, leading to increased unemployment.

IV. CLOSING THE MODEL: NEW KEYNESIAN MODELS

Like the real business cycle models, the model of the previous section has the unattractive feature that there is (by assumption) no unemployment. However, the model may easily be extended to incorporate unemployment. We simply substitute for the labor supply equation a no-shirking equation (as in Shapiro and Stiglitz [1984]), which specifies the wages firms must pay to elicit effort from workers as a function of the employment level:²⁹

$$(27) \quad w = \Omega(l).$$

Recognizing the dependence of l on q , we obtain an equation identical in form to (20). The rest of the analysis proceeds just as before.

In Figure VII we have drawn the no-shirking constraint, and the equilibrium is at the intersection of the labor demand curve and the no-shirking constraint. Shifts in the labor demand curve (caused by changes in equity levels or risk perceptions) now can

29. The no-shirking wage at time t will depend on expectations of wages and employment levels at future dates. For purposes of this analysis these expectations are being kept fixed.

cause marked changes in the level of unemployment, with relatively small changes in real wages.

A. Aggregate Demand Effects

To traditional Keynesians the model of this paper may appear strange: it seems to attribute all the sources of output variability to the supply rather than the demand side. In one sense, the paper can be thought of as attempting to establish the proposition that supply side effects, if appropriately modeled, may be able to explain a significant amount of the variability in economic activity, a proposition in accord with standard real business cycle doctrine.

On other hand, slight extensions of the model show how intimately demand and supply side considerations are interwoven, and that the dichotomy between “demand” and “supply” side shocks may be, at best, misleading.

In the model of this paper each firm only uses labor. But in fact, production of each commodity uses inputs from other sectors. Just as “equity” and “perception” shocks (whatever their sources) lead to decreased supply of output and decreased demand for labor, so too do they lead to decreased demand for the outputs of other firms. The demand curves these other firms face shift to the left, prices they receive fall, and hence, the effects of a shock to one sector have been transmitted to another sector, whence they can be retransmitted, amplified, back to the original sector. *Supply responses in one sector lead to demand disturbances in other sectors, which in turn lead to supply disturbances in those sectors.*

B. Investment Behavior

Equally importantly, not only does a firm respond to equity and perception shocks by reducing output, labor, and inputs of other goods, it also reduces investment.

One widely observed characteristic of business cycles is that fluctuations are disproportionately severe in the investment goods sectors—fixed business investment and construction, residential construction, consumer durables—of a typical industrial economy. Peak-to-trough variations in activity in these sectors are greater than variations in the economy as whole. This presents a puzzle for traditional models since, in theory at least, investment projects should be less intensely subject to the pressures of cyclical variations than shorter term undertakings. If firms are risk neutral and on average forecast future output accurately (including a future recovery from the current recession), then even firms facing

constraints on current demand should undertake some counter-cyclical investment (for plausible values of the relevant cost curves). The costs of installation and bringing plants on line should be lower in slack than in tight periods; long lead times for many investments argue against basing projections of demand at the time of plant completion on *current* capacity levels and relatively small reductions in investment goods prices should be sufficient to shift timing decisions. Thus, the fact that investment is so strongly procyclical suggests that more is involved than simply a passive response to fluctuations in aggregate demand. The paradoxical nature of these investment fluctuations is compounded by the observation that the fluctuations often appear largest in those sectors where traditional arguments for fixed prices (and wages) appear to be weakest, e.g., home construction.

There are at least two ways in which a simple extension of the model of this paper can account for these phenomena. First, investment goods sectors such as residential construction may for informational reasons (i.e., they produce highly complex goods with high private information content) have particularly restricted access to equity markets. At the same time firms in these industries operate with high degrees of leverage. Demand disturbances that reduce the equity bases of firms in these sectors will, thus, produce particularly large output responses.

