RECESSIONS AS REORGANIZATIONS

Robert E. Hall

Hoover Institution and Department of Economics

Stanford University

National Bureau of Economic Research

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1 *Introduction*

Figure 1 shows the basics of a theory of recessions. Labor supply is perfectly flat and labor demand is nearly flat. A small downward movement of either schedule generates a recession with a substantial decline in employment. Is the story of Figure 1 plausible in the light of all of the evidence about the labor market in recession? In particular, is Figure 1 consistent with the fact that recessions bring a large increase in the number of people interested in working, looking for work, but not at work? My purpose in this paper is to investigate the factual support for an interpretation of a recession as a leftward shift in the intersection of flat labor supply and labor demand.

Unemployment has an important role in the view developed in this paper. Two bodies of research on unemployment have been influential in the evolution of this view. First, Davis and Haltiwanger [1990] have shown that the employment declines that occur in recessions are concentrated among a small number of firms making large cutbacks. For the majority of firms, employment growth occurs at normal rates. To put it differently, the cross-sectional distribution of employment growth across firms looks much the same in recessions as in normal years, except that its lower tail, measuring large employment declines, is much larger in recessions. Davis and Haltiwanger's results suggest that recessions are times when there is a large increase in the number of job-seekers who have been released into

Figure 1
Normal and Recession Employment
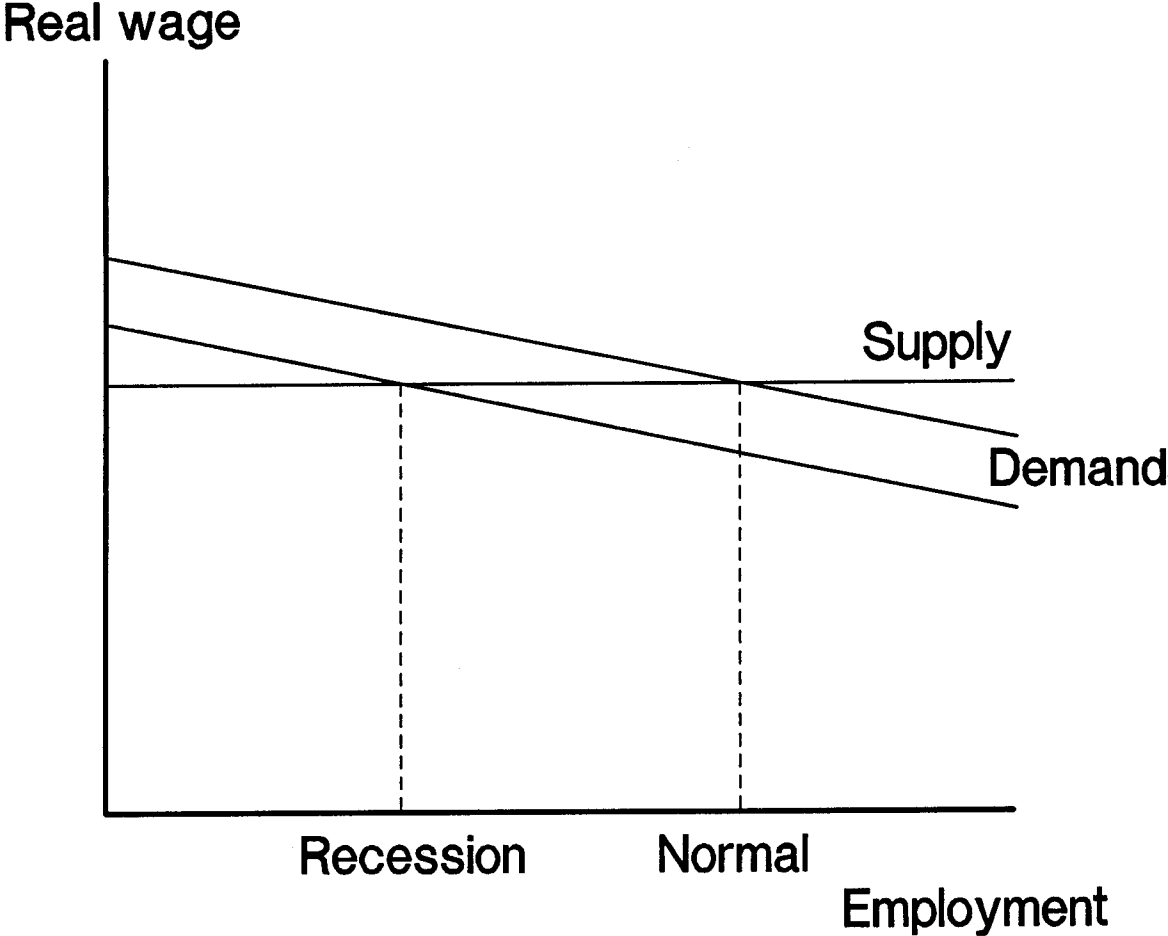
the labor market because of major upheavals at their previous employers.

The second important body of research is Blanchard and Diamond's investigation of flows in the labor market. Their central finding for the issues in this paper is that job-finding rates for unemployed workers are only slightly lower in recessions than in normal times. Essentially all of the increase in unemployment during a recession is the result of a greater flow of workers out of jobs; very little comes from increasing duration of job search. Although these findings need further validation with respect to their sensitivity to aggregation and measurement problems, they do seem to point in the following direction: In recession, the labor market carries out a much increased volume of worker-job matching, without suffering a decline in the efficiency in the process. Congestion in the matching process is apparently offset by agglomeration efficiencies.

The general view I advance in this paper, in support of the supply-and-demand analysis of Figure 1, is that the economy faces a choice at the margin between producing goods and reorganizing. The demand curve in Figure 1 is the marginal product of labor and the supply curve is the marginal product of job matching and other reorganizational use of time. Neither activity has significant diminishing marginal product of labor. Hence small perturbations in either schedule bring large movements in the allocation of labor between the two activities. This view is related to the idea proposed by Cooper and Haltiwanger [1990] that times of lower productivity are the best times to replace the capital stock. I take a more general view about the source of the perturbation and about the nature of the

alternative activity to production of goods.

A comparison with the real business cycle (RBC) model seems appropriate at this point. The model in this paper shares the RBC model's perspective that employment fluctuations are results of shifts of an economic equilibrium, not departures from equilibrium. Neither model suggests that there are unexploited gains from trade during recessions. The first key difference between the two models is in the alternative activity whose value determines the supply curve of labor to goods production. In the RBC model, the alternative activity is leisure (Kydland and Prescott [1982], Prescott [1986], and Rogerson [1988]) or work at home (Benhabib, Rogerson, and Wright [1991]). Here, the alternative activity is job seeking, either active (visiting employers, responding to help-wanted ads, and the like), or passive (waiting for a job to open up). In my model, there is no substitution at all between time spent at home and time devoted to work or job seeking.

The second critical difference between the reorganizational model and the RBC model is in the driving force of employment fluctuations. In the RBC model, the labor demand schedule is the marginal product of labor from a neoclassical production function (generally Cobb-Douglas). In that framework, only shifts of labor demand generate realistic employment fluctuations. Other perturbations, such as changes in government purchases (Barro [1980]) or in the timing of consumption (Baxter and King [1990]) cause countercyclical movements in the real wage as the level of employment moves up and down a relatively steep labor demand schedule.

