

Job Destruction in General Equilibrium

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I. Introduction

Aggregate job destruction occurs at an uneven pace over time. Recessions strike about once every five years, and are marked by sharp spikes in job destruction. At the same time, firms liquidate inventories—employment and production fall more than sales. Recessions are often preceded by sharp increases in real interest rates. This paper builds a general equilibrium model that mimics these events. In the model, firms face the question of whether to continue the operation of marginal plants and other productive units or to shut them down. An increase in the discount rate shifts the decision toward shutdown because the firm avoids the immediate costs of holding inventories and other capital, whereas the foregone profit lies in the future. The burst of job destruction and inventory decumulation that occurs during the sharp part of the typical contraction results from decisions to shut down units in firms throughout the economy.

Firms comprise productive units. A unit may be a plant, an operation within a plant, or the activities of a single worker. A unit is shut down when its continuation value falls below its liquidation value. The unit is closed and liquidated and the workers enter the labor market to make new matches. The two most prominent characteristics of recessions—bursts of job loss and high rates of inventory liquidation—are the result of the same mechanism, in this view. The role of shutdown decisions in inventory runoffs has not previously been explored, to my knowledge. It is well known, however, that shutdowns of various types account for a large fraction of the burst of job destruction that occurs at the beginning of a recession.

In the general equilibrium model I develop, the condition causing a recession is a widening of the wedge between the interest rate facing consumers

and the one facing producers. The widening of the wedge is exogenous and unexplained in the model, but is intended to resemble the financial crisis or stress that often precedes a recession, when, for example, the margin between private interest rates and those paid by the government widens. In the general equilibrium model, key macroeconomic variables move differently in different recessions, depending on the driving forces of the recessions. For example, consumption rises when a recession is caused by a decline in government purchases, but falls if the recession is caused by a temporary decline in technology or by a shift in the intertemporal marginal rate of substitution. But the relation between the discount rate and job destruction is common to many driving forces. Episodes of high discount rates tend to be accompanied by job destruction.

As a preliminary matter, I consider the channels that might operate in general equilibrium to inhibit the job-destruction-inventory-liquidation mechanism. In the standard model, the interest rate is locked to the marginal product of capital. The interest rate facing businesses can be no more volatile than the marginal product. Capital is smoothly substitutable for labor even in the short run. The standard DSGE model generates mild responses of the interest rate to surprises, because of the arbitrage principle. To put the point the other way around, the models embody a channel of strong intertemporal substitution. If goods are scarce in the current period relative to next period (that is, if the current one-period interest rate is high), goods can be moved from next period to this period by lowering the flow of investment.

An economy with flexible investment need never invade its inventories to alleviate an urgent need for current goods, nor will it ever experience the spikes of interest rates that go with inventory liquidation. Fluctuations in other categories of investment will cushion the economy against shocks. In the next section, I will consider the evidence on this point and conclude that the intertemporal substitution mechanism operating through investment is nowhere near as

powerful as it is portrayed in modern DSGE models. The investment arbitrage hypothesis is false. The DSGE program's quest for other mechanisms of intertemporal substitution—such as in labor supply—to explain the actual volatility of employment has been fighting the dampening effect of intertemporal substitution through investment. That fight is mistaken. DSGE models that employ more realistic views about investment can explain employment volatility without stretching in the direction of extreme intertemporal elasticities of substitution in labor supply.

The finding of the weakness of the intertemporal investment channel opens the way for fluctuations models based on relations between the interest rate and employment changes that would be almost fully offset otherwise. A key ingredient is explicit consideration of unemployment and the time required to place workers in new jobs after earlier jobs were destroyed. There has been an explosion of activity in the DSGE framework incorporating unemployment—see Hall [1998a] for many references. Almost without exception, modern research adopts the view of Diamond [1982] and Mortensen [1982] that unemployment is a bilateral search process. Their framework also provides a clear way to think about job destruction—the match between worker and firm ends when there is no longer any joint surplus from the relationship.

It appears to me that a coherent, realistic fluctuations model could be achieved by embedding the Diamond-Mortensen model of job destruction and search into a DSGE model with a realistic treatment of investment. The volatility in the discount rate that occurs when the investment channel is attenuated translates into a source of fluctuations in job destruction not present in a standard DSGE model. As I noted at the beginning of this introduction, job destruction accompanies high discount rates because output is freed when production units are shut down. Inventories are liquidated. High discount rates shift the decision about the continuation of marginal employment relationships toward termination

because the payoffs of continuation lie in the future, whereas the liquidation payoff is immediate. A simple general-equilibrium model of job destruction along these lines appears in Section V.

