"JOB DESTRUCTION AND PROPAGATION OF SHOCKS"

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JOB DESTRUCTION AND PROPAGATION OF SHOCKS

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ABSTRACT.   We develop and quantitatively implement a dynamic general equilibrium model with labor market matching and endogenous determination of the job destruction rate. The model produces a close match with data on job creation and destruction. Cyclical fluctuations in the job destruction rate serve to magnify the effects of productivity shocks on output, as well as making the effects much more persistent. Interactions between the labor and capital markets, mediated by the rental rate of capital, play the central role in propagating shocks.

1.   INTRODUCTION

It has been well documented that the cyclical adjustment of labor input represents chiefly movement of workers into and out of employment, rather than adjustment of hours at given jobs. Thus, in understanding business cycles, it is centrally important to understand the formation and breakdown of employment relationships. The nature of employment adjustments over the cycle has also received close scrutiny. Evidence from a number of sources indicates that recessionary employment reductions are accounted for by elimination of pre-existing jobs, i.e. job destruction, to a greater extent than by diminished creation of new

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jobs. Substantial cyclical variation in the rate of job destruction suggests that closer consideration of the breakdown of employment relationships may help to explain how shocks to the economy generate large and persistent output fluctuations.[1]

This paper addresses these issues by studying endogenous determination of the job destruction rate in a dynamic general equilibrium model with labor market matching. Production is assumed to entail long-term relationships between workers and firms. Each period, a worker and firm who are currently matched must decide whether to preserve or sever their relationship, based on their current-period productivity. By altering the tradeoff between match preservation and severance, aggregate productivity shocks induce fluctuations in the job destruction rate, thereby exerting effects on output that go beyond those resulting from productivity variations in continuing relationships. In our model, fluctuations in job destruction are accompanied by changes in job matching and savings rates in determining the overall effect of productivity shocks on output.

We calibrate parameters of the model to labor market data, where our measurements of worker and firm matching rates, as well as endogenous and exogenous separation rates, explicitly account for the observation that flows of workers out of employment relationships exceed flows of jobs out of firms. The calibrated model yields excellent matches between descriptive statistics from simulated data and measurements of job flows in manufacturing

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[1]For evidence on the importance of employment adjustment relative to hours adjustment, see Lilien and Hall (1986). Evidence on recessionary worker flows is provided by Blanchard and Diamond (1990), while Davis and Haltiwanger (1992) consider job flows in manufacturing. Corroborating evidence from Michigan data is provided by Foote (1995), who finds that for nearly all sectors, most of the recessionary employment adjustment in 1980 and 1982 can be accounted for by increased job destruction as opposed to reduced job creation.

drawn from the Longitudinal Research Database (LRD). In particular, our model generates dynamic correlations of job creation, destruction and employment that closely fit those observed in the data: destruction tends to lead employment, creation lags employment, and creation and destruction exhibit high negative contemporaneous correlation. Moreover, negative recessionary shocks in the model cause job destruction to rise by a greater amount than job creation falls, so that most of the net employment reduction is accounted for by increased job destruction.

Most quantitative business cycle models in the RBC tradition share the feature that model-generated output data exhibit dynamic characteristics nearly identical to those of the underlying business cycle shocks, so that economic mechanisms play a minimal role in propagating shocks (Cogley and Nason (1993,1995), Rotemberg and Woodford (1996)). We give a resolution to this issue by showing that fluctuations in the job destruction rate represent a significant propagation mechanism: relatively small and transitory aggregate productivity shocks can generate large and persistent output effects due to their ramifications for the rate of job destruction. In simulated data, the standard deviation of output in our model is two and one-half to three times larger than the standard deviation of the underlying driving process, reflecting magnification of shocks in the period of impact together with slower adjustment of output following shocks, which leads shocks to persist. By way of comparison, the standard RBC model, as well as Hansen's (1985) indivisible labor variant, yield magnification ratios of less than two; further, nearly all of the magnification in the latter models occurs on impact, meaning that the models generate only slight amounts of persistence. Further, our simulated data generate autocorrelations of output growth rates that match well the autocorrelations observed in U.S. data, reflecting the large amount of persistence generated by our propagation mechanism.

In our model, interactions between the labor and capital markets, mediated by the rental rate of capital, play the central role in propagating shocks. A negative aggregate productivity shock reduces the incentive to maintain employment relationships, leading to an increase in the job destruction rate. This causes the productivity of capital to fall, since capital must be spread over a smaller number of active employment relationships, and correspondingly the rental rate is driven down, giving lower levels of savings and capital relative to models in which the job destruction rate does not vary. Further, the capital stock returns more slowly to the steady state, since rental rates cannot rise as far in response to a reduced capital stock on account of the sensitivity of the job destruction rate to capital costs. In other words, endogeneity of the job destruction rate flattens the capital demand curve, generating more sluggish adjustment of capital following a shock. In the absence of these capital adjustment effects, persistence is nil in our model, as we show by considering the impulse response function when the capital stock is held fixed. This implies that the need for time-consuming rematching following worker displacement is not sufficient to explain persistent output effects.

Propagation is also affected by the ease with which capital can be adjusted between employment relationships. To consider this issue, we develop a version of the model in which firms must choose their capital levels before they observe their idiosyncratic productivity shock within the current period. Further, firms have the right to sever their employment relationships and walk away from rental agreements if low idiosyncratic productivity is realized, and capital suppliers must wait until the following period before rerenting the capital to other firms. This kind of costly capital adjustment reduces the effective rental rate received by capital suppliers, since they must factor in the possibility of nonpayment by renting firms. We show that propagation effects are much greater in the costly capital adjustment version

of the model, because of the extra idle capital associated with increases in the job destruction rate, along with the reduced savings generated by the correspondingly low levels of the effective rental rate. Thus, propagation of shocks is heavily influenced by costs of capital adjustment.

Mortensen and Pissarides' (1994) pioneering study has focussed economists' attention on the importance of fluctuations in the rate of job destruction in accounting for the cyclical variation of job flows.[2] Further, Cole and Rogerson (1996) have shown that a reduced form model inspired by Mortensen and Pissarides can do a good job explaining statistical regularities in the LRD. Our paper follows Mortensen and Pissarides in positing that employment relationships are formed on a matching market, and that relationships may be severed in response to idiosyncratic productivity shocks. We embed this basic mechanism into a full dynamic general equilibrium model, assess its quantitative properties for macroeconomic aggregates as well as job flow data, and analyze the role of fluctuations in the job destruction rate in propagating shocks. Importantly, we focus on interactions between the labor and capital markets that are central to the propagation mechanism.[3]

Several recent papers have considered labor market search and matching within a quantitative dynamic general equilibrium context. Merz (1995) and Andolfatto (1996) have implemented labor market matching models in the spirit of Pissarides (1985), where all job destruction is exogenous and the separation rates are constant over time. These pa-

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[2]Other papers incorporating endogenous determination of the job destruction rate include Aghion and Howitt (1994), Caballero and Hammour (1994,1996), Hosios (1994) and Ramey and Watson (forthcoming).

[3]While they consider a different class of models, Cogley and Nason (1995) and Burnside and Eichenbaum (1996) have also emphasized that imperfections in the adjustment of labor input can play a role in propagating business cycle shocks.

pers demonstrate that incorporating matching improves the ability of the RBC framework to explain macroeconomic facts, including low variability of wages and productivity, and persistence of unemployment movements. Using our labor market measurements, however, we show that the implied propagation mechanism is quite weak when the job destruction rate is fixed, and further, models in this vein cannot account for the cyclical patterns of job creation and destruction. More recently, Gomes, Greenwood and Rebelo (1997) have studied the ability of a simple search model incorporating endogenous separation to account for cyclical variability of the unemployment rate, the duration of unemployment spells, and flows into and out of unemployment.

Our paper features some methodological improvements with respect to previous literature. We compute the job destruction rate as a fixed point within a dynamic general equilibrium exhibiting heterogeneity on the production side. Importantly, we do not rely on social planner solutions that restrict model parameters, in contrast to Merz (1995) and Andolfatto (1996). Further, we utilize a new specification of the labor market matching function that is motivated by search-theoretic considerations.

Section 2 describes the theoretical model. Measurement, calibration and numerical implementation issues are discussed in Section 3, and results are presented in Section 4. Section 5 concludes.