But the real wage is not countercyclical. Hence the RBC view is inextricably committed to vibrations of technology as the driving force of employment fluctuations. The notion that recessions are times of technical regress has not appealed to most practical economists (Summers [1986]). By contrast, the view advanced in this paper is that labor demand is flatter than suggested by a neoclassical production function. I present direct evidence on the slope of labor demand. I also review evidence from the behavior of inventories and from productivity measures that provides indirect support for the flat labor demand hypothesis.

A comparison with views of employment volatility based on price and wage rigidity is also in order. First, a simple model portrays the level of employment as being at the intersection of a downward-sloping labor demand schedule and a prescribed rigid real wage. Though I am not aware of any recent attempts to apply this setup to the issue of employment fluctuations, precisely this model was used extensively to explain persistent high unemployment in Europe in the early 1980s. The flat line depicting the rigid real wage takes the place of the labor supply schedule in Figure 1. Absent a theory of the flat line based on rational economic behavior, the real wage rigidity model has not achieved much acceptance. As Barro [1977] pointed out, the central issue is not whether compensation is rigid – it is whether rational economic actors would absorb the deadweight losses associated with the employment fluctuations that a flat labor supply schedule causes, if the schedule does not properly reflect the marginal value of time.

The view of price-wage rigidity in the IS-LM model turns out to be more subtle and closer to the view advocated in this paper. As Barro and Grossman [1971] pointed out, the labor market is wholly irrelevant in a macro model where the price level is predetermined and sellers stand ready to meet all demand at that price level. Alternative values of the real or nominal wage have no effect at all on the level of employment. Modern expositions of the IS-LM model do not invoke price rigidity directly. Instead, they start from a predetermined nominal wage and derive price rigidity from a markup theory of pricing; a good exposition is Dornbusch and Fischer [1990], chapter 13, sections 3 and 4. The implicit labor demand schedule in that version of IS-LM is precisely flat — the flat marginal cost schedule needed for a markup theory corresponds to a constant marginal product of labor. The modern IS-LM model makes the assumption of a temporarily rigid nominal wage. Labor stands ready to supply whatever volume of effort is requested by employers. The overall view of the labor market implicit in the modern IS-LM model is an extreme version of Figure 1 in which labor demand and labor supply are both perfectly flat and lie atop one another. The level of employment is indeterminate as far as demand and supply in the labor market is concerned. The indeterminacy is resolved by the principle of short-run nominal wage rigidity. With respect to the modern IS-LM model, it would be appropriate to think of this paper as providing some additional foundations for the model's implicit hypotheses about labor demand and supply. The model developed here is not a rival for IS-LM.

Organizational capital

The concept of organizational capital is central to the argument made in this paper. An economy has high organizational capital when it has successfully matched its heterogeneous resources to each other in a way that achieves a high level of output. Organizational capital is built by the matching process. Most important is the matching of workers to jobs — the building of teams of managers, desk workers, troubleshooters, and production workers. The allocation of workers to the stock of fixed capital is also part of the process of organizational capital accumulation. Because many organizational decisions deal with the question of whether or not to operate units of production with substantial fixed costs when they are in operation, reorganization often involves large, sudden changes. As Davis and Haltiwanger [1990] show, large cutbacks in employment at the plant level are a central feature of recessions.

Organizational capital deteriorates over time. Products and capital become obsolete. Workers age and may lose their comparative advantages in their current jobs. An economy producing flat out with low unemployment and low rates of new job matching will gradually suffer a decline in productivity relative to the level that could be achieved by pausing to reorganize.

The way many professionals run their own offices provides an analogy that may be useful. During periods of intense effort, one's office becomes more and more disorganized. Piles of unsorted materials develop first on desks and tables and later

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on the floor. As disorganization cumulates and the office's level of organizational capital deteriorates further and further, the professional's productivity begins to suffer. Finally, at the first letup in the need to produce output, the professional turns to reorganizing the office. Measured output may be low during that period, but the time spent reorganizing pays off in its contribution to future productivity. That time represents a type of capital accumulation.

The concept of organizational capital involves some challenging issues of ownership. In particular, search theory generally concludes that employer and worker share the benefit of the bargain created by an improved job match. Can a free market ensure that a decentralized process of reorganization will satisfy the first-order condition that the marginal product of labor in goods production equal the marginal product in the creation of organizational capital? The model will make that assumption. However, I think that the basic conclusion — that the allocation of labor between the two activities is highly sensitive to current goods demand — carries over to more realistic models that recognize the limits of decentralization.

Reorganization may suffer from congestion effects — whose influence is similar to adjustment costs in the accumulation of physical capital — or from agglomeration efficiencies. In the model developed in the next section, I assume, in effect, that congestion and agglomeration just offset each other. The technology for building organizational capital is linear, rather than concave (as it would be if congestion dominated) or convex (as it would be if agglomeration dominated). Specifically, one hour of a worker's time devoted to job seeking or other organizational activities

builds one unit of organizational capital. The flatness of labor supply to goods production follows directly from this assumption of linearity. Work time diverted from goods production generates a flow of new organizational capital. Instantaneously, the flow has no effect on the magnitude of the stock. Hence the marginal product of time spent building organizational capital is independent of the amount of time currently being spent. This flat marginal product schedule is precisely the labor supply schedule to goods production.

One of the implications of this hypothesis is that the marginal value of time spent in job search is not sensitive to the number of other searchers. In particular, in recessions, time spent looking for or waiting for work is almost as valuable as it is in booms. The primary evidence is Blanchard and Diamond's [1990] finding that job-finding rates for unemployed workers are almost the same in recessions as in booms. Recessions are periods of greater total volume of job changes, but are not times when it takes longer to find work.

Flat labor demand

Flat labor demand is an equally important part of the theory of employment volatility developed in this paper. This paper considers the theory and evidence supporting the hypotheses of flat labor demand. The principle of diminishing returns teaches us that the schedule slopes downward. But the extent of diminishing returns is an empirical issue even under standard assumptions about the

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technology. Under non-standard conditions — complementarities or increasing returns — the labor demand schedule is more likely to be flat, and can even slope upward in the case of complementarities.

With respect to the evidence on the slope of labor demand, I start with empirical work on the relation between employment and the product wage. I derive an estimating equation suited to conditions of market power and increasing returns; it is a generalization of a standard approach to estimating the elasticity of substitution. The labor demand schedule of a particular industry is traced out as shifts occur in the product demand and labor supply to that industry. Estimation with two-digit data for the United States shows that the labor demand schedule is quite flat — there is little variation in product wages as employment responds to shifts in labor supply. I go on to cite other evidence that supports the flatness of labor demand. In particular, the behavior of inventories is inconsistent with diminishing marginal product of labor — firms do not generally take advantage of periods of low output to build up stocks of inventories.

2. A model with organizational capital

In this model, labor is allocated between production and creation of organizational capital. The amount of labor available for the combination of the two activities is a constant, independent of the real wage, real interest rate, or other

relative prices. In other words, substitution of work and leisure is not part of the story of employment fluctuations — in this respect, the model takes exactly the opposite view from the RBC model. The model developed here considers only the allocation of labor between the two activities; it is not a general equilibrium model. The essential relative price that connects labor allocation to the rest of the economy is the real interest rate, which I take as exogenous.