Second, if fixed investment is thought of as current expenditures that yield output several periods in the future, the relative price uncertainty surrounding these expenditures is likely to be far greater than that associated with expenditures on next period's output. As depletion of a firm's equity base requires a reduction in the risk that management is willing to bear, this reduction should fall disproportionately on the firm's riskiest activities. Hence, the model predicts disproportionate cyclical variations in the demand for investment goods.

C. Modeling Demand and Supply Effects Simultaneously

To see how these aggregate demand effects can easily be incorporated into our macro-model, we postulate that there are two sectors of the economy: an investment goods sector which produces to order, and for which, accordingly, there are no supply side effects; and the consumption goods sector, which we have previously modeled.

We postulate that the investment goods sector is competitive, and that its technology is described by the labor requirements

function $\varphi(I_t)$, with $\varphi' > 0$, $\varphi'' > 0$. There are (at least in the short run) diminishing returns in the investment goods sector. Let p_t be the price of capital goods at time t . Then, using an analysis parallel to that of the first part of the paper, it is easy to show that the demand for new capital I_t^d , is given by

$$(28) \quad I_t^d = I^d(p_t, w_t, \delta; a_t; K_t; x),$$

where x is a vector describing firms' expectations of future values of the relevant variables, including p and w , and K is the inherited capital stock. The demand for new capital goods depends on the price of capital goods, the cost of capital δ , the cost of alternative inputs (labor), the current capital stock, and expectations. For simplicity, we take expectations as given.³⁰ Then equilibrium in the new capital goods market, which we assume is competitive, requires that price equal marginal cost, or

$$(29) \quad p_t = w_t \varphi'(I_t),$$

and demand equal supply. Thus, substituting (28) into (29), we obtain

$$(30) \quad p_t = w_t \varphi'(I_t^d(p_t, w_t, \delta; a_t; K_t; x)).$$

Equation (30) can, in turn, be solved for p_t as a function of w_t , a_t and the other variables:

$$(31a) \quad p_t = y(w_t; a_t; \delta; K_t; x),$$

and, substituting (31a) into (28), for investment,

$$(31b) \quad I = I^*(w_t; a_t; \delta; K_t; x).$$

If we assume that the labor market is competitive, we can now rewrite the labor market equilibrium condition (19) as

$$(32) \quad \phi(q_t) + \varphi(I^*(w_t; a_t; \delta; K_t; x)) = s(w_t),$$

where, it will be remembered, q_t is now interpreted as the output of consumption goods, which depends on wages and a_t . This can be solved for w_t .

More relevant for our current purpose, with an efficiency wage model, we replace (32) with

$$(33) \quad \phi(q_t) + \varphi(I^*(w'_t; a_t; \delta; K_t; x)) = \Omega^{-1}(w_t).$$

30. Though the analysis would be little affected if we made them dependent on the other exogenous or endogenous variables within the model.

The left-hand side of (33) is the aggregate demand curve for labor.

The amount firms are willing to supply, q , and I , the amount firms wish to invest, depend on the same factors. Shocks to a_t will depress both q_t and I_t , hence shifting the demand curve for labor to the left, and (in Figure VII) increasing the unemployment rate.

This section has shown how bankruptcy risk can depress economy activity in a way quite independent from that discussed in earlier sections: bankruptcy risk affects the demand for investment as well as the supply of output.

We now see more clearly why the dichotomy between demand and supply effects is somewhat misleading. Decisions to invest are at least partly related to decisions concerning future supply. If similar factors affect current and future supply, similar factors will affect supply and investment demand.³¹

Separating out of the two, the demand and supply effects, may be an empirically difficult matter. Consider commercial construction. Some of the decrease in production during a slump is due to builders who normally build speculatively, in anticipation of demand, decreasing their production.³² Some of the decrease in production is due to a decrease in demand by firms for investment in plant. Restoration of the equity of builders (or increasing the availability of credit) will have a positive supply side effect; restoration of the equity of firms will have a positive demand side effect. Improved expectations about future economic conditions will have positive effects on both sides.