2.   MODEL

2.1.   Employment Relationships.   Employment relationships are taken to consist of two agents, a worker and a firm, who engage in production through discrete time until the relationship is severed. Individual employment relationships are indicated by subscript i. In each period t, firm i hires capital, denoted k_{it}. Output from production is given by $z_t a_{it} f(k_{it})$,

where z_t represents a random aggregate productivity disturbance, and a_{it} gives a random disturbance that is specific to relationship i. Shocks of the latter sort are assumed to be i.i.d. across relationships and over time.[4] Further, the relationship might be severed for exogenous reasons, in which case production does not take place. Let ρ^x indicate the probability of exogenous separation, assumed to be independent of z_t, a_{it} and of shocks realized in other relationships.

The firm's choice of capital will depend on what productivity information is known when the capital decision is made. Two possible information structures will be considered.

Case 1. Perfect Capital Adjustment (PCA). The firm selects k_{it} after observing z_t, a_{it} and whether or not exogenous separation has occurred.

Case 2. Costly Capital Adjustment (CCA). k_{it} is chosen after z_t has been observed, but before seeing either a_{it} or the exogenous separation shock.

After observing all the shocks, the worker and firm may choose to separate endogenously in period t. If either exogenous or endogenous separation occurs, then there is no production in period t. In this event, the worker obtains a payoff of $b + w_{it}^w$ based on opportunities outside of the current relationship, where b indicates the worker's benefit obtained in the current period from being unemployed, and w_{it}^w denotes the expected present value of payoffs obtained in future periods. We take b to be exogenous. Due to free entry of firms into the worker-firm matching process, as described in the following subsection, the firm obtains a payoff of zero outside of the relationship.

If the relationship is not severed, then production occurs and, in the PCA case, the

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[4]Assuming that the idiosyncratic shocks a_{it} are i.i.d. over time simplifies the analysis by eliminating the need to consider additional match-specific state variables. In this we depart from Mortensen and Pissarides (1994), who emphasize persistence of idiosyncratic shocks. We discuss this issue further in the Conclusion.

worker and firm obtain the following joint payoff:

$$\max_{k_{it}} \left[z_t a_{it} f(k_{it}) - r_t k_{it} \right] + g_{it}, \tag{1}$$

where r_t is the rental price of capital, and g_{it} gives the expected current value of future joint payoffs obtained from continuing the relationship into the following period.[5] The CCA case will be described below.

Given any contingency that arises, the worker and firm bargain over the division of their surplus. Negotiation is resolved according to the Nash bargaining solution, where π is the firm's bargaining weight. In particular, after observing productivity information, the worker and firm will choose whether or not to sever their relationship based on which option maximizes their joint surplus. Since the current period payoff becomes less attractive as a_{it} declines, it follows that there exists a level $\underline{a}_{it}$ such that the partners will opt for separation if $a_{it} < \underline{a}_{it}$, while the match will be preserved and production will occur if $a_{it} \geq \underline{a}_{it}$. We refer to $\underline{a}_{it}$ as the *job destruction margin*. In the PCA case, the job destruction margin is determined as follows:

$$z_t \underline{a}_{it} f(k_{it}^*) - r_t k_{it}^* + g_{it} = b + w_{it}^w, \tag{2}$$

where k_{it}^* is the solution to the maximization problem in (1).

In the CCA case, we assume that the firm may avoid making payments for capital if the relationship is severed, either exogenously or endogenously, i.e. the firm may declare bankruptcy in lieu of making payments. Thus, by renting capital the firm secures an option

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[5]Observe that in (1) the firm chooses capital to maximize the joint returns of the worker and firm. In essence, the worker and firm are able to contract efficiently over the choice of capital.

to utilize k_{it} units of capital, and the firm will exercise the option and pay the rental cost if productivity is sufficiently high. The value $\underline{a}_{it}$ and the firm's optimal choice of capital k_{it}^* simultaneously solve (2) and:

$$\max_{k_{it}} \int_{\underline{a}_{it}}^{\infty} [z_t a_{it} f(k_{it}) - r_t k_{it}] \, d\mu(a_{it}), \tag{3}$$

where μ is the probability distribution over a_{it}. Observe that in (3), the firm avoids making rental payments for realizations in the lower tail of the a_{it} distribution.

2.2. Matching Market.

Employment relationships are formed on a matching market. There is a continuum of workers in the economy, having unit mass, along with a continuum of potential firms having infinite mass. Let U_t denote the mass of unmatched workers seeking employment in period t, and let V_t denote the mass of firms that post vacancies. The matching process within a period takes place at the same time as production for that period, and workers and firms whose matches are severed can enter their respective matching pools and be rematched within the same period. All separated workers are assumed to reenter the unemployment pool, i.e., we abstract from workers' labor force participation decisions. Firms may choose whether or not to post vacancies, where posting entails a cost of c per period. Free entry by firms determines the size of the vacancy pool.

The flow of successful matches within a period is given by the matching function $m(U_t, V_t)$, which is increasing in its arguments and exhibits constant returns to scale. Workers and firms that are matched in period t begin active employment relationships, as described in the preceding subsection, at the start of period $t + 1$.

2.3. Savings Decision.

At the end of each period, following production and matching, output is allocated between consumption and capital for the following period. For simplicity,

we assume that workers pool their incomes at the end of the period and make the savings decision in manner that maximizes the expected utility function of a representative worker, which is given by:

$$E_t[\Sigma_{s=t}^{\infty}\beta^{s-t}u(C_s)],\tag{4}$$

where β gives the discount factor and C_t indicates aggregate consumption.[6] Symmetry in consumption together with independence over time in the match-specific productivity shocks a_{it} allows us to suppress the i subscripts for the remainder of the paper.

The wealth constraint is determined as follows. Aggregate wage and profit income in period t is given by:

$$H_t = (1 - \rho^x)N_t \int_{\underline{a}_t}^{\infty} [z_t a_t f(k_t^*) - r_t k_t^*] \, d\mu(a_t) - cV_t,\tag{5}$$

where N_t gives the mass of employment relationships at the start of the period, before any shocks have occured. Thus, wage and profit income consists of the payoffs generated in the current period by active employment relationships, net of total vacancy posting costs incurred by unmatched firms. Further, we interpret b as nontradable units of the consumption good that are produced at home by unemployed workers, so that aggregate home-produced output is $B_t = bU_t$. We assume that home-produced output cannot be used to generate capital.[7]

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[6]Merz (1995) and Andolfatto (1996) make a similar income-pooling assumption.

[7]The latter assumption implies the constraint $C_t \geq B_t$. It should be noted that this constraint does not bind in any of the subsequent analysis. Home production in standard RBC settings has been considered by Benhabib, Rogerson and Wright (1991) and Greenwood and Hercowitz (1991). In contrast to these papers, our results do not rely on stochastic variability of the home production technology.

In the PCA case, rental payments are collected on all traded capital. Thus, rental income is given by $r_t K_t$, where K_t indicates the aggregate capital stock. Given that capital depreciates at rate δ per period, it follows that the wealth constraint for the PCR case is:

$$C_t + K_{t+1} = H_t + (r_t + 1 - \delta)K_t + B_t. \qquad (6)$$

Note that total income in period t consists of wage, profit and capital income, which are equal to total market-produced output net of vacancy posting and depreciation costs, together with home-produced output.

In the CCA case, rental payments are collected only from firms whose relationships are not severed. We assume that capital that has been optioned to firms whose relationships are severed cannot be rented to other firms until the following period. Thus, adjustment of capital across relationships imposes a cost in the form of a one-period delay. The wealth constraint for this case is:

$$C_t + K_{t+1} = H_t + \left((1 - \rho^x)(1 - \rho_t^n)r_t + 1 - \delta\right) K_t + B_t, \qquad (7)$$

where $\rho_t^n = \Pr\{a_t < \underline{a}_t\}$ gives the *endogenous separation rate*. Comparing (6) and (7), it may be seen that the CCA case is associated with a lower effective rental rate for given r_t.

Our notion of capital adjustment costs is motivated by the idea that renting capital to a firm involves a certain amount of commitment by the capital supplier, e.g. firms differ in their locations or engineering specifications, so that capital is not immediately transferable across firms. Further, firms are unable to commit contractually to making rental payments under future contingencies. When productivity turns out to be low ex post, the firm can walk away from the rental contract, and the supplier is left to bear the cost of idle capital

for one period.

2.4. Equilibrium.

An equilibrium of this model involves three components: (i) payoff-maximizing choices of capital rental k_t^* and job destruction margin $\underline{a}_t$ for each employment relationship, given the expected future payoffs w_t^w and g_t and the rental rate r_t; (ii) equilibrium determination of the expected future payoffs, given the payoff-maximizing choices and rental rate; and (iii) equilibrium in the capital market.