One simple way to think of the model is that it describes a small economy embedded in a large world economy with a single tradable good. The small economy is a price-taker with respect to the relative price of current and future deliveries of the good. Alternatively, one can think of the real interest rate as the economic signal of the urgency of current production of goods in a closed economy. When product demand is high today relative to the future, a higher real interest rate is needed to clear the market for delivery of current goods. One source of high product demand could be higher military purchases, as studied by Barro [1980] in a model where the real interest rate clears the goods market. Another could be a shift of preferences toward current consumption, as in Baxter and King [1990]. A third could be a spontaneous element in physical capital accumulation, as in Hall [1991]. In any case, the mechanism to be described transmits an increase in product demand into an increase in employment.

Although there is reasonable evidence that exogenous increases in product demand raise the real interest rate in the U.S. economy (Hall [1980]), I think it is important to emphasize that observed real interest rates may be poorly correlated

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with the variable contemplated by the model. In the first place, absent markets for indexed securities, there is the problem of removing the expected inflation component from observed nominal interest rates. In the second place, agency problems may drive a wedge between the real rate applied by business managers and the rate observed in securities markets. In view of these problems, I prefer to think of the real rate in the model as the shadow price of current use of goods. In this framework, I would encourage the reader to think of the model as describing the effects of shifts in product demand on employment, rather than the effects of the real interest rate on employment.

Let

Q: Output of goods

N: Employment in goods production

$\bar{N}$: Total labor supply, a constant independent of the real wage or real interest rate

G: Stock of organizational capital

δ_G: Depreciation rate of organizational capital

K: Stock of physical capital

δ_k: Depreciation rate of physical capital

w: Real wage

r: Exogenous real interest rate

x: Rental price of organizational capital

c: Rental price of physical capital

The technology in goods production has constant returns to scale in the three factors and is described by the production function $F(N,G,K)$ with unit cost function $\phi(w,x,c)$; the cost of producing Q units of goods is $\phi(w,x,c)Q$. The factor price frontier $\rho(w,c)$ is defined by

$$\phi(w,\rho(w,c),c) = 1 \tag{2.1}$$

The negative of the slope of the factor price frontier is

$$\psi(w,c) = -\frac{\partial \rho(w,c)}{\partial w} = \frac{\partial \phi/\partial w}{\partial \phi/\partial x} \tag{2.2}$$

The demands for labor and organizational capital are

$$N = \frac{\partial \phi}{\partial w}Q \tag{2.3}$$

and

$$G = \frac{\partial \phi}{\partial x}Q \tag{2.4}$$

Thus the function $\psi(w,c)$ is also the factor intensity, N/G. By a similar argument,

$$-\frac{\partial \rho(w,c)}{\partial c} = \frac{K}{G} \tag{2.5}$$

The technology for the creation of organizational capital is that one unit of labor diverted from goods production creates one unit of capital. Consequently, organizational capital accumulation is total labor supply less labor employed in goods production and less the replacement of depreciated capital:

$$\dot{G} = \overline{N} - N - \delta_G G \tag{2.6}$$

The rental price of organizational capital is

$$x = w(r + \delta_G) - \dot{w} \tag{2.7}$$

Competition ensures that the real wage and the rental price of organizational capital lie on the factor price frontier. Hence the evolution of the real wage is governed by

$$\rho(w,c) = w(r + \delta_G) - \dot{w} \tag{2.8}$$

or

$$\dot{w} = w(r + \delta_G) - \rho(w,c) \tag{2.9}$$

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A linearization will help explain the implications of this equation:

$$\dot{w} = (w - w^*)(r^* + \delta_G) - \frac{\partial \rho}{\partial w}(w - w^*) + (w^* - \frac{\partial \rho}{\partial c})(r - r^*) \quad (2.10)$$

Here w^* is the stationary real wage defined by

$$w^*(r + \delta_G) = \rho(w^*, c^*) \quad (2.11)$$

The exogenous real interest rate, r, is seen as fluctuating around the level r^* and the rental price of physical capital is $c^* = r^* + \delta_K$. Let λ be the adjustment rate:

$$\lambda = \psi(w^*, c^*) + r^* + \delta_G \quad (2.12)$$

$$= \frac{N^*}{G^*} + r^* + \delta_G \quad (2.13)$$

A more compact version of the linearization is

$$\dot{w} = \lambda(w - w^*) + \pi w^*(r - r^*) \quad (2.14)$$

Here π is the sum of the direct effect of the interest rate and its effect through the rental price of physical capital:

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$$\pi = 1 + \frac{K^*}{w^* G^*} \qquad (2.15)$$

Over the period from t to T, participants in the economy will foresee that the real wage will evolve from the level $w(t)$ to

$$w(T) = w^* + e^{\lambda(T-t)}[w(t) - w^*] + \pi \int_t^T e^{\lambda(T-s)} w^*[r(s) - r^*]\, ds \qquad (2.16)$$

To put it differently, the value of $w(t)$ needed to achieve the terminal value of $w(T)$ is

$$w(t) = w^* + e^{-\lambda(T-t)}[w(T) - w^*] - \pi \int_t^T e^{-\lambda(s-t)} w^*[r(s) - r^*]\, ds \qquad (2.17)$$

The natural transversality condition is the vanishing of the first exponential term as the horizon T goes to infinity. Then the current real wage is governed by

$$w(t) = w^* - \pi \int_t^\infty e^{-\lambda(s-t)} w^*[r(s) - r^*]\, ds \qquad (2.18)$$

In times of high current product demand (high current and near future real interest rates), the economy substitutes toward goods production and away from the formation of organizational capital. As goods employment rises, the real wage falls.

At a particular moment, the level of employment in goods production is governed by the marginal product condition,

$$\frac{\partial F(N,G,K)}{\partial N} = w \qquad (2.19)$$

Again taking a linear approximation, I get

$$N - N^* = \frac{1}{\partial^2 F/\partial N^2} (w - w^*) \qquad (2.20)$$

In terms of elasticities, the linear approximation is

$$\frac{N - N^*}{N^*} = \frac{\partial F/\partial N}{N} \frac{1}{\partial^2 F/\partial N^2} \frac{w - w^*}{w^*} \qquad (2.21)$$

$$= -\beta\, n\, \frac{w - w^*}{w^*} \qquad (2.22)$$

Here β is the elasticity of the labor demand schedule. The relation between the real interest rate and the percentage employment deviation is

$$\frac{N - N^*}{N^*} = \beta\pi \int_t^\infty e^{-\lambda(s-t)}[r(s) - r^*]\,ds \qquad (2.23)$$

The only difficult-to-measure parameter is the labor demand elasticity, β.

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3. *Theoretical framework for measuring the elasticity of labor demand*

In this section I will derive a method for estimating the elasticity, β, of the labor demand schedule. The method rests on the idea that shifts in labor supply (and product demand, when the economy produces more than one product) trace out the labor demand schedule. In competition, only variables that affect the firm's technology can shift the labor demand schedule. Any other variable that affects employment must operate through the supply of labor to the firm. For a firm with market power, labor demand also depends on the elasticity of demand. Then the supply shift variables must be ones that affect neither the technology nor the elasticity of product demand. To keep the notation under control, I will derive the estimation method without considering organizational capital.