Section VI considers empirical evidence on the joint behavior of job destruction and inventory liquidation, on the one hand, and the discount rate on the other hand. The variables I consider are the Davis-Haltiwanger [1990] measure of job destruction, the change in employment, the change in inventories, and the 6-month commercial paper rate stated in real terms. In an 8-industry breakdown of U.S. industries, I find a strong positive relation between job destruction and the expected real rate and a strong negative relation between employment growth and the expected real rate. In the four industries that hold inventories (manufacturing durables and nondurables and wholesale and retail trade), there is some indication of a positive association between the expected real rate and inventory liquidation.

An unresolved but important issue in the economics of recessions is the efficiency of decisions to lay off workers. By efficiency, I mean the maximization of the joint value achieved by workers and firm. A shutdown imposes substantial periods of foregone work on the job-losers and it may require investment to occur elsewhere in the economy to create replacement jobs. Efficient decisions balance all of the positive and negative effects of a shutdown on the firm and the workers. The negatives are the lost output from the unit that is shut down and the resources needed to equip the replacement jobs (or, equivalently, the diminution in productivity of other workers when newly hired workers are squeezed onto existing facilities). The positives are the liquidation value of the old unit and the higher level of output in a new unit, after the time for the displaced workers to return to work. This paper assumes full efficiency in job destruction decisions.

It may be worth exploring a different framework in which shutdowns are not necessarily bilaterally efficient between employer and worker. In that

framework, firms make unilateral shutdown decisions guided by the profit they earn under simple contracts with their workers. A shutdown sacrifices the present value of profit from the unit—the difference between its revenue and the contractual wage payments made to workers. The shutdown gains the liquidation value. Such a model would yield much higher volatility of job destruction for given volatility of its driving forces.

II. Evidence on the Strength of Intertemporal Substitution through Investment

This section summarizes findings that are spelled out in more detail in Hall [1998b]. DSGE models generally incorporate, at least implicitly, a demand function for capital services along the lines of

$$(1 - \alpha) \frac{y_t}{k_t} = \bar{r}_t + \psi \quad (2.1)$$

Here α is the elasticity of output, y , with respect to employment, k is the capital stock, \bar{r} is the expected real interest rate, and ψ is a constant embodying depreciation and the difference in risk between physical capital and one-period debt.

Equation 2.1 should be considered in the light of finance theory. DSGE models embody, implicitly, the consumption capital-asset pricing model (Lucas [1978] and Hansen-Singleton [1983]). According to that view, the difference between two stochastic returns should be approximately a constant plus an unpredictable white noise disturbance. The formula on the left is the return to physical capital, that is, the marginal product of capital. It differs from the expected return to debt by a constant plus white noise. The empirical evidence

was unfavorable to the consumption CAPM even before Hansen and Singleton demonstrated the failure of the model. But the traditional CAPM based on the total market rather than consumption has been more successful and also has the property that expected returns differ by constants.

Despite its critical importance in the behavior of the DSGE model, the capital demand equation has received remarkably little attention. Kydland and Prescott [1982] considered one source of potential failure of the equation, the time required to put new capital in place. But since then, the topic has not been pursued in the DSGE literature. The subject has arisen in work on investment over the past three decades in the form of testing for adjustment costs—see Abel [1990]—but the results have not generally been interpreted as troublesome for the investment-arbitrage mechanism built into the DSGE model.

My testing allows for convex adjustment costs in the standard way. I compute the realized return to capital by renormalizing the investment Euler equation (Shapiro [1986]). The relation between this return, r_t , and the return from a financial instrument held for the same period, $r_{F,t}$, according to finance theory, should be

$$E_t(r_t - r_{F,t}) = \gamma \quad (2.2)$$

The corresponding relationship between the realizations is

$$r_t - r_{F,t} = \gamma + \varepsilon_t \quad (2.3)$$

where ε_t is a rational expectations error, orthogonal to all information available at the time the investment decision is made.

The basic strategy is to estimate the following generalization:

$$r_t - r_{F,t} = \gamma - \theta r_{X,t} + \varepsilon_t \quad (2.4)$$

The variable $r_{X,t}$ is constructed to be a close counterpart of $r_{F,t}$ that is known just before the investment decision is made. For $r_{F,t}$, I use the real after-tax commercial paper rate over a one-year period. $r_{X,t}$ is the nominal after-tax commercial paper rate in the month before the beginning of the year less the actual rate of inflation during the preceding year. If arbitrage occurs according to the dictates of finance theory and the return to capital, r_t , is properly measured, including the role of adjustment costs, then the parameter θ will be zero. On the other hand, if arbitrage between physical capital and financial capital is not completely effective, r_t will not track changes in $r_{F,t}$, and therefore in $r_{X,t}$, and the parameter θ will be positive.