The conditions for payoff-maximizing k_t^* and $\underline{a}_t$ under the PCA and CCA cases are given in (1), (2) and (3). Equilibrium values of the expected future payoff terms are determined as follows. Consider first the situation facing a worker and firm that are matched at the start of period $t+1$. If their relationship is severed in period $t+1$, then they obtain a joint payoff of $b + w_{t+1}^w$. If they avoid severance, then their relationship generates a surplus net of their outside joint payoff, which may be written as follows:

$$s_{t+1} = z_{t+1}a_{t+1}f(k_{t+1}^*) - r_{t+1}k_{t+1}^* + g_{t+1} - (b + w_{t+1}^w). \tag{8}$$

The worker and firm bargain over this surplus, obtaining shares $1 - \pi$ and π, respectively. Division of the surplus is accomplished via transfer payments, e.g. the firm makes a wage payment to the worker.

Next, consider the situation of a worker in the period t unemployment pool. The worker obtains future payoffs of $b + w_{t+1}^w$ if he does not succeed in being matched in period t, or if he is successfully matched in period t, but the match is severed prior to production in period $t+1$. Alternatively, the worker receives a share of surplus from a productive relationship in period $t+1$, and thus obtains future payoffs of $(1 - \pi)s_{t+1} + b + w_{t+1}^w$, if he is matched in period t and the match survives in period $t+1$. The worker's expected future payoffs,

appropriately discounted, may therefore be written:

$$w_t^w = E_t \left[\frac{\beta u'(C_{t+1})}{u'(C_t)} \left(\lambda_t^w (1 - \rho^x) \int_{\underline{a}_{t+1}}^{\infty} (1 - \pi) s_{t+1} d\mu(a_{t+1}) + b + w_{t+1}^w \right) \right], \qquad (9)$$

where $\lambda_t^w = m(U_t, V_t)/U_t$ gives the probability that the worker is successfully matched. Observe in (9) that the worker obtains $(1 - \pi)s_{t+1}$ with probability $\lambda_t^w (1 - \rho^x)(1 - \rho_t^n)$, reflecting the event that the worker is matched in period t and the match survives in period $t + 1$.

A firm in the period t vacancy pool, in contrast, must obtain a payoff of zero as a consequence of free entry. In particular, we have:

$$0 = -c + \lambda_t^f E_t \left[\frac{\beta u'(C_{t+1})}{u'(C_t)} (1 - \rho^x) \int_{\underline{a}_{t+1}}^{\infty} \pi s_{t+1} d\mu(a_{t+1}) \right], \qquad (10)$$

where $\lambda_t^f = m(U_t, V_t)/V_t$ gives the firm's matching probability. Finally, the expected future joint returns of a worker and firm who remain matched in period t are:

$$g_t = E_t \left[\frac{\beta u'(C_{t+1})}{u'(C_t)} \left((1 - \rho^x) \int_{\underline{a}_{t+1}}^{\infty} s_{t+1} d\mu(a_{t+1}) + b + w_{t+1}^w \right) \right]. \qquad (11)$$

In contrast to (9) and (10), the partners in a continuing relationship do not need to be matched, so that they obtain the surplus s_{t+1} with probability $(1 - \rho^x)(1 - \rho_t^n)$.

It remains to consider the capital market. In the PCA case, the equilibrium r_t is determined by the following market clearing condition:

$$N_t(1 - \rho^x) \int_{\underline{a}_t}^{\infty} k_t^* d\mu(a_t) = K_t. \qquad (12)$$

The left-hand side of (12) indicates the demand for capital, consisting of the total number of employment relationships at the start of period t times the expected capital rental for

each relationship. The capital market clears when capital demand is equal to the supply of capital in period t, given by K_t. In turn, K_{t+1} is determined by maximization of (4) subject to (6), for which the following is sufficient under the usual concavity condition:

$$u'(C_t) = E_t \left[u'(C_{t+1})(r_{t+1} + 1 - \delta) \right]. \tag{13}$$

As for the CCA case, (12) and (13) are replaced by:

$$N_t k_t^* = K_t, \tag{14}$$

$$u'(C_t) = E_t \left[u'(C_{t+1})((1 - \rho^x)(1 - \rho_{t+1}^n)r_{t+1} + 1 - \delta) \right]. \tag{15}$$

Observe in (14) that each matched firm selects the same level of capital, reflecting the assumption that capital is chosen before idiosyncratic productivity shocks are observed. Correspondingly, the effective rental rate in (15) is lower than r_{t+1}, since a proportion of firms will decline to make rental payments.

2.5. Summary.   The workings of the model may be summarized as follows. The variables K_t and N_t are predetermined at the start of period t, where N_t indicates the stock of matched workers and firms as of the end of the preceding period. The timing of actions within a period may be broken down into three stages.

Stage 1. The disturbances z_t and a_t, as well as the exogenous separation shocks, are determined. Firms also rent capital, where the match-specific capital levels are determined either after all the shocks have been observed, or after only z_t has been observed, under the PCA and CCA cases, respectively.

Stage 2. The matched pairs that survive the productivity shocks engage in production, while unmatched workers and firms posting vacancies undergo the matching process.

Stage 3. Workers allocate the market-produced output between consumption and capital purchase.

3. IMPLEMENTATION

3.1. Separation and Matching Probabilities. We first discuss measurement of separation and matching probabilities used in calibrating the model. For measurement purposes, we derive these probabilities from relationships between stocks and flows arising in a deterministic steady state of the model. These may be regarded as average relationships over the long run. In measuring labor market flows, we begin with the observation that flows of workers out of employment relationships exceed flows of jobs out of firms; in other words, worker flows exceed job flows. As a consequence, a substantial proportion of the firms that experience separations will desire to replace the lost workers, and will be successful at doing so, within the current period. We will need to account for firms' attempts to refill such job openings in our measurement of job flows.

Let N^s denote the steady state stock of employment relationships, and let U^s and V^s represent the per period flows of workers and firms, respectively, through the matching pools in the steady state. The probability of separation, for either exogenous or endogenous reasons, is indicated by ρ, so that ρN^s gives the total flow of workers and firms out of employment relationships within a given period. Note that $\rho = \rho^x + (1 - \rho^x)\rho^n$, where ρ^n gives the endogenous separation rate in the steady state.

Several direct measures of ρ are available. In surveying the empirical evidence, Hall (1995, p. 235) concludes that, for long-term employment relationships of the sort we consider, quarterly U.S. worker separation rates lie in the range of eight to ten percent. Using CPS data, Davis, Haltiwanger and Schuh (1996, p. 35) compute an annual separation rate of 36.8

percent, which works out to roughly 11 percent per quarter. From these estimates, we take 10 percent as our estimate of the quarterly steady state rate of exogenous and endogenous separation. That is, with periods in our model interpreted as quarters, we set $\rho = 0.10$.

To interpret exogenous and endogenous components of the separation rate, we make the assumption that firms experiencing exogenous separations attempt to refill the positions by posting vacancies in the ensuing matching phase, while firms having endogenous separations do not post vacancies. This assumption makes sense if exogenous separations are regarded as being worker-initiated, reflecting changes in the worker's personal circumstances. Such separations give rise to job vacancies that are reposted by the firm. Endogenous separations, in contrast, are driven by productivity changes that reflect on the firm's circumstances, and it is reasonable to assume that firms do not attempt to rehire following such separations. It follows that the rate at which separations are reposted by firms, denoted by ω^f, will be equal to the proportion of all separations that are exogenous, or $\omega^f = \rho^x/0.10$.

We define job destruction and job creation in the following way. Period-to-period job destruction is recorded as total separations ρN^s less those job openings that are reposted and successfully refilled by firms within the period. The steady state mass of jobs destroyed per period is thus given by $\rho(1 - \omega^f\lambda^f)N^s$, where λ^f indicates the steady state matching probability for a firm. Job creation is recorded as the mass of firms who have no employees at the beginning of the period, but who find workers in the matching phase of the period. Therefore, $\lambda^f(V^s - \rho\omega^f N^s)$ is the mass of jobs created each period in the steady state. Note that a job is neither created nor destroyed by a firm that both loses and gains a worker in the same period.

We next impose the condition that the flow of jobs out of the stock of employment relationships must equal the flow of jobs into relationships, or job destruction must equal

job creation, as required for a steady state. This condition may be written as follows:

$$\rho(1 - \omega^f \lambda^f) N^s = \lambda^f (V^s - \rho \omega^f N^s). \tag{16}$$

Observe that this condition is equivalent to the steady state property that total separations equal total new matches, or $\rho N^s = \lambda^f V^s$.