Consider a firm with constant-returns production function $\Theta F(N,K)$ whose ratio of price to marginal cost is μ. Its first-order condition for employment is

$$\mu w = \Theta \frac{\partial F}{\partial N} \quad .$$

(3.1)

Suppose that the markup ratio evolves according to

$$\Delta log\, \mu = -\nu \quad .$$

(3.2)

The random variable ν is a white-noise decrement.

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The change from one period to the next in the first-order condition is, approximately,

$$\Delta log \ w = \nu \ + \ \theta \ + \ \frac{\partial^2 F}{\partial N^2} \frac{\Delta N}{\partial F/\partial N} \ + \ \frac{\partial^2 F}{\partial N \partial K} \frac{\Delta K}{\partial F/\partial N} \qquad (3.3)$$

Under constant returns,

$$N \frac{\partial^2 F}{\partial N^2} + K \frac{\partial^2 F}{\partial N \partial K} = 0 \qquad (3.4)$$

Consequently,

$$\Delta log \ w = \ \frac{N}{\partial F/\partial N} \frac{\partial^2 F}{\partial N^2} (\Delta n - \Delta k) \ + \ \theta \ + \ \nu. \qquad (3.5)$$

Here Δn and Δk are proportional or log changes. As before, let β be the elasticity of labor demand,

$$\frac{1}{\beta} = - \ \frac{N}{\partial F/\partial N} \frac{\partial^2 F}{\partial N^2} \ . \qquad (3.6)$$

Then a compact form for decomposing the various influences on the product wage is

$$\Delta log \ w = \ -\frac{1}{\beta}(\Delta n - \Delta k) + \nu \ + \ \theta \qquad (3.7)$$

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Equation 3.7 decomposes the actual movements of the product wage into three components:

1. Changes associated with changes in the labor/capital ratio, $-\frac{1}{\beta}(\Delta n - \Delta k)$.

2. Changes in productivity, θ.

3. An unexplained residual, ν.

With convex technology, the elasticity of labor demand, β, must be non-negative. The firm's labor demand schedule slopes downward under all conditions, including non-convex technology — it would always be paradoxical for a firm to hire more labor if the wage rose.

4. Econometric method

The basic method I use to measure the elasticity of labor demand is instrumental variables. The instruments measure exogenous changes in product demand and labor supply that affect a particular industry. These changes move the industry along its labor demand schedule. The use of data for individual industries gives additional sources of changes that cause movements along labor demand. The variable on the vertical axis of the labor supply-and-demand diagram for a particular industry is the product wage for that industry — the ratio of the industry wage to the product price for the industry. Thus changes in product demand for the industry shift the labor supply schedule in terms of the product wage and trace out the labor

demand schedule.

Provided the instruments are uncorrelated with shifts of the industry's technology and with shifts in the elasticity of demand, the observed movements of the product wage and employment in response to changes in the instruments are purely movements along the labor demand schedule and not shifts of the schedule. For instruments that stimulate product demand, there are three effects at work. First, employment rises. Second, the price of the product rises. Third, the wage rises. The locus traced out by employment on the horizontal axis and the product wage (ratio of industry wage to product price) on the vertical axis is the labor demand schedule. For instruments that stimulate labor supply, on the other hand, the effects are an increase in employment, a decrease in price, and a decrease in the wage. Again, the employment-product wage locus traces out the labor demand schedule.

The basic estimation equation 3.7 contains the productivity shock θ. Estimation efficiency can be improved by one of two methods based on the fact that there is information about θ in observed variables other than the variables in the equation. One approach is to estimate the labor-demand equation jointly with a productivity growth equation. Bivariate estimation takes advantage of the high correlation of the disturbance in the labor demand equation and the disturbance in the productivity growth equation. An alternative approach that yields essentially the same efficiency gain is to exploit the high correlation of the productivity shock across industries by estimating a multivariate system consisting of equation 3.7 for

each of a group of industries. Experimentation suggested that both methods yielded about the same efficiency gain. Combining the two methods had little incremental value. I have chosen to use the multivariate approach in the work presented in this paper, to avoid involvement in controversies about productivity measurement.

The data are sufficiently noisy that estimation of the labor demand elasticity β separately for each industry results in huge sampling variation. To reduce the sampling variation, I impose the constraint that the elasticity is the same for all of the industries within groups of six or fewer two-digit industries.

The estimation method embodying these various principles is three-stage least squares applied to all two-digit industries simultaneously, with constraints on the labor demand elasticity across groups of industries.

I normalize the estimating equation as in equation 3.7 — with the log-change of the product wage on the left and the log-change in the employment/capital ratio on the right. The estimated coefficient is the reciprocal of the demand elasticity. It is an interesting econometric question whether useful results could be obtained with the reverse normalization — employment change on the left and product wage change on the right. That procedure would give direct estimates of the elasticity. With a single equation and a single instrument, the two normalizations would give identical results. In the multivariate setup used here and with three instruments, the results still come close to agreement when each industry has its own elasticity. But imposition of the constraint of equal elasticities within industry groups has a very different effect in the two normalizations because of sign effects. Quite a few

industries have small negative estimated values of $1/\beta$. These industries support the general thrust of this paper that the labor demand schedule is flat or even upward-sloping. But with the reverse normalization, these industries have large negative estimated values of β. The effect of imposing the constraint of equal coefficients within industry groups is not terribly different from estimating the coefficient as the average of the estimates for the individual industries. In the normalization I use, the average of $1/\beta$ is lowered a little by the inclusion of the negative-$1/\beta$ industries. These industries strengthen the evidence that labor demand is flat. On the other hand, with the reverse normalization, the average of β is dramatically lowered by the inclusion of the negative-$1/\beta$ industries, because they contribute huge negative values of β. The effect is to *weaken* the evidence for flat or negative slopes.

This paper will restrict its attention to results based on the normalization with the product wage on the left. The use of this normalization amounts to a rough application of Bayesian principles, with the prior belief that it is highly unlikely that there are industries that have large negative values of β. I note, however, that the opposing view is not ruled out by the evidence — that there are some industries with high positive labor demand elasticities and others with high negative elasticities, and that the average elasticity is small.

5. Data and results on the elasticity of labor demand

An instrumental variable is a variable that is uncorrelated with the random

productivity shift, θ, and the change in product demand elasticity, ν, but is correlated with changes in the labor/capital ratio, $\Delta n - \Delta k$. Variables measuring exogenous shifts in product demand or in factor supply would be eligible as instruments. In my empirical work, I use the instruments proposed by Valerie Ramey in related work: changes in military spending, changes in the world oil price, and the political party of the president.

The data for two-digit U.S. industries are taken from the same sources as my earlier work on productivity growth (Hall [1990]) updated through 1986. Labor input is carefully measured by combining information from the household and establishment surveys on annual hours of work. The wage is the ratio of nominal compensation to annual hours. Output is value added and the product price is the corresponding NIPA deflator.

Table 1 presents the results. Five out of the six groups have positive elasticities. The elasticities range from a little over two to about eight. The last column of the table gives the corresponding elasticities for the Cobb-Douglas technology — if α is labor's share, the elasticity of labor demand with a given capital stock is $1/(1-\alpha)$. For all industries except food-fiber (SIC 20 to 26) and transportation equipment, labor demand is more elastic than it would be in the Cobb-Douglas case. And Cobb-Douglas is a stringent standard. The Cobb-Douglas elasticities range from 2.1 for the capital-intensive communication-utilities-transportation industry to 5.3 for the labor-intensive transportation equipment industry.