The results to be discussed here are for industrial equipment aggregated over the private economy. Table 1 shows the basic results from testing the orthogonality condition, equation 3.5, for a range of values of the adjustment cost coefficient. The standard errors are calculated from the Newey-West [1987] HAC covariance matrix. The results strongly reject orthogonality. Over the entire range of values of the adjustment cost parameter, the estimate of the parameter, θ , that measures the magnitude of the failure of orthogonality is around 1, meaning that there is no indication from the results that the return to capital bears *any* resemblance to the return to an alternative financial investment.

Adjustment cost parameter	0.0	1.0	2.0	4.0
Coefficient for $r_{X,t}^*$	0.932	.980	1.018	1.073
Robust standard error	0.283	0.254	0.236	0.217
p -value for hypothesis $\theta = 0$.0024	0.0005	0.0001	0.0000

Table 1. Test Results for Orthogonality Condition

The coefficient of roughly 1 means that there is no tendency for the expected return to capital to incorporate, as of the beginning of the year, information available at that time about the real return to the alternative investment in commercial paper.

The standard DSGE model assumes that all vintages of capital can be aggregated—this assumption helps keep the dimension of the model’s state space under control. There are good reasons to think that vintages do not aggregate, however. Hall [1998b] builds a simple vintage capital model and asks whether the test developed in that paper gives a rejection in that model when arbitrage is occurring in the way dictated by the vintage model. According to the model, firms adjust the quantity of investment in the current period so that the expected return is equated to the expected return on financial assets, after adjustment for risk. New physical capital is not a close substitute for previously installed capital. Rather, each vintage has its own capital/labor ratio fixed at installation. For existing vintages, vintage-specific prices fluctuate to equate risk-adjusted rates of return.

I simulate an extended period with the vintage model and then apply the test to the resulting data. Although the standard error of the test coefficient θ is small, the test does not reject the arbitrage hypothesis. I conclude that the vintage

structure of the capital stock by itself does not explain the strong rejection of the arbitrage hypothesis in actual data.

These results support the research strategy of developing models with limited responses of investment to driving forces. In the standard DSGE model, fluctuations in the flow of investment inhibit many of the ways that shocks would otherwise influence the level of employment. For example, a transitory but large increase in government purchases of goods and services raises employment by only a little in the standard DSGE model because it results in an equally large transitory reduction in investment. Shutting down investment will result in a much larger employment increase.

The constraint to be explored in the rest of this paper is to make capital a perfect complement of labor. This assumption cannot be taken seriously across capital in general—the evidence of considerable capital-labor substitution is far too strong. Instead, the model should be considered an approximation to one where certain types of capital, especially inventories, are complements to labor. Other capital enjoys some degree of substitution for labor, especially before it is installed. But the process of substitution is sluggish and does not permit the strong fluctuations in the flow of investment that would otherwise inhibit interesting channels of response to shocks in the short run.

III. Economics of the Shutdown Decision

The shutdown decision fits into the general framework of research on the employment contract. That research has two branches relevant for this issue. The older branch—currently inactive—includes Hashimoto and Yu [1980], Hart [1983], Hall and Lazear [1984], and Kahn and Huberman [1988]. Separation or shutdown decisions are made unilaterally by worker or firm, subject to a fixed-

wage contract. The discussion of the design of the contract is strongly influenced by the literature on mechanism design derived from Mirrlees's [1971] famous paper.

Modern thinking about the employment relationship, as reflected in Diamond [1982a and b], Mortensen [1982], Ramey and Watson [1997], Caballero and Hammour [1996a, 1996b, and 1997], and hundreds of other papers, insists that strategic relationships, such as the employment relationship, satisfy the criterion of subgame perfection. Parties will not adhere to terms such as fixed wages that they can negotiate around later to their mutual benefit. An employment contract does not necessarily guide the relationship as stated, but only establishes the threat points for a subsequent bilateral bargaining problem. The Nash solution to that bargaining problem—where the parties split the joint surplus from their relationship—governs the outcome. For further discussion of the relation between the two branches, see Aghion, Dewatripont, and Rey [1990] and Hall [1995, 1997b, and 1998a].¹

The fixed-wage-contract view leads naturally to the conclusion that inefficient shutdowns can occur. The firm takes the wage as the value of the workers' time; if the wage overstates that value, the firm may shut a unit down despite the resulting reduction in joint value. Firms pay the lowest wage needed to attract workers in the first place and stick to that wage. In making decisions about shutdowns, firms treat the wage as a cost. These contracts have the substantial advantage of preventing workers from appropriating the investments that firms sink in their relations with their workers. Firms enjoy the full benefits of those investments and therefore invest up to the social optimum.²

¹ The recent literature on contracts in general has gone through a similar transformation—see, for example, Segal and Whinston [1996, 1997].

² Caballero and Hammour [1996a, 1996b, 1997] stress the inefficiencies of appropriability but assume that fixed-wage contracts cannot solve the problem, because of renegotiation.