Although the data is restricted to the manufacturing sector, the LRD evidence reported in Davis, Haltiwanger and Schuh (p. 19) allows us to pin down directly the job creation rate. From quarterly plant level data from U.S. manufacturing, 1972:2-88:4, we find the ratio of creation to employment to be:

$$\frac{\lambda^f (V^s - \rho \omega^f N^s)}{N^s} = .052. \tag{17}$$

Further, Davis, Haltiwanger and Schuh (p. 23) indicate that 72.3 percent of jobs counted as destroyed in a quarter fail to reappear in the following quarter, i.e. for plants experiencing employment reductions in a quarter, roughly three-quarters of the reduction persists into the following quarter. This implies:

$$\rho(1 - \omega^f(\lambda^f + (1 - \lambda^f)\lambda^f)) N^s = .723 \rho(1 - \omega^f \lambda^f) N^s. \tag{18}$$

Combining (16), (17) and (18) yields $\lambda^f = .71$ and $\omega^f = .68$. Using our assumption that only exogenous separations are reposted, we then calculate $\rho^x = 0.068$. Correspondingly, the steady state endogenous separation rate is computed to be $\rho^n = 0.032$. It is worth noting that our finding of $\lambda^f = .71$ agrees with Ours and Ridder's (1992) result from Dutch survey data that 71 percent of vacancies reported in an initial survey were found to be filled in a

follow-up survey roughly one quarter later.[8]

It remains to estimate the steady state matching probability for workers. Blanchard and Diamond (1990) use CPS data for 1968-86 to calculate an average stock of employed workers of 93.2 million. In abstracting from labor force participation decisions, we interpret unmatched workers in our model as including both workers classified as unemployed and those not in the labor force but stating that they "want a job," giving an average stock of unmatched workers of 11.2 million. Thus, the steady state ratio of unmatched to matched worker stocks is estimated to be 12 percent. In our model, we identify the mass of workers observed to be unemployed as $1 - N^s$, which equals $U^s - \rho N^s$ in the steady state. Note that this excludes workers with very short transitional terms of unemployment due to leaving one job and initiating another within the same period. The steady state condition for worker flows, corresponding to the job flow condition (16), may be written:

$$\rho(1 - \lambda^w)N^s = \lambda^w(U^s - \rho N^s), \tag{19}$$

which is equivalent to $\rho N^s = \lambda^w U^s$. Observe that all separated workers are assumed to enter the unemployment pool during the ensuing matching phase, i.e. the reposting rate for workers is unity. Combining (19) with our earlier findings $\rho = 0.10$ and $(U^s - \rho N^s)/N^s = 0.12$, we conclude that $\lambda^w = 0.45$ gives an appropriate estimate.[9]

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[8]As a further check on our estimates, we calculated that in the steady state, the estimates of ρ, λ^f and ω^f imply that 65 percent of the jobs destroyed in a quarter do not appear in the second quarter following. This number is reasonably close to Davis, Haltiwanger and Schuh's (p. 23) corresponding figure of 59 percent.

[9]Our approach to measuring λ^w is in line with Cole and Rogerson's (1996) idea that including part of the not-in-labor-force population in the unemployment pool makes for a comparatively low estimate of the worker matching probability.

3.2. Specification. We now turn to parameterization of the model. The following standard specifications of production and utility functions are adopted:

$$f(k_t) = k_t^\alpha,$$
$$u(C_t) = \frac{C_t^{1+\gamma} - 1}{1 + \gamma}.$$

The aggregate productivity shock is determined by the process $\ln z_t = \xi \ln z_{t-1} + \epsilon_t$, where ϵ_t is taken to be i.i.d. normal with unit mean and standard deviation σ_ϵ. Further, we assume a_t is i.i.d. lognormal with unit mean and standard deviation σ_a.

In choosing the matching function, we depart from the standard Cobb-Douglas specification that has been used in the previous literature. Our new specification is motivated by considering how the matching technology operates on individual workers and firms. Imagine that J_t channels are set up to carry out matching within a given period. Each worker is assigned randomly to one of the channels, as is each firm. Agents assigned to the same channel are successfully matched, while the remaining agents are unmatched. With this procedure, a worker locates a firm with probability V_t/J_t, a firm locates a worker with probability U_t/J_t, and the total mass of matches is $U_t V_t / J_t$.

The number of channels J_t depends on the sizes of the unemployment and vacancy pools, reflecting thick market externalities. In particular, we adopt the specification $J_t = (U_t^l + V_t^l)^{1/l}$, from which we obtain the following matching function:

$$m(U_t, V_t) = \frac{U_t V_t}{(U_t^l + V_t^l)^{1/l}}.$$

Observe that the matching function is increasing in its arguments and satisfies constant returns to scale.[10]

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[10]A major advantage of our new matching function, relative to the Cobb-Douglas specification, is that

3.3. Solution Procedure and Calibration. In computing solutions to the model, we express the equilibrium conditions in recursive form and compute equilibria using the PEA-Collocation method; see Christiano and Fisher (1994) for details. The four expectation terms in (9), (10), (11) and (13) are parameterized using Chebyshev polynomials of the state variables z_t, K_t and N_t. These polynomials are computed exactly on Chebyshev grid points. Further, within each iteration of the computation procedure, an equilibrium point for the capital market is determined, involving a fixed point of equations (2) and (13) in the PCA case, or (2) and (15) in the CCA case, with respect to the variables $\underline{a}_t$ and r_t. Hermite Gaussian quadrature is used for integration with respect to z_t; however, due to the nondifferentiability in the values of integrands at the point $\underline{a}_t$, integration with respect to a_t is carried out using the Simpson quadrature method incorporating a large number of quadrature points.

In selecting parameter values, we make standard choices for the parameters α, δ, γ, β, ξ and σ_ϵ, as summarized in the first column of Table 1.[11] We give the worker and firm equal bargaining power by setting $\pi = 0.5$, and the choice of ρ^x is discussed in Section 3.1. The remaining four parameters, b, c, l, and σ_a, are selected to match statistics from simulated data to corresponding empirical measures. The parameter b is varied between the PCA and

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the new function guarantees matching probabilities between zero and one for all U_t and V_t. In applying the Cobb-Douglas specification, truncation is necessary to rule out matching probabilities greater than unity. This raises the possibility that V_t will be slightly greater than zero with unit probability, which can lead to discontinuities in the value of V_t as a function of the state variables.

[11]Hansen and Wright (1992), for example, make these selections in their analysis of labor market implications of RBC models. Although we cannot directly invoke factor share comparisons in our setting, the choice of $\alpha = 0.36$ does yield a quarterly output/capital ratio of roughly 10 percent in our simulated data, in line with U.S. evidence.

CCA cases, as shown in Table 1, while the other parameters remain fixed across the two cases.

The first three rows of Table 2 report separation and matching probabilities estimated from U.S. data, as discussed in Section 3.1, along with values computed from steady states of the model having deterministic aggregate productivity. The fourth row considers the ratio of the standard deviation of employment to the standard deviation of output, which in the simulated data is sensitive to the level of σ_a. We measure employment and output by converting monthly nonagricultural employment and industrial production for U.S. manufacturing, expressed on a per capita basis, into quarterly series starting at the middle month of each quarter for 1972:2-88:4, in line with the LRD employment measures. For the PCA and CCA models, this ratio is estimated using simulated data.[12] Actual and simulated data for this case are logged and HP filtered. As seen in Table 2, the simulated data produce good matches along the four dimensions considered.

4. RESULTS

4.1. Empirical Evaluation. Evaluation of the model's performance relative to U.S. aggregate data is given in Panel A of Table 3. Although both versions of the model perform well, the CCA model does a slightly better job explaining the observed volatility of output, as well as matching the empirical volatilities of consumption, investment and employment relative to output, when compared to the PCA model.[13]

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[12]In particular, we generate 100 simulated samples of 67 observations each, where initial conditions are randomized by ignoring the first 200 observations. This procedure is also used to generate model statistics in Tables 3 through 5 below.

[13]It should be noted that measured consumption in the simulated data includes only consumption of market-produced output, in line with the empirical consumption data. While we do not offer a complete

We next consider the ability of the model to account for characteristics of the LRD data. Consistent with our measurement procedure, as expressed in equation (16), we define rates of job creation and destruction in the simulated data as follows:

$$cre_t = \lambda_t^f (V_t - \rho^x N_t)/N_t, \qquad (20)$$

$$des_t = \rho_t - \rho^x \lambda_t^f,$$

where ρ_t denotes the realized separation rate in period t. Thus, job creation is comprised of total matches in period t net of those matches serving to fill separations that are reposted within the period, while job destruction is given by total separations net of those that are refilled within the period.