Table 1. Estimates of the elasticity of labor demand

SIC: Industry	Estimated reciprocal elasticity, $1/\beta$ (standard error)	Implied elasticity, β	Elasticity implied by Cobb-Douglas
20: Food and kindred products 22: Textile mill products 23: Apparel and other textile products 24: Lumber and wood products 25: Furniture and fixtures 26: Paper and allied products	0.288 (0.071)	3.472	4.115
27: Printing and publishing 28: Chemicals and allied products 30: Rubber and miscellaneous plastic products 31: Leather and leather products 32: Stone, clay, and glass products 33: Primary metal industries	0.186 (0.072)	5.376	3.891
34: Fabricated metal products 35: Machinery, except electrical 36: Electric and electronic equipment 38: Instruments and related products 39: Miscellaneous manufacturing industries	0.142 (0.108)	7.042	4.444
71: Motor vehicles and equipment 72: Other transportation equipment	0.436 (0.078)	2.294	5.263
48: Communication 49: Electric, gas, and sanitary services Transportation	- 0.420 (0.220)	- 2.381	2.146
Wholesale Trade Retail Trade	0.124 (0.064)	8.065	3.344

Notes:
Instruments: Political dummy, percent change in oil prices, and growth of real military expenditures. Sample: 1953 to 1986.
Estimation method: Three-stage least squares with the elasticity constrained within industry groups.

In summary, the empirical results on labor demand say the following: When an exogenous event – a decline in oil prices, increase in military spending, or election of a Democrat as president – stimulates demand for the output of an industry, or stimulates labor supply by affecting labor demand in other industries, the resulting increase in employment is large in relation to the resulting decrease in the product wage. The ratio of the two – the elasticity of labor demand – is in the range from two to eight.

6. Explanations of flat labor demand

Economists think, as a rule, that the diminishing marginal product of labor means that marginal cost rises with output. Higher demand means higher prices, or at least no lower prices. Practical experience is hardly conclusive on this point. It is more expensive to vacation in Hawaii at Christmas than in October. But VCRs and many other Christmas goods are no more expensive during December than they are during the rest of the year (Warner and Barsky [1990]). Federal Express charges more for Saturday delivery, for which there is much less demand, than they do for weekday delivery. Cameras are much cheaper in mid-town Manhattan than anywhere else in the world, even though 47th Street is the worldwide hotspot in camera sales volume.

Congestion and agglomeration are opposing forces. Standard neoclassical

economic models emphasize congestion. Firms face diminishing marginal product of labor because the addition of workers crowds more of them onto the same machines, and the resulting congestion lowers productivity. But when coordination is an important part of production, the favorable side of crowding may dominate. Cameras are cheaper on 47th Street because the crowded stores filled with customers and salesmen make transactions at rates an order of magnitude greater than suburban camera stores.

Crowding more workers on the existing stock of machines lowers the marginal product of each worker. For the induced change in marginal product to be positive rather than negative, the congestion effect must be outweighed by thick-market effects or complementarities. Peter Diamond [1982] introduced thick-market effects. The basic idea is that the costs of one productive activity fall when related or neighboring activities are at higher levels. Transaction and search costs are lower in denser markets. Congestion is good for productivity. The analogy to the geographical distribution of productivity is helpful—productivity is highest in dense, congested cities like New York.

When thick-market effects are dominant, the marginal product of labor is an upward-sloping function of total employment. This schedule serves as the demand schedule for labor. It is important to consider it a relation between aggregate employment and marginal product, however. It would be a paradoxical violation of second-order conditions for the level of employment chosen by a single firm to be a positive function of the wage the firm faced. Each firm perceives a negative relation

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between its own employment and its own marginal product of labor. But the positive dependence of its production function on aggregate activity makes its marginal product a positive function of total employment.

A very simple example will explain most of what this section has to say. Consider first the neoclassical technology where production takes place in N separate units:

$$y = x_1^\alpha + x_2^\alpha + \cdots + x_N^\alpha \tag{6.1}$$

with $\alpha < 1$. Suppose the total endowment of the input, x, is 1. Then output will be maximized by allocating the endowment evenly over all N of the productive units. With $x_i = 1/N$, total output is $N^{1-\alpha}$. Any other allocation, such as giving the entire endowment to the first unit, will produce less output. With $N > 1$ and $\alpha < 1$, $N^{1-\alpha}$ exceeds 1. The neoclassical conclusion that it is better to avoid congestion applies to this example because of the concavity of the technologies of the units.

Now consider a related technology, where

$$y = x_1^\alpha x_2^\beta + x_2^\alpha x_1^\beta + x_3^\alpha x_4^\beta + x_4^\alpha x_3^\beta + \cdots + x_{N-1}^\alpha x_N^\beta + x_N^\alpha x_{N-1}^\beta \tag{6.2}$$

Here the productive units are related to one another in pairs. Each unit has diminishing marginal product of its own input, x_i ($\alpha < 1$), but the input used by its counterpart, x_{i+1}, makes a positive contribution, measured by the elasticity, β,

which is positive. Moreover, the externality measured by β is strong enough to yield overall increasing returns: $\alpha + \beta > 1$. With this technology, congestion or agglomeration is desirable. The contribution that an increase in the input to one firm makes to the output of the other firm in its pair is more than enough to offset the diminishing marginal product in the first firm. With uniform allocation of the input across firms, total output is $N^{-(\alpha+\beta-1)}$. On the other hand, it turns out that the optimal allocation is to give all of the inputs to a single pair of producers, to take full advantage of increasing returns. Then total output is $2^{-(\alpha+\beta-1)}$, which is larger for $N > 2$. The lesson is that agglomeration of activity pays off when there are complementarities .

Now suppose that the firms can purchase the input for a real wage w and that each firm takes the level of activity of its counterpart as given; there is no coordination between the two firms in the pair. Profit maximization results in the two factor demands,

$$\alpha x_1^{\alpha-1} x_2^{\beta} = w \qquad (6.3)$$

$$\alpha x_2^{\alpha-1} x_1^{\beta} = w \qquad (6.4)$$

The unique solution where each firm is basing its factor demand on the actual choice of the other firm is

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$$x_1 = x_2 = \left[\frac{w}{\alpha}\right]^{\frac{1}{\alpha+\beta-1}} \tag{6.5}$$

The crucial point is that this factor demand slopes *upward*. At a higher level of employment, the marginal product is higher. This conclusion depends fundamentally on the lack of coordination between the two firms with the complementarity. If the two firms merge or write an efficient contract to deal with the complementarity, they will behave as a firm with increasing returns, whose factor demand function cannot possibly slope upward.

Complementarities in economic activity seem a highly promising way to explain a flat or upward-sloping demand schedule for labor. The complementarities hypothesis seems to have strong support in the data in a number of ways. On the other hand, its acceptance is likely to be held back by the lack of a convincing story about the source of complementarities. Just what makes the production function of the auto industry shift upward in favorable times? Where is the externality linking auto-making with chemical production and hotel-keeping? Research has not yet answered these difficult questions.