The modern view holds that fixed-wage contracts—whatever their merits—fail the elementary test of subgame perfection. The parties have the power to make Pareto improvements after random realizations occur and they cannot be expected to fail to exploit the power. The source of the power is the requirement that the employment contract gives both workers and firms the unilateral rights to end the relationship. No practical contract can be designed without these rights. The exercise of these rights defines the threat points of a bargaining situation that exists throughout the relationship. In each period, the parties divide the joint surplus—the difference between the continuation value and the combined shutdown values—in specified proportions. Only when the joint surplus reaches zero does shutdown actually occur, and shutdown is efficient in this case.

As Mortensen [1982] pointed out in his original analysis, and recent authors in this branch of the literature, such as Hosios [1990] and Caballero and Hammour [1997] have stressed, match-specific investments are inadequately compensated in the surplus-sharing setup, unless they are made jointly.

I will not try to resolve this major watershed issue in the modern theory of the employment relationship. I follow most current thinking by positing efficient separations. On the other hand, the empirical results do not rest on any assumptions about efficiency. The strength of the findings might reasonably be interpreted as supporting the model of inefficient fixed-wage employment relationships.

IV. Inventories

A key feature of the view of recessions developed in this paper is that the burst of inventory disinvestment that occurs during the sharpest part of the typical

contraction is the result of a process that also causes job destruction. Employment changes and inventory investment are in fact closely linked, as Figure 1 shows. A two-sided distributed lag relation between manufacturing inventory investment (as a fraction of total GDP) and employment growth accounts for most of the cyclical behavior of inventories.

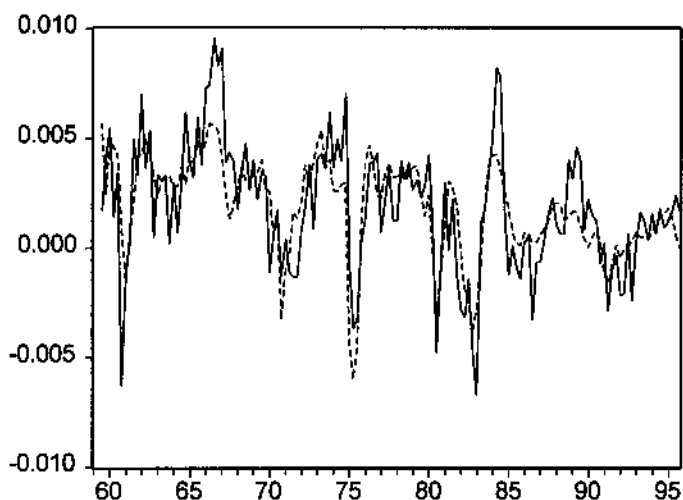


Figure 1. Relation between Manufacturing Inventory Investment (as a Percent of GDP) and Employment Growth

V. Recessions in General Equilibrium

This section develops a simple general equilibrium model of recessions where an event causes an increase in the interest rate, which then triggers a burst of job destruction. A simplifying assumption is perfect foresight—there is no uncertainty in the model (it is DGE, not DSGE).

In the model, new productive units are created when a searching worker is matched to a production opportunity. Initially, the worker produces one unit of output per period, when equipped with capital formed from γ units of output.

With probability π each period, the productive opportunity degrades so that it produces only $\omega < 1$ units of output with the same inputs. There are n_t workers in higher-productivity jobs and x_t workers in lower productivity jobs. At the beginning of the period, a decision is made whether to continue the employment of each worker in a lower-productivity job or to shut the unit down and release the worker into search. Searching workers have a probability ϕ of finding a new, high-productivity match each period (there are no congestion externalities).

Irrespective of their individual experiences, all workers consume the same amount,

$$c_t = n_{t-1} + \omega x_{t-1} - \gamma(n_t + x_t - n_{t-1} - x_{t-1}) , \quad (5.1)$$

thanks to perfect insurance markets. Consumers have constant-elastic preferences with intertemporal elasticity of substitution σ and rate of time preference δ . The rate of interest used in making shutdown decisions is

$$r_t = \left(\frac{c_{t+1}}{c_t} \right)^{\frac{1}{\sigma}} (1 + \delta) + z_t - 1 , \quad (5.2)$$

The sequence z_t describes a financial disturbance, the wedge between the consumer interest rate and the business rate used in shutdown decisions.