Panel B of Table 3 compares volatilities of job creation and destruction relative to manufacturing employment in the in the LRD and simulated data. The chief discrepency between model and observation is that job creation is too volatile in the simulated data: creation is roughly seven times more volatile than employment in the PCA and CCA cases, versus less than five times in the LRD data.[14]

theory of wage formation, it is possible to obtain a measure of bargaining transfers from the firm to the worker under the hypothesis that the firm appropriates the payoffs from an active employment relationship, which may be regarded as a measure of wages. In the CCA model, the standard deviation of this wage measure relative to the standard deviation of output is 0.28, and the contemporaneous correlation of wages and output is 0.75. Wage volatility and output correlation are smaller in our model relative to standard RBC models due to the fact that low productivity relationships experience separations in lieu of wage reductions.

[14]While our model does not produce the oft-discussed prediction that the volatility of destruction ought to exceed the volatility of creation, it should be noted that this prediction is distinct from the result that employment adjustment following recessionary shocks consists mostly of increases in job destruction rather than reductions in job creation. We show below that our model does generate the latter prediction.

High volatility of creation can be accounted for by the fact that creation rates become very small in periods when V_t is low relative to $\rho^x N_t$, as seen in (20). In essence, the large number of reposted vacancies implied by our assumption that all exogenous separations are reposted may crowd out vacancies associated with job creation. To assess this effect, we alter our calibrated parameter by setting $\rho^x = 0.05$, in order to reduce the number of reposted vacancies. For the CCA model, this reparameterization gives $\sigma_{cre}/\sigma_N = 5.89$ and $\sigma_{des}/\sigma_N = 7.62$; thus, reducing the amount of reposting lowers the volatility of creation. At the same time, the greater amount of endogenous separation raises the volatility of destruction.

Dynamic correlations between creation, destruction and manufacturing employment are presented in Table 4. In the LRD data, destruction tends to lead employment, in the sense that employment exhibits a large negative correlation with destruction lagged two quarters. Further, creation tends to lag employment. As may be observed in the table, the model displays remarkable agreement with the data, with signs and magnitudes of covariances being quite close. In particular, in both versions of the model, employment has a large negative correlation with past destruction and future creation. Observe further that the large negative contemporaneous correlation between creation and destruction is well matched by both the PCA and CCA models.

The cyclical variation in job creation and destruction implied by the model is illustrated in Figure 1, which shows impulse responses for a three standard deviation negative aggregate productivity shock in the CCA model. On impact, a large destruction spike is induced by an increase in the job destruction margin, accompanied by a smaller dip in creation, as firms post fewer vacancies in anticipation of lower future aggregate productivity. Thus, the model replicates the finding that recessionary employment reductions are accounted for by

increases in job destruction to a greater extent than by reductions in job creation.

The induced increase in unemployment following the shock is sufficiently large to drive creation above its preshock levels in the period following the shock, as the higher matching probability for firms offsets the reduction in vacancies. This "echo effect" of destruction on creation, along with the simultaneous negative movements in creation and employment at the point of the shock, account for the slight negative contemporaneous correlation between creation and employment. Further, the echo effect operates with a one period lag in the model, as opposed to a two period lag in the data, as the creation/destruction correlations indicate.

4.2. Propagation. A key issue in modelling business cycles is the manner in which economic factors captured by the model serve to amplify and spread over time the underlying driving processes. As pointed out by Cogley and Nason (1993,1995) and Rotemberg and Woodford (1996), the intertemporal substitution mechanism at the heart of the RBC model does a poor job propagating shocks, in that the characteristics of output series generated by the model closely mimic those of the underlying driving process. This property of the RBC model is strikingly at odds with the empirical observation of important differences between measured productivity and output. Our model introduces cyclical variation of the job destruction rate as a new mechanism for propagating shocks through the economy. Variations in the destruction rate lead shocks to be magnified, since small variations in productivity can lead to big changes in measured output, as workers substitute between market- and home-produced output. Moreover, the effects of an increase in job destruction have highly persistent effects. In the following subsection, we show that interactions between the labor and capital markets play the central role in generating large amounts of persistence

in our model.

To clarify the discussion, we break down propagation effects into two categories. First, a productivity shock may be magnified in its effect on output within the period that the shock occurs, which we refer to as *impulse magnification.* Second, following the initial period, the output effect of the shock may die away more slowly than the effect on productivity, so that the shock has a more persistent effect on output. The combined effects of impulse magnification and persistence give rise to *total magnification* of the shock, reflecting the greater effect on output in all periods. We measure total magnification by the ratio of the standard deviation of output to the standard deviation of productivity.

Table 5 reports impulse and total magnification for the two versions of the model, as well as for a standard RBC model with variable hours and Hansen's (1985) indivisible labor model. Impulse magnification is obtained by comparing the output reduction associated with a three standard deviation negative productivity shock with the corresponding productivity reduction. All four models generate impulse magnification, in the sense that the output adjustment exceeds the reduction in productivity. Impulse magnification in the CCA model is larger than in the PCA model, due to the added negative effect of idle capital associated with severed relationships under CCA. The RBC and Hansen models generate impulse magnification that is roughly similar to the PCA and CCA models, where the Hansen model delivers a larger effect on account of indivisibility.

Total magnification in the PCA and CCA models is much larger than is impulse magnification, indicating that these models generate signficant persistence. For unfiltered simulated data, total magnification is just under twice as large as impulse magnification in these models. For the CCA model, in particular, productivity shocks are magnified over three times in their effect on output. The greater amounts of impulse and total magnification in the

CCA model relative to the PCA model indicate the importance of capital adjustment costs for the propagation of shocks. In contrast, impulse and total magnification are virtually the same in the RBC and Hansen models, indicating that persistence is nil.

Table 5 also reports total magnification for HP filtered simulated data. HP filtering has almost no effect with respect to the RBC and Hansen models, reflecting lack of persistent effects. However, some of the total magnification is removed by filtering the PCA and CCA models, although magnification remains significant. Removing low frequency variation gives a misleading picture of total magnification under the PCA and CCA models, since magnification continues to be important even at low frequencies.

These results are expressed graphically in Figure 2, which presents impulse responses for aggregate productivity together with output in the four models. In the RBC and Hansen models, the shock is magnified in the initial period, but thereafter output dynamics track the productivity dynamics very closely. Persistent output effects are vividly apparent for the PCA and CCA models, however, as the adjustment of output toward the steady state is much slower than the productivity adjustment.

The added persistence introduced by our model is helpful for explaining the autocorrelation structure observed in U.S. data. Figure 3 depicts the autocorrelations of output growth rates in U.S. GNP over the period 1961:1-93:4, together with corresponding autocorrelations for the growth rate of the aggregate productivity shock and output in the PCA, CCA and RBC models. The PCA and CCA models account for much of the difference between the GNP data and the productivity shock, especially in the first order autocorrelations, while the RBC model generates autocorrelations that are substantially equivalent to those of the

shock.[15] Further, the PCA and CCA models yield positive second-order autocorrelations, which are qualitatively consistent with the data.[16]

To assess the importance of cyclical variation in the job destruction rate for our findings, we consider an alternative version of the CCA model, in which all separations are exogenous. This is accomplished by setting $b = 0$ and $\rho^x = 0.10$; since home production is zero, workers and firms will never voluntarily sever their relationships, meaning that all separations are exogenous. As seen in Figure 3, autocorrelations for this exogenous separation case represent a slight improvement over the RBC model, but are still far from those observed in the data. Impulse responses for the exogenous separation and CCA models are compared in Figure 4. While the output effect of the shock in the exogenous separation case is slightly more persistent than the effect on productivity, impulse magnification is virtually nonexistent. As a consequence, output reductions remain small relative to the CCA model, and total magnification is only 1.25. From this we conclude that fluctuations in the job destruction rate are central to producing the impulse magnification and persistence underlying our total magnification results.[17]

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[15]Autocorrelations in the Hansen model are nearly identical to those in the RBC model.

[16]The latter finding may be contrasted with results from Burnside and Eichenbaum's (1996) factor hoarding model, where the first-order autocorrelation of output growth rates closely matches the data, but the second-order autocorrelation is negative.

[17]Our finding of little persistence in the exogeneous separation case may appear to conflict with results of Andolfatto (1996), who considers a DGE model with labor market matching and an exogeneous separation rate. In calibrating his model, however, Andolfatto utilizes a quarterly worker matching probability of roughly 20 percent, which implies an unemployment duration of five quarters. Andolfatto obtains this measurement by including in the worker matching pool *all* adults that are out of the labor force, together with the unemployed. We simulated a version of our CCA model with $b = 0$, $\rho^x = 0.10$ and $\lambda^w = 0.20$, and

4.3. Interactions between the Labor and Capital Markets. Our model produces large amounts of total magnification as a consequence of the nature of capital adjustment following shocks. This may be seen by considering an impulse response function for the CCA model with the capital stock frozen at its steady state level. In this case, cyclical adjustment of capital plays no role in output variations. Impulse responses for the fixed capital and CCA models are shown in Figure 4. As observed in the figure, output dynamics for the fixed capital version display a large amount of impulse magnification, since the endogenous separation rate rises in response to the negative shock. However, adjustment of output back to the steady state is much more rapid than in the CCA model, indicating that the shock does not have a persistent effect in the absence of capital adjustment. Importantly, the need for gradual rematching of displaced workers does not in itself generate significant persistence.