V. SOURCES OF SHOCKS

This paper has stressed how, in the absence of perfect risk markets, shocks to the economy can be amplified, and transmitted from one firm or sector to another. Given our claim that relatively small shocks can generate large effects, there is little necessity to search for the basic cause of economic fluctuations: one time it may

31. The discussion of the preceding paragraph suggested several reasons why I might even be more sensitive to variations in a than is supply in the noninvestment goods sector.

By assuming that investment goods are produced to order, we have greatly simplified the analysis, but left out of it several of the considerations we noted in earlier paragraphs of this subsection. In this more general model, the price of investment goods, q_t , would be determined to equate demand and supply in the investment goods sector. Shocks to a shift both the demand and supply curve for investment to the left. We may thus see large variations in employment in the investment goods sector, with relatively little change in the price.

32. Part of this decrease is due to credit rationing effects, which we have ignored in this paper.

be a monetary shock; another time an oil price shock; and another time a failed harvest.

There are two basic sources of shocks in our model: price shocks (resulting from unanticipated shifts in the demand curve) and “uncertainty” shocks.

A. Sources of Price Shocks

There are innumerable possible ways to model the sources of these price shocks. The simplest is to assume that output is sold on a large international market and international prices vary in response to forces which are external to the economy in question.

A more traditional source of such “shocks” would be a monetary sector that determines the aggregate price level. From this perspective, an unexpectedly low level of P_{t+1} might be associated either with an unexpectedly low level of money supply or, for some money demand specifications, with an unexpectedly low level of consumption demand. Explorations of these phenomena are contained in Greenwald and Stiglitz [1986], but they add relatively little (at the cost of some complexity) to understanding the basic characteristics of the model in question.

In all cases, as in many monetary models with real effects, the source of the real effect is a redistribution of assets as a result of the “price shock.” In most of these models (see, for example, Grossman [1985]), the redistribution involved is a redistribution of wealth among households, and it is difficult to believe that such a redistribution would have significant macroeconomic consequences. In contrast, the redistribution that occurs in the model of this paper is between the equity and debt of firms. It is for practical purposes a redistribution between managers or owners who make production decisions and passive investors or lenders. Given the important information asymmetries, this should more readily be expected to have a significant impact on output. In the model the effects of any associated redistributions of wealth among consumers are, given the underlying assumptions on consumer behavior, nonexistent.

B. Uncertainty Shocks

The second variety of shock that might be expected to have persistent consequences is what might be referred to as an “uncertainty shock.” An increase in the perceived uncertainty of future relative prices will, in general, lead to a reduction in the level of output (i.e., a downward shift in the function $H(a_t)$, the output

supply equation (22)). If the increase in uncertainty is permanent, then the drop in output at each level of a will be permanent. However, if

$$1 - (1 + \delta)w_t\phi' - (1 + \delta)\psi'\phi < 0,$$

then the drop in output is associated with a simultaneous upward shift in the function G , the equity supply equation (25); assuming no change in the net dividend function $m(a_t)$, lower output raises profitability which increases the flow of new equity (see Figure VIII). As $G(a_t)$ shifts upward, a^* increases, and there is a gradual adjustment to the new higher steady-state level of equity. This is accompanied by a slow steady, but perhaps incomplete, recovery from the initial drop in output. The pattern is again one of slow, persistent, fully anticipated recovery.

VI. APPLICATIONS AND EXTENSION

The formal model presented above is a model of “persistent” cycles in the sense that recovery from the trough of a recession follows an extended path involving a predictable sequence of positive increments to output. As noted in the introduction to this paper, simple extensions of the model can account for other widely noted cyclical phenomena. Several extensions are described in this section of the paper.