Let d_t be the volume of job destruction—the number of workers released as a result of shutdowns. Then workers transit among states as follows:

$$n_t = (1 - \pi)n_{t-1} + \phi s_{t-1} , \quad (5.3)$$

$$x_t = \pi n_{t-1} + x_{t-1} - d_t , \quad (5.4)$$

$$s_t = (1 - \phi)s_{t-1} + d_t \quad , \quad (5.5)$$

The key economic decision in the model, captured by the variable d_t , is whether to retain workers and continue units in production, or whether to shut down units, destroy the corresponding jobs, and release workers into search. To describe this decision, I let H_t be the value associated with a high-productivity match, L_t be the value for a low-productivity match, and U_t be the value associated with unemployment and job search. The current values are related to discounted future values according to

$$H_t = \frac{1}{1+r_t} [1 + \pi L_{t+1} + (1 - \pi)H_{t+1}] \quad , \quad (5.6)$$

$$L_t = \max \left[\frac{1}{1+r_t} (\omega + L_{t+1}), \gamma + U_t \right] \quad , \text{ and} \quad (5.7)$$

$$U_t = \frac{1}{1+r_t} [(1 - \phi)U_{t+1} + \phi(H_{t+1} - \gamma)] \quad . \quad (5.8)$$

In equation 5.7, the firm and worker compare their joint continuation value, $\frac{1}{1+r_t}(\omega + L_{t+1})$, to their breakup value, $\gamma + U_t$, and act accordingly. The avoided investment cost, γ , is key. By liquidating some inventories and not making new investments in inventories and other capital, current outlays can be avoided or cash raised by shutting down.³

³ In principle, there is a third option, to continue the affiliation of the worker and the firm, but without working or holding capital (labor hoarding). The condition for this to occur is $r_t \gamma > \omega$. But the actual values never come close to this condition in practice.

I will assume that low-productivity jobs are viable in the steady state when $z_t = 0$ and $r_t = \delta$. That is, units are not shut down when their productivity first drops from high to low, and, since nothing changes thereafter, they are never shut down. In the steady state, all workers linger in low-productivity jobs and n_t and s_t are zero. The steady-state value of a low-productivity job is the present discounted value of its future earnings, $L = \frac{\omega}{\delta}$. The associated values of the other states are:

$$H = \frac{1 + \pi L}{\delta + \pi} \quad (5.9)$$

and

$$U = \frac{\phi(H - \gamma)}{\delta + \phi} \quad (5.10)$$

In the steady state, these values are implicit because no workers are actually holding high-productivity jobs or searching.

Low-productivity jobs are in fact viable in the steady state if:

$$L \geq \gamma + U \quad (5.11)$$

If the fundamentals result in the failure of this continuation condition, then the steady-state model will be, instead, a two-state Markoff process with workers distributed between high-productivity jobs and search. Job destruction occurs automatically whenever a unit drops to the lower productivity level. The corresponding dynamic model with z_t above and below zero will have constant

exogenous job destruction unless the discount rate drops low enough to cause a transitory interval when low-productivity units are kept in operation. During this interval, job destruction would fall to zero. A burst of destruction would follow if the interest rate rose to its normal level. Although this second case has some interesting features, I will concentrate on the first case where low-productivity jobs are viable in the steady state.

The model illustrates some simple points about reorganization and the cleansing effects of recessions. In the steady state, organizational capital is at a low level—if workers were rematched, they would be in more productive jobs at first. But that organizational capital is not worth its investment cost, that is, the search time of workers. So cleansing starting from the steady state does not pay off and does not occur. But a temporarily high interest rate will cause job destruction and subsequent formation of new organizational capital. The cleansing effect then more than offsets the search costs.

The effects of an increase in the interest rate in the model are ambiguous. Job destruction is part of the process of investing in organizational capital. On this account, one would expect a higher interest rate to go with lower job destruction. Times of high interest rates are times of scarce resources when it is appropriate to defer all types of investment, including the formation of organizational capital. On the other hand, job destruction is also part of the process of disinvesting in the capital resources tied up in low-productivity jobs. When the interest rate rises above a critical level, it pays to release these resources immediately rather than to retain them to make future production possible. The capital/labor ratio γ has a key role. For lower levels of γ , the role of organizational capital dominates and a higher interest rate lowers job destruction. For higher levels, the role of physical capital dominates and a higher interest rate stimulates job destruction. As I will show, the evidence strongly supports the latter case.

The equilibrium of the model can be seen as a social planning optimum, because the wedge between the consumer and producer interest rate could be viewed as an aspect of consumer preferences and because there are no search externalities. In that interpretation, one could not speak meaningfully of the cost of a recession, since it is an optimal response to a shift in preferences.

The model has an investment channel, but it is tightly limited. Because of the strict complementarity of inventories and employment, the economy can invade its inventories only by destroying jobs. The complementarity is intended to capture the nature of the shutdown decision, where workers are let go at the same time that plants are shut down or shifts abolished. If the model had a standard investment channel associated with, say, unit elasticity of substitution between capital and labor for an important part of the capital stock, and no adjustment costs, the model's behavior would be uninteresting. The business interest rate would hardly change when the financial shock occurred; the entire shock would be incorporated in the consumer rate. The resulting change in consumption would be offset by an equal change in the opposite direction in investment. Employment would be almost unaffected.