As Figure 4 makes clear, variability in both the employment separation rate and capital stock are needed in order to account for the persistence generated by the CCA model. At the heart of the propagation mechanism is the interaction between the labor and capital markets, mediated by the capital rental rate. Endogenous determination of the job destruction margin implies that ρ_t^n will rise in response to a persistent decline in z_t, since the payoffs from maintaining employment relationships will become less attractive. Further, the existing capital stock will be spread over a smaller number of active employment relationships, reducing the marginal productivity of capital at the market clearing rental rate. These effects lead the effective rental rate in the CCA case, given by $(1 - \rho^x)(1 - \rho_t^n)r_t$, to be driven down more sharply than in the absence of fluctuations in the separation rate. As seen in Figure 5, a negative productivity shock leads the effective rental rate for the CCA model to drop

we obtained output dynamics similar to those reported by Andolfatto.

by a greater amount than in either the RBC model or the exogenous separation variant of the CCA model. The lower effective rental rate reduces savings, and as a consequence the negative adjustment of the capital stock following the shock is much sharper in the CCA model, as Figure 6 illustrates.

In the PCA model, the actual and effective rental rates are the same, so that ρ_t^n does not exert an independent effect on the effective rental rate, as in the CCA model. Thus, fluctuations in ρ_t^n affect rental rates only through altering the marginal productivity of capital, and the propagation mechanism is correspondingly weaker. In essence, capital adjustment costs generate added persistence through their effect on the effective rental rate.

Figures 5 and 6 further indicate that the effective rental rate and capital stock in the CCA model remain low for a significantly longer period following the shock than in the RBC and exogenous separation models. This slow adjustment is explained by the dampening effect that variation of the separation rate exerts on capital adjustment. Reductions in the capital stock exert upward pressure on rental rates, due to rising marginal productivity of capital, but this upward pressure is dampened by increases in ρ_t^n that are induced by the higher rental rates, as greater capital costs reduce the payoffs to maintaining employment relationships. In other words, variation in the separation rate serves to flatten the capital demand curve in the CCA model, relative to a comparison model without employment separation effects. This may be seen in Figure 7, which depicts capital demand curves for the CCA and corresponding standard growth models, and where the flatter curve under CCA is evident. Thus, capital adjustment in the CCA model is slowed by the fact that reductions in the capital stock can induce only limited increases in the return to investment. In sum, the rental rate implications of variability in the job destruction rate lead to sharper and more persistent reduction in the capital stock following a negative shock.

5. CONCLUSION

In this paper we have established the quantitative importance of a macroeconomic prop-
agation mechanism associated with cyclical fluctuations in the job destruction rate. Our
theoretical model endogenizes the determination of the job destruction rate as part of a dy-
namic general equilibrium with labor market matching. The model is calibrated to data on
worker and job flows, and our specification features a new matching function motivated by
theoretical principles. Our computation procedure does not rely on a social planner solution,
allowing us to avoid restrictions on bargaining parameters that have been imposed in earlier
work. Empirical support for the model is found in the good matches that it produces with
U.S. data, particularly with respect to dynamic correlations of job creation, destruction and
employment in manufacturing.

In our model, aggregate productivity shocks are strongly magnified in their effects on
output, both in the period of impact and in the periods following. The degree to which
shocks produce persistent effects is especially great in our model, relative to other models,
due to the fact that fluctuations in the job destruction rate lead to large and persistent
adjustments in the effective rate of return on capital and the capital stock. Moreover,
magnification of shocks is increased to the extent that there are costs of adjusting capital
across employment relationships. Our results suggest that interactions between the labor
and capital markets may be of central importance in propagating shocks.

In assuming that idiosyncratic shocks are i.i.d. over time, we have departed from much
of the literature, which has followed Mortensen and Pissarides (1994) in focussing on persis-
tent idiosyncratic shocks. We have made the independence assumption for simplicity only,
however, and introducing persistence should not materially alter our propagation results. In
fact, persistence may lead to greater total magnification, to the extent that a given level

of employment variability can be sustained with lower variability of idiosyncratic shocks, thereby placing the job destruction margin closer to mean idiosyncratic productivity.[18]

In the model considered here, workers trade off payoffs from employment relationships against payoffs obtained from unemployment benefits. Separations that occur are privately efficient. As an alternative, separations may be driven by contracting problems, where agents cannot constrain themselves from double-crossing their partners, but benefits from double-crossing are not actually realized when separations occur. Privately inefficient separations associated with such fragile contracts are considered in Ramey and Watson (forthcoming). A useful extension of the current model would incorporate noncontractible choices by the worker and firm into the production process. Costs of job loss would depend on the extent to which separation is driven by contractual fragility as opposed to positive returns to unemployment.

A further useful extension would more closely examine the interactions between labor and capital adjustment. Recent work by Ramey and Shapiro (1997) has focussed on costs of reallocating capital across sectors. Incorporating these ideas into the current framework would make possible a rich synthetic analysis of factor adjustment.

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[18]Persistent idiosyncratic shocks give rise to a reallocative motive for job destruction, whereby negative shocks induce workers to break up employment relationships in order to search for higher-productivity matches; see Caballero and Hammour (1994) and Gomes, Greenwood and Rebelo (1997). This approach encounters difficulties in accounting for the observed experiences of displaced workers, who earn substantially lower wages in new jobs for a number of years following the displacement (Ruhm (1991)). In reconciling our own model with this evidence, we conjecture that job heterogeneity will play a pivotal role.

6. DATA APPENDIX

Tables 2, 3B, 4. Series are monthly, taken from CITIBASE, transformed into quarterly series starting at the middle month of each quarter, seasonally adjusted by regressing the log of each series on seasonal dummies.

N - Employees on nonagricultural payroll, manufacturing (LPM6).

Q - Industrial production, manufacturing (IPMFG6).

Table 3A and Figure 3. Series are seasonally adjusted, quarterly, taken from CITIBASE.

Q - Real gross domestic product (GDPQ) divided by over age 16 population, including resident armed forces, middle month (PO16).

C - Real consumption of nondurables (GCNQ) plus real consumption of services (GCSQ) plus real government consumption expenditures and gross investment (GGEQ), all divided by PO16.

I - Real Expenditures on durable consumption (GCDQ) plus real investment (GIFQ), all divided by PO16.

N - Civilian labor force, total employment (LHEM) divided by PO16.

Tables 3B, 4. Series are quarterly, taken from Davis, Haltiwanger and Schuh, "Job Creation and Destruction" database, seasonally adjusted by regressing the log of each series on seasonal dummies.

cre - Job creation rate for both startups and new establishments (POS).

des - Job destruction rate for both shutdowns and new establishments (NEG).

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α	0.36	π	0.50
δ	0.025	ρ^x	0.068
γ	−1.00	b^{PCA}	2.22
β	0.99	b^{CCA}	2.09
ξ	0.95	c	0.20
σ_ϵ	0.007	l	1.27
		σ_a	0.10

(handwritten annotations)
2.220305
2.077198
pca 0.203072
0.196046
pca 0.101461
0.098143

Table 1. Parameter Values.

	U.S. Data	PCA	CCA
ρ^n	0.032	0.033	0.038
λ^f	0.71	0.69	0.74
λ^w	0.45	0.46	0.41
σ_N/σ_Q	0.73	0.62	0.70

(handwritten annotations)
0.0337   0.02
0.700   0.69
0.452   0.45
0.626   0.61

Table 2. Data Match for Parameter Selection.

	U.S. Data	PCA	CCA		
A					
σ_Q	1.93 (0.0024)	1.45	1.84	$=$	*1.6?*
σ_C/σ_Q	0.44 (0.16)	0.55	0.54	$=$	*0.5*
σ_I/σ_Q	3.06 (0.057)	2.70	2.93	*2.71*	*2.85*
σ_N/σ_Q	0.63 (0.079)	0.62	0.70	*0.63*	*0.62*
$\sigma_{Q/N}/\sigma_Q$	0.42 (0.30)	0.39	0.33	*0.40*	*0.39*
B					
σ_{cre}/σ_N	4.71 (0.025)	7.52	7.00	*7.48*	*8.0*
σ_{des}/σ_N	6.86 (0.012)	6.23	5.47	*6.17*	*5.9*

Table 3. Comparison of U.S. and Model Data.