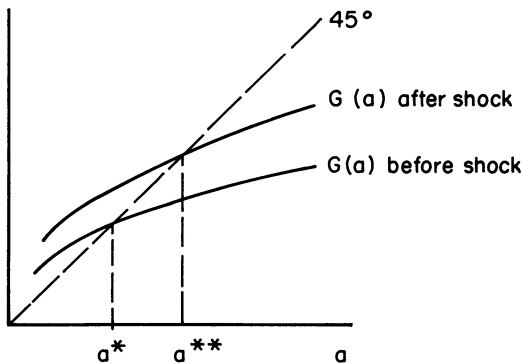


FIGURE VIII

Effect of “Uncertainty” Shocks on the Equity “Supply” Equations
At each value of a_t , a_{t+1} is increased. Equilibrium a is increased.

A. Inventory Fluctuations and Interfirm Interactions

Traditional theory has found it particularly difficult to account for the cyclical pattern of inventory fluctuations (see Blinder [1986]). While firms typically accumulate excess inventories in the early part of a recession, they typically not only reduce inventories in later parts of recessions, but even reduce inventory-sales ratios. With traditional production models, inventories should serve as buffers, allowing firms to engage in production smoothing. Given the low levels of real interest rates, and their relative invariance over time, even if real wages (and other factor costs) did not vary much over the business cycle, one would expect inventories to move countercyclically; a fortiori, if shadow wages (reflecting labor hoarding) are lower in recessions, then inventory accumulation should be greater.

Although our model, as it stands, does not directly incorporate inventories, a simple extension of the model offers some insight into the problem. Inventory accumulation early in the business cycle may simply reflect the desire of firms to take advantage of the lower marginal costs accompanying a reduction in demand. They do this until their asset position (achieved by converting financial assets into real assets in the process of inventory accumulation) so increases their potential exposure to financial distress that the process stops and, in the face of continuing shortfalls in demand, is reversed. This may be augmented by the effect of transfers of risk as the initial shock is transmitted to other firms in a vertical chain.

B. Unemployment

Earlier we suggested how the basic model could be extended to explain variations in unemployment, using the efficiency wage model. The model can also be used to explain why, in recessions, firms seem reluctant to hire new workers, even if there were no efficiency wage problems.

The existence of significant hiring and training costs may prevent the striking of mutually acceptable wage bargains between unemployed workers and potential employers. In making a wage offer in a recession (presumably involving an extended period of employment), a firm will count these costs highly since the associated outlays will carry a high "risk" premium at a time when the firm's equity base is severely depleted. In order to recoup this "risk" cost, the firm will require a substantial saving in future wages in order to justify countercyclical hiring. From the perspective of the worker, these wage sacrifices may not be justified.

Unless his financial position is so impaired that immediate employment is a necessity, it may well pay the worker to attempt to outwait the recession. He knows that as the financial positions of firms improve, the effective cost to a firm of hiring and training will decline and wage offers will improve accordingly. Thus, the model provides a "waiting" motive for unemployment; in a recession a worker may rationally wait for an improvement in economic conditions (until his financial resources are depleted and he must accept a job). The worker could, of course, himself offer to bear hiring and training costs and to defer wages but there are some basic difficulties with this.

First, the commitments of the firm to pay higher wages in the future³³ may not be credible. Second, the individual in this position is, in effect, a supplier of a kind of equity capital: there is no fixed commitment to repay, even if the firm has the best of intentions. Thus, the usual moral hazard and adverse selection difficulties arise; it is precisely those firms that are in the worst financial position (e.g., Eastern Airlines) that will be most anxious to "borrow" from their employees, and offer seemingly the most attractive terms.

C. Price Rigidities

Price rigidities may arise endogenously in the model whenever firms are imperfect competitors. Assume that these firms face demand curves that are inelastic in the short run but are characterized by sufficiently high long-run elasticities to restrain prices. Thus, raising prices increases current profits, but as customers are induced to search to find alternative suppliers, future profits are reduced. The restraint of this long-run elasticity depends on the rate at which future profits are discounted. As a firm's current equity base is depleted, the value of these uncertain future profits will fall relative to the immediate returns available from raising current prices. As a result, prices may increase despite low levels of current demand. And as all firms act in this way, the upward pressure on prices may be reinforced. In the context of empirical observation this may well look like downward price rigidity.³⁴

33. This is the flip side of the workers' inability to make commitments to accept low wages in the future. See Lindbeck and Snower [1989].