The most direct form of evidence on complementarities comes from the measurement of productivity. According to the complementarity hypothesis, productivity should rise in times of high overall activity. Procyclical productivity is a well-documented characteristic of the overall economy and most industries. It is essential to sort through some important productivity measurement issues in order to determine if the evidence supports the complementarity hypothesis uniquely,

whether it supports the hypothesis along with some alternatives, or if procyclical productivity is plainly just an artifact of incorrect measurement. Not surprisingly, the conclusion is ambiguous. After correcting the standard Solow productivity measure for problems caused by market power, I find that it remains strongly procyclical in many industries. When the economy in general surges, or when demand for the output of the industry itself rises, productivity rises.

A second important piece of evidence has to do with inventories. A firm with a neoclassical technology and no external complementarities will use inventories to offset the increase in cost that occurs when output rises. Inventories will rise when firms expect future output to exceed current output, as firms hedge against the increase in cost. With complementarities and other thick-market effects, marginal cost will be lower when output is higher, and inventory hedging will go in the opposite direction. Firms will shed inventories in times of low output and accumulate in times of high output. Work by Valerie Ramey, Kenneth West, and others has shown decisively that inventory accumulation follows the thick-market, not the neoclassical pattern.

7. Cyclical productivity

Robert Solow [1957] established the general framework within which productivity has been measured ever since. Consider a firm that produces output Q with a production function $\Theta F(K,N)$ using capital K and labor N as inputs. Θ is an

index of Hicks-neutral technical progress. The firm faces a stochastic demand for its output, possibly perfectly elastic. It faces a labor market where the firm can engage any amount of labor at the same wage, w, and that the firm chooses its labor input so as to maximize profit. This choice is made after the realization of demand. Some time in advance of the realization of demand, the firm chooses a capital stock, to maximize expected profit. Again, the firm is a price-taker in the market for the rental of capital services at price c. Solow derived a relationship involving output growth, product price, capital and labor input, and the wage rate, under the assumptions of competition and constant returns to scale. The relationship is

$$\theta_t = \Delta q_t - \alpha_t \Delta n_t - (1 - \alpha_t)\Delta k_t \qquad (7.1)$$

where θ is the rate of Hicks-neutral technical progress ($\Delta \log \Theta$), Δq is the rate of growth of output ($\Delta \log Q$), α is the elasticity of the production function with respect to labor input, Δn is the rate of growth of labor ($\Delta \log N$) and Δk is the rate of growth of capital ($\Delta \log K$). This measure has come to be known as total factor productivity because, unlike measures that consider only output and labor input, it accounts for capital input and, in a more general form, for all other types of inputs. In the version I will consider here, the elasticity α is measured as labor's share of total cost. For a further discussion of analytical issues surrounding the Solow residual, see Hall [1990].

Empirical results reveal statistically unambiguous and economically

important correlations between the instruments and measured productivity growth in many industries. Table 5.2 in Hall [1990] shows the results of regressing the Solow residual on the instruments for a number of industries. Contrary to hypothesis, when military spending or an oil price drop stimulates output and employment, measured productivity rises. A second important feature of the results is the high correlation of the productivity residuals with each other and with aggregate output. Table 2 shows the correlation of the productivity residual of the industry with the sum of the productivity residuals for all industries. The second column shows the correlation of the industry residual with the rate of growth of real GNP.

One important interpretation of the findings about the behavior of the productivity residual in the short run stresses the role of complementarities across industries. A statistical model that interprets the positive correlation of each industry with aggregate activity finds an elasticity of industry output with the aggregate of about 0.45, a very powerful complementarity (Caballero and Lyons [1989]). Working with very detailed four-digit data, Bartelsman, Caballero, and Lyons [1991] find that the most powerful complementarities in the short run are with downstream customer industries, whereas those operating in the longer run are with upstream supplier industries.

Table 2. Correlations between Industry Productivity Growth and Aggregate Variables

	Correlation of industry productivity growth with aggregate productivity growth	Correlation of industry productivity growth with aggregate real GNP
20: Food and kindred products	0.245	0.147
22: Textile mill products	0.219	0.083
23: Apparel and other textile products	- 0.005	0.033
24: Lumber and wood products	0.152	0.065
25: Furniture and fixtures	0.542	0.498
26: Paper and allied products	0.562	0.512
27: Printing and publishing	0.509	0.395
28: Chemicals and allied products	0.684	0.527
30: Rubber and miscellaneous plastic products	0.411	0.270
31: Leather and leather products	0.310	0.285
32: Stone, clay, and glass products	0.757	0.597
33: Primary metal industries	0.632	0.738
34: Fabricated metal products	0.365	0.394
35: Machinery, except electrical	0.417	0.389
36: Electric and electronic equipment	0.533	0.487
38: Instruments and related products	0.262	0.219
39: Miscellaneous manufacturing industries	0.387	0.263
71: Motor vehicles and equipment	0.772	0.665

Table 2. Correlations between Industry Productivity Growth and Aggregate Variables (Continued)

	Correlation of industry productivity growth with aggregate productivity growth	Correlation of industry productivity growth with aggregate real GNP
72: Other transportation equipment	0.021	-0.118
48: Communication	0.247	0.117
49: Electric, gas, and sanitary services	0.325	0.251
Transportation	0.762	0.605
Wholesale Trade	0.643	0.433
Retail Trade	0.657	0.738

Sample: 1953 to 1986.

In earlier work (Hall [1990]), I have suggested that increasing returns could explain some of the findings about the correlation of productivity growth with exogenous instruments and correlation across industries. Caballero and Lyons argue that their empirical work shows that complementarities are superior to increasing returns as an explanation of procyclical productivity. A potent argument holds that we should never observe increasing returns in easily variable factors when output can be stored. Instead, production should take place episodically. In the case of a storable output, increasing returns can make the marginal product of labor schedule flat, but not upward sloping. Only complementarities can make the schedule slope upward.

Qualifications to the findings on cyclical productivity

The evidence on measured productivity is not definitive. The principal alternative explanations of cyclical fluctuations in productivity invoke measurement errors in labor and capital input. If each contraction of output involves an unmeasured contraction in labor and capital, then the apparent flatness of labor demand may be an artifact of those measurement errors. A detailed discussion of measurement errors appears in Hall [1990].

Hours of work are reasonably well measured in the U.S. economy. The most likely source of measurement error in labor input is not in the quantity of hours, but

in the amount of effort per hour. The best case for an alternative explanation of cyclical productivity fluctuations based on measurement problems in labor input runs along the following lines: When demand is strong, workers accomplish more per hour. They are paid for their accomplishments, but not in cash on a current basis. The pay is in the form of low accomplishments in the next slump. Workers suffer a disamenity from higher rates of accomplishment and firms perceive the disamenity in the form of an implicit piece-rate wage for accomplishments. Long-term implicit contracts pass on the psychic costs as implicit financial costs to the firm.

All of the ingredients I have listed are essential to make the measurement error explanation work. If there is no disamenity to accomplishing more, the firm is not in equilibrium unless it is asking for the maximal rate of accomplishments in recessions as well as booms. Cyclical fluctuations in work effort can only occur if the firm has to pay for effort. The payment for higher effort cannot occur on a current basis. If it did, real compensation per hour would fluctuate along with productivity. In fact, hourly compensation is very stable over wide fluctuations in employment, output, and productivity (see Figure 5.2 in Hall [1990]). But the majority of workers work under long-term employment relationships, so it is certainly possible that there are fluctuations in work effort as part of the workings of implicit employment contracts.