U.S. data are 1972:2-88:4. All series are logged and HP filtered.

		-3	-2	-1	0	1	2	3
	U.S. Data	0.27	0.15	0.04	-0.19	-0.58	-0.68	-0.60
$\text{Cov}[cre_{t+k}, N_t]$	PCA	0.17	0.13	0.06	-0.15	-0.77	-0.68	-0.52
	CCA	0.26	0.18	0.15	-0.07	-0.62	-0.62	-0.47
	U.S. Data	-0.63	-0.65	-0.59	-0.35	-0.01	0.29	0.45
$\text{Cov}[des_{t+k}, N_t]$	PCA	-0.35	-0.53	-0.72	-0.78	-0.24	-0.02	0.08
	CCA	-0.33	-0.49	-0.66	-0.69	-0.11	0.07	0.13
	U.S. Data	-0.39	-0.44	-0.47	-0.43	-0.14	0.18	0.34
$\text{Cov}[cre_{t+k}, des_t]$	PCA	-0.14	-0.14	-0.21	-0.46	0.44	0.56	0.48
	CCA	-0.10	-0.11	-0.23	-0.65	0.30	0.45	0.39

Table 4. Dynamic Correlations of Job Flows.

U.S. data are 1972:2-88:4. All series are logged and HP filtered.

	PCA	CCA	RBC	Hansen
Impulse Magnification	1.31	1.89	1.45	1.85
σ_Q/σ_z - Unfiltered	2.44	3.24	1.55	1.86
σ_Q/σ_z - HP Filtered	1.70	2.15	1.46	1.87

Table 5. Impulse and Total Magnification.

Figure 1.
Impulse Responses of Job Creation and Destruction Rates.
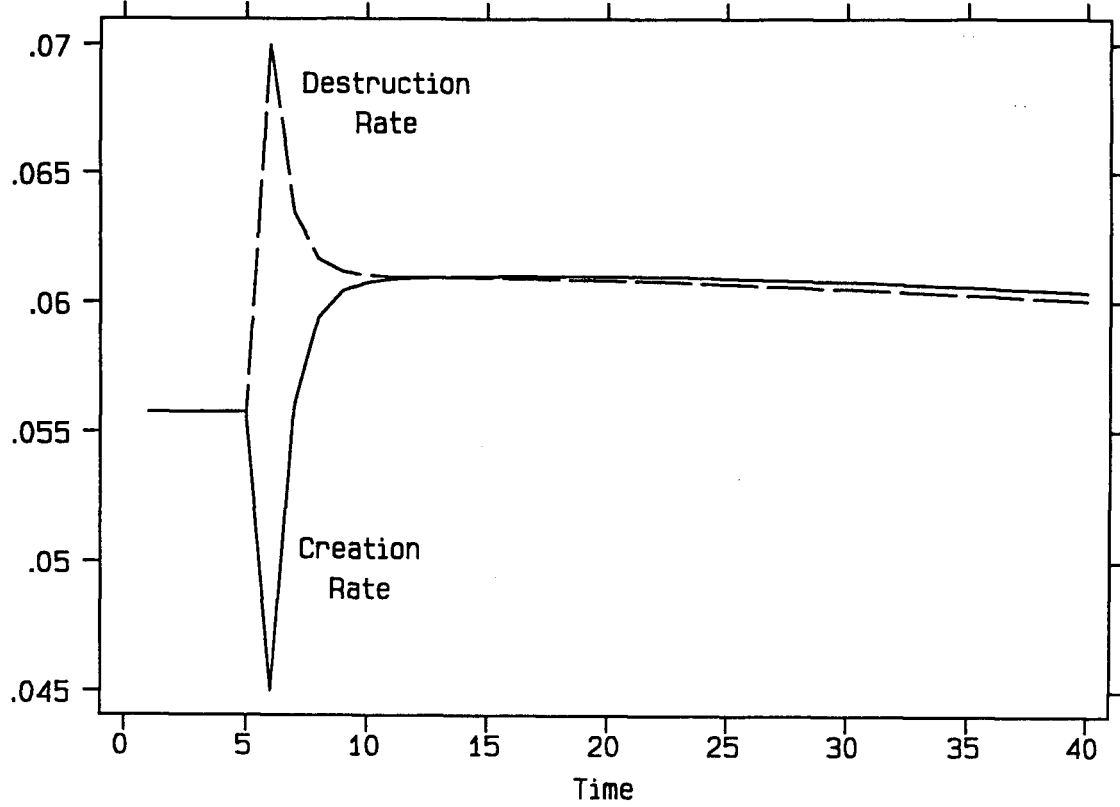
Figure 2.
Impulse Responses of Productivity and Output.

Figure 3.
Autocorrelations of Output Growth Rates.

CCA
.238
.046
.010
-.003
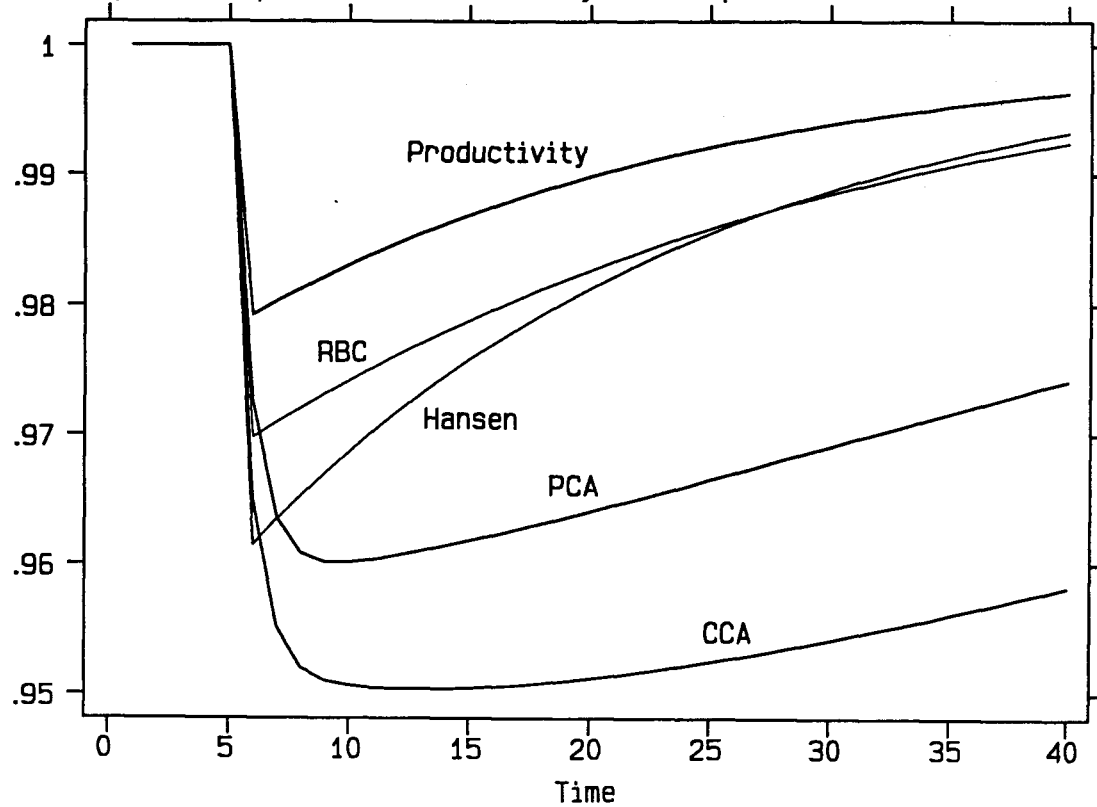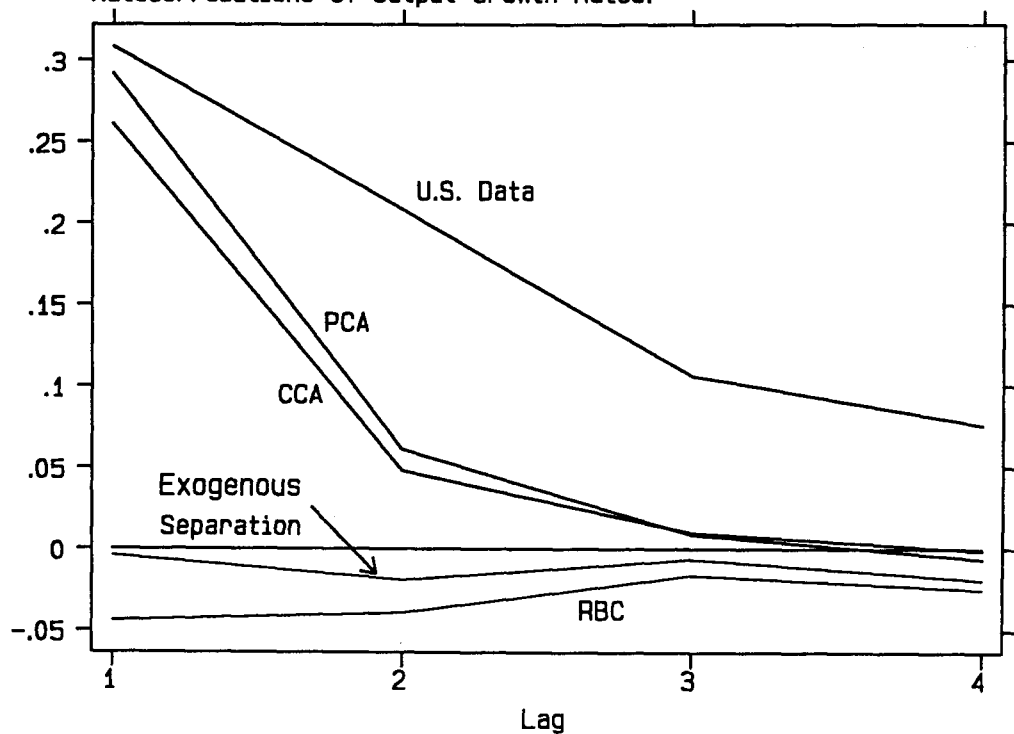
PCA
.295
.062
.009
-.001