Notice that the path of job destruction completely determines allocations in the economy—equation 5.3, 5.4, and 5.5 gives employment and equation 5.1 gives consumption, conditional on the path of job destruction. The economy begins with exogenous levels of employment and corresponding levels of capital. The supporting path of the interest rate can be calculated from equation 5.2 and the values associated with the states from equations 5.6 through 5.8. Terminal values can be taken as zero for a finite time horizon or the model can be subject to standard transversality conditions for an infinite horizon. It turns out to be easy to find the general equilibrium by starting with a vector of zero job destruction, calculating the net continuation value

$$C_t = \frac{1}{1+r_t}(\omega + L_{t+1}) - (\gamma + U_t), \quad (5.12)$$

and then updating the job-destruction vector by raising job destruction slightly for periods with negative values of C_t . This process can be iterated to the point of equilibrium, where job destruction is zero for all periods with positive values of C_t and $C_t = 0$ for periods with some destruction and some continuing low-productivity employment. As a practical matter, the possibility of all low-productivity jobs being destroyed in a period (with $C_t < 0$) can be neglected.

The model as described assumes perfect foresight—the economy faces no uncertainty about the future. I will use the model to calculate impulse response functions to changes in the financial driving force. The paths for the driving forces are the expected values immediately after an innovation has occurred. That is, I solve the perfect-foresight model as if the expected values were the deterministic future values. The resulting general-equilibrium calculations are analogous to the linearization often used in dynamic stochastic general equilibrium macro models.

The innovation in the driving force occurs during period 0, after employment has been determined, but before the division of the resulting output between end-of-period consumption and investment in period-1 capital. If the shock raises the discount rate to its critical value, job destruction will occur at the beginning of period 1, making a higher level of consumption possible at the beginning of period 1 by reducing the carryover of inventories to period 1. I performed the calculations with a horizon of 30 periods, but only display the first 15 values of the impulse responses.

I use the following parameter values:

γ	Inventory-sales ratio	6
σ	Intertemporal elasticity of substitution	1.0
δ	Rate of time preference	0.06
x_0	Labor supply	1
ϕ	Job-finding rate	0.4
π	Transition probability from high to low productivity	0.03
ω	Ratio of low productivity level to high level	0.885
σ	Intertemporal elasticity of substitution in consumption	

These values are illustrative and are not calibrated to empirical findings except in the roughest way. They place the economy just over the boundary where low-productivity jobs are viable in the steady state.

I consider the response to an innovation in the financial wedge of 0.20 which has just become known when the period-1 job-destruction-consumption decision is made. The wedge is eliminated by 60 percent each period thereafter. Figure 2 shows that job destruction occurs primarily in period 1 but slightly in period 2; there is none in later periods. Employment falls in period 1 by the amount of job destruction, unemployment rises by the same amount, and then both gradually return to normal as the displaced workers are matched to new jobs. The net continuation values for low-productivity jobs are zero in periods 1 and 2. The upper right panel shows the impulse response of the business interest rate. Of the 20 percentage points by which the financial wedge rose in period 1, the increase in the business rate accounts for a little over 6 percentage points. The consumer interest rate (not shown) falls by the other 12 points.

The lower right panel of Figure 2 shows the impulse response of consumption. In period 1, consumption jumps up to about 0.98 from its steady-

state value of 0.88. In period 2, consumption falls to a point below its steady state and then gradually works its way back to normal.