The same story can be told about capital. Productivity measures assume that the firm uses the services of all of the capital available. If equipment and

structures deteriorate over time and not because of use, there is no pure user cost of capital. It costs a firm no more to use all of its capital than to use part, so it would be inexplicable if part of the existing capital stock were unused. In that case, there would be no possibility of cyclical errors in measuring capital input. But if there is a user cost of capital, firms have a capital supply decision that is formally similar to the labor supply decision. Optimal capital utilization declines in recessions. Productivity measurements based on the assumption of full capital utilization overstate cyclical fluctuations in productivity. Johnson's [1989] careful review of this issue finds little support for the user cost explanation of variations in utilization.

One of the assumptions underlying Solow's productivity measurement method in the form used in my work is that firms choose the level of capital to minimize expected cost. This assumption rules out chronic excess capacity. If firms systematically over-invest, the marginal product of capital will fall short of the real rental cost of capital. The elasticity used for capital in the productivity formula overstates the true elasticity of the production function with respect to capital, and, as a result, there is an understatement of the true elasticity with respect to labor. The result is to make measured productivity procyclical when true productivity is not. One interpretation of the finding of procyclical productivity is chronic excess capacity in many industries. This interpretation presents no problems for the message of this paper. Chronic excess capacity almost certainly leads to flat labor demand — the basic explanation for the standard view of an downward sloping marginal product schedule is the inefficiency of crowding more and more workers

onto a limited stock of machines.

8. Inventories

The behavior of inventories of storable goods provides another type of evidence on marginal cost and the slope of the marginal product of labor. Firms should use inventories to schedule production during periods when marginal cost is low and the marginal product of labor is high. Under neoclassical assumptions, these periods should be slumps, so firms should use inventories to make production smoother over time than sales are. With external complementarities and thick-market effects, times of lowest cost and highest productivity will be the times of highest output. Firms will schedule high output to coincide with times of high sales. They will build inventories during peak periods, rather than depleting inventories as they would under neoclassical conditions. The cyclical behavior of inventories provides a simple way to distinguish a neoclassical convex economy from an economy with important complementarities.

This evidence seems to favor complementarities. First, it has been known for some years that production is more, not less volatile than sales. Blinder[1986], West [1986] and others have noted this departure from the predictions of neoclassical models. But the excess volatility of production is not conclusive. If costs vary over time, the neoclassical firm will take advantage of periods of low cost to build inventories and will deplete them during times of high cost. Production will vary

over time even if sales are completely stable. A simple comparison of volatility is not enough if there are other sources of production volatility beyond variations in sales.

Valerie Ramey [1988] demonstrates fairly convincingly that cost variations do not explain why firms accumulate inventories during times of high production. She examines the joint behavior of output and finished goods inventories in industries that produce to stock rather than to order. The following simplification of Ramey's approach shows how inventory behavior reveals the curvature of technology.

Consider a profit-maximizing firm. Within a broader optimization problem through which the firm determines its sales, there is a sub-problem of minimizing the cost of those sales. Suppose the expected cost of producing to meet given sales is proportional to

$$\frac{1}{2} E_t \sum_{\tau = t}^{T} \left[\gamma y_\tau^2 + (x_{\tau-1} - \alpha s_\tau)^2 \right] \tag{8.1}$$

Here E_t is the expectation conditional on information at time t, y is output, x is the end-of-period stock of finished-goods inventories, and s is the level of sales. The parameter γ controls the curvature of the technology; if the firm perceives upward-sloping marginal cost, γ will be positive. The parameter α controls the inventory/sales ratio. An identity links the variables:

$$x_t = x_{t-1} + y_t - s_t \tag{8.2}$$

A first-order condition necessary for the optimal scheduling of production is

$$E_t\Big[\gamma(y_t - y_{t+1}) + x_t - \alpha s_{t+1}\Big] = 0 \qquad (8.3)$$

This condition characterizes the cost-minimizing policy, for negative as well as positive values of γ (see Ramey [1988]).

Now let

$$h_t = x_t - \alpha s_{t+1} \qquad (8.4)$$
$$= x_t - x_{t-1} - (\alpha s_{t+1} - x_{t-1})$$

The variable h_t is inventory investment in excess of the amount needed to maintain the level of inventories at its usual relation to sales; h_t measures inventory investment undertaken to smooth production plus a purely random element related to surprises in sales. The first-order condition in terms of h_t is

$$E_t h_t = -\gamma(y_t - E_t y_{t+1}) \qquad (8.5)$$

Alternatively,

$$h_t = -\gamma(y_t - y_{t+1}) + \epsilon_t \qquad (8.6)$$

Here ϵ is an expectation error satisfying $E_t \epsilon_t = 0$.

Equation 8.6 strips the first-order condition to its bare essentials. A firm with sharply rising marginal cost ($\gamma \gg 0$) will deplete its inventories by setting $h_t < 0$ when it is producing more this period than it plans to produce next period ($y_t - y_{t+1} > 0$). Note that the inventory draw-down affects the magnitude of $y_t - y_{t+1}$; h_t, y_t, and y_{t+1} are all variables controlled directly by the firm. When the optimal output plan calls for lower output this period than next period, the firm with rising marginal cost will accumulate inventories in excess of the level required by maintenance of the inventory/sales ratio.

Rising marginal cost has a sharp and robust implication: When an outside event stimulates product demand temporarily, it should also cause an inventory draw-down, in the sense of a negative value of h_t. To put it differently, an instrumental variable positively correlated with $y_t - y_{t+1}$ should be negatively correlated with h_t. The negative of the ratio of the covariances is the instrumental variable estimator of γ. By contrast, the firm with flat marginal cost is indifferent to the scheduling of production. Its only objective is to maintain its inventory/sales ratio at the prescribed level α, so it always plans for $h_t = 0$. An instrumental variable positively correlated with $y_t - y_{t+1}$ will have zero correlation with excess inventory accumulation. The instrumental variable estimator for γ will be zero.

For a firm with decreasing marginal cost ($\gamma < 0$), it is efficient to bunch production. The firm would produce its output for all periods in the first period but

for the cost of departing from the normal inventory/sales ratio, α. Even in the face of that cost, the firm amplifies fluctuations in output so as to obtain the economies of bunching output. Equation 8.6 shows that the firm builds extra inventories in the same periods when current output exceeds expected future output. An instrument positively correlated with $y_t - y_{t+1}$ will also be positively correlated with h_t, and the IV estimate of γ will be negative.

Ramey's model as estimated is considerably more elaborate than the one just discussed. The cost function is cubic in output and the linear term depends on the wage, the price of materials, and the price of energy. There is a time trend in the quadratic term. There are costs of adjustment of the level of output in the form of a term involving the square of $y_t - y_{t-1}$. Finally, there are random shifts in the technology itself, in the adjustment cost term, and in the target inventory/sales ratio.

In Ramey's work, the exogenous variables that shift product demand and do not shift product supply are three measures of federal military spending, the relative price of oil, a dummy variable for the political party of the president, and population. The seven industries Ramey studies are food, tobacco, apparel, chemicals, petroleum, and autos. Except for the auto industry, a dummy for auto strikes also serves as an instrument. For the tobacco industry, a set of variables characterizing federal regulation is included. In all seven industries, the estimate of γ, the slope of the marginal cost schedule, is negative. In four of the seven industries, the point estimate of γ is more than two standard errors below zero, so

the evidence against rising marginal cost is statistically unambiguous. All seven of the industries tend to bunch production during times of high sales. They typically accumulate inventories beyond the amount needed to maintain the normal inventory/sales ratio at the same time that output is strong because sales are high. Firms with rising marginal cost would behave in the opposite way, building inventory stocks in times of weak sales and drawing them down when sales are high. Ramey's strong statistical evidence in favor of production bunching is inconsistent with rising marginal cost and downward-sloping labor demand.