Figure 4.
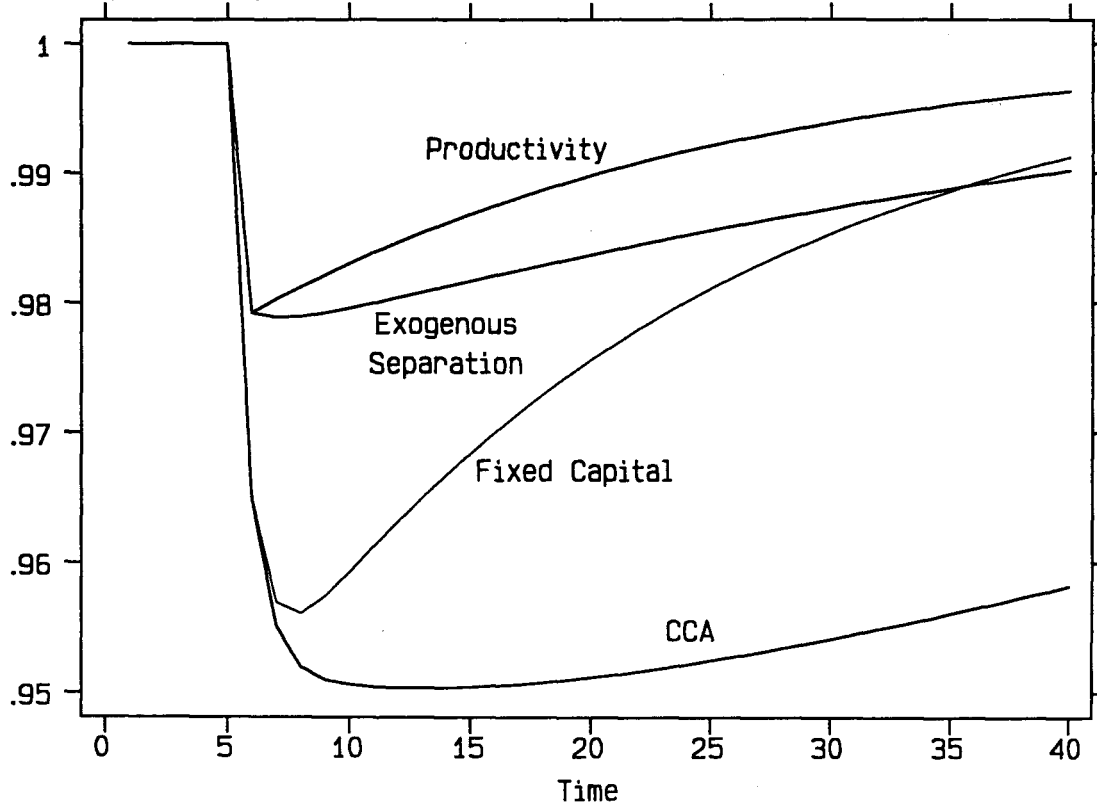Impulse Responses for Variants of CCA Model.

Figure 5.
Impulse Responses for Effective Rental Rates.
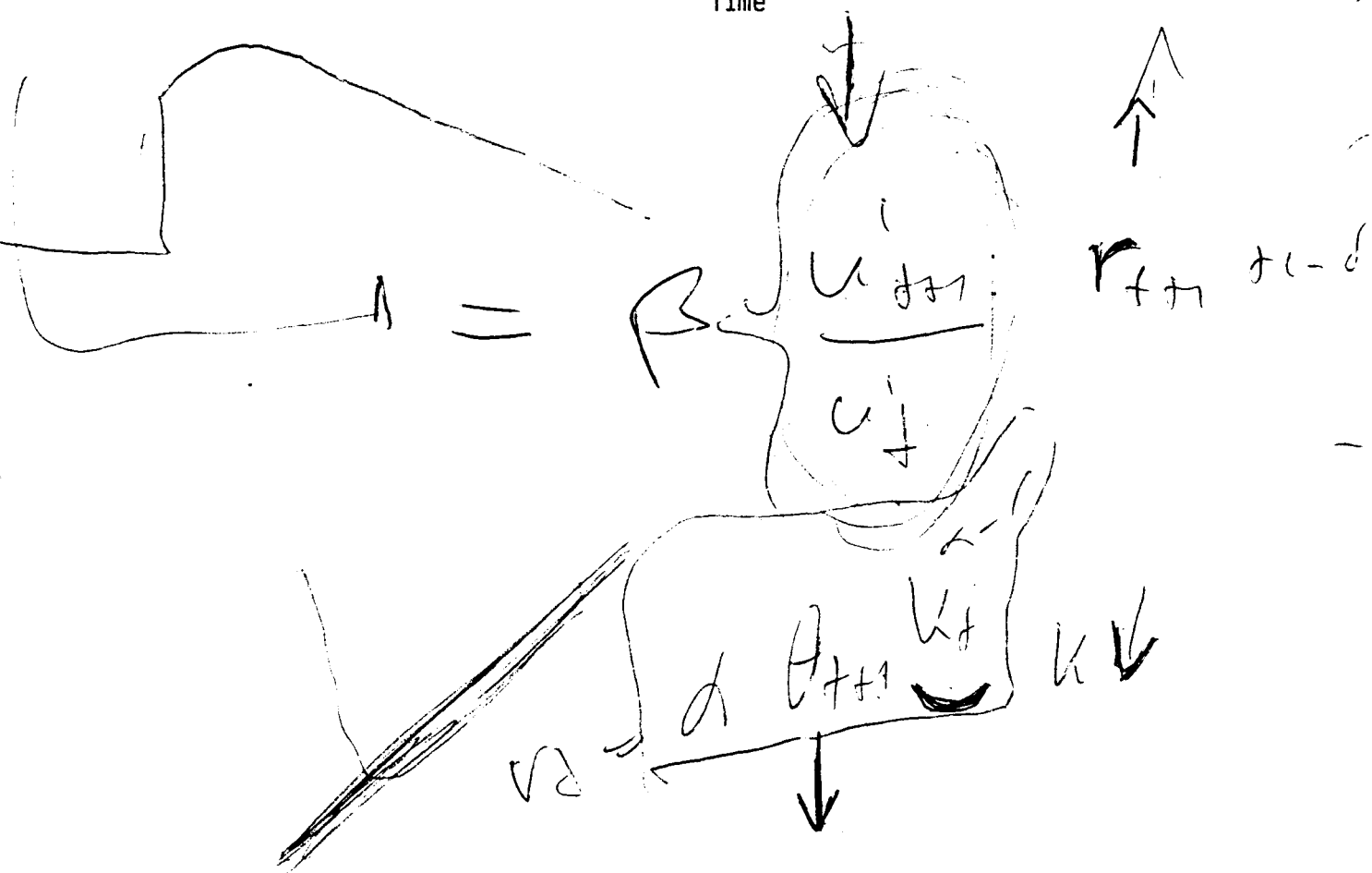
Figure 6.
Impulse Responses for Capital.

Figure 7.
Demand Curves for Capital.

Figure 7. Demand Curves for Capital.