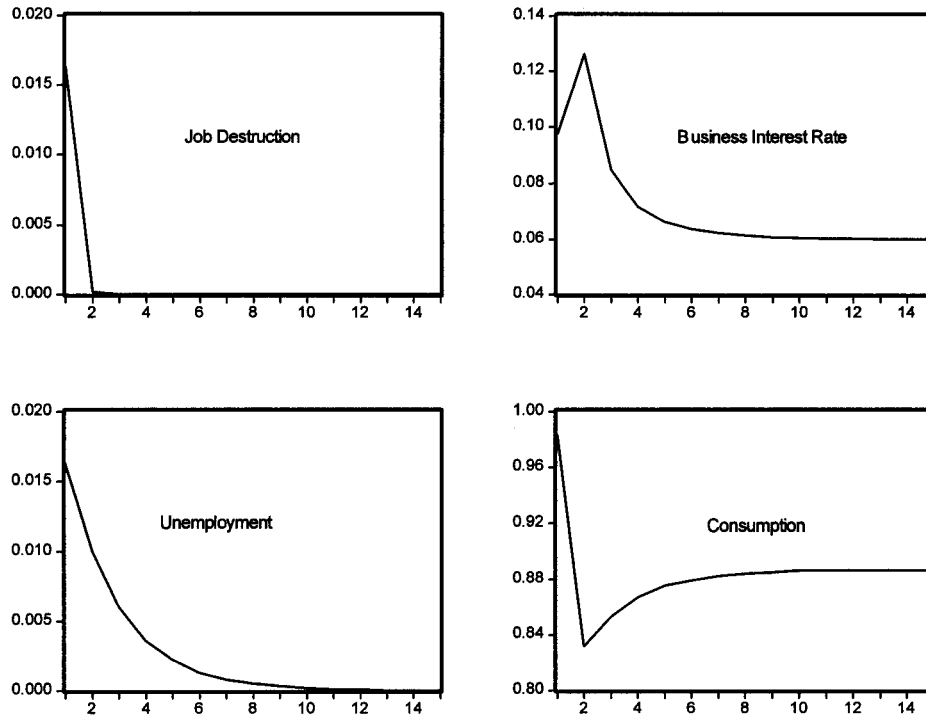


Figure 2. Impulse Response Functions for a Financial Shock

The dynamics shown in Figure 2 share important properties with actual recessions—the sharp spike in job destruction accompanied by a high interest rate followed by a prolonged period of above-normal unemployment. They differ from reality in another respect, however. In actual recessions, consumption typically remains steady while output declines—inventory disinvestment makes up the difference. Here, consumption rises during the recession because the amount of inventory disinvestment is much larger than the output decline. The reason is that it takes a high value of the capital/output ratio γ to put the model into the region where an increase in the interest rate triggers job destruction. In an alternative

model with inefficient fixed-wage employment governance, much more realistic behavior would result, based on a value of γ of, say, 1.

VI. The Association of Real Interest Rates, Job Destruction, and Inventory Liquidation in the U.S. Economy

I take the time period to be 6 months and use the real 6-month commercial paper rate, which I will denote r_t . The relations I consider are:

$$d_t = \alpha_d + \beta_d r_t - \beta_d \varepsilon_t + u_{d,t} \quad (6.1)$$

$$\Delta n_t = \alpha_n - \beta_n r_t + \beta_n \varepsilon_t + u_{n,t} \quad (6.2)$$

$$\Delta v_t = \alpha_v - \beta_v r_t + \beta_v \varepsilon_t + u_{v,t} \quad (6.3)$$

The coefficients β_d , β_n , and β_v are semi-structural coefficients summarizing the implications of the earlier model: job destruction d_t is higher when the discount rate is higher; employment growth Δn_t and inventory investment Δv_t are lower when the discount rate is higher. The normalization with quantities on the left is not intended to suggest any causal relation—the variables are all jointly determined in general equilibrium. The random variable ε_t is the expectation error in the real discount rate—it is the difference between the realized rate and the expected rate. The expectation error is uncorrelated with all variables known at the time the expectation is formed. The u s are disturbances capturing other influences on the two variables, including the approximation error associated with the simple linear relation.

By standard rational expectations logic, the \bullet s are uncorrelated with variables known before the beginning of period t . I make the identifying assumption that the disturbances $u_{\bullet,t}$ are also uncorrelated with lagged variables. The most useful instruments are those most correlated with expected real rates. Because commercial paper is an instrument whose nominal return is known at the time it is issued, the most recent nominal rate is a very good instrument. I use the nominal rate for the month before the beginning of the 6-month period, that is, for December and June. I also use the nominal rates for the three preceding months, primarily as predictors of inflation. The other instruments are the quarterly rates of inflation of the consumption deflator one, two, three, and four quarters earlier. Figure 3 shows the success of the instruments in forecasting the realized real rate. Because the multiple correlation of the instruments with the endogenous variable is high, instrumental variables estimation here is free from the problem of poor first-stage fit.