9. Flatness of the marginal value of job search and accumulation of organizational capital

The distinctive feature of the model in this paper is its perfectly elastic supply of labor to the production of goods and services. The flatness arises from the hypothesis that a linear technology transforms labor time into organizational capital. The stock of organizational capital has diminishing marginal product, but the instantaneous marginal product of the flow is the same for all values of the flow. As I noted earlier, congestion in the worker-job matching process would cause diminishing marginal product of time spent reorganizing as the flow through the labor market increased. The supply of labor to production of goods and services would be upward-sloping, not flat. Agglomeration efficiencies would have the opposite effect. Does the hypothesis that congestion and agglomeration are absent

or offsetting find any support in the data?

Blanchard and Diamond [1990] have studied flows in the labor market in considerable detail. The flow of workers into jobs from unemployment may be considered a rough measure of the flow of newly created organizational capital. Then the relation between the flow of time spent in unemployment and the flow of workers to employment measures the relevant technology. If the technology were one of strict proportionality, the hazard rate — the monthly probability of a job-seeker finding a new job — would be the same when unemployment is low or high. Blanchard and Diamond find that the hazard rate falls slightly when unemployment rises — a recession that raises unemployment by two percentage points reduces the job-finding rate from a normal level of 24.0 percent per month to 21.8 percent per month. There are two reasons to think that this figure overstates the structural response to a shift in product demand. First, there are mix effects over the business cycle. In a recession, a larger fraction of the unemployed are experienced workers who probably have lower job-finding rates under any conditions. Second, some of the fluctuations in unemployment considered in Blanchard and Diamond's work are the result of spontaneous shifts in the job-finding rate. A decline in job-finding will result in higher unemployment. Hence there may be a simultaneity bias in the direction of apparent congestion effects.

Davis and Haltiwanger [1990] (D-H) provide data on the volume of job matching in manufacturing. They observe quarterly changes in the employment levels of individual plants. If plants with rising employment never lost or

terminated workers, and if plants with declining employment never hired workers, then the D-H data would reveal the volume of new matches directly. Instead, their data understate actual movements of workers. My impression is that the understatement is not a serious problem in interpreting the data, but confirming that impression is a topic for further research. Under the hypothesis of no counterflows, D-H consider the volume of employment declines as a measure of job terminations and the volume of employment increases as a measure of newly created jobs. From these, they derive two measures of new matches. One is an upper bound that is attained in the case where every worker who departs goes off to another industry and every worker who is hired comes from another industry. The other is a lower bound that is attained if every departing worker is hired within the same industry (when growth exceeds shrinkage) or if every new hire comes from those just leaving jobs in the same industry (when shrinkage exceeds growth).

D-H document the positive relationship between unemployment and the volume of job matches (Table 8, p. 164). The issue for this paper, however, is not whether the marginal product of time spent looking for work is positive, but rather if it declines with increases in the number of job seekers. In that connection, I have looked at the statistical relation between the D-H job-matching flows, the total civilian unemployment rate, and the squared unemployment rate (standard errors in parentheses):

Upper bound measure of job-matching flow

$$m_t = .204 - .80\ u_t + 10.5\ u_t^2$$

$$(3.17) \qquad (21.0)$$

Lower bound measure of job-matching flow

$$m_t = .292 - 5.3\ u_t + 40.3\ u_t^2$$

$$(3.3) \qquad (22.2)$$

In both cases, the marginal product of unemployment in producing job matches *rises* with unemployment, according to the positive coefficient on squared unemployment. For the upper-bound measure, the positive coefficient could easily have arisen from sampling variation. For the lower-bound measure, there is only a small likelihood that the nonlinearity arose from sampling variation; the t-statistic is 1.8.

Blanchard and Diamond's data suggest small departures from linearity in the direction of congestion effects — diminishing marginal value of time spent looking for work as the number of people looking increases. D-H's data, on the other hand, show some signs of increasing marginal value of time spent looking. Tentatively, it appears to me that the hypothesis of linear transformation of time into organizational capital is not unreasonable. Plainly this is an area where further research will pay off.

10. General equilibrium summary

Recall that the model of the allocation of labor between goods production and creation of organizational capital reached the following relation between the real interest rate and the level of employment:

$$\frac{N - N^*}{N^*} = \beta\pi \int_t^\infty e^{-\lambda(s-t)}[r(s) - r^*]\,ds \tag{2.23}$$

The empirical work reported earlier suggested that the labor demand elasticity, β, is around 5. Even with Cobb-Douglas technology, the elasticity is around 3. To illustrate the magnitudes involved, I will assume that both physical and organizational capital deteriorate 10 percent per year, that organizational capital formation uses 6 percent of available labor (a typical unemployment rate), on the average, and that physical capital formation averages 17 percent of output (the U.S. level in 1989). The resulting values of λ and π are 1.8 and 5.4 at annual rates. The adjustment speed λ is sufficiently rapid that equation 2.23 effectively reduces to the steady-state relation,

$$\frac{N - N^*}{N^*} = \frac{\beta\pi}{\lambda}[r(t) - r^*] \tag{10.1}$$

The value of the composite $\beta\pi/\lambda$ is about 14 with these parameter values. Small

changes in the urgency of goods production, as measured by the shadow real interest rate $r(t)$, generate large movements of labor between goods employment and building organizational capital.

To complete the model, suppose that d is a product demand disturbance stated as a proportion of GNP, and that the reduced form equation relating the shadow real interest rate to the demand disturbance is

$$r(t) - r^* = \gamma d \qquad (10.2)$$

A representative value for γ might be .05 — a shift in product demand equal to one percent of GNP might raise the shadow real interest rate by 5 basis points. Then the elasticity of employment with respect to the demand shift would be $\gamma \beta \pi / \lambda = 0.7$, which is in line with direct regression measures of the effect of, say, military spending on employment.

11. Conclusions

A major theme of the line of thought put forward in this paper is that macroeconomics should take unemployment seriously. The conspicuous fact that large numbers of workers move from employment to unemployment in the course of a recession calls for real economic analysis. Efforts to make wage rigidity the

starting point for a model of the high substitutability of work and unemployment have not been widely accepted, for lack of good underlying economic rationalization. The model in this paper makes wage rigidity a derived conclusion rather than the starting point.

I think it is fair to say that most economists who take unemployment seriously believe that the marginal value of unemployment declines sharply with the volume of unemployment. But there is growing evidence that the labor market in recession does not undergo a decline in matching efficiency. Rather, a recession is a time when the matching process is called upon to operate at much higher than normal volumes. In recessions, some firms cut back employment sharply while the majority continue to hire workers. The volume of matches each month rises approximately in proportion to the number of unemployed job-seekers. Although the numerical volume of new matches is only a rough proxy for the underlying concept of creation of organizational capital, the facts on matching do seem to provide some support for the view that the marginal product of time spent job seeking does not fall in recessions.

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