34. It should finally be noted that all these phenomena may be intensified by expectations cycles (see Woodford [1988]) which may be added within the framework of the basic model.

D. Wage Flexibility

Traditional theory has ascribed great importance to price and wage rigidities, without fully or even adequately explaining the sources of those rigidities.

We have already noted that sectors with more flexible prices are among the more volatile in the economy, which suggests that something beyond price and wage flexibility is at issue. Keynes too was skeptical about the importance of wage and price flexibility: he tried to argue that lowering wages might actually exacerbate the recession because of the induced aggregate demand effect.

Our paper has shown that the economy can exhibit high volatility even with flexible wages and prices. Indeed, as for Keynes, but for quite different reasons, downward wage and price flexibility may exacerbate an economic downturn. If prices and wages fall (or even rise less than anticipated), equity will be depleted, as firms have to pay back debt at real rates higher than anticipated. This paper has traced out the large negative effects that such equity depletion has on the whole economy.³⁵

VII. CONCLUDING COMMENTS

This paper has explored the consequences of three simple, but we believe plausible, characteristics of the economy: (a) firms act as if they are equity rationed; (b) firms act as if they are averse to risk, to increasing the likelihood of bankruptcy; and (c) there are imperfect futures markets, production takes time, and inputs have to be paid before goods are sold. Accordingly, every production decision is a risky decision.

Under these circumstances, the level and distribution of net worth among firms has real macroeconomic implications. The simple model we presented can generate cyclical behavior and can explain why a variety of shocks to the economy (such as price shocks) have persistent effects. Moreover, the theory provides a set of explanations for a variety of phenomena which, at best, are difficult to explain within the traditional neoclassical paradigm. Most notably, while in the traditional model, investment, particu-

35. Elsewhere [Greenwald and Stiglitz, 1990] we model the banking sector, the effect of price declines on that sector, and the effect of that sector on the rest of the economy. Lower than anticipated prices represent a redistribution from firms to lenders, which, in many cases, are banks; at the same time higher rates of bankruptcy both increase their perception of risk and deplete bank's equity supply; both of these effects lead to reduced lending behavior.

larly in inventories, should have a smoothing effect, dampening fluctuations in demand, the variability of investment seems to contribute to these fluctuations. Such fluctuations could only be consistent with plausible assumptions concerning technology (adjustment costs, etc.) if the cyclical movements were accompanied by greater variations in real interest rates and movements in (shadow) real wages than are in fact observed. While Keynes was willing to let Animal Spirits serve as the *deus ex machina* to retrieve an explanation of investment variability, our theory provides a more plausible explanation of variability in investment, or at least one that is more consistent with currently fashionable strictures on hypotheses concerning expectation formation.

We have noted too that traditional theory failed to provide a rationale for price (and wage) rigidity and, while ascribing considerable importance to these rigidities, failed to explain why output fluctuations were greater in the seemingly flexible price sectors. Our theory provides a rationale for price rigidities and an explanation for why sectors with flexible prices (e.g., residential construction) may suffer greater output variability.

Our model provides an explanation of another long-standing conundrum in economics. Keynes argued that firms should be on their supply functions, and that accordingly, when output was reduced, real wages should increase. Real wages do not increase to the extent that standard production function models would have predicted. The resolution provided by much of the recent (fixed-price) literature, that firms are demand constrained (just as in the labor market, workers are demand constrained), is not totally plausible: why in a competitive environment should firms that are able to solve the complex production problems which these models postulate that they can, not be able to discover that by lowering their prices, they could steal customers away from their rivals and hence increase their profits?