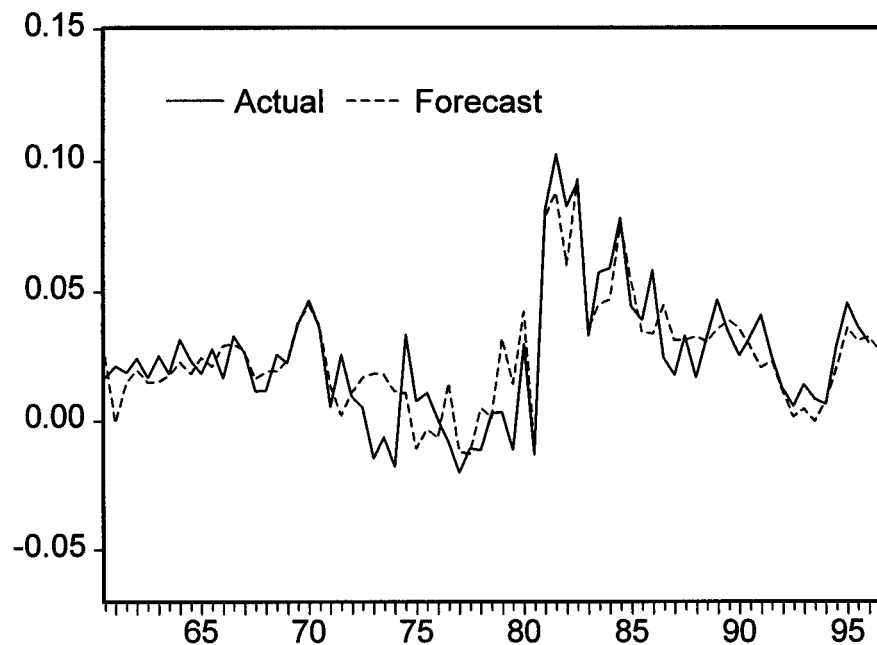


Figure 3. Actual Values and Forecast of the 6-Month Real Commercial Paper Rate

I estimate with GMM, using the HAC covariance matrix of Newey and West [1987].

Job destruction is measured currently only for manufacturing—see Davis, Haltiwanger, and Schuh [1996]. I use data for durables and non-durables. Employment is measured in a number of ways by detailed industry. I use the 9-industry breakdown shown in Table 2. The particular measures I use are the number of workers, production and non-production, from the Bureau of Labor Statistics' Establishment Survey, and aggregate weekly hours of production workers from the same survey. I measure inventory investment as the nominal level of inventory investment in the industry (U.S. National Income and Product Accounts, Table 5.10) divided by total nominal GDP. Only 4 of the 9 industries hold any inventories.

	<i>Coefficient</i>	<i>Standard error</i>	<i>p-value</i>	<i>Coefficient</i>	<i>Standard error</i>	<i>p-value</i>
<i>Job destruction</i>						
Manufacturing durables	0.669	0.161	0.000			
Manufacturing non-durables	0.173	0.066	0.013			
<i>Number of workers</i> <i>Hours of production workers</i>						
Mining	0.890	0.452	0.053	0.655	0.288	0.026
Construction	0.479	0.423	0.261	0.283	0.334	0.401
Manufacturing durables	0.971	0.178	0.000	0.832	0.214	0.000
Manufacturing non-durables	0.408	0.081	0.000	0.432	0.100	0.000
Transportation-utilities	0.152	0.087	0.084	0.223	0.047	0.000
Wholesale trade	0.283	0.081	0.001	0.240	0.075	0.002
Retail trade	0.218	0.114	0.059	0.149	0.065	0.026
Finance-insurance-real estate	0.120	0.080	0.138	0.111	0.041	0.008
Services	0.117	0.048	0.017	0.064	0.039	0.112
<i>Inventory investment as a ratio to GDP</i>						
	<i>Contemporaneous</i>			<i>With 6-month lag</i>		
Manufacturing durables	0.006	0.027		0.063	0.028	
Manufacturing non-durables	0.012	0.010		0.036	0.010	
Wholesale trade	0.003	0.015		0.035	0.016	
Retail trade	-0.011	0.017		0.019	0.022	

Table 2. GMM Estimation Results.

The results generally show strong relationships of the predicted signs (recall that the equations are normalized so that the predicted signs are positive). An increase of 1 percentage point in the real commercial paper rate is associated with an increase of about 0.7 percentage points in the job destruction rate in manufacturing durables. For non-durables, the corresponding effect is 0.17 percentage points. The coefficients for the total number of workers are larger—durables employment falls by about 0.97 percent and nondurables by 0.41 percent. The focus on job destruction rather than adjustment of hours within jobs is supported by the finding that the coefficients on total hours are about the same

as for numbers of workers. One can infer that there is almost no association between changes in the commercial paper rate and hours per worker.

The results for inventory changes are much less supportive. The set of results on the left of the inventory block show almost no contemporaneous relation between the real commercial paper rate and inventory disinvestment. Those on the right suggest that a limited response of inventory investment occurs 6 months after a rise in the rate. These results confirm the folklore of inventory research that it is hard to find a relation between inventory investment and the financial cost of carrying inventories.

VII. Concluding Remarks

The previous section of the paper documented the strong association between measures of interest or discount rates and job destruction. The model in the preceding section attributed changes in the discount rate to changes in the financial wedge. But the plunges in the discount rate shown in Figure 3 often occur in times of monetary tightening—1969, 1974, 1980, and 1982. There appears to be a substantial role for the monetary authority to trigger a burst of job destruction and inventory liquidation by stepping hard on the monetary brake. Explanation of this role requires an understanding of monetary non-neutrality, an elusive subject. The mechanism considered in Section V would come into play if monetary tightening widens the financial wedge. Then the burst of job destruction and inventory liquidation makes sense for the reasons discussed here. But we are a long way from having all the elements of that theory in place.

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