The explanation provided by our model is that firms may, indeed, be on their supply function; but that the supply function has shifted to the left, not because of the disappearance of capital, but because of increases in uncertainty and changes in the distribution of firm equity.

While our model suggests that wage and price flexibility may exacerbate the problems of an economy facing a downturn, it suggests that other government policies to stabilize the economy may be less effective than a partial-equilibrium model might suggest. Stabler environments induce firms to take more risks,

making them and the economy more vulnerable to shocks. But the welfare gains from such stabilization measures are to be measured not just by the reduced volatility of the economy, but by the increased output (productivity, investment) which (at any level of firm equity) the firm undertakes.

Macroeconomic phenomena—unemployment, the variability in output and investment, the lack of variability in wages and prices—are complex. No single model, or even a simple set of explanations, is likely to inform us concerning all of its important aspects.

In this paper we have argued that understanding capital markets, the constraints that imperfect information imposes on the ability of individuals to divest themselves of risk, is essential to understanding certain aspects of macroeconomic behavior. Other informational problems and the constraints to which they give rise, including credit rationing, are, we would argue, essential to understanding other aspects of these phenomena.

COLUMBIA UNIVERSITY
STANFORD UNIVERSITY

REFERENCES

- Asquith, P., and D. W. Mullins, "Equity Issues and Stock Price Dilution," *Journal of Financial Economics*, XIII (1986), 296–320.
- Bernanke, B., and M. Gertler, "Agency Costs, Net Worth and Business Fluctuations," *American Economic Review*, LXXIX (1989), 14–31.
- Bhattacharya, S., "Imperfect Information, Dividend Policy and the Bird-in-the-Hand Fallacy," *Bell Journal of Economics and Management Science*, X (1979), 259–70.
- Blinder, Alan S., "Can the Production Smoothing Model of Inventory Behavior Be Saved?" *Quarterly Journal of Economics*, CI (1986), 431–54.
- Eaton, J., M. Gersovitz, and J. E. Stiglitz, "Pure Theory of Country Risk," in *European Economic Review*, XXX (1986), 481–513.
- Fazzari, S., G. Hubbard, and G. Peterson, "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity* (1988), 141–206.
- Grandmont, J. M., "On Endogenous Competitive Business Cycles," *Econometrica*, LIII (1985), 995–1046.
- Greenwald, B., and J. E. Stiglitz, "Information, Finance Constraints and Business Fluctuations," *Proceedings of the Taiwan Conference on Monetary Theory* (Taipei, Taiwan: Chung-Hua Institute, 1986).
- Greenwald, B., and J. E. Stiglitz, "Imperfect Information, Credit Markets and Unemployment," *European Economic Review*, XXXI (1987), 223–230.
- Greenwald, B., and J. E. Stiglitz, "Examining Alternative Macroeconomic Theories," *Brookings Papers on Economic Activity* (1988a), 207–70.
- Greenwald, B., and J. E. Stiglitz, "Financial Market Imperfections and Business Cycles," NBER Working Paper No. 2494, 1988b.
- Greenwald, B., and J. E. Stiglitz, "Toward a Theory of Rigidities," *American Economic Review*, LXXIX (1989), 364–69.
- Greenwald, B., and J. E. Stiglitz, "Macroeconomic Models with Equity and Credit Rationing," in *Information, Capital Markets and Investments*, R. Glenn Hubbard, ed. (Chicago, IL: University of Chicago Press, 1990).

- Greenwald, B., J. E. Stiglitz, and A. M. Weiss, "Informational Imperfections and Macroeconomic Fluctuations," *American Economic Review, Papers and Proceedings*, LXXIV (1984), 194-99.
- Grossman, S. J., "Money and Macroeconomic Fluctuations," unpublished paper, Princeton University, 1985.
- Hall, R. E., "The Relation Between Price and Marginal Cost in U. S. Industry," *Journal of Political Economy*, XCVI (1988), 921-47.
- Hart, Oliver, "Comment on Costly State Verification Models," presented at Nobel Symposium, August 1990, Saltsjöbaden/Stockholm.
- Hicks, John, "Towards a More General Theory," in *Finance Constraints, Expectations, and Macroeconomics*, M. Kohn and S.-C. Tsiang, eds. (Oxford: Clarendon Press, 1988).
- Hubbard, G., editor, *Asymmetric Information, Corporate Finance and Investment* (Chicago, IL: University of Chicago Press, 1990).
- Kalecki, M., *Essays in the Theory of Economic Fluctuations* (New York, NY: Russell and Russell, 1939).
- Klamer, A., "An Accountant Among Economists: Conversations with Sir John Hicks," *Journal of Economic Perspectives*, III (1989), 167-180.
- Kuh, Edwin, and John R. Meyer, *The Investment Decision* (Cambridge, MA: Harvard University Press, 1959).
- Leijonhufvud, Axel, *On Keynesian Economics and the Economics of Keynes* (New York, NY: Oxford University Press, 1968).
- Lindbeck, Assar, *A Study in Monetary Analysis* (Uppsala, Sweden: Almqvist and Wicksell, 1963).
- Lindbeck, Assar, and Dennis J. Snower, *The Insider-Outsider Theory of Employment and Unemployment* (Cambridge, MA: MIT Press, 1989).
- Lintner, J., "Corporate Finance: Risk and Investment," in *Determinants of Investment Behavior*, R. Ferber, ed. (New York, NY: NBER, 1971).
- Mankiw, N. Gregory, "Real Business Cycles: A New Keynesian Perspective," *Journal of Economic Perspectives*, III (1989), 79-90.
- Mayer, C., "Financial Systems, Corporate Finance, and Economic Development," *Asymmetric Information, Corporate Finance, and Investment*, R. G. Hubbard, ed. (Chicago, IL: University of Chicago Press, 1990).
- Minsky, Hyman, *John Maynard Keynes* (Cambridge University Press, 1975).
- Myers, S. C., and N. S. Majluf, "Corporate Financing and Investment Decisions When Firms Have Information that Investors Do Not," *Journal of Financial Economics*, XI (1984), 187-221.
- Phelps, E. S., and S. G. Winter, "Optimal Price Policy Under Atomistic Competition," in E. S. Phelps, ed., *Microeconomic Foundations of Employment and Inflation Theory* (New York, NY: W. W. Norton and Co., 1970).
- Rotemberg, Julio J., and Garth Saloner, "The Relative Rigidity of Monopoly Pricing," *American Economic Review*, LXXVII (1987), 917-26.
- Shapiro, C., and J. E. Stiglitz, "Equilibrium Unemployment as a Worker Discipline Device," *American Economic Review*, LXXIV (1984), 433-44.
- Shleifer, A., "Do Demand Curves for Stock Slope Down?" *Journal of Finance*, XLI (1986), 579-90.
- Stiglitz, J. E., "On the Optimality of the Stock Market Allocation of Investment," *Quarterly Journal of Economics*, LXXXVI (1972), 25-60.
- , "Price Rigidities and Market Structure," *American Economic Review*, LXXIV (1984), 350-56.
- , "Imperfect Information in the Product Market," in R. Schmalensee and R. Willig, eds., *Handbook of Industrial Organization* (Amsterdam: North-Holland, 1989a), pp. 769-847.
- , "Monopolistic Competition and the Capital Market," in *The Economics of Imperfect Competition and Employment—Joan Robinson and Beyond*, G. Feiwel, ed. (New York, NY: New York University Press, 1989b).
- Woodford, M., "Expectations, Finance and Aggregate Instability," in M. Kohn and S. C. Tsiang, eds. *Financial Constraints, Expectations, and Macroeconomics* (Oxford: Clarendon Press, 1988).